


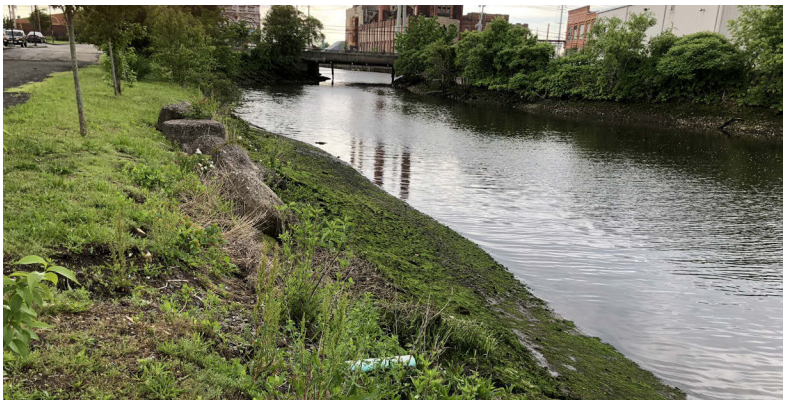


Mill River Watershed Based Plan

prepared by FUSS & O'NEILL

SEPTEMBER 2018

FUSS & O'NEILL

Acknowledgements

We would like to thank the following individuals and organizations for their contributions of time and effort to the development of this plan:

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Save the Sound/Connecticut Fund for the Environment
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Cover photos taken and provided by Connecticut Fund for the Environment/Save the Sound

Funding support for this plan was provided by the Connecticut Department of Energy and Environmental Protection through a U.S. EPA Clean Water Act Section 319 grant, a grant awarded to Connecticut Fund for the Environment from Connecticut Community Foundation, and The Watershed Fund of the Regional Water Authority.

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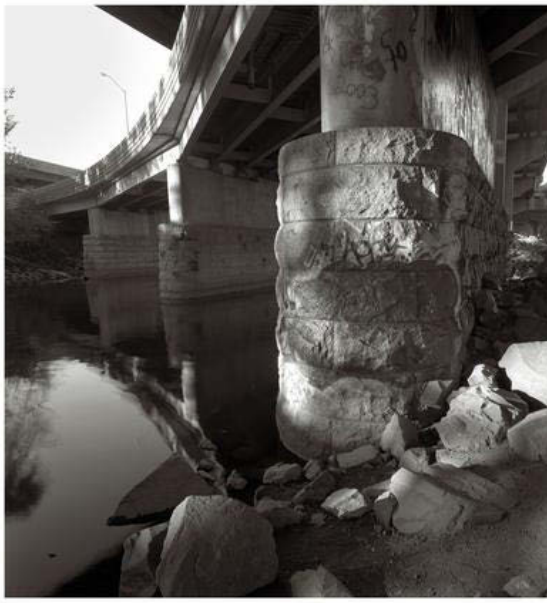
1 Introduction

1.1 Background

The Mill River and Its Watershed

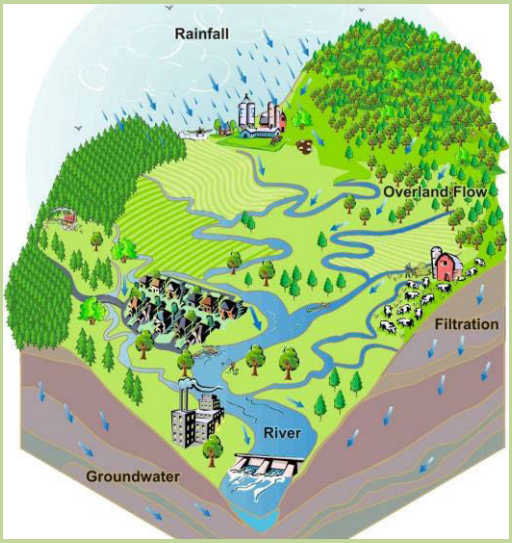
The Mill River watershed covers an area of approximately 38 square miles in New Haven County. The majority of the watershed is in the municipalities of Cheshire (where the headwaters are located) and Hamden, with smaller portions in New Haven, Wallingford, North Haven, Prospect, and Bethany (**Figure 1-1, Figure 1-2**). The upper watershed is generally rural or suburban in nature, with development intensity increasing at the southern end of the watershed and in the vicinity of the mouth of the river.



Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

What is a Watershed?

A watershed is the area of land that contributes runoff to a lake, river, stream, wetland, estuary, or bay. Land use activities within a watershed affect the water quality of the receiving waters.



The main stem of the Mill River winds from its northern headwaters in Cheshire, south to Long Island Sound, following a similar path to route 10 through Cheshire and Hamden before bending to the east to flow into Lake Whitney and then on through New Haven to the New Haven Harbor. The Mill River is one of three major rivers that all converge in the New Haven Harbor. Its path is sandwiched between that of the Quinnipiac River to the east and the West River to the west. Several major tributaries, including Willow Brook, Shepard Brook, Butterworth Brook, Jepp Brook, Eatons Brook, and Brooksvale Stream all converge with the Mill River along its course. Other major landmarks in the watershed include Sleeping Giant State Park, East Rock Park, Naugatuck State Forest, and Quinnipiac University.

The existing physical, land use, and water quality characteristics of the Mill River watershed are further described in *Section* 2, and in the document entitled *Technical Memorandum 1 – Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a) (*Appendix A*).

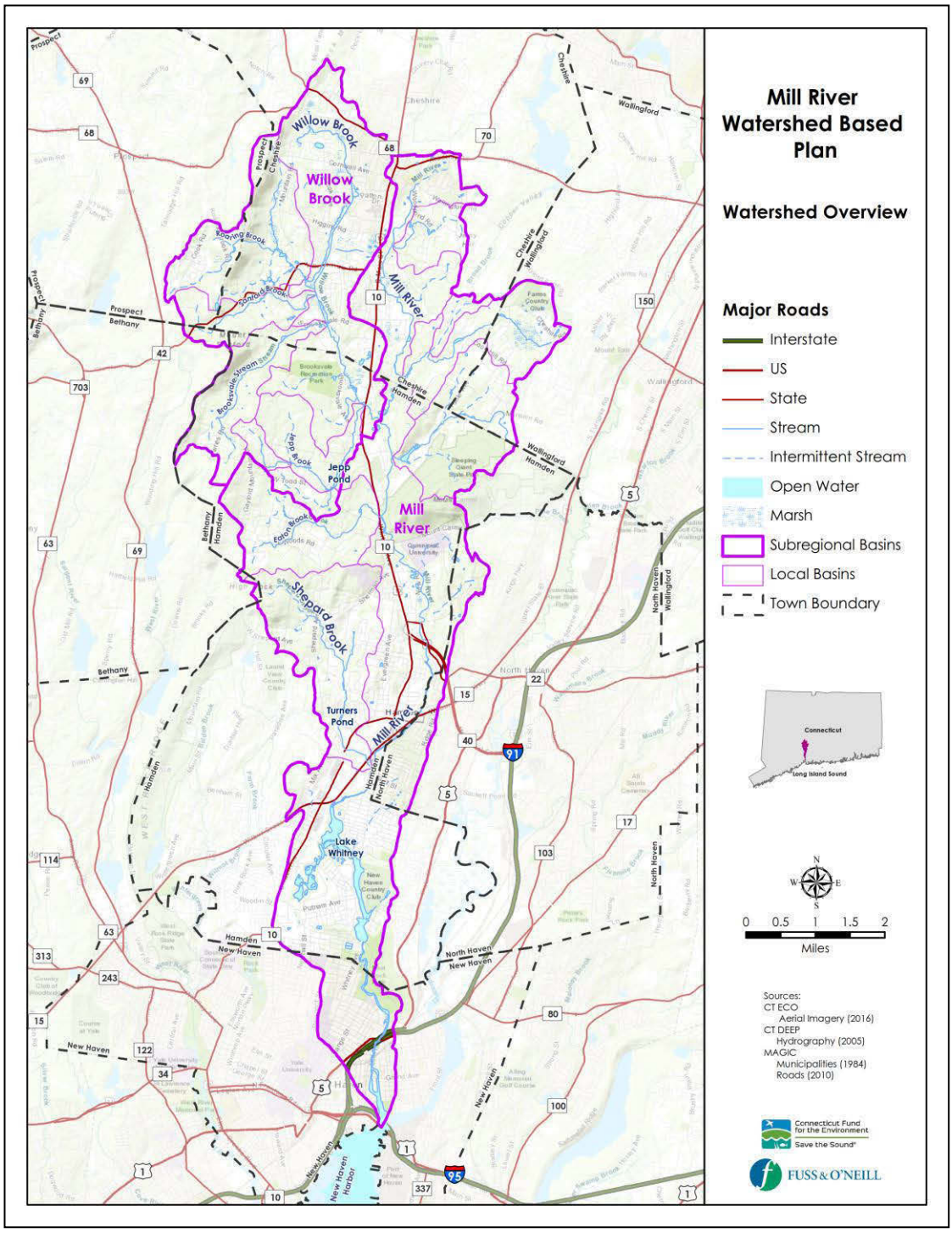


Figure 1-1. Mill River Watershed

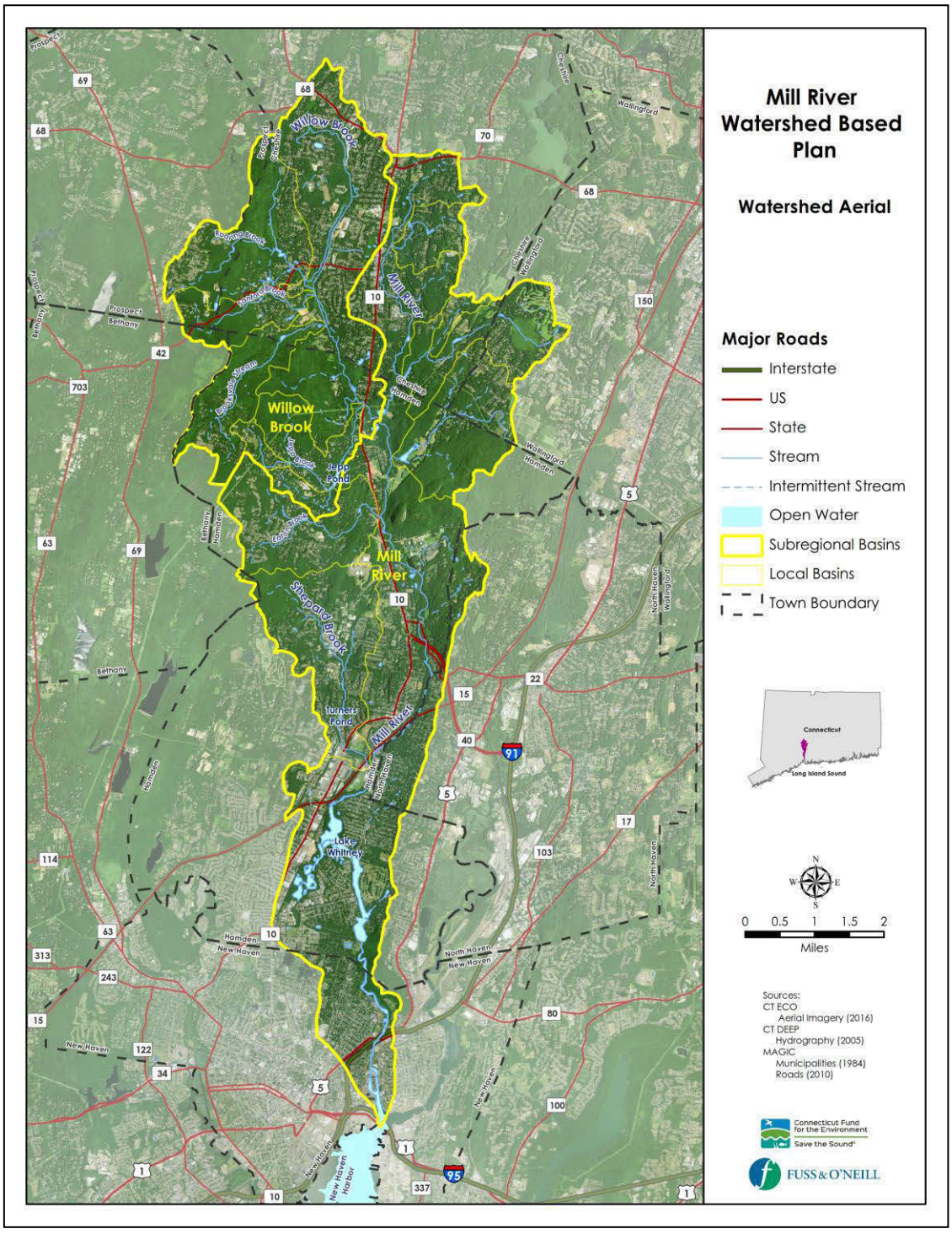


Figure 1-2. Aerial View of Mill River Watershed

Issues Facing the Watershed

Degraded Water Quality

Like many suburban and urban rivers and streams in Connecticut, including the West River and Quinnipiac River, the Mill River has been impacted by historical development and land use activities in its watershed. Water quality in multiple reaches of the Mill River and its tributaries are degraded due to elevated bacteria levels resulting from stormwater runoff, agriculture, combined sewer overflows, illicit discharges, pets, wildlife, and other sources. This has resulted in water quality "impairments," which means that the waterbodies cannot support certain types of uses such as recreation or habitat for aquatic life (**Figure 1-3**). *Section 2.2* provides detailed information on impairments in specific waterbody segments.

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. Stormwater runoff collected by the combined sanitary and storm sewer system in the City of New Haven also contributes to Combined Sewer Overflow (CSO) discharges to the Mill River during periods of heavy rainfall, when the combined sewer system becomes overwhelmed and untreated sewage is discharged directly to the river.

The Greater New Haven Water Pollution Control Authority (GNHWPCA) is in the process of implementing a long-term plan to reduce CSOs to the Mill River, which includes traditional gray infrastructure and green infrastructure[1] approaches. In addition to GNHWPCA, the City of New Haven, private development, and other groups are implementing green infrastructure in the Mill River watershed, which will reduce CSO discharges, runoff volumes, and wet weather pollutant loads.

Limited River Access

Due to the high level of development along the river, especially commercial and industrial development along route 10 and in New Haven, access to many portions of the Mill River is limited. Improved access to the Mill River and its tributaries is needed to enhance recreational opportunities as well as public appreciation and stewardship of the river. An extensive plan to develop the Mill River Trail aims to provide this additional access [see the *Mill River Trail Framework Plan;* (Reed Hilderbrand, LLC, 2017)], and funding is in place to construct the first stretch of trail through the Fair Haven neighborhood.

1.2 Prior Watershed Planning

The Mill River has been the focus of numerous prior studies, planning efforts, and projects, which are documented by a large and diverse collection of existing reports, from formal water quality assessments, to University-sponsored research, to advocacy reports. Information from many of these documents, which are summarized in **Table 1-1** beginning with the most recent documents, has been incorporated into this plan.

[1] Green infrastructure refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, green infrastructure includes stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

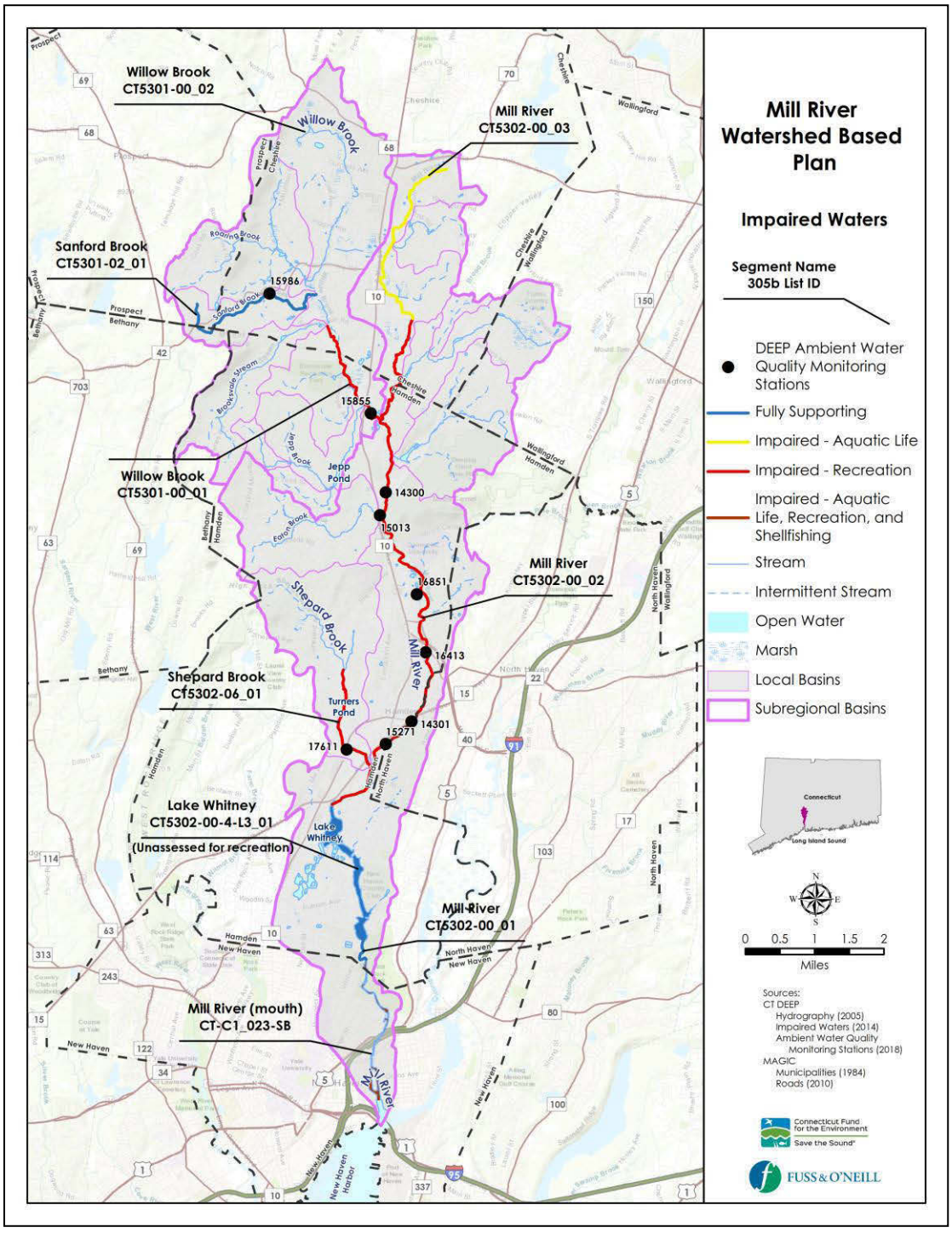


Figure 1-3. Water Quality Impairments in the Mill River Watershed

Table 1-1. Existing Documentation Related to the Mill River

Document/Information Source	Author (Date)	Notes
Public Information Meeting Presentation: New Haven CSO Long Term Control Plan	City of New Haven and GNHWPCA (2017)	Public update on the Long Term Control Plan for CSOs in New Haven, as well as rainfall conditions modeling.
Greater New Haven Water Pollution Control Authority Consent Order WC5509 Annual Progress Report: July 1, 2016- June 30, 2017	GHNWPCA (2017)	Provides updated sewer system mapping, status of all CSOs, and metering data for CSOs during the reporting period.
2016 Connecticut Integrated Water Quality Report	CTDEEP (2016)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
Lower Mill River Water Quality Monitoring Reports	RWA (2000-2016)	Weekly, warm season measurement data for salinity and dissolved oxygen at the plunge pool, spillway, and footbridge sites.
New Haven Vision 2025: Chapter VII: Environment	City of New Haven (2015)	Chapter of the New Haven comprehensive plan dealing with environmental issues. Addresses water quality in Long Island Sound, sewage, and stormwater issues.
Connecticut Watershed Response Plan for Impervious Cover: Core Document	CTDEEP (2015)	Provides background information on the effects of stormwater on water quality, identifies 12% as a critical impervious cover threshold.
Connecticut Watershed Response Plan for Impervious Cover: Appendix 6-9—Mill River (CT5302) Summary	CTDEEP (2015)	Provides specific information on impaired segments, extant impervious cover and target reduction
New Haven Vision 2025: Status of Sewer Separation Map	GHNWPCA (2015)	Indicates area where separation of sanitary and stormwater sewers has been completed, is under construction, or under design.
Urban River Permits Review and Advocacy Recommendations for the Quinnipiac, Mill, and West Rivers	Mushinsky, M. (2015)	Report produced in conjunction with the Mill River Watershed Association of South Central Connecticut and River Advocates of South Central Connecticut. Descriptions of the three rivers in the New Haven area, water quality pollutants, relevant permits affecting water quality, and advocacy recommendations.
Public Meeting Presentation	RWA (2015)	Update on the Lake Whitney management plan and monitoring efforts.
2014 Connecticut Integrated Water Quality Report	CTDEEP (2014)	Identifies waterbody segments that are classified as impaired relative to aquatic life, recreation, or shellfish.
WUCC Report to the Commissioner	Connecticut Department of Public Health (2014)	Details recommendations for proposed alteration of the boundaries of Connecticut Public Water Supply Management Areas.
Connecticut Statewide Total Maximum Daily Load (TMDL)for Bacteria-Impaired Waters: Core Document	CTDEEP (2012)	Provides documentation for the impaired waters listing status and need for a TMDL, water quality targets, and estimated percent reductions needed to attain water quality targets.
Connecticut Statewide TMDL for Bacteria-Impaired Waters: Appendix 50—Mill River Watershed Summary	CTDEEP (2012)	Provides specific information on impaired segments, potential bacteria sources, current management activities, and recommendations for impaired segments in the Mill River subregional basin.

Document/Information Source	Author (Date)	Notes
Drinking Water Assessment and Source Protection Program	Connecticut Department of Public Health (2012)	Statewide assessment results and source water areas for public drinking water supply systems. Potential contaminant sources impacting surface or groundwater are discussed.
Mill River Freshwater Tidal Marshes: 2011 Vegetation Monitoring	Sharp, P.; prepared for RWA (2012)	Summarizes vegetation monitoring efforts from 2000-2011.
Management Plan for Lake Whitney Water Treatment Plant: Revised April 2, 2012	RWA (2012)	Recommended performance standards and mitigation/monitoring measures for the operation of Lake Whitney as a public water supply.
2000-2011 Lower Mill River Invertebrate Monitoring Report	Water Resource Services; prepared for RWA (2012)	Summarizes macroinvertebrate data for the Lower Mill River.
A Biological Assessment of Upper Lake Whitney	AECOM; prepared for RWA (2010)	Summarizes biological assessments conducted from 2004 to 2009, including studies of plankton, aquatic macrophytes, benthic macroinvertebrates, fish, and water quality.
Effectiveness of Stormwater Treatment Systems Within a Highly Urbanized Watershed	Hudak, J.P., and M.E. Ellum (2003)	Report on a stormwater treatment system designed to treat a 20-acre watershed in the vicinity of Lake Whitney.
Summary of Upper Lake Whitney Management Study: January 23, 2002	Milone & MacBroom (2002)	Summarizes monitoring efforts by the RWA to collect baseline and continuing data on Lake Whitney in conjunction with the reestablishment of the lake as a public water supply.
Polycyclic Aromatic Hydrocarbons (PAHs) in the Sediments and Fish of the Mill River, New Haven, Connecticut, USA	White, J.C. and T. Triplett (2002)	Investigation of PAHs in the segment of the Mill River from Lake Whitney to the tidegates, where the most intense use for fishing and recreation occurs.
Baseline Description of the Lower Mill River Benthos	Mador, M., A. Saar, and M. Funaro (2001)	Baseline description of watershed contributions to the health of the river, local threats and potential future issues related to ecological health. Aquatic chemistry course project from Prof. Gabe Benoit's course at Yale School of Forestry.
Environmental Evaluation: Whitney Environmental Study Team Recommendations	Hudak, J.P., S.R. Kellert, J.T. Maughan, J.L. Rogers, and P.C. Sharp (1999)	Summary of recommendations from the Lake Whitney Water Treatment Plant Environmental Evaluation, including minimum spillway flow, minimum flow releases, dissolved oxygen, spring flood releases, and ongoing ecological monitoring.
The Lake Whitney Urban Runoff Project Final Report	Hudak, J.P. (1996)	Report on planning, construction, and monitoring of a stormwater treatment system designed to address runoff from an urban outfall pipe in the vicinity of Lake Whitney.
Lake Whitney Reservoir Urban Runoff Treatment Project Phase II	New Haven County Soil and Water Conservation District (1995)	A review of existing regulations relating to watershed protection and/or water quality.

Document/Information Source	Author (Date)	Notes
Phosphorus Transport in the Mill River, New Haven County, Connecticut	Perkins, E.J. (1993)	Yale University study of processes affecting phosphorus transport in the Mill River.
Lake Whitney Stormwater Treatment Systems Map	RWA (n.d.)	Map showing locations of stormwater treatment systems in the vicinity of Lake Whitney.
Lake Whitney Project Mill River Subbasins	Unknown (n.d.)	Prioritization of subbasins for urban runoff, subwatershed descriptions, and historic outfall mapping.

1.3 Why Develop a Watershed Plan?

Save the Sound, a program of Connecticut Fund for the Environment (CFE/Save the Sound), the Connecticut Department of Energy and Environmental Protection (CTDEEP), the watershed municipalities, and other key stakeholders recognize the need to address the water quality issues facing the Mill River and its tributaries. Several of these waterbodies have impairments for recreation or aquatic life support due to elevated levels of bacteria and other pollutants. A primary step toward addressing these issues is to develop and implement a comprehensive watershed based plan. The watershed-based planning process brings together stakeholders from throughout the watershed to identify projects and practices that will satisfy United States Environmental Protection Agency (EPA) and CTDEEP requirements for watershed planning for the Mill River, and in doing so, improve water quality and restore conditions in the watershed. The watershed plan provides a blueprint to help groups within the watershed work across municipal boundaries to better protect and restore water resource conditions throughout the watershed.

Watershed Management

Watershed planning is a process that identifies ways to protect and restore the water quality and other natural resources in a watershed. The outcome of the watershed planning process is documented in a watershed based plan.

Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

The major objectives of developing a watershed-based plan for the Mill River are to:

- Characterize current watershed conditions and issues
- Identify existing water quality issues and pollutant sources
- Consolidate previous and ongoing efforts within the watershed under one plan
- Facilitate capacity-building and engage the watershed municipalities and other stakeholder groups, as well as the general public, in the watershed planning process and future plan implementation
- Promote collaboration across municipal boundaries, bringing the watershed communities and groups together to cooperate around shared issues of concern and objectives without compromising their “home rule” principles

- Create a plan that satisfies EPA and CTDEEP requirements for watershed-based plans to better position the Mill River for future grant funding from certain State and Federal sources.
- Improve water quality and de-list "impaired waters"

1.4 Watershed Management Goals and Objectives

This section presents management goals and objectives for the Mill River watershed, each of which will be developed in more detail in *Section 3* of this plan. The goals and objectives were developed over the course of the watershed planning process, with input from the Project Steering Committee, the public, and other watershed stakeholders.

- **Goal #1 – Capacity Building.** Strengthen and build local capacity to implement the watershed based plan.

  Capacity Building Objectives
  - **Establish a framework and lead entity** for implementation of the watershed based plan
  - **Promote inter-municipal coordination** to formally adopt the watershed plan and coordinate and oversee watershed based plan implementation activities.
  - **Promote regional collaboration** to share ideas and strengthen regional watershed management efforts, particularly with groups representing the neighboring West River and Quinnipiac River watersheds.
  - **Identify and pursue funding** to implement the recommendations outlined in this plan.
  - **Conduct streamwalks** in priority subwatersheds to assess the condition of the streams and riparian corridors, identify retrofit opportunities and problem areas, and involve the public and volunteers as a form of outreach.
  - **Prepare and implement subwatershed action plans** for priority subwatersheds.

Mill River watershed management goals.

- **Goal #2 – Water Quality.** Improve the water quality of the impaired segments of the Mill River and its tributaries by reducing loadings of bacteria and other pollutants. Consistently meet water quality standards for recreation and aquatic habitat. Protect and enhance high quality and unimpaired waterbodies.

  Water Quality Objectives
  - Continue **water quality monitoring** to identify pollution sources, follow long-term trends in water quality, and track the progress of the watershed plan.

- **Eliminate Combined Sewer Overflow (CSO)** discharges to the Mill River.
- Reduce the impacts of **subsurface sewage disposal systems** through proper homeowner inspection and maintenance.
- Expand the use of **green infrastructure** throughout the watershed.
- Implement **municipal stormwater management** programs to comply with state and federal permit requirements.
- Protect and restore **natural streamside vegetation** in the watershed to protect and improve water quality.
- Reduce bacteria loads from **wildlife and pet waste**.
- Identify and remove **illicit connections and non-stormwater discharges** to the Mill River and its tributaries.
- Promote **sustainable lawn care practices** to reduce the use of water, fertilizer, and toxic chemicals.
- Reduce the threats to water quality from **commercial and industrial land uses**.

- **Goal #3 – Habitat Protection and Restoration.** Protect and restore terrestrial, streamside, and aquatic habitat.

  Habitat Objectives
  - Protect and restore **in-stream habitat for resident and migratory fish species** in the Mill River and its tributaries by removing barriers to fish passage.
  - Protect and restore **natural vegetated buffers** along the Mill River, its tributaries, and other water bodies.
  - Manage **invasive plant species** that threaten local biodiversity and ecosystem function in the watershed.
  - Protect and restore **forested areas and tree canopy** within the watershed.

- **Goal #4 – Sustainable Land Use, Open Space, and Public Access.** Promote sustainable land use and appropriate development in the watershed while protecting and improving water quality and natural resources, enhancing public access to and connectivity of waterbodies and open space, and addressing current and future flooding problems.

  Land Use, Open Space, and Public Access Objectives
  - **Preserve existing open space** and prioritize additional lands for open space conservation.
  - Increase **public access to the Mill River and connectivity of water bodies and open space** to improve public use, appreciation, and stewardship.
  - Strengthen municipal **land use policy and regulations** for broader implementation of low impact development and green infrastructure.
  - Increase **flood resilience through a watershed approach**.

- **Goal #5 – Education and Stewardship.** Promote stewardship of the watershed through education and outreach, improved access to the Mill River and its tributaries, and citizen involvement in science, conservation, and restoration activities.

  Education and Stewardship Objectives
  - **Implement a green infrastructure public outreach campaign** focused on citizens, businesses, and communities.
  - **Provide incentives** for residential "green" practices.

- **Conduct homeowner education and outreach** on animal waste, sustainable lawn care and landscaping practices, streamside buffers, and septic system maintenance.
- **Promote, publicize, and support existing community engagement events** that focus on the Mill River and its watershed such as the work of the Mill River Trail Advocates.
- **Conduct education and outreach for the watershed business community** on pollution prevention.
- **Conduct municipal education and outreach** on animal waste, parks and open space maintenance, green infrastructure, storm sewer system and BMP maintenance, and identification and removal of illicit connections.
- **Enhance youth education, community service, and environmental stewardship programs.**
- **Conduct outreach to public and private institutional property owners** in the watershed such as Quinnipiac University and the local schools.
- **Increase watershed stewardship signage** in targeted areas.

1.5 Plan Development Process

Funding for this project was provided in part by the CTDEEP through a U.S. EPA Clean Water Act Section 319 Nonpoint Source grant. Fuss & O'Neill, Inc. was retained by CFE/Save the Sound to lead the development of the watershed based plan.

This plan has been developed consistent with EPA and CTDEEP guidance for watershed-based plans. The guidance outlines nine key elements (see text box on this page) that establish the structure of the plan, including specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act and improve the chances for funding through other State and Federal sources. Development of the watershed based plan consisted of the following tasks.

EPA Nine Key Elements of a Watershed-Based Plan

a. Identify causes and sources of pollution
b. Estimate pollutant loading to the watershed and the expected load reductions
c. Describe management measures that will achieve load reductions and targeted critical areas
d. Estimated amount of technical and financial assistance and the relevant authorities needed to implement the plan
e. Develop and information/education component
f. Develop a project schedule
g. Describe the interim, measurable milestones
h. Identify indicators to measure progress
i. Develop a monitoring component

Project Steering Committee

A Project Steering Committee was formed to guide the plan development. The Steering Committee consisted of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed.

A series of meetings were held with the Steering Committee and other invited stakeholders to discuss issues of concern in the watershed and to identify watershed planning goals and objectives that would form the basis of the plan recommendations. The Steering Committee and other stakeholders also provided review

comments on draft deliverables. The watershed plan reflects the combined efforts of CFE/Save the Sound, CTDEEP, the watershed municipalities, other stakeholders, and the Fuss & O'Neill project team. Members of the Project Steering Committee and other individuals involved in the plan development process are listed in the Acknowledgments section at the beginning of this document.

Existing Watershed Conditions

A baseline assessment was performed to document the existing physical, land use, and water quality characteristics of the Mill River watershed. The project team reviewed existing watershed data, studies, and reports; and compiled and analyzed GIS mapping of the watershed and various subregional basins. The document entitled *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a) serves as a basis for the watershed plan recommendations and also provides a background reference document to support future implementation activities within the watershed. A copy of the technical memorandum is provided in *Appendix A* of this plan.

Watershed Survey

A survey was conducted to obtain early feedback from the Project Steering Committee and other stakeholders regarding the top concerns and issues in the Mill River watershed and the desired outcomes of the watershed planning process. A summary of the survey results are presented below.

Pollutant Load Modeling

Pollutant loading models were developed for the watershed based on impervious cover data and land use information. The methods and findings of this assessment are documented in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b). A copy of the technical memorandum is provided in *Appendix B* of this plan. The pollutant loading models provide baseline estimates on overall pollutant contributions from each subwatershed, as well as breaking down the loads by source. These estimates form the basis for further load reduction modeling presented in *Section 4* of this document.

Green Infrastructure Assessment

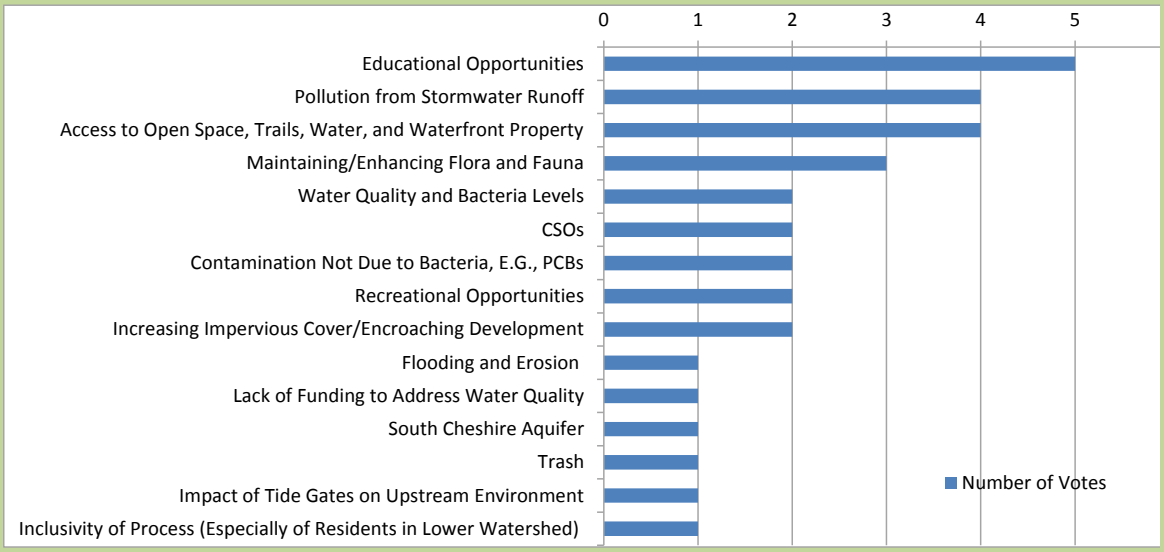
An assessment was performed to identify opportunities and develop concepts for site-specific green infrastructure retrofits in the Mill River watershed. The assessment included a screening evaluation to quickly identify areas of the watershed with the greatest feasibility for and potential benefits from green infrastructure retrofits, field inventories of the most promising green infrastructure retrofit opportunities in the watershed identified from the screening step, and development of green infrastructure concepts for selected retrofit sites. The site-specific project concepts are intended to serve as future implementation projects and examples of the types of projects that could also be implemented for other similar land uses and locations in the watershed. The methods and findings of this assessment are documented in *Technical Memorandum 3— Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c). A copy of the technical memorandum is provided in *Appendix C* of this plan.

Plan Recommendations

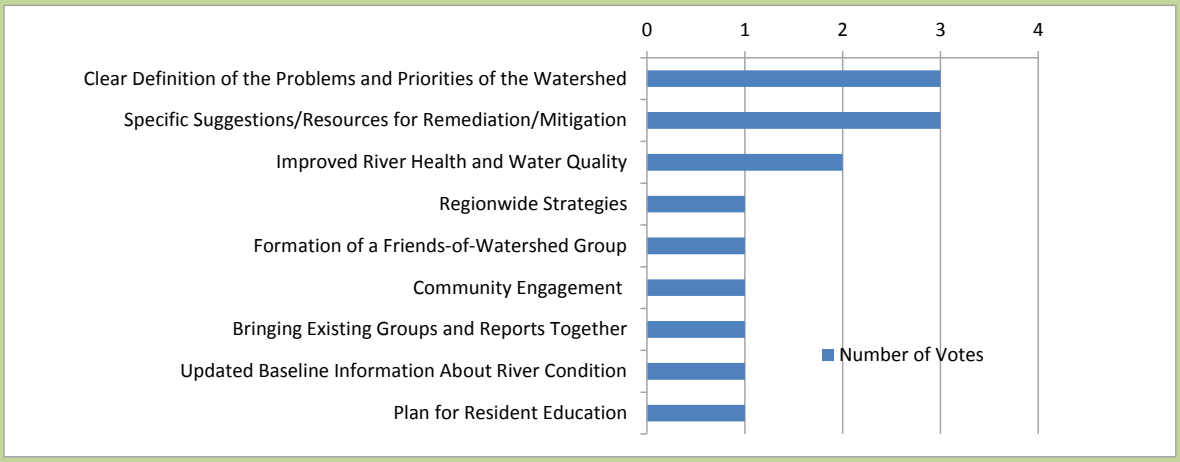
Potential management actions were identified for each of the plan goals and objectives and subsequently refined based upon input from the Project Steering Committee and other stakeholders, culminating in the management recommendations that are presented in *Section 3* of this document.

Mill River Watershed Survey Responses

Top Issues/Concerns in the Mill River Watershed



Desired Outcomes of the Watershed Planning Process



1.6 Public Participation and Outreach

Public participation and outreach was conducted as part of the watershed planning process to increase public understanding of issues affecting the watershed, to encourage participation in the development of the watershed plan, and to build support for implementation of the plan. The following public outreach activities occurred during the watershed planning process:

- **March 2018** – A Project Steering Committee was formed in March 2018. An initial project kickoff meeting was held with the Steering Committee and other invited stakeholders (34 attendees in total) at the Eli Whitney Museum on March 1, 2018. A watershed survey was circulated to the stakeholders at this meeting to identify issues of concern and watershed planning priorities. An additional presentation was made to the Whitneyville Civic Association on March 18, 2018. Meeting summaries are included in *Appendix D* of this plan.

- **April 2018** – A Project Steering Committee meeting was held on April 10, 2018 at Cheshire Senior Center in Cheshire. The primary purpose of the meeting was to review the watershed survey responses, baseline watershed conditions, and the watershed plan goals. *Appendix D* contains a summary of the meeting.

- **May 2018** – Additional Project Steering Committee meetings were held on May 1, 2018 at the Eli Whitney Museum in Hamden, and May 29, 2018 at Cold Spring School in New Haven. The latter meeting included a screening from the film, *The Mill River—Water and Wildlife* and a discussion of the continued efforts of RWA and GNHWPCA throughout the Mill River watershed. Meeting summaries are included in *Appendix D* of this plan.

- **June 2018**—Presentations on the Mill River watershed planning process were made to the New Haven Environmental Advisory Council on June 6, 2018, and to the community at Green Drinks New Haven on June 20, 2018.

- **July 2018** – A Project Steering Committee meeting was held on July 10, 2018 at Cheshire Senior Center in Cheshire. The meeting centered around presentation of the pollutant loading model calculations and green infrastructure assessments. *Appendix D* contains a summary of the meeting. Fuss & O'Neill and staff from the RWA and CFE/Save the Sound conducted streamwalk assessment training on July 21, 2018 for Cheshire Land Trust, members of the Project Steering Committee, and other volunteers. The training provided volunteers with basic information on conducting stream assessments of the Mill River and its tributaries following the NRCS protocols for performing visual stream assessments in Connecticut. Further details of the stream assessments are discussed in *Section 3.1.5* of this plan.

- **August 2018** – A steering committee meeting was held at the Eli Whitney Museum on August 21, 2018 to discuss the draft Mill River Watershed Plan and to plan public outreach events to share the plan with the greater watershed community.

- **September 2018** – Two community meetings open to the public were held on September 5th and 6th, 2018. In order to accommodate residents from both ends of the watershed, the September 5 meeting was held at the Eli Whitney Museum in Hamden, while the September 6 meeting was held at Cheshire Senior Center. The public meetings centered around a presentation of the watershed

based planning process, current watershed conditions, plan recommendations and site-specific design concepts. Each meeting included a public comment period as well as information on how to provide written comments. Information on the draft watershed based plan was also made available at the CT Folk Festival & Green Expo on September 8, 2018 and the Whitneyville Fall Festival and Cheshire Fall Festival, both held on September 15, 2018.

Credit: RWA

FUSS & O'NEILL

2 Watershed Characterization

2.1 Watershed Description

The Mill River watershed consists of two subregional basins: Mill River Subregional Basin (#5302) and Willow Brook Subregional Basin (#5301). Each subregional basin contains 7 local basins of varying size (**Figure 1-1**). The watershed covers an area of approximately 38 square miles (24,584 acres) in the municipalities of Bethany, Prospect, Cheshire, Hamden, North Haven, Wallingford, and New Haven, in New Haven County (**Table 2-1**). The upper watershed is generally rural or suburban in nature, with development intensity increasing at the southern end of the watershed and in the vicinity of the mouth of the river. Population density ranges from 262 people per square mile in Bethany to 6,992 people per square mile in New Haven. Cheshire and Hamden, which together make up 83% of the watershed area, have population densities of 885 and 1,884 people per square mile, respectively.

Table 2-1. Distribution of Municipalities in the Mill River Watershed

Municipality	Total Acreage of Municipality	Acreage in Watershed	% of Municipality in Watershed	% of Watershed	Population Density (people/sq.mi.)
Bethany	13,690	128	0.9	0.5	262
Cheshire	21,165	7,377	34.9	30.0	885
Hamden	21,278	13,117	61.6	53.4	1,884
New Haven	12,288	1,179	9.6	4.8	6,992
North Haven	13,510	835	6.2	3.4	1,149
Prospect	9,238	799	8.7	3.3	680
Wallingford	25,821	1,149	4.5	4.7	1,155
Watershed (total)	**116,990**	**24,585**	**N/A**	**100.0**	**1,723**

The main stem of the Mill River is approximately 12.6 miles long, and stretches from Cheshire south to Long Island Sound, passing through an approximately 0.068 square mile estuary region of tidal influence, before ultimately flowing into New Haven Harbor. The largest tributary to the Mill River is Willow Brook, which drains an approximately 13 square mile area before joining the Mill River in Hamden. Shepard Brook, Butterworth Brook, Jepp Brook, Eatons Brook, and Brooksvale Stream are additional major tributaries. Numerous smaller streams complete the network of waterbodies draining through the Mill River to New Haven Harbor. Major surface waterbodies in the watershed include Lake Whitney, Turners Pond, Clark's Pond, and Jepp Pond.

2.2 Water Quality

In compliance with section 305(b) of the Federal Clean Water Act, the state of Connecticut submits a water quality report to the EPA every two years. That report lists waterbody segments and denotes whether they have met water quality standards for certain designated uses, including aquatic life use support, recreation, and shellfish harvesting. Six river segments and one estuary segment within the Mill River Watershed were identified in the 2016 Integrated Water Quality Report (IWQR). Of these, four river segments and the estuary

are impaired for at least one use category (**Figure 1-3**). Two additional segments within the watershed were included in the 2014 IWQR as fully supporting or not assessed but were not reported in the 2016 update.

- **Sanford Brook:** Sanford Brook segment CT5301-02_01 ("Sanford Brook (Cheshire)-01") is 2.68 miles long and extends from its mouth at the confluence with Willow Brook downstream of South Brooksvale Road in Cheshire, upstream to the headwaters (just upstream of Candee Road) in Prospect. It is fully supporting of both aquatic life and recreation.

- **Willow Brook:** Willow Brook segment CT5301-00_01 ("Willow Brook (Hamden)-01") is 1.87 miles long and extends from its mouth at the confluence with the Mill River downstream of the Willow Street crossing in Hamden, upstream to the confluence with Brooksvale Stream in Cheshire, traveling along the railroad tracks. It is impaired for recreation and is not assessed for aquatic life. Willow Brook segment CT5302-00_02 ("Willow Brook (Hamden)-02") is 3.84 miles long and extends from its confluence with Brooksvale Stream to the headwaters near Timber Lane, in Cheshire. The segment was included in the 2014 IWQR as not assessed for aquatic life and having insufficient information for recreation; it was not included in the 2016 IWQR.

- **Shepard Brook:** Shepard Brook segment CT5302-06_01 ("Shepard Brook (Hamden)-01") is 1.78 miles long and extends from its mouth at the confluence with the Mill River just downstream of Route 15, includes Turners Pond, and continues upstream to the confluence with an unnamed tributary behind the business park off Sherman Avenue and Town Walk Drive. The segment is not assessed for aquatic life and is impaired for recreation.

- **Mill River:** Mill River segment CT5302-00_01 ("Mill River (Hamden)-01") is 0.41 miles long and extends from the footbridge crossing to the Lake Whitney outlet dam, in Hamden. The segment is tidally affected freshwater, and is fully supporting of both aquatic life and recreation uses. Mill River segment CT5302-00_02 ("Mill River(Hamden/Cheshire)-02") is 9.06 miles long and extends from the inlet to Lake Whitney on the east side of Route 15, just downstream of Connolly Parkway in Hamden, to the Cook Hill Road crossing in Cheshire. The segment is impaired for both recreation and aquatic life. Mill River segment CT5302-00_03 ("Mill River (Cheshire)-03") is 3.09 miles long and extends from the Cook Hill Road crossing to the headwaters, just upstream of Williamsburg Drive. The segment is impaired for aquatic life; there is insufficient information to assess recreation impairments.

- **Lake Whitney:** The Lake Whitney segment CT5302-00-4-L3_01 ("Whitney, Lake (Hamden)") is reported in the 2014 IWQR but not included in the 2016 report. The Lake, which is an impoundment of the Mill River, covers 140.42 acres and was denoted in the 2014 IWQR as fully supporting for aquatic life and unassessed for recreation.

- **Inner-Mill River Estuary:** The estuary segment CT-C1_023-SB (identified in the IWQR as "LIS CB Inner-Mill River (mouth), New Haven/Hamden") covers 0.068 mi^2, extending northward from the mouth of the Mill River at its confluence with the Quinnipiac River in New Haven to the footbridge crossing just upstream of East Rock Road in Hamden. The estuary segment is impaired for recreation, aquatic life, and shellfish.

Further details of the impaired waterbody segments within the watershed, including causes of impairment, can be found in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill 2018a; included in *Appendix A* of this document).

Bacteria Impairments

CTDEEP completed a "Statewide Bacteria Total Maximum Daily Load" (TMDL) for 176 impaired waterbody segments based on the 2010 Impaired Waters List (CTDEEP, 2012). The TMDL sets target pollution levels and establishes a framework for restoring water quality of the impaired segments. Only two of the bacteria impaired segments listed above are included in the approved TMDL (Mill River-02 and Shepard Brook). This is because several of the waterbody segments in the Mill River watershed that are now classified as impaired were assessed more recently than 2010. However, like the segments listed in the TMDL, the Willow Brook segment (Willow Brook-01) is also impaired for recreation due to *E. coli,* and the Inner-Mill River Estuary is impaired for recreation due to Enterococcus and fecal coliform. Based on the 2010 data included in the TMDL, the Mill River-02 segment requires a 77% reduction in geometric mean indicator bacteria (*E. coli*) levels and a 94% single sample *E. coli* reduction in order to meet the TMDL. For the Shepard Brook segment, the required percent reductions are 77% and 71%, respectively.

Potential sources of indicator bacteria identified in the TMDL include point sources, such as permitted discharges from Municipal Separate Storm Sewer Systems (MS4s), combined sewer overflows (CSOs), and industrial and commercial facilities. Additional non-point sources include stormwater runoff, failing septic systems, agricultural activities, and wastes from wildlife and pets. Stormwater discharges to MS4s and illicit discharges are two of the primary targets identified in the Statewide Bacteria TMDL for pollution reduction of freshwater segments. The TMDL also recommends removal of CSOs in New Haven for bacteria reduction in the New Haven estuaries.

Water Quality Monitoring

CTDEEP routinely monitors ambient water quality, macroinvertebrate diversity, and fisheries at various locations within the watershed (**Figure 1-3**). Many of these data are ultimately incorporated into the biannual IWQRs and TMDLs. Additional water quality and biological monitoring took place in the Lake Whitney portion of the watershed in conjunction with the planning and eventual opening of the new Lake Whitney Water Treatment Plant, which opened in April, 2005 (discussed in more detail in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill 2018a; included in *Appendix A* of this document). Other studies (some published, some unpublished) have been conducted in association with local organizations or academic institutions that focus on specific water quality issues, such as polycyclic aromatic hydrocarbons in Mill River sediments and fish, phosphorus transport, and aquatic chemistry.

Impervious Cover Response Plan

The Mill River headwaters segment (CT5302-00_03) has been designated as impaired for aquatic life and fish habitat, but the cause of the impairment is unknown. This segment has been included in the *Connecticut Watershed Response Plan for Impervious Cover* (IC Response Plan) (CTDEEP, 2015), along with 15 other streams that are also impaired for aquatic life but have no known cause for the impairment. The IC Response Plan uses impervious cover as a surrogate for the suite of potential pollution sources carried by stormwater runoff, and sets a target of 11% impervious cover. The target is not a required reduction or a regulatory limit, but is meant to guide best management practices (BMPs) and low impact development (LID) within the impaired drainage areas. The current impervious cover of the watershed area corresponding to the impaired segment is 15%; meeting the target would therefore require a 27% reduction in impervious cover (CTDEEP, 2015).

2.3 Land Use and Land Cover

2.3.1 Land Cover[2]

The distribution of land cover (physical land type) and land use (how people are making use of land) within the watershed plays an important role in shaping spatial patterns and sources of nonpoint source pollution and surface water quality. Impervious cover, in particular, is central to determining rates and volume of stormwater runoff, which is often a key contributing factor to water quality impairments.

Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

The National Land Cover Database (NLCD) provides Landsat-based, 30-meter resolution land cover data for the entire nation. The most recent national data, which are presented here, are from 2011. The University of Connecticut Center for Land Use Education and Research (UConn CLEAR) provides a more recent dataset (2015), but the NLCD data are preferred as they disaggregate developed land into more precise categories based on density of development, and provide more detailed divisions for agricultural land and other habitat types.

Based on NLCD data, approximately 47% of the watershed falls into one of the four developed land categories (**Table 2-2**), while 41.9% is deciduous forest land. At 55.9% developed land and 33.8% forest, the Mill River subregional basin is substantially more developed than the Willow Brook subregional basin, which has 30.6% developed land and 57.7% deciduous forest cover. This is consistent with the trend noted above, that highly developed areas are concentrated to a large degree at the southern end of the watershed, while the northern portion of the watershed is generally less developed. This pattern is even more pronounced for land cover in the riparian zone. Vegetated riparian buffers can slow stormwater runoff, and trap sediment and other pollutants. On the other hand, riparian lands that are developed and lack a dense stand of vegetation may be especially vulnerable to water quality issues.

2.3.2 Land Use

Whereas land cover categorizes the physical landscape, land use refers to the way that humans are utilizing the land and focuses on five primary categories (commercial/mixed use, industrial, institutional, residential, open space) in addition to an 'other' category. Land use data were obtained from both the South Central Regional Council of Governments (SCRCOG) and the Naugatuck Valley Council of Governments (NVCOG). SCRCOG last updated their land use data in 2016; NVCOG last revised their data in 2017.

[2] Note that additional land cover and land use figures can be found in Appendix A.

Residential use dominates land use across the entire watershed, comprising slightly more than half of all land use in both subregional basins (**Table 2-3**). Open space is the next largest category in both watersheds, but makes up nearly 1/3 of land use in the Willow Brook subregional basin compared with only 18% in the Mill River subregional basin. Commercial, industrial, and institutional uses make up a small proportion of land use in both subregional basins, but are more concentrated in the Mill River subregional basin, and tend to cluster at the southern-most end of the watershed, in New Haven.

Table 2-2. Distribution of Land Cover Types in the Mill River Watershed (NLCD 2011)

Acres				Percent		
Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed	Land Cover	Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed
23	277	300	**Open Water**	0.3	1.7	1.2
1,166	3,314	4,480	**Developed, Open Space**	14.1	20.4	18.3
1,008	2,946	3,954	**Developed, Low Density**	12.2	18.1	16.1
318	2,194	2,512	**Developed, Medium Density**	3.8	13.5	10.2
41	641	683	**Developed, High Density**	0.5	3.9	2.8
3.3	7.8	11	**Barren**	0.0	0.0	0.0
4,775	5,495	10,270	**Deciduous Forest**	57.7	33.8	41.9
81	300	381	**Coniferous Forest**	1.0	1.8	1.6
45	130	176	**Mixed Forest**	0.5	0.8	0.7
118	122	240	**Shrub/Scrub**	1.4	0.7	1.0
45	213	258	**Herbaceous**	0.5	1.3	1.1
153	175	328	**Pasture/Hay**	1.9	1.1	1.3
5.3	0.0	5	**Cropland**	0.1	0.0	0.0
481	431	912	**Woody Wetland**	5.8	2.6	3.7
7	19	26	**Emergent Herbaceous Wetland**	0.1	0.1	0.1
8,271	16,265	24,536	**Total**	100.0	100.0	100.0

2.3.3 Historic Land Use

In general, commercial/industrial land use in the watershed is a potential source of bacteria and other pollutants. As indicated in the TMDL, there are approximately 11 permitted commercial and industrial facilities in the Mill River watershed. Historic industrial land uses continue to affect the Mill River watershed through legacy contamination. One such historic site is English Station, a closed power plant located on Ball Island, near the mouth of the Mill River. Occupying nearly 9 acres, the site is known to be widely contaminated with polychlorinated biphenyls (PCBs) and other hazardous contaminants. Excavation on the site in 1997 resulted in a documented release of PCBs into the Mill River (CTDEEP, 2016) and a 2005 report noted that PCBs were present in concentrations thirty times the industrial direct exposure criteria (CTDEEP, 2016). Early stages of remediation for English Station are currently underway.

Table 2-3. Distribution of Land Use Types in the Mill River Watershed (NVCOG 2017, SCRCOG 2016)

Acres				Percent		
Mill River Subregional Basin	Willow Brook Subregional Basin	Entire Watershed	Land Use	Mill River Subregional Basin	Willow Brook Subregional Basin	Entire Watershed
810	160	971	Commercial & Mixed Use	5.1	1.9	4.0
416	25	442	Industrial	2.6	0.3	1.8
1,101	303	1,405	Institutional	6.9	3.7	5.8
2,938	2,640	5,578	Open Space	18.5	32.1	23.1
1,289	694	1,984	Other	8.1	8.4	8.2
9,367	4,413	13,781	Residential	58.8	53.6	57.0
15,923	8,237	24,160	Total	100.0	100.0	100.0

There are also known petroleum, metal, and PCB impacts to the river in the vicinity of 470 James Street due to legacy contamination from the former trolley garage (later a state bus garage), related underground storage tanks and fueling system releases. Erosion of polluted urban fill at the site has impacted sediment and water quality in the Mill River. Conceptual planning for remediation and restoration of the site is in progress.

2.4 Impervious Cover

Impervious cover (IC) refers to any surface which prevents natural infiltration of stormwater into the soil, most notably buildings and pavement. As stormwater travels across impervious surfaces, rather than sinking into the ground, it picks up pollutants (e.g. oils, sediment) from the surface and transports these materials as part of the stormwater discharge. If not treated before the stormwater drains into a waterbody, these pollutants can become a major contributor to waterbody impairments. Extensive research has documented the effects of urbanization on stream and watershed health, including studies by CTDEEP that have documented a negative relationship between upstream impervious cover and aquatic life in adjacent waters, with predictable detrimental impacts to aquatic life when impervious cover exceeds 12% (CTDEEP, 2015).

In 2017, UConn CLEAR analyzed 2012 aerial imagery to estimate the amount of total impervious cover in each local basin (**Table 2-4**). As a whole, the Mill River watershed has 17.2% impervious cover. At 10.2%, total impervious cover in the Willow Brook subregional basin is below the 12% threshold; the Mill River subregional basin, however, has total impervious cover of 20.8%. At the local basin scale, 6 of the 14 local basins across the entire watershed exceed the 12% threshold. The highest impervious cover in the watershed is found in the local basin that contains the main stem of the Mill River, where overall IC was 27.3%. This high percentage of IC is driven by particularly dense development in New Haven and in areas adjacent to the main stem. The local basin that contains Shepard Brook is similarly affected, with 21.2% impervious cover. Unsurprisingly, local basins that are predominantly rural and/or are less-developed tend to have impervious cover below 10%.

Table 2-4. Distribution of Impervious Cover in the Mill River Watershed (UConn CLEAR 2012)

Acres				Percent		
Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed	Impervious Surface Type	Willow Brook Subregional Basin	Mill River Subregional Basin	Entire Watershed
239	975	1,214	**Building**	2.9	6.0	4.9
365	1,523	1,889	**Other***	4.4	9.4	7.7
245	890	1,135	**Road**	2.9	5.5	4.6
849	**3,389**	**4,238**	**Total**	**10.2**	**20.8**	**17.2**

*Includes parking lots, sidewalks, driveways, patios, swimming pools, and decks.

2.5 Open Space

Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious cover, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply. Open space includes preserved natural areas as well as lightly developed parks, playgrounds, and cemeteries.

An initial assessment of active and passive open space areas in the Mill River watershed was identified based on GIS information provided by NVCOG (data updated in 2017) in addition to data compiled and published by CTDEEP in 2015, including federal land, state-owned property, and other municipal and privately-owned open space. The largest open space land includes:

- Sleeping Giant State Park (1,615 acres)
- Regional Water Authority land (850 acres)
- Naugatuck State Forest (746 acres)
- Farmington Canal Heritage Trail (18.1 miles of linear trail)
- East Rock Park (425 acres)
- DeDominicis Property (200 acres)
- Puchalski Property (103 acres)
- Roaring Brook (87 acres)
- Hamden Fish and Game Protection Association (85.6 acres)
- Bens Homestead (63.4 acres)
- Brooksvale Farm Preserve (48 acres)
- Brooksvale Park (500 acres)
- Fresh Meadows, Wallingford (93 acres)

2.6 Geology and Soils

Typical of coastal watersheds in Connecticut, the topography of the Mill River watershed is quite variable, encompassing flat plains along the coast and estuaries, with a mixture of rolling hills and steep slopes to the

north. The surficial geology of the watershed has been shaped by glaciation and is a major factor shaping topography, soils, and drainage characteristics within the watershed. Fresh Meadows in Wallingford is comprised primarily of swamp deposits with a noteworthy glacial erratic that measures 21 feet in diameter. The Mill River runs along the historic path of a glacial meltwater stream; surficial geology along its channel is thus characterized by sand and gravel deposits.

To the east and west of the Mill River, the landscape rises and is characterized by thick glacial till (unsorted glacial deposits). On the east side of the watershed, Sleeping Giant State Park encompasses Mt. Carmel, a large drumlin with a maximum elevation of approximately 730 feet. The western slope of Mt. Carmel drains to the Mill River, while the eastern slope drains toward the Quinnipiac River. Mt. Sanford sits on the western edge of the Mill River watershed, within the Willow Brook subregional basin. At approximately 880 feet, Mt. Sanford is the highest point in the watershed; its northern and eastern slopes drain toward Willow Brook and eventually flow into the Mill River, while the southwestern slope drains toward the West River. A ridge runs northward from Mt. Sanford, forming much of the western edge of the watershed.

The City of New Haven is located on a plain at the southernmost tip of the watershed, where the Mill River meets the Quinnipiac River, New Haven Harbor, and then Long Island Sound. Much of the shoreline in this area has been reclaimed from the Sound and consists of artificial fill. The rest is glacial outwash consisting of sands and gravels over fine silts and clays.

The Natural Resources Conservation Service (NRCS) classifies soils into Hydrologic Soil Groups (HSG) that characterize a soil's runoff versus infiltration potential after prolonged wetting. Group A soils are the most well drained, meaning that they have low runoff potential and high infiltration potential. At the other extreme, Group D soils are the most poorly drained. Water movement through Group D soils is restricted, causing them to have high runoff potential and low infiltration potential. Group D soils are frequently either high in clay content or shallow soils over an impermeable layer (such as shallow bedrock or a dense glacial till) or a shallow water table. Group B and C soils complete the continuum between these extremes. Group B soils have moderately low runoff potential and unimpeded water transmission through the soil, while group C soils have moderately high runoff potential and are somewhat restrictive of water movement.

Table 2-5. Distribution of Hydrologic Soil Groups

HSG	Mill River Subregional Basin (Acres)	Willow Brook Subregional Basin (Acre)	Grand Total (Acres)	% of Watershed
A	1,859	1,054	2,913	11.9
B	6,030	3,849	9,878	40.2
C	3,638	1,412	5,051	20.5
D	4,413	1,940	6,353	25.8
Water	346	44	390	1.6
Total	**16,286**	**8,299**	**24,585**	**100.0**

Within the Mill River watershed, areas of poor infiltration potential characterized by Group D soils include Mt. Carmel, Mt. Sanford, and the ridge that runs along the northwestern edge of the watershed. Approximately 46% of the watershed is characterized as either Group C or Group D soils, indicating moderately high to high runoff potential, and relatively limited infiltration potential. 52% of the watershed as a whole consists of areas with Group A & B soils, which have greater infiltration potential and are generally

more conducive to infiltration-based Low Impact development (LID) and green stormwater infrastructure practices. The Willow Brook subregional basin has a greater percentage of Group A & B soils than does the Mill River subregional basin (59% as compared to 48%, respectively), and is thus expected to have somewhat better infiltration potential than the Mill River subregional basin(**Table 2-5**). Additionally, some of the areas of Group A & B soils in the Mill River subregional basin coincide with areas of dense development, which makes these areas potential targets for urban stormwater retrofits.

2.7 Wetlands and Endangered Species

2.7.1 Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and plant and animal communities living in the soil and on its surface. Wetlands can vary widely in type and characteristics, but are an important feature of a watershed, providing water quality benefits by removing pollutants and mitigating flooding. Wetlands make up approximately 12% of the watershed overall. 7.4% of the Mill River subregional basin consists of poorly drained and very poorly drained soils, with an additional 3.1% alluvial and floodplain soils. The Willow Brook subregional basin has a somewhat higher percentage of poorly drained and very poorly drained soils (11.5%) and 2.7% alluvial and floodplain soils.

2.7.2 Endangered, Threatened, and Special Concern Species

CTDEEP maintains information on the location and status of endangered, threatened, and other species of special concern throughout the state through the CTDEEP Natural Diversity Database (NDDB). Activities in these areas are potentially subject to review by CTDEEP. The CTDEEP Wildlife Division may provide recommendations for avoiding impacts to listed species.

2.8 Water Infrastructure

2.8.1 Dams

There are approximately 22 dams within the watershed, including 5 on the Mill River, and 1 on Shepard Brook. Most of the dams are located in the northern part of the watershed, in Hamden, with a few each in Cheshire and Wallingford. None are located on Willow Brook. The largest and most notable dam is the Lake Whitney Dam, which was established in 1860 for drinking water, fire-fighting, and hydropower. Flows over the dam average 55 million gallons per day (mgd) (RWA, 2018), with high flows during wet months typically ranging from 100 to 300 mgd. Smaller dams may provide recreational opportunities, habitat, or other amenities, but are likely also hindering fish passage through the watershed and may alter hydrologic characteristics in ways that affect water quality.

At least two of the smaller dams along the Mill River have been partially or fully breached at some point in their history. The Axle Shop Pond Dam was reported as partially breached, and Clarke's Pond Dam was reportedly rebuilt in the mid-1980s to repair a breach.

2.8.2 Water Supply

The Mill River watershed feeds Lake Whitney, which is part of the South Central Connecticut Regional Water Authority (RWA) public water supply system. Lake Whitney was established as the water supply for the City of New Haven in 1862. The original filtration plant, built in 1906, operated until 1991 and was demolished in 2002. A new Lake Whitney Water Treatment Plant went online in 2005, reestablishing Lake Whitney as an active water supply. In 2000, prior to the plant's opening, the RWA commissioned a series of ongoing studies to collect baseline data and monitor changes due to lake withdrawals. Operating standards were established with the intent of balancing ecological, aesthetic, and water supply interests. As part of those standards, it was established that a pre-emptive maintenance approach focused on watershed management techniques designed to control sediment loading should take priority over dredging, and periods of no flow should be minimized so as to limit disturbance to river ecology (Milone & MacBroom, Inc., 2002). The Lake Whitney Water Treatment Plant pumps approximately 3-15 mgd for the RWA under normal conditions, which supplies 45 mgd to an overall service population (i.e., both within the watershed and beyond) of approximately 430,000 people. Current operating guidelines, which were developed in part based on the recommendations of environmental monitoring studies, dictate that when lake levels are lower than 0.2 feet above the spillway, withdrawals are limited to 5 mgd except under extreme circumstances.

The regulations and protections in place for public water supply watersheds convey a variety of advantages in terms of water quality. The State of Connecticut prohibits sewage discharges to public water supply sources. Water Utilities are also required to perform sanitary surveys within the watershed, which results in regular inspection of commercial, industrial, and development sites. Departments of Public Health and the local water utility are notified and given the opportunity to comment whenever development applications are submitted to local land use commissions.

Groundwater serves as the primary water supply source for a significant portion of the northern half of the watershed. There are four Aquifer Protection Areas (APAs) (also referred to as "wellhead protection areas") located within the watershed. APAs are designated around active well fields in sand and gravel aquifers that serve more than 1,000 people to protect major public water supply wells. The State Aquifer Protection Regulations further require all existing uses to meet Best Management Practice standards and prohibit new high risk uses in groundwater supply areas.

2.8.3 Wastewater

Approximately half of the watershed area is served by sanitary sewers and half by on-site wastewater treatment systems, also referred to as septic systems. Most of these septic systems are located in the upper half of the Mill River watershed in Cheshire and the northern portion of Hamden. Failing or older, sub-standard septic systems can impact surface water and groundwater quality and can be a source of bacteria to the Mill River and other surface waterbodies. Local health directors and health districts regulate the installation of subsurface sewage disposal systems and are responsible for site inspections, plan review, the issuing of permits and inspections of all new, repair and replacement systems. The Towns of Cheshire and Prospect are part of the Chesprocott Health District, located in Cheshire, and the City of North Haven and

Towns of Hamden, and Bethany are part of the Quinnipiac Valley Health District, located in North Haven. The City of New Haven and Town of Wallingford each have independent, local health departments.

Combined Sewer Overflows (CSOs) impact water quality in the lower Mill River. CSOs are designated outfalls where combined sewers (carrying both sanitary wastes and stormwater) overflow when precipitation overwhelms the combined sewer system's capacity; such overflows result in discharge of untreated sanitary wastes into receiving waters. The City of New Haven has combined sanitary and storm sewer systems that discharge untreated sewage into New Haven Harbor during periods of heavy rain. The City of New Haven has been working to address CSOs since the early 1980s, and has worked in cooperation with the Greater New Haven Water Pollution Control Authority (GNHWPCA) since regionalization in the mid-2000s. The GNHWPCA's actions are guided in large part by CTDEEP consent order WC5509, last amended in 2015. As part of the consent order, GNHWPCA has developed a Long Term Control Plan (LTCP) which impacts both the Mill River watershed and neighboring Quinnipiac River and West River watersheds. The LTCP includes closure of some CSOs, modifications to others to ensure sewer separation, installation of additional storage, and CSO flow monitoring.

Of the 13 remaining CSOs maintained by GNHWPCA that discharge directly to receiving waters, three discharge to the Mill River:

- **CSO #009 at Grand Avenue and James Street**: The weir was raised in 2015. The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016 compared to 1997 is 0.1 million gallons. The LTCP calls for a final status of inactive.

- **CSO #011 at Humphrey Street and I-91**: 2017 update status indicates that sewer separation design is complete. A CSO Storage Tank is proposed as a capital improvement in the LTCP. Two additional active regulators (#010(A), and #026) contribute discharges to the CSO #011 outfall. Construction of improvements to the Humphrey Street Pump Station is underway. The project will result in closure of Regulator #026 in 2019.

- **CSO #012 on Mitchell Drive east of Nicoll Street**: The weir was raised in 2013.The reported reduction in CSO discharge volume based on the modeled 2-year design storm in 2016 compared to 1997 is 0.8 million gallons. One additional active regulator (#028) contributes discharges to the CSO #012 outfall. Construction of a capacity improvement project and improvements to the Mitchell Drive Pump Station are underway. These projects will result in closure of Regulator #028 and CSO #012 by 2019.

Three additional CSOs that previously discharged to the Mill River were closed in 2014. Note that a portion of the watershed is also within the drainage catchment of CSO #015, which is located at the confluence of the Mill and Quinnipiac Rivers.

In 2017, CSO discharges resulted in 4.86 million gallons of CSO flow into the Mill River from a combined 43 overflow events (another 10.64 million gallons discharged directly to the New Haven Harbor). One CSO in particular (CSO #011) contributed the majority (81%) of the discharge volume, at 3.916 million gallons over 13 events. This made it one of the top four CSO overflows in Greater New Haven in terms of volume of discharge during the 2017 reporting period (May 2016 to April 2017). The remaining 19% of CSO discharges to the Mill River came from CSO 009 (0.855 million gallons) and CSO 012 (0.087 million gallons). CSO discharge volume to the Mill River during the 2017 reporting period was more than double that of the 2016 reporting period (2.22 million gallons). CSO discharge volume for the 2015 reporting period was 6.27 million

gallons. Differences from one reporting period to the next reflect both differences in annual precipitation and changes due to CSO closures/modifications.

2.8.4 Stormwater

Urban stormwater runoff generated in developed areas from buildings, pavement, and other compacted or impervious surfaces is a significant source of pollutants to the Mill River and its tributaries. Impervious surfaces prevent infiltration of rainfall and runoff into the ground. Stormwater generated from impervious surfaces typically contains increased pollutants from the atmosphere, vehicles, industry, lawns, construction sites, humans and animals. Without treatment, these pollutants are conveyed from the impervious surfaces to storm drainage systems and eventually to the receiving waterbodies during storms. Impervious surfaces and traditional piped storm drainage systems increase the volume, peak flow rates, and velocity of stormwater runoff to receiving waters. This can contribute to channel erosion, sedimentation, and reduced stream baseflow during dry periods. The amount of impervious cover in the Mill River watershed and the implications for water quality and overall stream health is discussed in Section 5 of this technical memorandum.

In recognition of the impacts of stormwater runoff on water quality, CTDEEP regulates stormwater discharges from municipalities, commercial and industrial sites, and construction sites. As of the 2012 TMDL, permitted stormwater discharges within the Mill River subregional basin included: 1 commercial permittee, 10 industrial permittees, and 2 construction permittees. All of the municipalities within the watershed are regulated under the CTDEEP General Permit for the Discharge of Small Municipal Separate Storm Sewer Systems (MS4 Permit), and therefore are required to implement stormwater management programs centered around 6 minimum control measures, including public education and involvement, illicit discharges, land use regulatory controls for construction and post-construction runoff, impervious cover reduction, and good housekeeping and pollution prevention. The MS4 Permit, in particular, requires increasingly stringent approaches to limit stormwater pollution over the next five years, largely through addressing impervious area and illicit discharges to the stormwater system and encouraging green infrastructure and low impact development. The MS4 permit also requires all municipalities to create updated and detailed stormwater infrastructure mapping, which will help to facilitate identification and tracking of illicit discharges, storm system maintenance, and stormwater retrofits.

Green infrastructure solutions are also a key objective of the GNHWPCA strategic plan (GNHWPCA, 2017). GNHWPCA requires the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development projects within combined sewer areas in accordance with the GNHWPCA Permitting and Design Criteria Manual. GNHWPCA and the City of New Haven, working with CFE/Save the Sound and other groups, are also installing bioswales at numerous locations throughout the City within the public right-of-way to reduce runoff to the combined sewer system and reduce pollutant loads to surface waters. The City of New Haven has also adopted regulatory requirements to reduce stormwater runoff from development projects contributing to the City's combined sewer system.

2.8.5 Flood Zones

Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified recurrence interval (e.g., the "100-year flood" is defined as having a probability of occurring once in 100 years, or a 1% chance of occurring in any single year).

Similarly, the "500-year flood" has a 0.2% chance of occurring in a given year. FEMA also defines a 'floodway' as the stream channel and adjacent areas that carry the majority of the flood flow at a significant velocity, whereas 'floodplain' also includes the flood fringe or areas that are flooded without a strong current.

The region, including the Mill River watershed, has suffered flood damage in inland and coastal areas from Tropical Storm Irene (2011) and Hurricane Sandy (2012). Historic flood events that have impacted the region include the June 1982 storms in which the most severe flooding occurred along the Mill River in Hamden (and along the Wepawaug River in Orange and Milford) and the historic floods of 1955 and 1936.

Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

FUSS & O'NEILL

3 Management Recommendations

This section describes recommended actions to meet the watershed management goals and objectives outlined in *Section 1*. The recommendations include watershed-wide and targeted actions:

- **Watershed-wide Recommendations** are recommendations that can be implemented throughout the Mill River watershed. These basic measures can be implemented in most areas of the watershed and are intended to address nonpoint source pollution. The water quality benefits of these measures are primarily long-term and cumulative in nature resulting from runoff reduction, source control, pollution prevention, and improved stormwater management.

- **Targeted Recommendations** include site-specific projects and/or actions intended to address issues within specific subwatersheds or areas, rather than watershed-wide. Targeted recommendations also include actions to address common types of problems that are identified at representative locations throughout the watershed, but where additional field assessments or evaluations are required to develop site-specific recommendations. Targeted recommendations can have both short and long-term benefits.

Due to the large size of the Mill River watershed and limited field assessment scope of the watershed planning process, additional field assessments are recommended to further characterize pollutant sources and potential site-specific restoration projects. An objective of the ongoing and proposed stream assessments is to help identify additional site-specific projects and develop action plans for targeted subwatersheds. This plan is not meant to be a complete list of projects, but is a living document that will be adapted to include new projects and priorities as they are identified.

The recommendations presented in this section are classified according to their timeframe and implementation priority. Recommendations include ongoing, short-term, mid-term, and long-term actions:

- **Ongoing Actions** are actions that occur annually or more frequently such as routine water quality monitoring, fundraising, and education and outreach.

- **Short-Term Actions** are initial actions to be accomplished within the first two years of plan implementation. These actions have the potential to demonstrate immediate progress and success and/or help establish the framework for implementing subsequent plan recommendations.

- **Mid-Term Actions** involve continued programmatic and operational measures, delivery of educational and outreach materials, and construction of larger retrofit and/or restoration projects between two and five years after plan adoption.

- **Long-Term Actions** consist of continued implementation of watershed projects, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed based plan. Long-term actions are intended to be completed between five and ten years or longer after plan adoption. The feasibility of long-term actions, many of which involve significant infrastructure improvements, depends upon the availability of sustainable funding programs and mechanisms.

The remainder of this section describes the recommended actions presented in this watershed based plan. The recommended actions are categorized according to the five major goals of this plan – (1) capacity

building, (2) education and outreach, (3) water quality monitoring and assessment, (4) urban/suburban BMPs, and (5) habitat protection and restoration.

3.1 Capacity Building/Plan Oversight

Goal Statement: Strengthen and build local capacity to implement the watershed management plan.

The success of this watershed plan will depend on effective leadership, active participation by the watershed stakeholders, and local buy-in of the plan recommendations by the watershed municipalities, in addition to funding and technical assistance. Fortunately, significant local support and human capital for watershed protection and restoration already exists within the Mill River Watershed, led by CFE/Save the Sound, the Mill River Watershed Coordinator, and other stakeholder groups. Strengthening local capacity for implementing this watershed plan, by building on the existing network of volunteers and programs, is a critical early and ongoing part of the watershed plan implementation process. *Table 3-1* summarizes Capacity Building recommendations, which are described below in greater detail.

3.1.1 Establish a Framework and Lead Entity

Recommended Actions

- The Mill River currently benefits from a funded watershed coordinator position housed within CFE/Save the Sound. The watershed coordinator should be tasked with leading watershed based plan implementation activities such as:
    - Coordinating the efforts of plan implementation sub-committees
    - Identifying funding sources, as well as pursuing grant funding for projects
    - Periodically reviewing and updating action items in the plan
    - Developing annual work plans (i.e., specific "to-do" lists)
    - Coordinating and leading public outreach activities
    - Hosting public meetings to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps.

- Form watershed plan implementation sub-committees around the watershed plan goals – water quality, habitat restoration, land use/open space, and education/outreach. The sub-committees would ideally consist of volunteers with a particular interest or area of expertise in each topic.

- Hold regular meetings/forums for citizen input.

- Create and maintain a website dedicated to the Mill River watershed to serve as a centralized source of information on the watershed and based plan implementation activities.

Table 3-1. Capacity Building Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Continue to support and fund a dedicated watershed coordinator position for the Mill River	CFE/SAVE THE SOUND	Ongoing	Funded watershed coordinator position	$$$	Grants
2. Form watershed plan implementation sub-committees or work groups • Recruit members • Develop work plans • Hold regular forums for citizen input	Watershed Coordinator, CFE/Save the Sound, Steering Committee	0-2 years	Committee membership and work plans	$	Grants
3. Create and maintain a Mill River watershed website	Watershed Coordinator, CFE/Save the Sound, Consultant	0-2 years	Dedicated website	$$$	Grants
4. Obtain municipal endorsement of the watershed plan	Watershed Coordinator, CFE/Save the Sound	0-2 years	Memorandum of Agreement (MOA), inter-municipal agreement, compact or similar mechanism	$	
5. Engage and involve local, state, and regional organizations. Promote grassroots involvement.	Steering Committee	Ongoing	Active participation in watershed plan activities by organizations	$	
6. Identify and pursue funding • Review and prioritize funding sources • Prepare and submit grant applications	Watershed Coordinator, CFE/Save the Sound, Watershed Municipalities	0-2 years Ongoing	List of funding sources and funding pursued	$$	See Section 5 and Appendix G of this plan for funding sources
7. Conduct streamwalk assessments • Complete streamwalks • Compile and analyze data • Plan and conduct "track down" surveys	Watershed Coordinator, CFE/Save the Sound, and Volunteers	0-2 years (repeat streamwalks every 5 yrs)	Streamwalk assessment and track down survey findings and recommendations	$$	

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
8. Prepare and implement subwatershed action plans	Watershed Coordinator, CFE/Save the Sound, Steering Committee	0-2 years	Subwatershed action plans prepared and implemented	$$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment

3.1.2 Promote Inter-Municipal Coordination

Many of the recommendations in this watershed based plan can benefit from a partnership among the watershed municipalities. For example, applying jointly for grants to fund the implementation of these activities allows the sharing of grant-writing assistance, and the leveraging of match and in-kind services. Additionally, a watershed partnership permits the sharing of technical and human resources, volunteers, equipment, and materials. Endorsement of the watershed based plan by the watershed municipalities is an important first step in implementing the plan recommendations.

Recommended Actions

- The Mill River Watershed Coordinator, with the assistance of CFE/Save the Sound, should seek endorsement of the watershed based plan by the watershed municipalities through a Memorandum of Agreement (MOA), inter-municipal agreement, compact or similar mechanism to encourage inter-municipal coordination and accountability and to formalize the municipalities' agreement to support the watershed planning effort through funding, staff, or other resources.

3.1.3 Promote Regional Collaboration

Many watershed organizations and municipalities in Connecticut are involved in watershed management planning to meet common resource protection objectives and are faced with similar water quality issues. Lessons learned from other watershed planning efforts in Connecticut and throughout Long Island Sound, particularly groups representing the neighboring West River and Quinnipiac River watersheds, can help to improve the effectiveness of this watershed plan. This objective is to coordinate water quality planning with other watershed groups to share ideas and strengthen regional watershed management efforts. CFE/Save the Sound is already a major contributor to this coordination effort.

Increasingly, neighborhood groups with focuses and missions that are not specifically environmentally-focused are recognizing the synergies between their goals and watershed and ecosystem health. Pursuing partnerships with these organizations can greatly expand the scope and reach of watershed management efforts.

Recommended Actions

- Engage and involve the following local, state, and regional organizations with an interest in the Mill River watershed and other neighboring regional watershed initiatives. These groups should work together to implement this plan. Implementation is most effective when municipalities work together with volunteers and local stewards (i.e., grassroots involvement).

Table 3-2. Local, Regional and State Organizations

Local Organizations	Regional Organizations	State Organizations
• Municipal Staff and Land Use Commissions • New Haven Environmental Justice Network • The Elm City Parks Conservancy • Neighborhood Housing Services of New Haven • New Haven Land Trust • Cheshire Land Trust	• Greater New Haven Water Pollution Control Authority • Regional Water Authority • Naugutuck Valley Council of Governments • South Central Regional Council of Governments	• Rivers Alliance of Connecticut • American Rivers • CT Audubon Society • The Nature Conservancy • CT Forest and Park

Local Organizations	Regional Organizations	State Organizations
• Hamden Land Trust • Wallingford Land Trust • Local Schools and Universities • Urban Resources Initiative • Greater New Haven Green Fund • Mill River Trail Advocates • Eli Whitney Museum • New Haven Parks • Friends of East Rock Park • Quinnipiac University • Community Foundation of Greater New Haven • Whitneyville Civic Association • Neighborhood Housing Services (NHS) • Local neighborhood associations	• Southwest Conservation District • Quinnipiac River Watershed Association • River Advocates of South Central Connecticut • Greater New Haven Green Fund • West River Watershed Coalition	Association • Trout Unlimited • CTDEEP • CT Coalition for Environmental Justice • Bikewalk CT • Natural Resources Conservation Service (NRCS-CT) • CFE/Save the Sound

3.1.4 Identify and Pursue Funding

Many actions in this plan are only achievable with sufficient funding and staffing. A variety of funding opportunities should be pursued to implement the recommendations outlined in this plan.

Recommended Actions

- Review and prioritize potential funding sources that have been preliminarily identified in this watershed plan (see *Section 6*). High-priority funding sources that should be considered include:
    - CTDEEP/EPA Section 319 Nonpoint Source Grants
    - National Fish and Wildlife Foundation Long Island Sound Futures Fund
    - Connecticut Clean Water Fund
    - HUD Community Development Block Grants for green infrastructure and coastal resilience
    - Community Foundation for Greater New Haven
    - Stormwater utilities and other innovative stormwater program financing mechanisms; Northampton, MA implemented a stormwater utility that serves as one example of such a fee structure: https://www.northamptonma.gov/726/Stormwater-Flood-Control-Utility.
- Prepare and submit grant applications for projects identified in this plan on an ongoing basis.
- Pursue funding for ongoing, long-term water quality monitoring within the watershed.
- Advocate for state and federal funding, working jointly with other watershed organizations in the region and state.

3.1.5 Conduct Streamwalk Assessments

Visual stream assessments or streamwalks are a simplified assessment protocol to evaluate the condition of aquatic ecosystems associated with streams. They help to evaluate the overall condition of the stream, riparian buffer, and floodplain based on a consideration of in-stream habitat, vegetative protection, bank erosion, floodplain connection, vegetated buffer width, floodplain vegetation and habitat, and floodplain encroachment. Visual stream assessments also help to identify problem areas and provide a basis for further

detailed field investigation and potential restoration opportunities. Streamwalks also provide an ideal opportunity to involve the public and volunteers as a form of outreach.

Fuss & O'Neill and staff from the Regional Water Authority (RWA) and CFE/Save the Sound conducted streamwalk assessment training at Quinnipiac University on July 21, 2018 for Cheshire Land Trust, members of the Project Steering Committee, and other volunteers. The classroom and field training provided information on conducting stream assessments of the Mill River and its tributaries following the NRCS protocols for performing visual stream assessments in Connecticut http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/water/?cid=nrcs142p2_011198.

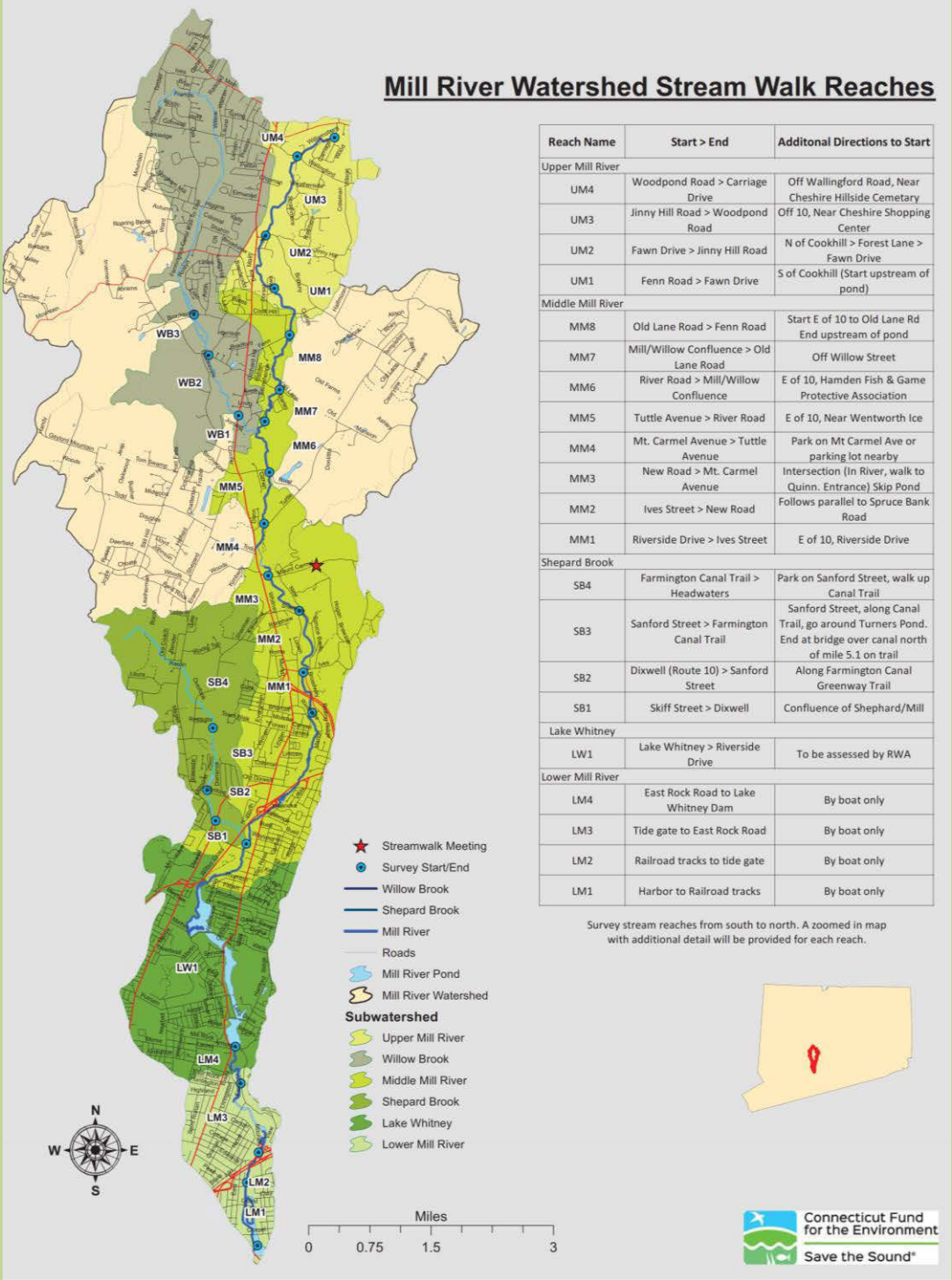
CFE/Save the Sound, members of the Project Steering Committee, members of the Cheshire Land Trust, and other volunteers conducted streamwalk assessments of selected reaches of the Mill River and its tributaries during the summer of 2018; additional streamwalks are expected to take place later in 2018. The selected reaches cover most of the length of the Mill River (although several reaches in the Lower Mill River, below Lake Whitney, require boat access) as well as impaired segments of Shepard Brook and Willow Brook.

Recommended Actions

- Complete streamwalk assessment surveys of all selected reaches in the watershed using the Connecticut NRCS protocols and field data collection sheets.
- Compile and analyze the collected data.
- Following the streamwalks and evaluation of the assessment results, plan and conduct subwatershed visual "track down" surveys of identified or suspected pollution sources. Visual track down surveys are a tool commonly used by the Connecticut Conservation Districts to help identify conditions responsible for water quality impairments in streams. The goals of the track down survey are to collect information on the possible causes of impairment and recommend and implement solutions to address the identified issues of concern.
- Subwatershed stream assessments and track down surveys should be updated every five to ten years to monitor changing watershed conditions and the progress of plan implementation.

Volunteers during the Mill River Streamwalk Training, July 21, 2018

Mill River Watershed Streamwalk Reaches



Reach Name	Start > End	Additonal Directions to Start
Upper Mill River		
UM4	Woodpond Road > Carriage Drive	Off Wallingford Road, Near Cheshire Hillside Cemetary
UM3	Jinny Hill Road > Woodpond Road	Off 10, Near Cheshire Shopping Center
UM2	Fawn Drive > Jinny Hill Road	N of Cookhill > Forest Lane > Fawn Drive
UM1	Fenn Road > Fawn Drive	S of Cookhill (Start upstream of pond)
Middle Mill River		
MM8	Old Lane Road > Fenn Road	Start E of 10 to Old Lane Rd End upstream of pond
MM7	Mill/Willow Confluence > Old Lane Road	Off Willow Street
MM6	River Road > Mill/Willow Confluence	E of 10, Hamden Fish & Game Protective Association
MM5	Tuttle Avenue > River Road	E of 10, Near Wentworth Ice
MM4	Mt. Carmel Avenue > Tuttle Avenue	Park on Mt Carmel Ave or parking lot nearby
MM3	New Road > Mt. Carmel Avenue	Intersection (In River, walk to Quinn. Entrance) Skip Pond
MM2	Ives Street > New Road	Follows parallel to Spruce Bank Road
MM1	Riverside Drive > Ives Street	E of 10, Riverside Drive
Shepard Brook		
SB4	Farmington Canal Trail > Headwaters	Park on Sanford Street, walk up Canal Trail
SB3	Sanford Street > Farmington Canal Trail	Sanford Street, along Canal Trail, go around Turners Pond. End at bridge over canal north of mile 5.1 on trail
SB2	Dixwell (Route 10) > Sanford Street	Along Farmington Canal Greenway Trail
SB1	Skiff Street > Dixwell	Confluence of Shephard/Mill
Lake Whitney		
LW1	Lake Whitney > Riverside Drive	To be assessed by RWA
Lower Mill River		
LM4	East Rock Road to Lake Whitney Dam	By boat only
LM3	Tide gate to East Rock Road	By boat only
LM2	Railroad tracks to tide gate	By boat only
LM1	Harbor to Railroad tracks	By boat only

Survey stream reaches from south to north. A zoomed in map with additional detail will be provided for each reach.

3.1.6 Prepare and Implement Subwatershed Action Plans

Development and implementation of site-specific restoration and protection strategies is most effective at the subwatershed scale for larger watersheds such as the Mill River watershed. Although this watershed plan identifies a number of site-specific recommendations and green infrastructure concepts that are examples of the types of projects that could be implemented elsewhere in the watershed, the limited scope of this watershed planning effort did not allow for comprehensive field assessments of the Mill River and its entire watershed. Additional targeted watershed assessment and planning is recommended for various subwatersheds, including streamwalk assessments, track down surveys, and volunteer monitoring. These additional assessments will help to better characterize current conditions within specific reaches of the Mill River, its tributaries, and upland areas of the subwatersheds. The goal of the streamwalks and track down surveys is to develop action plans for each priority subwatershed and identify additional site-specific restoration projects.

Recommended Actions

- Prepare and implement more detailed subwatershed action plans for priority subwatersheds based on the findings of streamwalk assessments and associated track down surveys (see recommendations in previous section).

- Target subwatersheds, including major tributaries and municipalities located within each subwatershed, are summarized in *Table 3-3*. The municipalities located within each subwatershed should be encouraged to participate in development and implementation of the respective subwatershed action plans. *Table 3-3* also includes the average percent reductions in bacterial loads to meet water quality standards, as reported in the statewide bacteria TMDL for the Mill River. Higher priority subwatersheds are those watersheds containing water bodies with bacterial impairments listed in the TMDL. Lower priority subwatersheds include other water body segments with listed bacteria impairments for which a TMDL has not yet been developed.

- Subwatershed action plans could be maintained as an appendix to the overall Mill River Watershed Based Plan, relying on watershed background information, goals, and objectives contained in the larger watershed plan. A recommended framework for simplified subwatershed action plans is as follows:
    - Subwatershed Pollutant Sources
    - Load Reductions Needed
    - Recommended Actions

Table 3-3. Target Subwatersheds for Development of Subwatershed Action Plans

Subwatershed	Waterbody Segment	Municipalities Located within Subwatershed	Required Percent Reduction in Bacterial Loads (TMDL)
Higher Priority (Bacteria Impairment with Approved TMDL)			
Middle Mill River	Mill River from the inlet to Lake Whitney on the east side of Route 15, just downstream of Connolly Parkway in Hamden, to the Cook Hill Road Crossing in Cheshire. CTDEEP Waterbody ID CT5302-00_02	Hamden North Haven Cheshire	77% (geomean) 94% (single sample)
Shepard Brook	Shepard Brook from its mouth at the confluence with the Mill River just downstream of Route 15, including Turners Pond and continuing upstream to the confluence with an unnamed tributary behind the business park off Sherman Avenue and Town Walk Drive. CTDEEP Waterbody ID CT5302-06_01	Hamden	77% (geomean) 71% (single sample)
Lower Priority (Impaired and TMDL Required)			
Upper Mill River	Mill River from the Cook Hill Road crossing to the headwaters, just upstream of Williamsburg Drive in Cheshire. CTDEEP Waterbody ID CT5302-00_03	Cheshire	Not Applicable
Lower Mill River	Mill River extending northward from the mouth at its confluence with the Quinnipiac River in New Haven to the footbridge crossing just upstream of East Rock Road in Hamden. CTDEEP Waterbody ID CT-C1_023-SB	New Haven Hamden	Not Applicable
Willow Brook	Willow Brook from its mouth at the confluence with the Mill River downstream of the Willow Street crossing in Hamden, upstream to the confluence with Brooksvale Stream in Cheshire. CTDEEP Waterbody ID CT5301-00_01	Hamden Cheshire	Not Applicable

3.2 Education and Outreach

Goal Statement: Promote stewardship of the watershed through education and outreach, improved access to the Mill River and its tributaries, and citizen involvement in science, conservation, and restoration activities.

A goal of this watershed plan is to modify the behaviors of individuals and the public to affect a positive change in the watershed. Often, the public is not aware of the impacts that their every-day activities can have on water quality. Public education is critical to the long-term success of watershed management because it raises awareness and reminds people of the individual actions they can take to protect and improve water quality in their watershed. This increased understanding has the additional benefit of fostering support for watershed management efforts and cultivating a long-term environmental watershed stewardship ethic, particularly with respect to the benefits of green infrastructure.

The education and outreach recommendations of this watershed plan are targeted at reaching four primary audiences, in addition to other stakeholder groups:

- Homeowners
- Municipalities
- Volunteer groups
- Students (K-12)/higher education
- Businesses and industry

Education and outreach recommendations that are tailored to these audiences are described in the following sections. Watershed public outreach and educational programs should build upon the successful programs and models that already exist in the watershed, elsewhere in Connecticut, and nationally.

Table 3-4 summarizes education and outreach recommendations for the Mill River watershed.

3.2.1 Implement a Public Outreach Campaign

Local and regional partners, including CFE/Save the Sound, CTDEEP, the watershed municipalities and GNHWPCA, should consider developing and implementing a watershed-based green infrastructure public outreach campaign[3] for the Mill River (or a regional effort for the Greater New Haven watersheds including the Mill River, Quinnipiac River, and West River) focused on citizens, businesses, and communities. The public outreach campaign could be developed based on other successful models such as EPA's "Soak Up the Rain" program, RWA's "Harvest the Rain" rain barrel program, or the award-winning "Save the Rain" initiative in Onondaga County (Syracuse), New York. Startup funding for such a campaign may be possible through CTDEEP, particularly if the campaign is developed/designed to be transferable to other watersheds or organizations or for use statewide.

Key aspects of developing a successful outreach campaign include identifying and analyzing the target audiences, drafting an effective message and branding the program, and packaging and delivering the message through a variety of media. EPA's *Getting In Step: A Guide for Conducting Watershed Outreach Campaigns* (2010) is an excellent resource for developing and implementing a successful program.

[3] A campaign is not a single product or event, but rather a suite of activities, materials, and distribution formats that are carefully coordinated to achieve specific goals and objectives.

The outreach campaign should target, at a minimum, watershed residents, businesses, and municipalities, including incentive programs for residential "green" practices. The recommended website dedicated to the Mill River watershed (see *Section 3.1 – Capacity Building*) could also serve as the on-line home for the public outreach initiative. The website could include downloadable educational and outreach materials on green infrastructure and other residential, business, and municipal practices to protect and improve water quality, as well as project updates, funding resources, technical resources, and current events.

The outreach campaign could also be coordinated with the public education and involvement efforts of the watershed municipalities to comply with the new MS4 Permit, as well as public education efforts associated with implementation of a municipal or regional stormwater utility.

Credit: RWA

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Public Outreach Campaign					
1. Develop and implement a green infrastructure public outreach campaign, including a more formal and consistent watershed signage program	CFE/Save the Sound, GNHWPCA, watershed municipalities, CTDEEP	2-5 years	Public outreach messages developed and delivered through a variety of media	$$$$	CTDEEP 319 NPS Grants
Homeowner Education and Outreach					
2. Evaluate and implement residential LID incentive programs • **Identify and build upon existing programs (e.g., NHS Environmental Leadership Program, The Sound School and RWA's rain barrel program)** • **Evaluate feasibility of alternative programs** • **Pursue funding** • **Implement program(s)**	CFE/Save the Sound, GNHWPCA, NHS, RWA	0-2 years establish program Ongoing implementation thereafter	Program(s) identified, funding secured, program established, number of homeowners participating	$$$$	Grants, future stormwater fees
3. Provide homeowner education and outreach on using LID	Municipalities, CFE/Save the Sound, UConn NEMO, NHS	Ongoing	Outreach materials disseminated	$$	Municipal, grants
4. Provide homeowner outreach on sustainable lawn care practices and backyard habitat	Municipalities, NHS, UConn NEMO, CFE/Save the Sound	Ongoing	Outreach materials disseminated	$$	Municipal, grants
5. Provide homeowner outreach on septic systems	Hamden, Cheshire, Bethany, Prospect, Wallingford, Quinnipiack Valley Health District, Chesprocott Health District	2-5 years	Outreach materials provided or made available to homeowners	$	NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, CTDEEP 319 NPS Grants

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Outreach to Municipalities and Volunteer Groups					
6. **Provide education and training for municipal employees, land use boards, and building inspectors**	Municipalities (as part of MS4 Permit outreach), UConn NEMO	2018-2021 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
7. **Provide education and outreach to volunteers of local non-profit organizations** • **Cheshire Land Trust** • **New Haven Environmental Justice Network** • **The Sleeping Giant Park Association** • **NHS** • **Friends of East Rock Park** • **Neighborhood Associations** • **Eli Whitney Museum** • **Mill River Trail Advocates**	CFE/Save the Sound, municipalities (as part of MS4 Permit outreach)	2018-2021 (MS4 permit term)	Outreach events completed	$$	
Outreach to Business Community					
8. **Conduct outreach to commercial and industrial property owners**	Municipalities (as part of MS4 Permit outreach)	2018-2021 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Outreach to Institutional Property Owners					
9. Conduct workshops on best practices for institutional facilities for water quality protection	CFE/Save the Sound, CTDEEP, Colleges and Universities, URI	2-5 years	Workshops developed and conducted	$$$	Grants
10. Encourage participation in EPA's annual Campus RainWorks Challenge	CFE/Save the Sound, Colleges and Universities, URI	Ongoing	Student applications submitted	$	
Community Engagement Events					
11. Engage local, state, and regional organizations in the Mill River watershed • **Promote, publicize, and support existing events**	Mill River Watershed Coordinator, Municipalities, CFE/Save the Sound, NHS	Ongoing	Ongoing coordination with groups, events publicized and held	$$	
Youth Education, Community Service, and Stewardship Programs					
12. Expand existing relationships and educational programs with schools	Mill River Watershed Coordinator, CFE/Save the Sound, Schools, URI	Ongoing	Expanded or new programming and curricula	$$	
13. Consider implementing a watershed-based component to the curriculum in school districts where such programs are not already in place.	CFE/Save the Sound Watershed School Districts, individual school faculty	2-5 years	Expanded or new programming and curricula	$$$	
14. Continue to recruit student volunteers to participate in water quality and benthic monitoring and streamwalks	CFE/Save the Sound, Cheshire Land Trust, school faculty and students	Ongoing	Student participation in monitoring and streamwalks	$	

Table 3-4. Education and Outreach Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
15. Continue to collaborate with college faculty and research staff on the Mill River watershed	CFE/Save the Sound, Quinnipiac University, and other colleges and universities	Ongoing	Collaboration with research faculty and staff on Mill River projects	$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

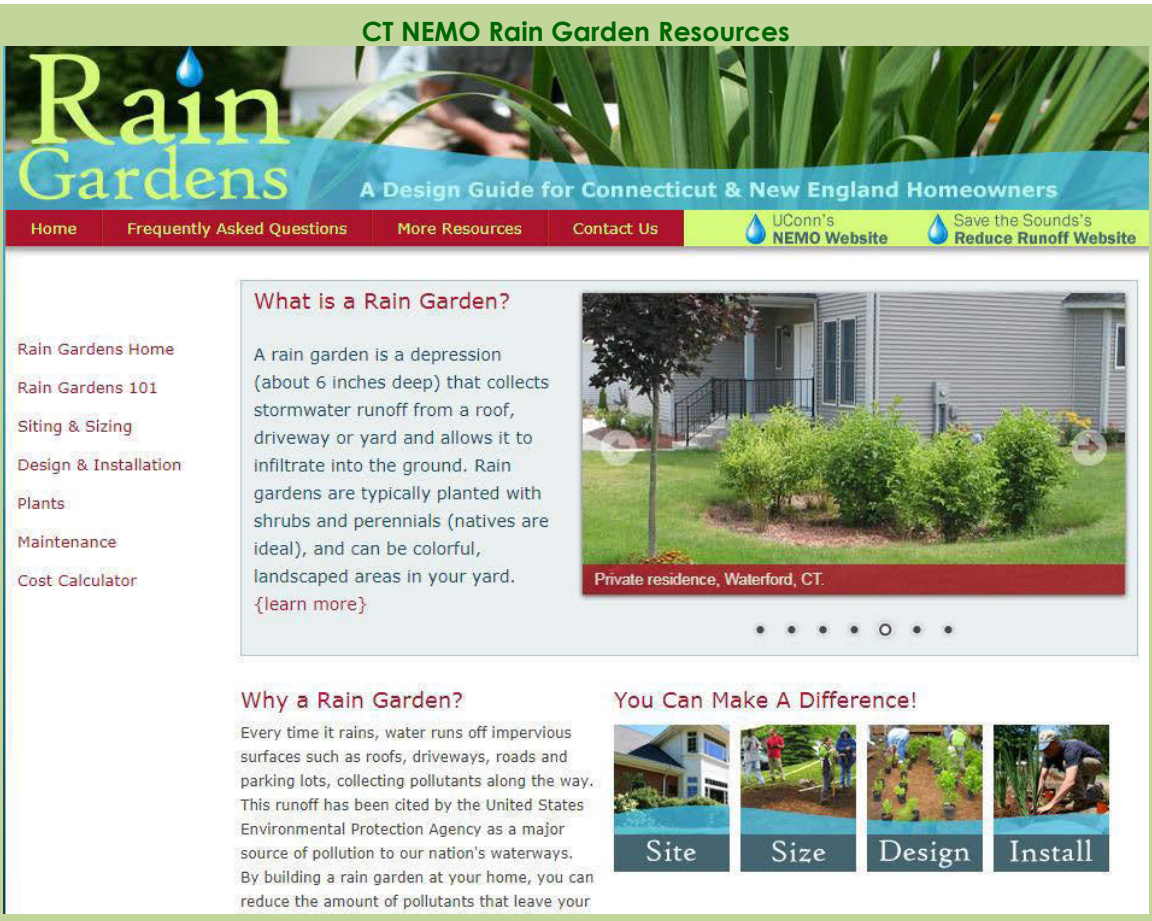
CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment NHS = Neighborhood Housing Services of New Haven URI = Yale University School of Forestry and Environmental Studies Urban Resources Initiative

3.2.2 Homeowner Education and Outreach

An objective of the watershed plan is to build awareness of land stewardship and management practices and reduce water quality impacts associated with residential land use, which comprises approximately 57% of the watershed land area. Successful homeowner outreach programs have been developed by other watershed groups, including Neighborhood Housing Services (NHS). NHS's Environmental Leadership Program has hosted workshops on "Climate, Health, and Neighborhoods" and "Water in Your Home and Neighborhood." NHS also has a program in the neighboring West River Watershed that allows homeowners to apply to have a free rain garden installed at their home; their website provides information and resources for DIY rain garden projects as well.

The Norwalk River Watershed Association serves as an excellent example of a watershed-focused group with a wide range of educational information available to homeowners: http://norwalkriver.org/links/. River Smart is another education and outreach program that provides steps homeowners can take to reduce the impact of nonpoint source pollution from residential properties. The program is led cooperatively by Housatonic Valley Association, Pomperaug River Watershed Coalition, Kent Land Trust, Weantinoge Heritage Land Trust, Rivers Alliance of Connecticut, and the Farmington River Watershed Association: https://www.riversmartct.org/.

CT NEMO Rain Garden Resources



Encourage the use of Residential LID Practices

Homeowners should be encouraged to implement green infrastructure or Low Impact Development (LID) practices on their properties.

- Encourage disconnection of rooftop runoff from the storm drainage system and impervious areas to reduce the quantity of runoff by redirecting the runoff to pervious lawn areas, through the use of dry wells, or through the use of rain barrels or rain gardens.

- Provide education and outreach to homeowners, neighborhood groups, and roofing contractors on disconnecting roof downspouts and installing and maintaining residential rain gardens and rain barrels. The Connecticut NEMO web site provides a wealth of information about residential rain gardens: http://nemo.uconn.edu/raingardens/index.htm

- Provide residential LID incentive programs such as those described in *Section 3.4.3* of this plan.

Promote Sustainable Lawn Care Practices – Homeowners and Lawn Care Professionals

Homeowners should be encouraged to use environmentally-friendly lawn care practices such as reducing or eliminating fertilizer and pesticide usage through the use of slow release fertilizers and fertilizer application timing; utilizing alternative landscaping that decreases maintenance; soil testing and non-chemical lawn care measures. Although sustainable lawn care practices will not significantly reduce bacteria loadings, they will reduce nutrient loadings, the use of toxic chemicals, and promote water conservation. New Haven is already encouraging these practices through the "Voluntary Non-Use of Pesticides and Synthetic Fertilizers on Lawns and Gardens" program.

Extensive educational materials are available on these topics, including:

- CTDEEP Organic Lawn Care website: http://www.ct.gov/deep/cwp/view.asp?A=2708&Q=382644
- CTDEEP Transitioning To Organic Land Care (OLC) In Your Town http://www.ct.gov/deep/cwp/view.asp?a=2708&q=379676&deepNav_GID=1763
- Connecticut Chapter of the Northeast Organic Farming Association http://www.organiclandcare.net/

Other resources include the EPA's GreenScape program, and more locally, the UCONN Cooperative Extension System's Home & Garden Education Center. The Home & Garden Education Center's web site, along with information on their soil testing services can be found at: http://www.ladybug.uconn.edu
Recognizing the trend toward greater use of professional lawn care services by homeowners, outreach to local landscapers and lawn care companies is an essential element of a successful lawn care outreach program. Potential outreach programs, which could be developed in partnership with local land trusts and garden clubs, could include:

- Identifying and promoting sustainable landscape provider certification programs
- Developing a placard campaign to identify lawns that implement preferred practices
- Develop a sustainable lawn care and gardening recognition and incentive program, with landscapers and homeowners highlighted on a rotating basis, or institute an alternative landscape competition. The Environmental Concerns Coalition of Milford, Connecticut, has developed a very successful

organic lawn care competition and incentive program called "Freedom Lawns." A Freedom Lawn brochure developed by the Farmington River Watershed Association can be found at: http://www.frwa.org/publications/freedomlawntips.pdf.

- Implement a public awareness campaign modeled after the City of Middletown's Project Green Lawn to encourage residents and businesses to eliminate lawn chemicals. http://www.cityofmiddletown.com/content/117/121/167/1862/486.aspx

Promote Backyard Habitat

Encourage the creation of backyard buffers in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public.

- Educate homeowners about the value and importance of stream buffers by building on existing stream buffer outreach and educational programming (e.g., public recognition programs for cooperating landowners, *Streamside Landowners' Guide to the Quinnipiac Greenway,* Audubon's backyard program, and programs from the EPA- Long Island Sound Study and Connecticut Sea Grant).

Provide Homeowner Outreach on Septic Systems

Provide homeowners in Hamden, Cheshire, Bethany, Prospect, and Wallingford with educational materials on how to identify improperly functioning septic systems and procedures to have systems inspected, cleaned, and repaired or upgraded. Septic system educational materials offered by The Quinnipiack Valley Health District (QVHD), which serves Bethany and Hamden, should be disseminated by these towns to homeowners in their respective communities, which could also be used to meet the public outreach/education minimum control measure of the MS4 Permit and the related municipal stormwater management plans. Similar materials should be adapted or developed for use within the Chesprocott Health District (serving Cheshire and Prospect) and by the Town of Wallingford's Health Department.

Increase Watershed Stewardship Signage

Stewardship signage can increase public awareness and visibility of the Mill River and the connection between the community, the watershed, and the river. Watershed signage can take the form of kiosks in public areas, storm drain markers or stencils, anti-dumping signs, proper pet waste management signs, and roadside/stream side signage (examples include "adopt a stream/roadway" programs).

CFE/Save the Sound and local partners should consider developing a more formal and consistent watershed sign program that could be implemented as a component of the recommended green infrastructure public outreach program. The signs should incorporate a simple, yet consistent message and logo. Watershed signs are recommended in highly-visible public areas of the watershed such as municipal facilities (schools, parks, libraries, other municipal properties, commercial areas, etc.) and public access areas along the river. Implementation of such signage should be coordinated with the watershed municipalities to fulfill the required education and outreach components of the MS4 Permit.

3.2.3 Outreach to Municipalities and Volunteer Groups

A key objective of this plan is to advance local government awareness, understanding, and stewardship of the Mill River watershed. Ongoing outreach to municipal departments, staff, and volunteer board members is an

important element of municipal stormwater management programs, as required by the MS4 Permit. Suggested topics include common municipal activities and operations that can impact bacteria loads to the Mill River including parks and open space maintenance, green infrastructure and LID, storm sewer system and BMP maintenance, and identification and removal of illicit connections.

- Municipalities should provide annual pollution prevention and good housekeeping training for all municipal employees whose activities potentially impact stormwater and water quality. The training should include municipal personnel with responsibility for public works, parks and recreation, building maintenance, lakes and pond management, and water/wastewater.

- Provide training for municipal reviewers (municipal land use commissions and boards, planners, etc.) of land development projects and designers (developers, architects, engineers, contractors, etc.). Suggested training topics include stream buffer protection, LID and green infrastructure, and construction erosion and sediment controls.

- Building inspectors in Connecticut must earn a requisite amount of continuing education credits each year. Existing training programs often do not address stormwater, LID, green infrastructure or erosion and sedimentation control methods. Building inspectors in each watershed municipality should be required to receive regular training on these topics. Additionally, training should also be required on sanitary sewer and stormwater connection inspections.

- Continue to invite and involve the municipal staff and land use board members in Mill River planning efforts, restoration efforts, outreach events, and river clean-ups.

Ongoing education and outreach to those that work as volunteers of local stewardship groups is also important. Local volunteer-based nonprofit groups such as Cheshire Land Trust and other local land trusts, Friends of East Rock Park, Mill River Trail Advocates, The Sleeping Giant Park Association, and neighborhood and watershed associations should provide opportunities for their member volunteers to participate in seminars, presentations, and other training offered by groups such as CFE/Save the Sound, and public education provided by the watershed municipalities to comply with the MS4 Permit.

3.2.4 Outreach to Business Community

Commercial businesses along the major transportation corridors and industrial facilities in the middle and lower Mill River watershed, whether located directly adjacent to the river or in upland areas of the watershed, contribute stormwater runoff that ultimately reaches the Mill River. An objective of this plan is to advance local business awareness, understanding, and stewardship of the Mill River watershed.
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- Provide outreach to commercial and industrial property owners in the watershed explaining how their activities contribute to the water quality impairments of the Mill River. Focus on activities that contribute bacteria to the Mill River, including dumpster and trash management issues. Think Blue Massachusetts provides excellent examples of outreach geared toward businesses: https://www.thinkbluemassachusetts.org/for-businesses

- Continue to involve businesses in restoration efforts, outreach events, and river clean-ups.

3.2.5 Outreach to Institutional Property Owners

Management and maintenance practices at institutional facilities with large intensively managed lawn areas and expansive parking lots can have a significant impact on water quality. Several large institutional land owners are located in the Mill River watershed (e.g., Quinnipiac University and other public and private schools) and, therefore, play an important collective role in improving and protecting water quality.

- CFE/Save the Sound should consider partnering with CTDEEP and the colleges and universities in the watershed to conduct workshops on best practices for institutional facilities for water quality protection. Topics could include:
    - Integrated Pest Management (IPM)
    - Turf management and low fertilizer usage
    - Protection and restoration of stream buffer areas
    - Parking lot and road maintenance (deicing, snow management)
    - Drainage system inspection/ maintenance (catch basins, storm drains, stormwater BMPs)
    - Water quantity and flooding issues
    - Low Impact Development and green infrastructure approaches

- Encourage the colleges and universities in the watershed (faculty, students, and facilities) to participate in EPA's annual Campus RainWorks Challenge, which is a national competition for student teams to design an innovative green infrastructure project for their campus showing how managing stormwater at its source can benefit the campus community and the environment. http://water.epa.gov/infrastructure/greeninfrastructure/crw_challenge.cfm

3.2.6 Promote Community Engagement Events

Community events focused on the Mill River and its watershed are also an effective way to provide public outreach and stewardship of the Mill River. There are many community groups and organizations involved in environmental and watershed-related activities in the greater New Haven area, providing a strong base upon which to build local support and interest in the Mill River.

- The Mill River Watershed Coordinator and CFE/Save the Sound should continue to engage the many local, state, and regional organizations with an interest in the Mill River watershed, including the organizations listed in *Table 3-2* and other groups.

- Promote, publicize, and support existing community engagement events such as NHS Environmental Leadership workshops, Mill River Trail clearing and planning efforts, watershed clean ups, etc.

3.2.7 Promote Youth Education, Community Service, and Stewardship Programs

The Mill River watershed is also home to numerous public and private primary and secondary schools, many of which offer environmental education and community service programs. These existing programs and resources provide an excellent opportunity to promote youth education on issues related to watersheds, water quality, and the Mill River.

- CFE/Save the Sound should build connections and relationships with schools known to have existing environmental education programs, such as Hooker Middle School ("Schoolyard Habitat Program"), and other local schools. Other interested schools throughout the watershed communities should be identified as potential candidates for involvement in the Mill River watershed restoration efforts. Green Infrastructure projects proposed at local schools should be coordinated with teachers and students to encourage learning opportunities throughout the implementation process.

- Consider implementing a watershed-based component to the curriculum in school districts where such programs are not already in place. Use existing educational materials available through the EPA-Long Island Sound Study, Connecticut Sea Grant, CTDEEP, and area colleges. The curriculum could combine lessons, field activities, classroom experiments, and regional networking into learning activities that build shared scientific knowledge and stewardship experiences. The Farmington River Watershed (FRWA) has developed a place-based environmental curriculum consisting of 30 lessons for teachers to use at the elementary, secondary, and high school levels to communicate about the cultural, historical, wildlife, and water resources of the Farmington River Watershed. The lessons, training, and a cross-walk to current state curriculum standards are available for teachers in the watershed.

- Continue to recruit student volunteers to participate in water quality and benthic monitoring and streamwalks in the Mill River watershed.

- Encourage collaborations with college faculty and research staff to develop research activities and new student projects focused on the Mill River watershed.

3.2.8 Address Homeless Encampments

Temporary or permanent homeless encampments along waterways where human waste is disposed can be a common problem in highly urbanized areas with an urban stream corridor (ASCE, 2014). Homeless encampments along portions of the lower Mill River, especially in East Rock Park and along the Lower Mill River, are a recognized problem and potential source of fecal indicator bacteria to the river. Homelessness is a serious social issue and sensitive public policy issue without an immediate or clear solution. Several options exist to begin to address this issue from a water quality standpoint, based on the experience of urban communities in other parts of the U.S.:

- Support of city shelters and services to reduce homelessness
- Periodic cleanup of homeless camps near streams
- Police enforcement/sweeps
- Providing public restrooms
- Partnering with non-governmental organizations to address homelessness.

The Contra Costa County Flood Control and Water Conservation District in southern California undertook an extensive research project to understand the best approaches for addressing water quality pollution from homeless encampments (DeVuono-Powell 2013). The study found that collaboration with other agencies was the most effective approach for addressing the long-term concerns of homeless encampments (ASCE, 2014).

3.3 Water Quality Monitoring and Assessment

Goal Statement: Improve the water quality of the impaired segments of the Mill River and its tributaries by reducing loadings of bacteria and other pollutants. Consistently meet water quality standards for recreation and aquatic habitat. Protect and enhance high quality and unimpaired waterbodies.

Ongoing water quality monitoring is recommended for the Mill River watershed to refine the understanding of water quality impacts from potential point and non-point pollution sources in the watershed, to measure the progress toward meeting watershed management goals and TMDL pollutant load reductions, and ultimately support removal of the impaired segments of the Mill River and its tributaries from the CTDEEP impaired waters list. Water quality monitoring recommendations are summarized in *Table 3-5*.

Recommended Actions

- Consider establishing a volunteer water quality monitoring program for the Mill River. Volunteer monitoring promotes citizen awareness, involvement, and environmental stewardship. Volunteer monitoring can also help to identify ambient water quality and trends, fill in gaps in statewide monitoring data, and provide data for regulatory and land use decision-making. Many examples of successful volunteer monitoring programs exist around Long Island Sound. Additional information about the CTDEEP Volunteer Monitoring Program is available online at http://www.ct.gov/deep/streamvolmon.

- Consistent with the bacteria TMDL for the Mill River watershed, the monitoring program should be designed to accomplish two objectives: (1) source detection to identify specific sources of bacterial loading and (2) fixed station monitoring to track water quality improvements.

    - Bacteria Source Detection – Source detection monitoring may include visual inspection of storm sewer outfalls under dry weather conditions, event sampling of individual storm sewer outfalls, and monitoring of ambient (in-stream) conditions at closely spaced intervals to identify "hot spots" for more detailed investigations leading to specific sources of high bacteria loads. Source detection monitoring should be informed by the findings of streamwalk assessments and follow-up track down surveys. Source detection monitoring should also be implemented by the watershed municipalities as part of their "Illicit Discharge Detection and Elimination" efforts as required by the MS4 permit.
    - Fixed Station Bacteria Monitoring – Conduct routine bacteria monitoring at fixed sites along the impaired reaches of the Mill River, Shepard Brook, and Willow Brook to measure progress toward achieving the watershed plan and TMDL pollutant load reduction goals. Sampling should be scheduled at regularly spaced intervals during the recreational season. Therefore, the data set at the end of each season would include ambient values for both "wet" and "dry" conditions in relative proportion to the number of "wet" and "dry" days that occurred during the monitoring period. The TMDL calculations can be updated over time to compare the percent reductions needed under "dry" and "wet" conditions to the percent reductions that were needed at the time of TMDL adoption.

Recommended Fixed Station Bacteria Monitoring Locations – Mill River Watershed

- Mill River at Whitney Road exit at Park and Ride (TMDL station ID 5410)
- Mill River downstream of Dixwell Avenue (TMDL station ID 176)
- Mill River at first pull-off downstream of Tuttle Avenue (TMDL station ID 923)
- Mill River upstream of Tuttle Avenue (TMDL station ID 175)
- Mill River adjacent to Route 22
- Mill River 400 meters downstream of Clark's Pond
- Shepard Brook at Route 10 (TMDL station ID 6180)
- Sanford Brook near Mountaincrest Drive
- Willow Brook at Willow Street

- Also consider implementing the Riffle Bioassessment by Volunteers (RBV) Program within the Mill River watershed. The RBV program is a volunteer water quality monitoring protocol developed and administered by the CTDEEP. Volunteers are trained to assess benthic macroinvertebrates in small wadeable streams to screen local stream segments for water quality. Volunteers could include students and faculty from local schools and universities. The non-tidal portions of the Mill River and both impaired and unimpaired segments of its major tributaries are potential candidates for RBV surveys. Information on the RBV Program is available at http://www.ct.gov/deep/rbv.

- Conduct stream flow monitoring in the Upper Mill River Subwatershed.

- Develop and implement a centralized water quality database for historical and new water quality monitoring data for the Mill River watershed. The database could be made accessible to the watershed municipalities, educational groups for teaching purposes, and the general public. The database could be implemented using an existing tool such as the Global Learning and Observations to Benefit the Environment (GLOBE) Program https://www.globe.gov/home, which is an international science and education program that provides students and the public worldwide with the opportunity to participate in citizen science through data collection, data entry, and data visualization, or a custom software application such as the water quality database and web resource developed for the Bronx River http://bronxriverwater.org/.

- Pursue dedicated funding to finance future monitoring and reporting.

- Prepare a periodic "Water Quality Report Card" for the Mill River watershed modeled after similar report cards that have been prepared for other rivers and embayments around Long Island Sound and elsewhere in the U.S. The report card would provide a transparent, timely, and geographically detailed assessment of water quality for the Mill River to inform the public of water quality conditions and actions that are occurring to improve and protect water quality in the river. Report card scores are determined by comparing water quality indicators to scientifically-derived ecological thresholds or goals.

Water Quality Report Card

An example of a water quality report card developed for Hempstead Harbor on the north shore of Long Island.
http://www.nfwf.org/whoweare/mediacenter/pr/Documents/hempstead-harbor-report-card.pdf

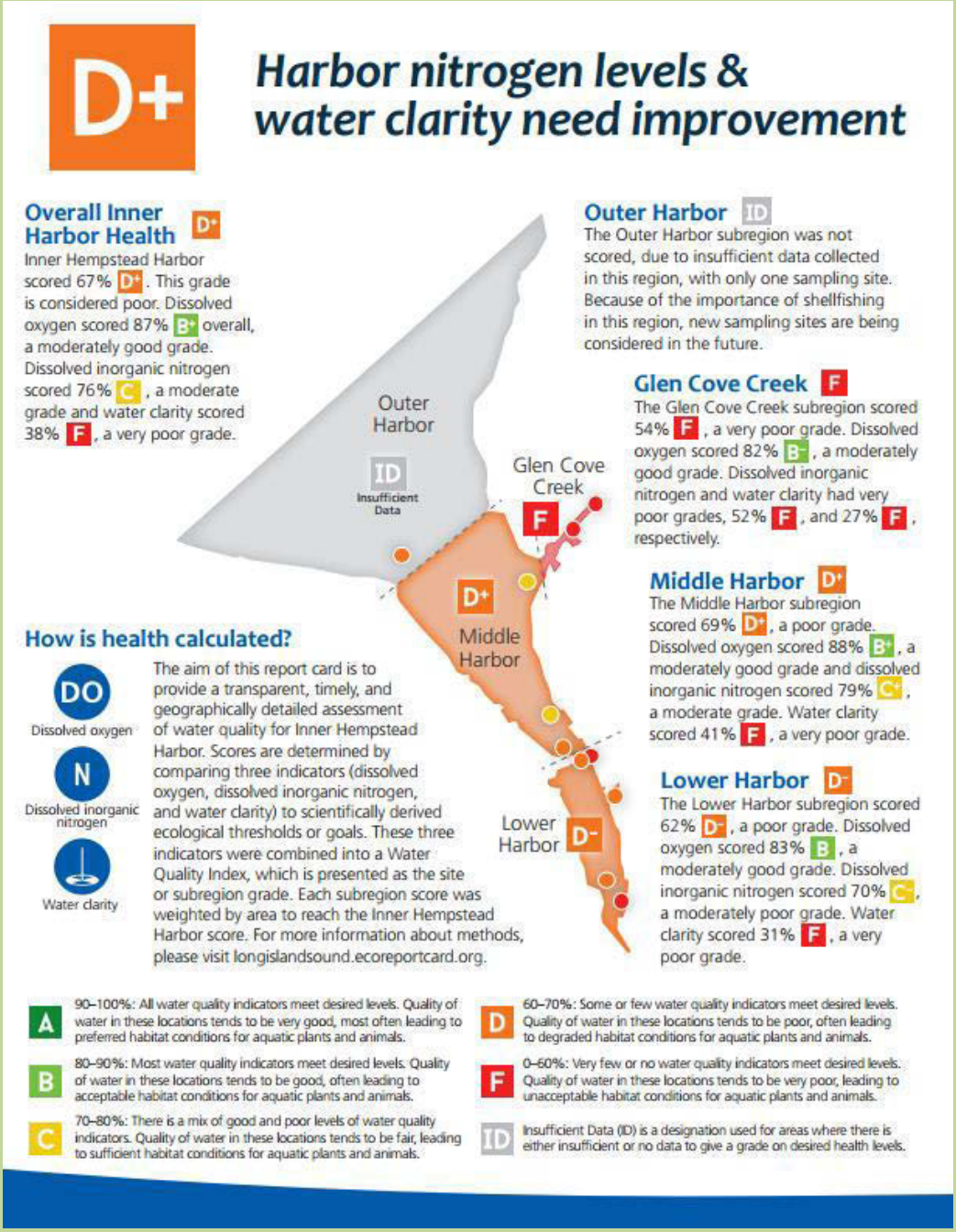


Table 3-5. Water Quality Monitoring Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Establish and implement a volunteer water quality monitoring program • Identify funding sources • Identify monitoring coordinator • Develop program with CTDEEP • Recruit volunteers • Conduct training and prepare QAPP	Mill River Watershed Coordinator, CFE/Save the Sound, CTDEEP, colleges and universities, and volunteers	2-5 years initial program development Annual monitoring	Approved QAPP, monitoring results/reports	$$$	Local businesses, National Fish and Wildlife Foundation, The Conservation Fund, Earthwatch Institute
2. Implement RBV program • Contact CTDEEP RBV Coordinator • Recruit volunteers • Conduct training and surveys	Mill River Watershed Coordinator, CFE/Save the Sound, colleges and universities, and volunteers	0-2 years and annually thereafter	Survey results/reports	$$	
3. Develop and implement a centralized water quality database	Mill River Watershed Coordinator, CFE/Save the Sound, and consultant	2-5 years	Functional database	$$$	
4. Prepare a periodic "Water Quality Report Card"	Mill River Watershed Coordinator, CFE/Save the Sound, and consultant	2-5 years	Report cards	$$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment CTDEEP = Connecticut Department of Energy and Environmental Protection

3.4 Urban/Suburban BMPs

Goal Statement: Promote sustainable land use and appropriate development in the watershed while protecting and improving water quality and natural resources, enhancing public access to and connectivity of waterbodies and open space, and addressing current and future flooding problems.

3.4.1 Combined Sewer Overflows

As described in *Technical Memorandum 1—Existing Watershed Conditions: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018a), during wet weather, portions of the combined sanitary and storm sewer system in the City of New Haven become overwhelmed and combined sewage overflows to nearby receiving waters. These discharges are referred to as Combined Sewer Overflows (CSOs). There are three remaining permitted CSO outfalls to the Mill River – CSOs 009, 011, and 012. The Greater New Haven Water Pollution Control Authority (GNHWPCA) is in the process of implementing a phased plan to reduce CSOs to the Mill River, which includes traditional gray infrastructure and green infrastructure approaches.

GNHWPCA should continue to implement CSO abatement measures to further reduce CSO discharges to the Mill River consistent with its CSO abatement plan. Specific CSO-related recommendations are described below and summarized in *Table 3-6*.

Recommended Actions

- Continue to update and implement the CSO Long Term Control Plan, including short, intermediate and long term CSO control measures to achieve zero discharges from CSO outfalls for up to a 2-year, 6-hour rainfall event by 2036. CSO wet weather capacity improvements in the Mill River watershed that are identified in the GNHWPCA Long Term Control Plan include:
    - Raising the regulator weir at CSO 009 (completed in 2015)
    - Conducting an Infiltration and Inflow removal project at CSO 009 (completed in 2016)
    - Completing sewer separation at CSO 009
    - Installing a 1.3 million gallon CSO storage tank at CSO 011
    - Closing Regulator 014 (completed in 2014)
    - Upgrading the pump station at Regulator 026 (under construction)
    - Closing Regulator 026 (scheduled to be completed in 2019)
    - Raising the weir at CSO 012 (completed in 2013)
    - Completing a capacity improvement project at CSO 012 (under construction)
    - Closing CSO 012 (scheduled to be completed in 2019)
    - Upgrading the pump station at Regulator 028 (under construction)
    - Closing Regulator 028 (scheduled to be completed in 2019)

- Continue to require the use of green infrastructure stormwater management practices (e.g., infiltrators and drywells, rain water storage tanks, bioswales and tree wells, water features) for development projects within combined sewer areas in accordance with the GNHWPCA Permitting and Design Criteria Manual (retain runoff on-site for the 2-year, 6-hour rainfall event, or approximately 2.05 inches).

- Continue to collect flow monitoring data to evaluate the effectiveness of the ongoing CSO improvements in the Mill River watershed (i.e., CSO events, volumes, and pollutant loads)

3.4.2 Green Infrastructure and Low Impact Development

Urban stormwater runoff is a significant source of pollutants and a leading cause of water quality impairments in the Mill River. Stormwater runoff from developed areas and other nonpoint sources of pollution in the watershed are major contributors of bacteria, sediment, and nutrients. As discussed previously, CSOs are also a major source of pollutants to the Mill River during wet weather.

Low Impact Development (LID) is a site design strategy that maintains, mimics, or replicates pre-development hydrology through the use of numerous site design principles and small-scale treatment practices distributed throughout a site to manage runoff volume and water quality at the source. Similarly, "green infrastructure" refers to systems and practices that reduce runoff through the use of vegetation, soils, and natural processes to manage water and create healthier urban and suburban environments (EPA, 2014). When applied to sites or neighborhoods, LID and green infrastructure (referred to hereafter as simply "green infrastructure") include stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

Green Infrastructure (GI) can be defined as the natural and man-made landscapes and features that can be used to manage runoff. Examples of natural green infrastructure include forests, meadows and floodplains. Examples of man-made green infrastructure include green roofs, rain gardens and rainwater cisterns.

Low Impact Development (LID) is a land development approach that is intended to reduce development related impacts on water resources through the use of stormwater management practices that infiltrate, evapotranspirate, or harvest and use stormwater on the site where it falls.

In addition to reducing polluted runoff and improving water quality, GI has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change (Center for Neighborhood Technology and American Rivers, 2010; EPA Green Infrastructure Website http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm). For these reasons, many communities are exploring the use of and are adopting GI within their municipal infrastructure programs.

As described in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c), GI is being implemented by the City of New Haven, GNHWPCA, private development, and other groups working in the Mill River watershed. An important objective of the Mill River Watershed Based Plan is to reduce CSO discharges, runoff volumes, and pollutant loads through the use of GI by building on the previous and ongoing GI initiatives in the watershed and region. Additional opportunities for GI retrofits in the Mill River watershed were identified during the development of this watershed plan. Ten of the priority site design concepts are presented in *Section 4*. Additional concepts are documented in *Table 4-1*.

Table 3-6 contains a summary of green infrastructure recommendations for the Mill River watershed.

Table 3-6. Combined Sewer Overflow and Green Infrastructure Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Continue to implement CSO improvements identified in the GNHWPCA Long Term Control Plan	GNHWPCA	Ongoing	Updated 2022 LTCP, completed projects	$$$$	GNHWPCA, CWF
2. Flow monitoring to evaluate effectiveness of CSO improvements • Compare modeled and measured CSO events, volumes, and pollutant loads	GNHWPCA	Ongoing	Flow monitoring reports including analysis of modeled and measured parameters	$$$$	GNHWPCA, CWF
3. Require use of GI for development projects within combined sewer areas	GNHWPCA	Ongoing	Completed projects	$	Private
4. Implement identified GI retrofit projects on public lands • Pursue grant funding • Design and construct projects	CFE/Save the Sound, municipalities, private partners, consultants	Ongoing	Completed projects	$$$$	319 NPS Grant
5. Incorporate GI into municipal projects including "green streets" projects • Work with Regional Councils of Governments to ensure that GI and LID are considered and incorporated into all plans and projects	Municipalities, NVCOG, SCRCOG, Mill River Watershed Coordinator	Ongoing	Completed projects	$$$$	
6. Evaluate and modify existing municipal land use regulations and policy to require the use of GI and LID for development projects • Conduct land use regulatory review • Implement recommendations of land use regulatory review	UConn NEMO, NVCOG, SCRCOG, municipalities, (conduct reviews) Municipalities, consultants (implement recommendations)	0-2 years 2-5 years	Final project reports Amendments to local land use regulations and policies	$$$$ $$$$	Long Island Sound Study NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, 319

Table 3-6. Combined Sewer Overflow and Green Infrastructure Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
					NPS Grants
7. **Support and implement recommendations identified as part of the CT NEMO Stormwater Corps pilot project focused on incorporating cost-effective Green Infrastructure practices into local projects within the South Central Basin.**	CFE/Save the Sound, Municipalities, CT NEMO	Ongoing	Implementation of pilot recommendations	$$$$	
8. **Pursue sustainable, long-term funding sources for large-scale GI implementation**	Regional collaboration of CFE/SAVE THE SOUND, SCRCOG, NVCOG, GNHWPCA, Municipalities	5-10 years	Framework and action plan to evaluate and implement stormwater infrastructure financing	$$$$	Stormwater utilities, property tax credits and incentive rate structures, green bonds, public private partnerships, CWF

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/SAVE THE SOUND = Connecticut Fund for the Environment/Save the Sound CTDEEP = Connecticut Department of Energy and Environmental Protection NVCOG = Naugatuck Valley Council of Governments SCRCOG = South Central Regional Council of Governments CWF = Connecticut Clean Water Fund

Recommended Actions

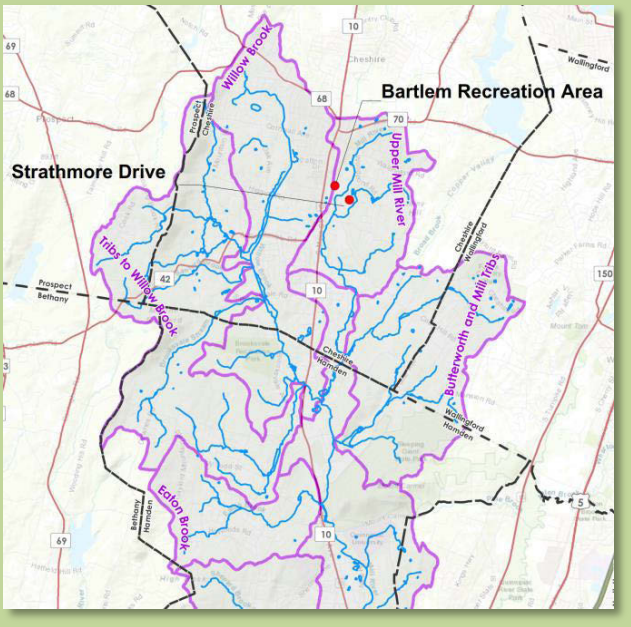
- Pursue funding for and implement identified high-priority, site-specific GI retrofits on public lands based on the site-specific GI concepts identified in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018c) (see *Section 3.5 and Appendix C*). Simultaneously, pursue partnerships with businesses and homeowner associations to advance those site-specific GI concepts developed for privately owned sites.

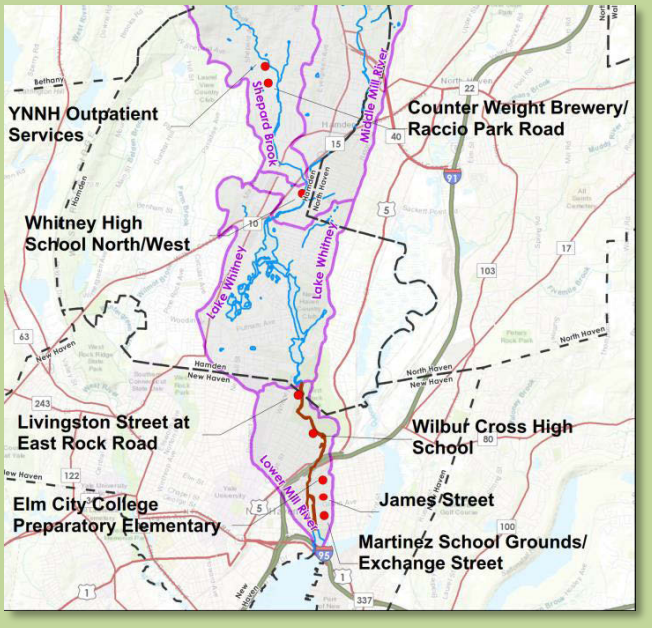
- Continue to develop additional retrofit projects, including identifying potential project sites through future streamwalks, track down surveys, and subwatershed action plans.

- The watershed municipalities should incorporate GI into planned municipal projects, including roadway projects in the context of "green streets" approaches, following the City of New Haven's "Complete Streets" initiative. The City of New Haven should update its Complete Streets Design Manual (2010) to provide urban street design standards and promote the use of GI.

Site-Specific Green Infrastructure Retrofits in the Mill River Watershed

An assessment was performed to identify opportunities and develop concepts for site-specific GI retrofits in the Mill River watershed. The assessment began with a screening evaluation of the approximately 230 publicly-owned parcels in the targeted subwatersheds to quickly identify areas with the greatest feasibility for and potential benefits from GI retrofits. Field inventories were then conducted at approximately 40 sites with the greatest opportunity for GI retrofits. GI concepts were prepared for 10 of the highest priority sites visited. (Note that Hamden Town Center Park is also identified as highest priority.) Details of the assessment methods, concepts, and other GI retrofit opportunities in the watershed are provided in *Section 4* and also in *Technical Memorandum 3—Low Impact Development and Green Infrastructure Assessment: Mill River Watershed-Based Plan (Fuss & O'Neill, 2018c)* (see *Appendix C*).





- Cost-effective, large-scale implementation of GI will require non-traditional financing. Possible long-term funding sources including user fees, stormwater utilities, property tax credits or rebates, green bonds and community-based public-private partnerships. The following alternative funding approaches should be considered:

    - Stormwater Utilities – Watershed municipalities should consider the feasibility of implementing a municipal or regional stormwater utility, incorporating lessons learned from previous and ongoing efforts by New Haven and other Connecticut communities. Critical to the success of such an effort is an effective public outreach and community stakeholder engagement program.

    - General Fund/Property Taxes – while many issues exist with using property taxes to fund municipal stormwater management programs (e.g., property taxes are not assessed based on runoff generation, some significant runoff generators are tax-exempt, many competing priorities for general funds), tax credits or incentive rate structures could be explored that would incentivize the use of green infrastructure by property owners.

    - Clean Water Fund – grant and loan funding from the Connecticut Clean Water Fund should be focused on implementing green infrastructure throughout New Haven's combined sewer areas, including the Mill River watershed.

    - Green Bonds – Green Bonds are a growing mechanism for funding green projects, including green infrastructure and flood resilience projects. Green bonds are debt instruments issued to finance environmental projects focused on climate change initiatives. The identification and labeling of a green bond is typically based on a set of voluntary standards drafted by a consortium of investment banks that outlines the process for issuers to designate specific

Green Infrastructure in New Haven

City of New Haven bump-out bioretention planter along Clinton Avenue(top) and typical bioswale (bottom). The City plans on installing bioswales across the City to manage stormwater runoff effectively. GNHWPCA is also installing bioswales in areas of combined sewers in New Haven. Photo credit: Dawn Henning, City of New Haven Engineering.

green projects. The guidelines specify that a bond issue qualifies as green if the issuer uses the proceeds solely for capital expenditures associated with green or climate-related environmental benefits in accordance with certain standards.

- Public Private Partnerships –A Public Private Partnership (P3) is an arrangement between government and the private sector in which the private sector assumes a large share of the risk in terms of financing, constructing, and maintaining the infrastructure. Government repays the private sector over the long term if the infrastructure is built and maintained according to specifications. Prince George's County is implementing a P3 program to retrofit 2,000 acres of impervious surfaces in the public right of way. Private funds will finance 30% to 40% of the program costs upfront, enabling project construction to begin sooner and proceed more quickly.

3.4.3 Residential Low Impact Development

Residential land use accounts for approximately 57% of the land area in the Mill River watershed. Residential areas are a significant source of runoff and nonpoint source pollutant loads to the Mill River. The actions of individual homeowners can help to reduce runoff and pollutant loads to the combined and separate storm sewer systems in residential areas. The previous section describes larger-scale green infrastructure recommendations primarily targeted at municipalities, institutions, and private development. Low Impact Development (LID) management practices can also be implemented by homeowners on individual residential lots.

Residences in parts of the watershed generate significant quantities of rooftop runoff, which can also be a source of bacterial loads from birds and squirrels especially in areas with overhead tree canopy. Opportunities exist to disconnect residential rooftop runoff from the combined or storm drainage systems and reuse or redirect it to pervious areas through the use of rain barrels, rain gardens, and drywells.

Downspout disconnection can be a cost-effective option, in certain residential settings[4], for reducing the volume and cost of stormwater that requires public management. The use of pervious materials for patios, walkways and driveways, as well as pavement removal and planting new yard trees, can also reduce impervious surfaces on residential lots and the contribution of runoff and pollutant loads to waterbodies.

Residential LID retrofits on individual lots target small areas, requiring the participation of many homeowners to make a measurable difference across a watershed. A coordinated effort is required for widespread participation in such a program, which typically includes a combination of targeted education, technical assistance, and financial subsidies to homeowners. Successful implementation of residential/small-scale LID practices therefore requires homeowner education and incentive programs.

[4] In densely developed urban areas with combined sewer systems, such as parts of the Mill River watershed in New Haven, downspout disconnection (i.e., roof leader separation) can be extremely expensive and less cost-effective than other BMPs since disconnecting roof leaders from the combined sewer system often requires costly interior plumbing modifications.

Recommendations for implementation of residential LID practices in the Mill River watershed are described below and summarized in *Table 3-7*.

Recommended Actions

- Encourage disconnection of rooftop runoff from the storm drainage system by redirecting exterior roof leaders to pervious lawn areas and through the use of dry wells, rain barrels or rain gardens.

- The watershed municipalities, together with the GNHWPCA, should consider developing residential LID incentive programs to encourage implementation of LID practices by homeowners, which will help reduce the burden on municipal stormwater and wastewater infrastructure for managing runoff from residential lots. Incentives to encourage residential property owners to use LID include:
    - Stormwater Fee Discounts or Credits – reduced fees or utility bills by installing LID practices; requires a stormwater utility or similar fee-based system
    - Rebates and Installation Financing – funding, property tax credits (i.e., reduction in property taxes), or reimbursements to property owners who install green infrastructure
    - Workshop and Give-Away or Discount Programs - rain barrel workshops for homeowners that provide a free rain barrel to each participating household, along with training on how to install and maintain the rain barrel. Some rain barrel companies, such as the Great American Rain Barrel Company, offer programs for communities that enable municipalities to offer discounted rain barrels through a community campaign, with convenient barrel pick-up for residents at a Town or City office (https://www.greatamericanrainbarrel.com/community/)
    - Certification and Recognition Programs – certification of residential properties as watershed-friendly by implementing LID practices
    - Municipal sponsored public workshops on how to build rain gardens emphasizing the increase in property value and curb appeal of LID landscaping

Incentive programs can also serve as a mode of public outreach. Several examples of successful residential LID incentive programs are highlighted in the following text box.

Disconnecting Roof Downspouts

Disconnecting roof downspouts is one of the easiest things homeowners can do to help reduce stormwater runoff. Disconnecting downspouts will reroute the runoff into rain barrels or permeable areas like lawns or rain garden instead of the sewer. http://reducerunoff.org/ (Save the Sound).

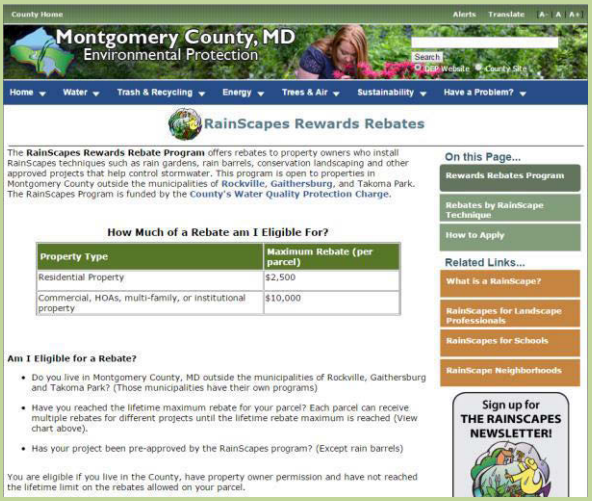
Reroute your downspout so your yard or rain garden absorbs and filters the runoff from your roof.

Disconnecting your downspout is a simple and effective way of reducing stormwater runoff. (Photo from grandbuilding.ca)

Residential LID Incentive Programs

Lake Champlain BLUE® Certification Program
Program developed by Lake Champlain International that certifies residential properties as watershed friendly, or BLUE®, if they follow simple, yet scientifically accepted, practices that reduce water pollution runoff starting on their properties. Certified homeowners receive a BLUE certification lawn sign, increased property values, and the satisfaction of improving local water quality.
http://www.mychamplain.net/blue-program

Montgomery County, MD Rainscapes Rewards
Montgomery County coordinates RainScapes Rewards, a rebate program used to meet part of its municipal separate storm sewer system (MS4) permit goals. The county provides rebates based on the amount of runoff captured. Residential properties are capped at $2,500.
https://www.montgomerycountymd.gov/DEP/water/rainscapes-rebates.html



- Provide education and outreach to homeowners, neighborhood groups, and roofing contractors on disconnecting roof downspouts and installing and maintaining residential rain gardens and rain barrels. The Connecticut NEMO web site provides a wealth of information about residential rain gardens: http://nemo.uconn.edu/rain gardens/

- Encourage participation among New Haven residents in the "Voluntary Non-Use of Pesticides and Synthetic Fertilizers on Lawns and Gardens" program.

- Additional homeowner education and outreach recommendations are discussed above in *Section 3.2.2* of this plan.

Table 3-7. Residential Low Impact Development Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Evaluate and implement residential LID incentive programs • Identify and build upon existing programs (e.g., NHS Free Rain Garden Program, The Sound School and RWA's rain barrel program) • Evaluate feasibility of alternative programs • Pursue funding • Implement program(s)	Mill River Watershed Coordinator, CFE/SAVE THE SOUND, GNHWPCA, NHS	0-2 years establish program Ongoing implementation thereafter	Program(s) identified, funding secured, program established, number of homeowners participating	$$$$	Grants, future stormwater fees, property tax credits
2. Provide homeowner education and outreach on using LID	Municipalities, CFE/SAVE THE SOUND, UConn NEMO, NHS	Ongoing	Outreach materials disseminated	$$	Municipal, grants

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/Save the Sound = Connecticut Fund for the Environment/Save the Sound NHS = Neighborhood Housing Services of New Haven NEMO = Nonpoint Education for Municipal Officials GNHWWC = Greater New Haven Waterworks Coalition

3.4.4 Municipal Stormwater Management Programs

The stormwater collection and drainage systems within the watershed consist of drainage infrastructure operated and maintained by the watershed municipalities and the Connecticut Department of Transportation. The watershed municipalities are regulated under the CTDEEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 Permit). Stormwater discharges associated with the state drainage system are regulated under a similar MS4 permit issued specifically to the Connecticut Department of Transportation (CTDOT), which will become effective July 1, 2019.

Through their MS4 Permit stormwater management programs and other planning initiatives, the watershed municipalities have developed and implemented a variety of Best Management Practices to address stormwater quality and quantity issues associated with municipal activities as well as land development and redevelopment projects.

Updated CTDEEP MS4 Permit

CTDEEP reissued an updated MS4 Permit which took effect July 1, 2017. The new permit contains more stringent requirements than the previous permit relative to storm system mapping, illicit discharge detection and elimination, and monitoring, as well as more prescriptive requirements for discharges to impaired waters, such as the Mill River. The MS4 Permit also requires municipalities to address impervious area that is directly connected to municipal storm drain systems through tracking and reductions of impervious cover, with the ultimate goal of reducing nonpoint source pollution by lessening stormwater runoff.

Construction sites that disturb one or more acres of land are regulated by the CTDEEP under the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities. Municipalities also have jurisdiction over construction sites that disturb 0.5 or more acres of land.

Municipal stormwater management recommendations are summarized in *Table 3-8*.

Recommended Actions

The watershed municipalities should continue to implement municipal stormwater management programs for their regulated MS4s, as required by the MS4 Permit. The six minimum control measures of the MS4 Permit include public education, public involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention and good housekeeping. Specific recommendations include:

- Consider developing a regional stormwater coalition to pool resources and facilitate more cost-effective compliance with the MS4 Permit. The South Central Regional Council of Governments (SCRCOG) has previously expressed interest in forming a regional coalition and might serve as a leader in forming such a coalition. There are other successful stormwater coalitions that can provide a model for the region. One example is the Central Massachusetts Regional Stormwater Coalition (http://centralmastormwater.org/Pages/index).

- CTDOT will be developing and implementing a Stormwater Management Plan to comply with its MS4 Permit. CFE/Save the Sound and the Mill River Watershed Committee should review and comment on the draft Stormwater Management Plan during the public comment period, which is 90 days prior to the effective date of the MS4 Permit (July 1, 2019).

Table 3-8. Municipal Stormwater Management Program Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. Form a regional stormwater coalition to cost-effectively comply with the new MS4 Permit	SCRCOG, NVCOG, municipalities, consultant	0-2 years	Regional coalition established	$$$$	SCRCOG/NVCOG

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

SCRCOG = South Central Regional Council of Governments NVCOG = Naugatuck Valley Council of Governments

- CFE/Save the Sound should work collaboratively with the watershed municipalities and CTDOT during implementation of their MS4 Stormwater Management Programs to share stormwater outfall screening and monitoring results, the results of streamwalks and track down surveys, the results of illicit discharge investigations, and opportunities for GI/LID retrofits in the Mill River watershed.

- The Naugatuck Valley Council of Governments (NVCOG) should continue to explore the possibility of providing regional training and outreach materials to its member communities to facilitate sharing of resources and to more cost-effectively comply with the MS4 General Permit, borrowing from the successes of regional stormwater coalitions in Massachusetts such as the Central Massachusetts Regional Stormwater Coalition (http://centralmastormwater.org/Pages/index).

3.4.5 Land Use Regulations

Municipal land use plans and regulations help shape the development patterns within a watershed and can play a significant role in protecting water quality and other natural resources at the watershed scale. These commonly include municipal plans of conservation and development, zoning regulations, subdivision regulations, inland wetlands and watercourses regulations, and stormwater regulations, all of which influence the type and density of development that can occur within a watershed. Local land use regulations often vary by municipality within a watershed, and regulations are periodically revised in response to development pressure, shifts in attitude toward natural resource protection, and political and socioeconomic factors. The Town of Hamden Zoning regulations were significantly revised in 2009 from a use-based zoning to form-based zoning. This overhaul of the Town's regulations also included a significant strengthening of Stormwater regulations and a more realistic approach to required parking. These types of changes can serve as an example for other watershed municipalities.

Because a watershed based plan encompasses multiple municipalities, a watershed-based regulations review also provides an opportunity for towns or cities to compare their regulatory mechanisms to those of neighboring municipalities. By doing so, they can evaluate the relative merits of different approaches, adopt the best models, and improve region-wide consistency in how the common water resource is managed.

Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

The Nonpoint Education for Municipal Officials (NEMO) Program of the UConn Center for Land Use Education and Research (CLEAR) has completed reviews of land use regulations for Cheshire, Bethany, Hamden, and New Haven. NVCOG also conducted regulatory reviews for Cheshire and Prospect, two towns comprising approximately one third of the Mill River watershed. These reviews compared existing regulations to the legal authority requirements of the CTDEEP MS4 General Permit. In addition, each review looked for potential barriers to low-impact design within Town regulations (e.g., road width or parking requirements which encourage an excess of impervious area). Where relevant, the reviews provide

suggestions for eliminating these barriers to further encourage LID and green infrastructure. These reviews build upon a previous review by the Mill River Watershed Association of municipal land use regulations in the Mill River, West River, and Quinnipiac River watersheds, which found that most of the municipalities surveyed require some form of green infrastructure or LID for new construction but few, if any, require retrofits for existing development (Mushinsky, 2015).

Recommended Actions

- Cheshire and Prospect should take steps to revise their land use regulations in accordance with the recommendations of the NVCOG land use regulatory reviews for each municipality. A similar land use regulatory review process is required of all Towns registered under the MS4 permit, and the other watershed municipalities should conduct a similar land use regulatory review process to identify and eliminate barriers to LID in each municipality.

- The other watershed municipalities should ensure that their land use regulations includes green infrastructure and LID stormwater requirements, including runoff reduction standards, following the lead of the City of New Haven and GNHWPCA, particularly for new development and redevelopment of sites with large amounts of existing or proposed impervious surfaces.

- The Mill River Watershed Based Plan should be referenced by the watershed municipalities in any updates to municipal Plans of Conservation and Development (POCDs). The POCDs should emphasize that municipal land use agencies (i.e., inland wetlands and watercourses, planning and zoning, conservation) should consider the long-term protection and use of the watershed when implementing their statutory abilities to balance resource protection and development.

3.4.5.1 Increase Flood Resilience Using a Watershed Approach

Water quality is the primary focus of this watershed based plan, although water quality and quantity (i.e., flooding) issues are closely related in terms of watershed resource management. This watershed plan, although not intended as a flood mitigation plan, also addresses flooding due to the prevalence of concerns around inland and coastal flooding and the significant attention that flood mitigation has received in the watershed communities, particularly in the face of climate change and the potential for more frequent and intense storms in the future.

The flooding-related recommendations in this watershed plan are intended to enhance flood resilience[5] by supplementing previous and ongoing flood mitigation efforts in the watershed. These recommendations focus on an integrated, watershed-based approach to addressing flooding, water quality, and habitat restoration. The emphasis is on restoring the functions, and often the forms, of the resources provided by natural riverine, wetland, and estuarine

Use of Green Infrastructure and Other Innovative Approaches to Urban Flooding

Green infrastructure and other techniques are recommended to address urban flooding problems in the watershed. These recommendations focus on an integrated, watershed-based approach to addressing flooding, water quality, and habitat restoration. The emphasis is on restoring the functions, and often the forms, of the resources provided by natural riverine, wetland, and estuarine systems, which is a change from past, conventional approaches to flood control.

[5] "Flood resilience" is a community's ability to plan for, respond to, and recover from flooding.

systems, which is a change from past, conventional approaches to watershed development and traditional flood control. This plan also recognizes the critical importance of wetland/marsh protection and restoration for flood resilience.

The recommendations include elements of the National Flood Insurance Program for planning and restoration of riverine corridors (insurance claims, adaptation-avoidance by elevating structures, discouraging future development activities within flood prone areas, floodplain easements, etc.), as well as other approaches such as green infrastructure, which recognize that flooding damage in urban and suburban areas is not confined to floodplains (Center for Neighborhood Technology, 2013).

Recommended Actions

- Continue to implement the flood protection recommendations in the City of New Haven's Comprehensive Plan Update:
    - Continue to restrict land clearing activities and development in low-lying areas through the enforcement of the city's floodplain ordinances
    - Encourage flood proofing of structures in areas prone to repetitive floods. Identify and seek pre-disaster mitigation funding and other sources of funding available at the state and federal level to implement flood proofing measures within the city.
    - Review, assess, and revise the floodplain ordinances of the city periodically to protect the health, safety, and welfare of residents.
    - Delineate Base Flood Elevations (BFEs) at the parcel level, as designated by FEMA, on official City maps and publish them on City webpage so that they can be used by residents and potential developers.
    - Continue to update and adopt the City's Natural Hazard Mitigation Plan (updated in 2017).

Updated Design Storm Rainfall

The National Oceanic and Atmospheric Administration National Weather Service issued updated precipitation frequency data (i.e., design storm rainfall amounts) in its Atlas 14, Volume 10 published in 2015. A similar tool for updated extreme precipitation data was developed as a joint collaboration between the Northeast Regional Climate Center and the USDA Natural Resources Conservation Services, http://precip.eas.cornell.edu, for New York and New England. The design storm rainfall amounts provided by these newer resources offer significant advantages over previous products since the design storm rainfall amounts are based on a much longer period of record, including future updates as new rainfall data is available.

- Adopt a policy of no-net-loss of flood storage capacity or flood conveyance within the watershed. Preserve and protect existing wetlands that provide flood storage and attenuation.
    - Keep working riparian buffers intact to slow runoff velocities and help control flooding.
- Remove, redesign and reduce in-channel and in-floodway structures and restore channels, floodways and floodplains. Restore floodplain storage by excavating fill and removing flood-prone structures.
- Emphasize infiltration using green infrastructure techniques, which provides water quality and other benefits in addition to reducing water volumes and decreasing peak flows to mitigate flooding.
- Incorporate updated design storm rainfall amounts into local land use regulations and policies to account for the influence of climate change.

- Ensure that future flood mitigation projects and designs include provisions for water quality and riparian/aquatic habitat restoration. Provide or maintain vegetated buffers around all watercourses and wetlands where feasible.

- Assess the vulnerability of public and private infrastructure (e.g., utilities, transportation, structures), the environment, and society (e.g., vulnerable populations) to climate change and increased frequency of extreme storms, sea level rise, etc. and develop adaptation strategies. The Massachusetts Municipal Vulnerability Preparedness Program (https://www.mass.gov/municipal-vulnerability-preparedness-mvp-program) and The Nature Conservancy's Community Resilience Building Framework (https://www.communityresiliencebuilding.com/) provide excellent resources for structuring a vulnerability assessment and prioritization process.

- Climate change tools and resources for Connecticut are available from CTDEEP (www.ct.gov/deep/climatechange) and the Connecticut Institute for Resilience & Climate Adaptation (https://circa.uconn.edu/).

- Engage federal and state agencies on available assistance and resources to develop and implement engineering solutions to address flood problems.

3.4.5.2 *Preserve and Protect Open Space*

An objective of this plan is to manage, maintain, and promote existing open space and continue to protect and acquire open space that meets resource protection and recreational goals. Open space plays a critical role in protecting and preserving the health of a watershed by limiting development and impervious coverage, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space is also important as habitat for native and migratory species and protection of public water supply, both significant uses of open space in the Mill River watershed.

Open space in the Mill River watershed includes preserved natural areas (e.g., East Rock Park, Naugatuck State Forest, Sleeping Giant State Park, and Regional Water Authority public water supply land) as well as lightly developed parks, playgrounds, and

Rocky Top

The Hamden Land Conservation Trust's Rocky Top property is a wooded, taprock ridge that boasts a diverse ecosystem and the original Connecticut Blue Trail System. Located off Rocky Top Road in Hamden, this property was threatened with development several times between 2008 and 2018. During this time neighbors banded together to fight to preserve this remarkable property. When a new development was proposed in 2017 the community organized, raising awareness through social media, gathering donations to hire a legal team and partnering with Connecticut Forest and Park Association. The developer listened to the communities concerns and decided to donate the 18 acres to Hamden Land Conservation Trust. http://www.hlct.org/

Credit: Hamden Land Conservation Trust

cemeteries. The watershed communities have identified open space protection goals and priorities primarily through their Plans of Conservation and Development, and Cheshire and Hamden, which make up the largest portion of the watershed, have excellent histories of protecting and preserving open space.

Recommended Actions

- The watershed municipalities should develop or update existing municipal open space conservation plans. As a rule, update open space planning documents at least every five years.

- Work closely with land owners to protect and/or acquire unprotected open space as recommended in this watershed based plan, the municipal Plans of Conservation and Development, and related open space planning efforts.

- Continue to promote conservation easements as a tool to local or regional land trusts to protect, conserve, and maintain open space. Alternative funding sources and approaches for open space acquisition include state funding (e.g., Community Investment Act - Public Act 05-228), limited market rate development on a parcel to help fund the acquisition of the remainder of the parcel as open space, and transferring development rights from sensitive locations to locations better suited for development. Regardless of the mechanism, critical to the success of protecting open space land is the ability to readily leverage financing when windows of opportunity arise to acquire or preserve significant parcels.

- Plan and provide for public access to open space areas, and connect existing open spaces to avoid open space fragmentation. Obtain public access easements from property owners to link open space areas. Partner with non-profit organizations such as the local land trusts to acquire adequate vacant lands or easements to create a linked network of trails within the Mill River watershed.

- Ensure that open spaces remain available for passive recreation. Promote awareness and appropriate use of existing open space by publicizing parks, trails, community gardens, and historic landscapes as well as educational events on open space parcels.

- Encourage watershed-friendly management practices on open space parcels, including voluntary non-use of pesticides are fertilizers on lawns and gardens.

    - Encourage golf courses to participate in Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses https://www.audubonintenational.org/acspgolf

- Assess, improve, and restore parcels already acquired. Develop management plans for the use of acquired open space parcels.

- Proposed open space acquisitions should be evaluated based on a set of criteria that considers the environmental and physical characteristics of each property proposed for acquisition. In general, priority for open space protection should be given to properties that meet one or more of the following environmental criteria, in addition to multiple public benefits:
    - Size – Larger parcels provide greater opportunity for contiguous undeveloped areas or corridors to benefit wildlife, water quality and provide recreation.
    - Water Resources – Parcels that provide buffers for rivers and streams and associated riparian communities, headwater streams, and coastal areas.

- Wetlands and Wildlife Habitat – Parcels that provide upland buffers around high quality wetlands and habitat areas and that support, enhance or protect biodiversity. In addition, areas of unprotected land within threatened or endangered species habitat should be made a priority for acquisition or conservation.
- Floodplain Protection – Parcels in floodplain areas to provide habitat, protect or improve water quality, and preserve natural flood storage or function (to the 500-year flood level).
- Streamflow Protection – Parcels that provide protection of groundwater recharge areas and headwater streams or parcels whose protection would prevent fragmentation of large forest tracts.
- Recreation – Parcels that provide water and land-based recreational opportunities including swimming, fishing, boating, hunting, other water-access, or could accommodate multi-use trails as part of an existing or planned greenway, trail or linear park or provide connectivity of existing trail systems.

- Evaluate undeveloped and underdeveloped parcels in the watershed based upon the above factors to help identify open space protection priorities. Consider two types of open space protection – acquisition or protection through a conservation easement or restriction. Parcels that are currently undeveloped should be assigned higher priority for acquisition, while those parcels that are partially developed but have potential for future development should be assigned higher priority for a conservation restriction.

3.4.5.3 *Increase Public Access to the River via the Mill River Trail*

Fishing is allowed along the Mill River from River Road to Skiff Street, with several sites along the Mill River stocked by the CT DEEP. Clarks Pond offers one of the few handicapped accessible fishing areas in the state of Connecticut. Nonetheless, access to many portions of the Mill River is limited due to development along the river. Improved access to the Mill River and its tributaries, including connectivity of waterbodies and open space, is needed to enhance recreational opportunities as well as public appreciation and stewardship of the river.

Recommended Actions

- Continue to expand the Mill River Trail, implementing the plan laid out in the *Mill River Trail Framework Plan* (Reed Hilderbrand, LLC, 2017). An approximately 1,000 foot long section of the trail adjacent to Radiall and Grand Paint was approved in April, 2018, with funding from a Connecticut Recreational

Proposed Mill River Trail Concept

The map below depicts the Mill River Trail concept as envisioned in the Mill River Trail Framework Plan (Reed Hilderbrand, LLC, 2017).

Trails Grant from CTDEEP.

- Encourage continued use and stewardship at existing river access points, such as the pull off on Route 10 near Wentworth's which is used as an access point for fishing.

- Implement trail improvements at the Eli Whitney Museum, focusing on the stretch of trail from the museum property line to the Boy Scout bridge. This is an ideal location to encourage river access and education, as there is tidally-influenced fresh water marsh on one side of the trail, and the Mill River on the other.

- Work with the Mill River Trail Advocates group to increase available walk-to-school options that utilize the Mill River Trail, focusing especially on the areas served by Wilbur Cross High School, Elm City College Preparatory Elementary School, and the John Martinez School, each of which is also a site proposed for additional green infrastructure retrofits and outreach.

- Plan and create new trails to connect existing trails and open space in the Mill River watershed.

- Coordinate with outreach and education activities (*Section 3.2*) to foster an increased sense of connection between local residents and the river, particularly beginning with school-aged groups.

- Develop a public access area inventory for the Mill River and its tributaries that includes a map and listing of the areas summarizing location, size, current and potential uses, and ownership.

- Target acquisition of new access points or areas at locations that are underserved by open space or access to the river and with residential neighborhoods within walking distance. Public access areas should not adversely affect sensitive areas. Incorporate LID and other sensitive design elements into access area designs.

- Introduce educational signage, interpretive stations, laminated maps and guides, and online resources in the design of new or modified public access to waterways and open space areas.

- Collaborate with the Regional Water Authority to promote public access to public water supply land in the Mill River watershed where appropriate as a way to educate the public about the watershed and water quality protection. The public can access the public water supply land by obtaining a permit from the Regional Water Authority.

Table 3-9 summarizes land use, flood resilience, open space, and public access recommendations.

Table 3-9. Land Use, Flood Resilience, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Land Use Regulations					
1. **Implement the recommendations of the UConn/NEMO and NVCOG land use regulatory reviews**	Municipalities	2-5 years	Adopted or revised land use regulations or policies	$$$	
2. **Watershed municipalities should adopt green infrastructure and Low Impact Development stormwater requirements**	Municipalities	2-5 years	Adopted or revised land use regulations or policies	$$$$	
3. **Reference the Mill River Watershed Based Plan in updated municipal Plans of Conservation and Development**	Municipalities	Ongoing	Updated POCDs	$	
Flood Resilience					
4. **Implement flood protection recommendations in City of New Haven's Comprehensive Plan Update**	City of New Haven	0-2 years	Updated Comprehensive Plan	$$$$	
5. **Adopt a policy of no-net-loss of flood storage capacity or flood conveyance** • Keep working riparian buffers intact to slow runoff velocities and help control flooding.	Municipalities	2-5 years	Revised flood hazard regulations	$$$	
6. **Update design storm rainfall amounts and assess the vulnerability of public and private infrastructure to climate change**	Municipalities	2-5 years	Revised design storms in regulations, climate change vulnerability assessments	$$$$	
7. **Implement coastal resilience measures for the tidally influenced portion of the Mill River**	New Haven	5-10 years	Coastal resilience plans prepared and implementation projects completed	$$$$	Grant funding – FEMA, HUD, NOAA, CIRCA
8. **Address current flood problems using federal and state agency assistance and resources**	Municipalities	Ongoing	Pursue federal grants and technical assistance	$$$	FEMA, HUD, NOAA, CIRCA, CTDEEP

Table 3-9. Land Use, Flood Resilience, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
Open Space					
9. Develop/update municipal open space conservation plans	Municipalities, land trusts	2-5 years	Open space planning document updates	$$$	
10. Acquire unprotected open space	Land trusts, municipalities, RWA	Ongoing	Protected land	$$$$	Federal (USDA Forest Service and NRCS), State (CTDEEP and CTDOA), CT Land Conservation Council, and private organizations
11. Provide for public access to open space areas	Municipalities	Ongoing	Completed projects and number of sites	$$$	
12. Perform an evaluation of undeveloped and underdeveloped parcels in the watershed	Land trusts, Municipalities, NVCOG, SCRCOG	2-5 years	Evaluation report with recommendations	$$$	
Public Access					
13. Expand the existing Mill River Trail. Plan and create new trails to connect existing trails and open space. • Implement the Mill River Trail Framework Plan, including planned pedestrian, bike, and water trail routes	New Haven	5-10 years	New trail sections	$$$$	
14. Update the 2004 Plan for Greenways and Cycling Systems	City of New Haven	2-5 years	Updated plan	$$$	
15. Develop a public access area inventory for the Mill River and its tributaries. Identify and acquire new access points.	Mill River Watershed Coordinator, CFE/Save the Sound (inventory)	2-5 years	Map and listing of the areas summarizing location, size, current and potential uses, and ownership	$$$	

Table 3-9. Land Use, Flood Resilience, Open Space, and Public Access Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
	Municipalities, land trusts (acquisition)				
16. Introduce educational signage, interpretive stations, maps and online resources for new or modified public access points	Municipalities, Mill River Trail Advocates, land trusts	Ongoing	Public access locations with signage	$$$	
17. Promote public access to the Regional Water Authority public water supply land	RWA	Ongoing	Increase in public access permits issued by RWA	$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

CFE/SAVE THE SOUND = Connecticut Fund for the Environment/Save the Sound FEMA = Federal Emergency Management Agency HUD = U.S. Department of Housing and Urban Development NOAA = National Oceanic and Atmospheric Administration CIRCA = Connecticut Institute for Resilience and Climate Adaptation CTDOA = Connecticut Department of Agriculture USDA = U.S. Department of Agriculture NRCS = Natural Resources Conservation Service

3.4.6 Subsurface Sewage Disposal Systems

Approximately one-half of the watershed area, and approximately 11 percent of the watershed population, is served by on-site subsurface sewage disposal systems, also referred to as septic systems. Most of these systems are located in the upper portion of the Mill River watershed, in Cheshire and the northern portion of Hamden. Failing or older, sub-standard septic systems can impact surface water and groundwater quality and can be a source of bacteria to the Mill River. The Quinnipiack Valley Health District (QVHD), which serves the watershed communities of Bethany and Hamden, and the Chesprocott Health District, which serves Cheshire and Prospect, regulate the installation of subsurface sewage disposal systems and are responsible for site inspections, plan review, the issuing of permits and inspections of all new, repair and replacement systems.

Recommendations regarding subsurface sewage disposal systems are summarized in *Table 3-10*.

Recommended Actions

- Strengthen state and local regulations to require regular septic system inspection and maintenance and upgrades to sub-standard systems, such as requiring systems to pass an inspection or be upgraded upon the sale of a property.

- Continue to encourage regular maintenance of septic systems by providing homeowners with educational materials on how to identify improperly functioning systems and procedures to have systems inspected, cleaned, and repaired or upgraded. Septic system educational materials offered by QVHD should be disseminated by these towns to homeowners in their respective communities, which could also be used to meet the public outreach/education minimum control measure of the MS4 Permit and the related municipal stormwater management plans. Chesprocott Health District and municipal health departments should develop and disseminate similar educational materials.

Septic System Educational Materials for Homeowners

In addition to regulating the installation, maintenance, and repair/replacement of septic systems in their district municipalities, the Quinnipiack Valley Health District uses their website to provide homeowners with educational materials on septic system maintenance and repair http://www.qvhd.org/.

3.4.7 Illicit Connections and Discharges

Illicit discharges are non-stormwater flows that discharge into the stormwater drainage system or directly into surface waters. Wastewater connections to the storm drain system, sanitary sewer overflows, and illegal dumping are among the types of illicit discharges that may exist in sewered residential and commercial areas within the watershed. Identifying and eliminating these discharges is an important means of pollution source control for the watershed. Dry weather sources of bacteria such as illicit connections are the most likely to be identified and effectively managed (and to include human sources). Controlling dry weather sources of bacteria is typically more cost-effective than trying to address elevated bacteria in wet weather conditions.

All of the watershed municipalities are subject to the requirements of the CTDEEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 Permit). The MS4 Permit regulates the quality of discharges from municipal storm drainage systems. The permit requires municipalities to implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the municipal storm drainage system, as well as sanctions to ensure compliance. This includes developing and implementing an Illicit Discharge Detection and Elimination (IDDE) program to systematically find and eliminate sources of non-stormwater discharges to its municipal separate storm sewer system and implement procedures to prevent such discharges. CTDOT is also subject to similar IDDE requirements under its own MS4 Permit, effective July 1, 2019.

Recommendations relative to eliminating illicit connections and discharges to the Mill River and its tributaries are summarized in *Table 3-11*.

Recommended Actions

- The watershed municipalities should implement IDDE programs as required by the MS4 Permit, including an ordinance or other regulatory mechanism to effectively prohibit non-stormwater discharges into the regulated municipal separate storm sewer system and an IDDE program to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.
    - Educate municipal staff and the public about illicit discharges and the importance of eliminating or avoiding such discharges.
    - Implement priority stream cleanups identified by streamwalks and track down surveys.
    - Conduct follow-up illicit discharge investigations at priority outfalls identified during stormwater outfall monitoring, streamwalks, and track down surveys.

Table 3-10. Subsurface Sewage Disposal Systems Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Strengthen municipal regulations regarding septic system inspection, maintenance, and repair/upgrade**	Municipalities	0-2 years	Amended regulations	$$$	NFWF Long Island Sound Futures Fund, CTDEEP Supplemental Environmental Project Funds, CTDEEP 319 NPS Grants
2. **Provide homeowner outreach on septic systems**	Municipalities, QVHD, CHD	2-5 years	Outreach materials provided or made available to homeowners	$	Same as above

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

Table 3-11. Illicit Connections and Discharges Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Implement IDDE program consistent with new MS4 Permit** • IDDE legal authority • Outfall mapping • IDDE Plan • Outfall screening and sampling • Catchment investigations and discharge removal projects • Education and outreach to municipal staff and the public	Watershed Municipalities, SCRCOG/NVCOG, consultants	2016-2022 (MS4 permit term)	Ordinance/legal mechanism, outfall map IDDE Plan, outfall screening and sampling results	$$$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies can be realized through participation in a regional stormwater coalition

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

SCRCOG = South Central Regional Council of Governments NVCOG = Naugatuck Valley Council of Governments

3.4.8 Commercial and Industrial Land Use

Commercial and industrial land uses have the potential for higher potential pollutant loads due to the pollutant sources associated with commercial and industrial activities and the significant runoff generated from these highly impervious sites. Most of the commercial development in the watershed is located along the major transportation corridor, Route 10, and at the southern end of the watershed in New Haven. Industrial land use is primarily concentrated in New Haven along the lower Mill River.

Recommendations related to reducing the impacts from commercial and industrial land uses are summarized in *Table 3-12.*

Recommended Actions

- Conduct outreach to commercial, institutional, and industrial property owners in the watershed explaining how their activities contribute to the water quality impairments of the Mill River.
    - Encourage large, institutional landowners, such as Quinnipiac University, to incorporate GI and LID into all campus renovations and planning initiatives
    - Work with local schools to incorporate GI and LID into all planned renovation and improvement projects.

- Consider establishing or strengthening municipal ordinances requiring covered trash enclosures and frequent cleaning to reduce the bacteria load associated with dumpsters, consistent with the good housekeeping requirements in the CTDEEP industrial and commercial stormwater permit programs, which apply to certain categories of industrial facilities and to larger commercial sites such as

Table 3-12. Commercial, Institutional, and Industrial Land Use Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Conduct outreach to commercial and industrial property owners**	Municipalities (as part of MS4 Permit outreach)	2016-2022 (MS4 permit term)	Outreach completed as documented in MS4 annual Reports	$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. **Establish or strengthen municipal ordinances requiring covered trash enclosures and frequent cleaning**	Municipalities (as part of MS4 Permit IDDE Ordinance)	2016-2022 (MS4 permit term)	New or modified ordinance or other enforceable regulatory mechanism	$$	
3. **Strengthen CTDEEP inspection and enforcement of commercial and industrial facilities covered under the CTDEEP stormwater general permit programs**	CTDEEP	2-5 years	Facility compliance reviews/ inspections and followup actions to address deficiencies	$$$	CTDEEP
4. **Review commercial and industrial facilities to identify sites that need coverage under the CTDEEP stormwater permit programs**	CFE/SAVE THE SOUND, CTDEEP	2-5 years	Non-compliant sites identified and notified	$$	
5. **Ensure reissued NPDES industrial water discharge permits contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection**	CFE/SAVE THE SOUND	Ongoing as draft permits are reissued	Comments submitted on CTDEEP draft permits	$	
6. **Promote green infrastructure for redevelopment of commercial, institutional, and industrial sites, including contaminated sites, institutions, and schools**	City of New Haven and other watershed municipalities	Ongoing	GI requirements for large-scale commercial and industrial development parcels	$$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

GNHWPCA = Greater New Haven Water Pollution Control Authority CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment
CTDEEP = Connecticut Department of Energy and Environmental Protection

Commercial and Industrial Land Uses in the Mill River Watershed

The commercial areas along Route 10 (below, left) contain multiple parking areas which constitute a large amount of impervious cover in the Middle Mill River subwatershed. Runoff from these areas drains to the Mill River with little or no riparian buffer to slow stormwater or filter pollutants.

Likewise, the commercial and industrial sites in the Lower Mill River subwatershed in New Haven (such as the salt storage facility shown below, right) have large amounts of impervious cover and discharge stormwater directly to the Mill River, with little or no natural vegetation along the river. Stormwater discharges from many of these industrial sites are regulated under the CTDEEP General Permit for the Discharge of Stormwater Associated with Industrial Activities, which require good housekeeping and source control best management practices.

These primarily privately-owned commercial and industrial sites throughout the watershed should also be the focus of green infrastructure (GI) retrofits or large-scale GI implementation during future redevelopment. Stream buffer restoration should also be promoted wherever possible

shopping centers. Leaking dumpsters can be a major source of fecal indicator bacteria during wet weather. Include dumpster and trash management issues in commercial and industrial outreach.

- Strengthen CTDEEP inspection and enforcement of commercial and industrial facilities in the watershed that are regulated under the CTDEEP industrial and commercial stormwater permit programs, particularly those facilities that are located adjacent to the Mill River or its tributaries.

- Review the commercial and industrial facilities in the watershed to identify sites that are subject to the CTDEEP industrial and commercial stormwater permit programs, but that are not currently registered.

- Ensure that reissued NPDES industrial water discharge permits in the watershed contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection.

- Ensure that facilities with potential stormwater pollutant sources practice proper management and containment for water quality protection. E.g., ensure that the salt pile adjacent to the Lower Mill River at Chapel Street is properly covered.

- Cleanup and promote sustainable re-use of contaminated sites including the use of green infrastructure.

3.4.9 Wildlife and Pet Waste

Wildlife and domesticated animals within the Mill River watershed are a source of fecal indicator bacteria that can significantly impact stream water quality and be extremely difficult to control. Fecal material can be deposited directly into waterbodies, as well as from stormwater and dry-weather washing of feces deposited on the ground into storm sewers and receiving waters (ASCE, 2014). Domesticated animals (dogs and cats) and wildlife such as birds, raccoons, and rodents can be significant contributors, particularly in urban areas where open space corridors have been preserved along waterways, such as East Rock Park and Criscuolo Park in the lower Mill River, and Sleeping Giant State Park in the middle Mill River, as well as other parks, golf courses (e.g., New Haven Country Club), commercial areas, and cemeteries near waterbodies in the watershed.

Existing bans on feeding of waterfowl and pet waste (i.e., "pooper scooper") ordinances are difficult to enforce. Furthermore, there are no easy solutions to nuisance waterfowl problems. Canada geese are persistent when they have become habituated to an area (CTDEEP, 2011). A more effective nuisance waterfowl control strategy is needed, focusing on education and outreach and other proven control methods.

Recommendations related to wildlife and pet waste are summarized in *Table 3-13*.

Recommended Actions

- Continue waterfowl deterrent efforts – habitat modification and barriers/exclusion methods – to reduce feeding of waterfowl by the public, waterfowl nesting, and terrestrial waterfowl habitat in the watershed. Creation of a vegetated buffer along ponds or streams as a form of habitat modification (to disrupt travel and sight lines) is the preferred deterrent method since it also provides water quality benefits.

- Existing regulatory controls prohibiting the feeding of waterfowl should be augmented through additional and/or more effective signage in public parks including the potential for fines. Signage should emphasize that feeding of waterfowl such as ducks, geese, and swans is harmful to their health. People feed geese and other waterfowl because they love them; emphasizing protection of waterfowl health is often the most effective strategy.

- Provide pet waste bag dispensers and disposal cans at high-use areas and conveniently spaced intervals on trails and in open space areas. Provide park and trail signs regarding pet waste disposal requirements and leash laws at the disposal cans. Consider allowing advertising on signs placed at pet waste bag dispensers and disposal cans to partially offset the cost (e.g., Poo Free Parks®). Allow natural vegetated buffers to grow alongside streams to deter pet access. Provide educational materials regarding the impact of improperly disposed pet waste. These materials should be made available in locations such as pet stores, animal shelters, veterinary offices, and other sites frequented by pet owners.

Table 3-13. Wildlife and Pet Waste Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Continue waterfowl deterrent efforts** • Physical barriers • Regulatory controls • Signage • Educational programs	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Waterfowl programs implemented	$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. **Implement and enforce pet waste programs** • Provide bag dispensers and disposal cans • Provide park and trail signage • Allow natural buffers to grow • Provide educational materials • Provide and maintain off-leash dog parks	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Pet waste programs implemented	$$	
3. **Implement stormwater Best Management Practices (BMPs) at animal shelters or kennel facilities.**	Municipalities (as part of MS4 Permit compliance)	2016-2022 (MS4 permit term)	Review of facility operations and BMPs implemented	$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

- Provide and properly maintain off-leash dog parks, preferably at locations that do not directly drain to receiving waters. Improperly managed dog parks can become a source of bacteria.

- Work with the watershed municipalities to ensure that their IDDE ordinances (required under the MS4 permit) include a clause regarding proper waste management and stormwater runoff control from pet shelters, kennels, and other animal-focused facilities. Animal waste, animal washing, or other animal handling activities can introduce bacteria, excess nutrients, soaps, chemicals, or sediment into waterbodies.

3.4.10 Natural Stream Buffers

Stream buffers are naturally vegetated areas adjacent to streams, ponds, and wetlands. Stream buffers help encourage infiltration of rainfall and runoff, and provide absorption for high stream flows, which helps reduce flooding and drought. The buffer area provides a living "cushion" between upland land use and water, protecting water quality, the hydrologic regime of the waterway and stream structure. Naturally vegetated buffers filter out pollutants, capture sediment, regulate stream water temperature and process many contaminants through vegetative uptake. The vegetative community of stream buffers provides habitat for plants and animals, many of which are dependent on riparian habitat features for survival. Changes to the natural riparian buffer zone can reduce the effectiveness of the buffer and contribute to water quality impairment.

An objective of this plan is to protect and restore degraded stream buffers in the watershed to enhance water quality. Recommendations related to stream buffers for water quality purposes are summarized in *Table 3-14*. Related recommendations for protection and restoration of riparian habitat, including in-stream habitat, are addressed in *Section 3* of this plan.

Geese Deterrent Methods (CTDEEP, Wildlife Division, 2009)

Habitat Modification: As long as favorable habitat is available, geese will be attracted to an area. Plant unpalatable vegetation, such as pachysandra to replace some of the mowed lawn. Allow grass to grow tall which makes it unpalatable to the geese. Plant hedges, shrubs, or visual barriers between feeding areas and water. Be sure the geese are not being fed artificially by people.

Barriers and Exclusion Methods: Low fences are very effective at keeping geese from lawns especially during June and July when geese have molted their flight feathers and are unable to fly. A 3-foot high chicken wire or weld wire fence should be used. Soft or hard nylon fences are also potential barriers.

Credit: Joseph Gerhard – Mill River, *Manton Westwood Books, New Haven, CT, 2011*

Recommended Actions

- Encourage the creation of backyard buffers in residential areas near stream corridors, including the importance of maintaining healthy vegetated buffers to streams, ponds, and wetlands, and recognize the efforts of the public.
    - Educate homeowners about the value and importance of stream buffers by building on existing stream buffer outreach and educational programming (e.g., public recognition programs for cooperating landowners, *Streamside Landowners' Guide to the Quinnipiac Greenway,* Audubon's backyard program, and programs from the EPA- Long Island Sound Study and Connecticut Sea Grant).

- Prioritize and implement any buffer restoration projects identified during streamwalks.
    - Focus efforts on publicly-owned, high-profile sites such as existing parks or golf courses along the Mill River, as well as smaller tributaries, ponds, and lakes. Future streamwalks and track down surveys will help to identify additional stream buffer restoration candidates.
    - Potential buffer restoration approaches for the watershed include installation of new buffers, widening existing buffers, invasive species removal/management, and tree planting/reforestation.
    - Engage volunteers in riparian buffer implementation projects.
    - Further evaluate the feasibility of buffer restoration at specific sites based on consideration of site-specific factors including site access, available land area, land ownership, soil conditions, appropriate buffer width, and native plant species.

Degraded Stream Buffers

Examples of degraded stream buffers along the Lower Mill River in New Haven: Criscuolo Park (top) and vicinity of Humphrey Street and Mill River Street (bottom).

- Provide stream buffer protection through aggressive implementation and enforcement of 100-foot setback zones in local Inland Wetlands and Watercourses regulations. Consider modifying existing land use regulations to incorporate incentives for developers to restore or establish vegetative buffers as part of new development or redevelopment.

- Ensure there are sufficient stream buffers along the limited agricultural lands (including nursery operations) in the middle and upper Mill River watershed (primarily in Hamden, Cheshire, and Wallingford). Focusing agricultural BMPs to improve buffer areas around streams will reduce the volume and improve the quality of stormwater runoff from the farm before it enters the stream. Other related conservation practices that should be considered for these farms include vegetated filter strips, stream habitat improvement and protection, and streambank protection projects. The USDA Natural Resources Conservation Service (NRCS) National Water Quality Initiative offers financial and technical assistance to farmers and forest landowners interested in improving water quality and aquatic habitats in priority watersheds with impaired streams.

Table 3-14. Stream Buffer Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
1. **Encourage backyard stream buffers** • Provide homeowner education by building on existing materials and programs	Municipalities (as part of MS4 Permit compliance), CFE/SAVE THE SOUND	Ongoing	Educational materials disseminated	$$	Municipal funds (permit requirements not eligible for state/federal funding) Cost efficiencies through participation in a regional stormwater coalition
2. **Implement priority buffer restoration projects**	Municipalities, CFE/SAVE THE SOUND	Ongoing	Priority projects identified, funding secured, projects completed	$$$	
3. **Aggressively implement and enforce 100-foot setback zones in local Inland Wetlands and Watercourses regulations**	Municipalities	Ongoing	Modified or updated land use regulations	$$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment

3.5 Habitat Protection and Restoration

Goal Statement: Protect and restore terrestrial, streamside, and aquatic habitat.

Table 3-15 summarizes habitat protection and restoration recommendations for the Mill River watershed.

3.5.1 Protect and Restore In-Stream Habitat

Numerous man-made impoundments, most notably the Lake Whitney Dam, have altered in-stream and riparian habitat and restricted fish migration throughout the watershed. Of the approximately 22 dams in the watershed, most are located in the northern part of the watershed, in Hamden, with a few each in the towns of Cheshire and Wallingford. Five of the dams are located on the main stem of the Mill River. No known dams are located on Willow brook, however fish passage to Willow Brook is restricted by downstream obstacles on the Mill River.

Other issues that affect in-stream habitat in the Mill River watershed include elevated stream temperatures due to a lack of stream shading and inputs of stormwater runoff and numerous culverts on smaller streams that impede resident fish migration.

Recommended Actions

- Conduct a stream crossing (culvert and bridge) survey of the Mill River watershed for anadromous and resident fish species to identify and prioritize barriers to fish passage and opportunities for restoring fish passage. The survey should focus on areas of the watershed that have not yet been assessed, and should follow standardized protocols developed by the North Atlantic Aquatic Connectivity Collaborative https://www.streamcontinuity.org/.

- Revise local storm drainage design standards such that new or modified stream crossings are designed following the *Connecticut Stream Crossing Guidelines* (CTDEEP, 2008).

- Implement priority stream restoration projects identified during streamwalks and track down surveys. Address areas of stream erosion and sedimentation using appropriate bioengineering and habitat-sensitive measures.

3.5.2 Protect and Restore Forested Areas and Tree Canopy

Forest cover, including natural forest soils with irregular topography, provides numerous benefits at both the site and watershed scales. In addition to providing habitat for terrestrial and aquatic wildlife, watershed forest cover also reduces stormwater runoff and flooding, improves regional air quality, reduces stream and channel erosion, improves soil and water quality, and reduces summer air and water temperatures (USDA Forest Service, 2005).

Forested areas comprise approximately 44% of the Mill River watershed. The Willow Brook subwatershed, at the north end of the watershed, is the most heavily forested portion of the watershed, with much lower levels of tree canopy in the lower watershed. The following recommendations (summarized in *Table 3-15*)

will help protect existing forested areas and enhance the tree canopy in the more urban areas of the watershed.

Recommended Actions

- In 2018, the City of New Haven released the *New Haven Climate and Sustainability Framework*, which highlights the unequal distribution of tree canopy across the city, with some neighborhoods having up to 60% tree canopy, while others have as little as 6%. As outlined in the framework plan, the City should create a tree ordinance to establish standards for tree removal and replanting and set goals for increased tree cover.

- In addition to establishing a tree ordinance, amend existing site development regulations and zoning codes to encourage tree retention and maintenance, restrict tree removal and limit clearing during development projects, and require landscaping and parking lot shading.

- Efforts to enhance the tree canopy throughout the watershed should focus on parcels with no or little existing tree canopy, large amounts of impervious surfaces (such as former commercial and industrial sites), and proximity to the Mill River and its tributaries. In setting new tree planting goals, the City should continue to build upon the previous tree planting goal "Tree Haven 10K."

- Sleeping Giant State Park suffered significant tree damage from tornadoes in May, 2018. Unstable trees and debris should be removed and new tree cover established in the damaged areas to facilitate natural forest regeneration.

- Implement sustainable management practices in woodlands along utility corridors. Utility companies statewide, including The United Illuminating Company (UI), continue to implement tree and forest management programs to reduce the risk of tree-related storm damage to power lines. UI should implement Best Management Practices and strategies for storm-related utility line tree cutting. The "Stormwise" vegetation management initiative and research program led by UConn and the CT Agricultural Experiment Station, partnered with various stakeholders including UI and other utility companies, is identifying management strategies to reduce the risk of tree-related power and transportation disruptions during storms while sustaining trees and forested areas and protecting wetlands and water quality.

- Demonstrate the importance of trees and vegetation as a critical component of green infrastructure and the related water quality benefits through local tree canopy demonstration projects.

- Protect existing forested land through land acquisition and conservation easements.

3.5.3 Manage Invasive Plant Species

Native vegetation plays an important role in ecosystem biodiversity. Invasive plant species, which are mostly non-native plant species that successfully out-compete native plants, are prevalent throughout the watershed. The most common invasive plant species observed in the watershed include multiflora rose, Japanese knotweed, Norway maple, purple loosestrife, common reed, and Oriental or ornamental bittersweet. Invasive species removal efforts are ongoing at East Rock Park, Sleeping Giant State Park, and other parks and open space parcels throughout the watershed.

Recommended Actions

- Focus invasive species management efforts on site-specific and targeted stream corridor improvements identified during streamwalks and track down surveys. Focus on properties that are actively maintained with opportunity and interest for control since it is impractical to successfully control or eradicate invasive plant species on unmaintained sites.

- Educate residents, facility maintenance personnel, landscapers and local nurseries, and land use commissions about the negative effects of non-native invasive species, pathways of introduction, and alternatives to invasive ornamental plants.

- Involve volunteers and neighborhood groups in invasive species removal and stream corridor improvements.

Credit: RWA

Table 3-15. Habitat Protection and Restoration Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
In-Stream Habitat					
1. Conduct stream crossing surveys	CFE/SAVE THE SOUND, TNC	2-5 years	Completed surveys with prioritized recommendations	$$$	Grant funding – NFWF
2. Revise local design standards for stream crossings	Municipalities	2-5 years	Revised standards	$$	
3. Implement priority stream restoration projects	CFE/SAVE THE SOUND, municipalities	5-10 years	Completed projects	$$$$	Grant funding – NFWF
Forested Areas and Tree Canopy					
4. Implement the tree canopy recommendations from the *New Haven Climate and Sustainability Framework*, including establishing a tree ordinance and standards for tree removal and replanting	New Haven, URI	5-10+ years	Tree ordinance, numeric or qualitative tree canopy goal and implementation criteria	$$$	
5. Amend site development regulations and zoning	Municipalities, consultants	5-10 years	Amendments to local land use regulations and policies	$$$	
6. Restore tree cover to tornado-damaged areas of Sleeping Giant State Park	Hamden, URI, SGPA	0-10+ years	Restored canopy	$$$	
7. Implement sustainable management practices in woodlands along utility corridors	United Illuminating, Municipalities, UConn	Ongoing	Use of BMPs for tree cutting along utility lines	$$$$	
8. Protect forested land through land acquisition and conservation easements	Municipalities	Ongoing	Area of forest land acquired or preserved	$$$$	
Invasive Plant Species					
9. Implement priority invasive species management projects identified during	CFE/Save the Sound, Municipalities, URI,	Ongoing	Completed projects	$$$	

Table 3-15. Habitat Protection and Restoration Recommendations

Actions	Who	Timeframe	Products/ Evaluation Criteria	Estimated Costs	Potential Funding Sources
streamwalks and track down surveys	SGPA, Mill River Trail Advocates, land trusts				
10. Educate residents, facility maintenance personnel, landscapers and local nurseries, and land use commissions about non-native invasive species	Mill River Watershed Coordinator, CFE/Save the Sound, land trusts	5-10 years	Education events and materials, number of participants and audiences reached	$$	
11. Involve volunteers and neighborhood groups in invasive species removal	CFE/Save the Sound, Schools, land trusts, Mill River Trail Advocates, SGPA	Ongoing	Invasive species removal, number of sites or areas restored	$$$	

$ = $0 to $5,000 $$ = $5,000 to $10,000 $$$ = $10,000 to $50,000 $$$$ = Greater than $50,000

CFE/SAVE THE SOUND = Save the Sound/Connecticut Fund for the Environment TNC = The Nature Conservancy URI = Yale School of Forestry and Environmental Studies Urban Resources Initiative SGPA = Sleeping Giant Park Association

4 Site-Specific Green Infrastructure Concepts

The site-specific green infrastructure retrofit concepts presented in this section are intended to serve as potential on-the-ground projects for future implementation. They also provide examples of the types of projects that could be implemented at similar sites throughout the watershed. It is important to note that the concepts presented in this section are examples of potential opportunities, yet do not reflect site-specific project designs. Individual project proponents (e.g., municipalities, private property owners, developers) are responsible for evaluating the ultimate feasibility of, as well as design and permitting for, these and similar site-specific concepts.

Preliminary, planning-level costs were estimated for the site-specific concepts presented in this section. These estimates are based upon unit costs derived from published sources, engineering experience, and the proposed concepts. Capital (construction, design, permitting, and contingency) and operation and maintenance costs are included in the estimates. *Appendix C* includes additional pricing information, including total annualized costs based on the anticipated design life of each green infrastructure practice, and a range of likely costs, reflecting the inherent uncertainty in these planning-level cost estimates.

In some cases, costs are presented for multiple alternative project approaches, for example, both a subsurface infiltration option and a pervious pavement option[6]. Subsurface infiltration chambers are a far more expensive option, but have the benefit of increased potential infiltration capacity in certain soils and the ability to accept stormwater that is already in an underground drainage system, whereas pervious pavement is limited to infiltrating surface flows. Pervious pavement also poses increased maintenance concerns over subsurface infiltration options, as the pavement can be damaged by snow removal operations and must be kept clean of silt and other fine materials that would clog the pavement and reduce its ability to infiltrate.

Where bioretention/rain gardens are recommended, pricing assumes the 'bioretention' rate (see *Appendix C*), which utilizes contracted labor for design and implementation. Simple rain gardens can also be constructed using volunteer labor for hand-digging and planting at reduced costs that would be more in line with the 'rain garden' pricing rate (see *Appendix C*).

Preliminary sizing calculations are also provided for each practice and are based on the goal of capturing and treating/infiltrating the water quality volume (WQV), generally defined as the first one-inch of runoff from the contributing drainage area. Approximate drainage areas are provided for each practice within the designs, along with the expected WQV to be generated from that drainage area.

Table 4-1 contains information on site characteristics and potential green infrastructure opportunities for the other sites visited during the field inventories that were deemed to have good potential for green infrastructure retrofits.

[6] Note that pervious pavement costs presented in the plan and in *Appendix C* are based upon a porous asphalt design. More decorative alternatives, such as pervious pavers, will have increased costs (see *Appendix C*).

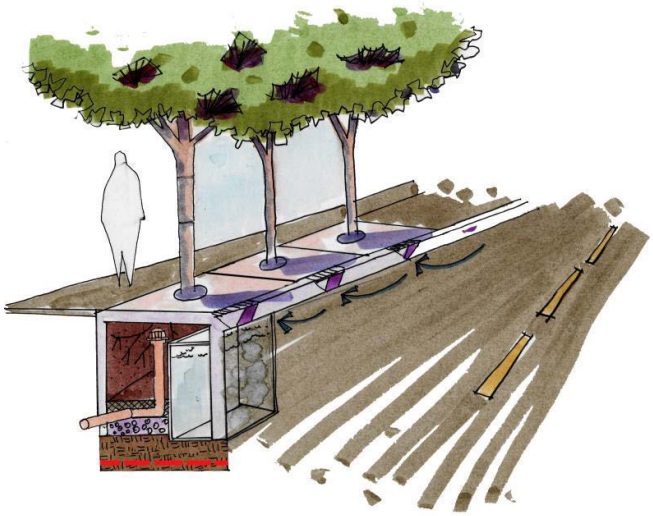
4.1 Elm City College Preparatory Elementary School

Located at 407 James Street, New Haven, Elm City Preparatory Elementary occupies an approximately 1.5-acre site at the corner of James Street and Lombard Street, in a CSO area (CSO #009). With the exception of a 0.25-acre artificial turf field, the site is entirely impervious. Existing catch basins capture parking lot runoff along the western edge of the lot. Downspouts from the building appear to be internal and to tie in to the drainage system at the downgradient catch basin before connecting to the City's stormwater infrastructure running along James Street. A broken curb at the west edge of the parking lot is currently allowing runoff to bypass the catch basins and travel down a short embankment to the sidewalk.

The sidewalk in front of the school along James Street is approximately 11 feet wide in most places. Planters with trees are incorporated into the sidewalk at 50 foot intervals; however, there is a tree missing directly in front of the school parking area.

Space is the most significant constraint at this site, as parking is tight and there is little pervious area. Existing street trees, a fire hydrant/water lines, and other utilities pose additional constraints. A variety of BMPs are recommended for this site in order to best achieve the following goals: maximize enhancement of curricular value in a limited space, maximize infiltration/treatment potential, and keep implementation costs manageable. These elements could be implemented all at once, or installed gradually as funding permits (total project costs will vary widely depending on which components are chosen).

- **Tree Box Filter and Bioretention/Infiltration.** A tree box filter and replacement tree are proposed for the location where a tree is currently missing. A tree box filter design with additional subsurface infiltration capacity is recommended. A curb cut from James Street would channel runoff from the street into the filter and infiltration system. It is also proposed to convert five feet of sidewalk directly adjacent to the street to bioretention areas or rain gardens with native grasses and other plantings. Additional curb cuts would direct water into these bioretention areas, which would also serve to enhance the landscape around the school. These bioretention areas could be integrated into the curriculum as demonstration sites to supplement lessons on science and the environment, and, of the BMPs proposed, would likely offer the greatest opportunity for interactive lessons (planting, maintenance, etc.). For ease of implementation and consistency with the proposed James Street design concept, the City could choose to implement their standard 5 foot by 15 foot bioswale design along the sidewalk at this location. *Estimated Cost for Tree Box Filter: $9,000; Estimated Cost per Bioswale: $20,000*



Schematic of a typical tree box filter with underground storage capacity.

- **Parking Lot Retrofits.** Subsurface infiltration and/or pervious pavement is proposed for the parking area to manage stormwater falling on the parking area as well as roof runoff captured by the school's gutters and downspouts.

    - Based on available field data, using subsurface infiltration in the area adjacent to the turf play area would make it possible to intercept existing lines carrying downspout runoff and turf drainage without significantly reconfiguring these drainage systems (approximately 40,000 square feet of drainage area, and a Water Quality Volume (WQV), equal to the volume of water associated with the first 1 inch of runoff, of 3,200 cubic feet). A 1,100 square feet practice underneath the six parking spaces adjacent to the turf field would potentially allow for treatment of up to 4,150 cubic feet WQV. The existing downgradient catch basin located in the school's driveway would serve as overflow to allow any excess water to be conveyed to the storm sewer in James Street, as is currently occurring. Note that site-specific soil drainage characteristics may allow for effective use of pervious pavement without additional subsurface infrastructure, for a significantly reduced project cost (although this would make it more difficult and costly to accept stormwater from roof and turf drains and would therefore likely result in treatment of a significantly lower percentage of total site runoff). *Estimated Cost: $108,000 (Subsurface infiltration); Estimated Cost: $5,000 (Pervious Pavement)*

    - To minimize costs, and to increase the variety of BMPs demonstrated on site, pervious pavement is proposed as the preferred option for the parking spaces parallel to James Street. Converting these spaces to pervious pavement would remove 2,500 square feet of pervious surface from the lot, and depending on the infiltration capacity of the soils and precise slope of the site, may be sufficient area to effectively infiltrate the roughly 800 cubic feet WQV of stormwater runoff expected from the entire 10,000 square feet main parking area, as the remainder of the surface slopes slightly to the west. *Estimated Cost: $10,000*

- **Management of Dumpster Area.** The school's dumpsters are located in the southeast corner of the parking lot, at the top of a slope which drains to James Street. Dumpsters should always be kept closed to minimize exposure to stormwater. For additional protection, a containment system consisting of spill containment grooves could be incorporated into the pavement to further prevent pollutants from being carried into the storm drainage system. *Estimated Cost: $0-$1,000*

Total Estimated Cost: Approximately $167,000; Variable, depending on components installed.

Elm City College Preparatory Elementary School

A mixture of bioretention plantings and tree box filters are proposed to replace part of the 11-foot wide sidewalks adjacent to the school parking lot (top). In the proposed conditions graphic, "CB" indicates existing catch basins. Blue arrows indicate existing surface flow patterns.

4.2 James Street

James Street was identified as a potential demonstration site for a "green streets" approach to stormwater retrofits in the road right-of-way. The site is proposed to begin at Elm City College Preparatory Elementary School (at Lombard Street), and continue south to Chapel Street. This portion of James Street represents a typical residential street in the Fair Haven neighborhood, an underserved area of New Haven. The street is also within the area served by CSO #009 and CSO #015. In addition to providing stormwater runoff reduction and pollution control benefits, the proposed retrofits for James Street would also provide green space in the neighborhood and yield aesthetic benefits for residents. Specific siting considerations along James Street include the feasibility of working around existing utilities while simultaneously selecting sites with sufficient catchment area to justify installation costs. Bioswales or bump-outs must also be sited appropriately relative to existing catch basin infrastructure (i.e., bioswales should ideally be located right before a catch basin) in order to maximize capture of stormwater and facilitate returning overflows to the existing drainage system.

- **Tree Box Filters.** Additional tree box filters of the type proposed for Elm City Preparatory School are proposed for various locations along James Street. Obvious sites are locations where street trees are missing; one such site exists on the east side of James Street, immediately south of the Elm City Preparatory School. *Estimated Cost: $9,000 per tree box filter*

- **Bump-Outs or Curbside Bioswales.** Two possible types of green infrastructure are proposed to provide bioretention along the length of James Street: bump-outs and curbside bioswales. Both are types of linear bioretention retrofit used alongside or within a public street, designed to collect and infiltrate/treat runoff from the adjacent roadway (see *Section 3.4.2* for examples of each). These practices consist of a stone storage layer, a soil layer designed to filter runoff, plantings, and curb cuts to allow runoff to enter and exit the system. Both bioswales and bump-outs are sized to capture and treat/infiltrate the water quality volume.
    - Bioswales utilize space in the right of way, converting impervious area between the sidewalk and the street into bioretention. The City of New Haven and GNHWPCA are already installing bioswales throughout the downtown area and West River watershed, using a modified version of a bioswale design developed by New York City, which has a 5-foot by 15-foot footprint. At 75 square feet, this design can capture and treat approximately 276 cubic feet WQV. This is sufficient to capture the drainage from one side of an approximately 200 foot stretch of road. As with bump-outs, bioswales would be designed to accept stormwater from the street, using curb-cuts as an inlet, with existing downgradient catch basins serving to receive excess water from the BMPs' overflows.
    - Bump-outs would replace a portion of the existing road shoulder with bioretention areas, utilizing "No Standing" zones near intersections to intercept stormwater runoff from the road. Bump-outs serve a dual purpose as traffic calming features, which can make residential streets more friendly to pedestrians and bicycles.

Bump-outs and bioswales could be used in combination along the length of James Street, or a single practice type could be repeated for a more uniform design. Pervious pavement may again be a less expensive alternative option, but would offer far fewer aesthetic benefits to the neighborhood. Several specific locations along James Street were identified as potential sites for BMP implementation in the public road right of way. In some instances, multiple potential addresses were noted in close proximity to one another (i.e., where drainage areas would overlap based on the 200 foot drainage area assumption). In these cases, the options should be evaluated during detailed site design to select the option with the least constraints or conflicts. Based on a preliminary assessment, locations shown represent locations suitable for bioswales in the public right of way.

Two additional opportunities were identified along James Street for more extensive BMP installations:

- At the southeast corner of James Street and Market Street, there is a large green parcel adjacent to the Market and James Street Farms, which is operated under the umbrella of New Haven Farms. The standardized BMPs described above could be implemented in the road right of way at this location; this site could also be proposed for a more extensive rain garden demonstration and education site.

- Rain gardens could be implemented at the condominium complex at the northeast corner of James Street and Grand Avenue, particularly at the southwest and northwest corners of the complex, although existing trees may impose siting constraints. The catch basins in the approximately 8,500 square feet parking lot could also be converted to infiltrating catch basins, with overflows being returned to the storm drain system via the existing infrastructure.

Estimated Cost: $20,000 per Bioswale or Bump-out (lower unit pricing may be available when multiple practices are installed together; see notes in Appendix C)

Total Estimated Cost Assuming 1 Tree Box Filter and 13 Bump-Out/Bioswale Practices: $263,000

Existing Conditions Along James Street

Typical existing conditions include degraded sidewalks and non-vegetated filter strips, some of which are proposed for conversion to bioretention practices. The images below highlight possible locations for bioretention practices in the right of way along James Street.

Proposed Green Infrastructure Retrofits for James Street

Repeating bioswales and/or bump-outs, are proposed for the public right of way, community garden, and condo complex along the length of James Street at or near the marked locations. These practices will capture and treat stormwater, reduce runoff, and transform the aesthetics of the street. The inset image demonstrates a street-view rendering of the concept.

4.3 Mill River Trail Park, Haven and Exchange Street Green Infrastructure

The John S. Martinez School building is located on James Street, one block south of Wolcott Street, while the parking lot and athletic fields for the school are located one block north of the school, between Wolcott Street and Exchange Street. The Martinez School and the surrounding parcels are served by CSO #015, which discharges at the confluence of the Mill and Quinnipiac Rivers. Stormwater designs for the school and parking area median have previously been developed, and the design proposed at this location focuses on the north end of the property that has not yet received attention. The proposed project will convert four blocks of degraded roadway and vacant land into a linear trail park, create a parklet that incorporates Green Infrastructure adjacent to the playfields at John S. Martinez School, and expand the Mill River Trail Phase 1 currently under construction by the City of New Haven. Design features include:

- **Trash Clean-up:** The first step to any improvement at this site should be the engagement of community volunteers in removal of trash and debris located at the west edge of the site. This opportunity could also be used to grow interest in the site and discuss further improvement options with local residents and potential project partners.

- **Pavement Removal:** Removal of pavement from the portion of Exchange Street west of Haven Street and permanent conversion from automobile access to multi modal access. This would result in a nearly 9,000 square foot reduction of impervious surface, thereby reducing surface runoff and creating space for natural infiltration.

- **Integrated Stormwater Treatment:** The modification of the site will manage runoff from over 120,000 square feet of surrounding roadway and parking lots through 42,000 square feet of green

Mill River Trail Park Stormwater Features

infrastructure practices (22,000 square feet of bioretention and 20,000 square feet of pervious trail). This will divert over 3 million gallons of stormwater from the combined sewer system each year reducing a source of impairment for the Mill River. Additionally, the green infrastructure installations will provide urban habitat refuge for birds and other pollinators. The Trail will ultimately link Long Island Sound to East Rock Park, which has been designated as an Important Bird Area by Audubon Connecticut and is one of the most important springtime landbird stopover areas in Connecticut, thereby expanding flora and fauna habitat and creating opportunities for a diverse species to flourish.

- **Mill River Trail Phase 2**: This will connect Phase 1 of the Mill River Trail (currently under construction) with the recently upgraded Criscuolo Park, creating a passive recreation greenway accessing western Fair Haven's two parks and adding significant bioretention capacity along Haven Street and Mill Street.

Estimated Cost: $300,000

4.4 Wilbur Cross High School

Wilbur Cross High School is located in the East Rock neighborhood of New Haven, immediately west of the Mill River. Not including athletic facilities, the school and parking cover nearly 10 acres in the Lower Mill River subwatershed. The school lies immediately northwest of CSO #012, but the school building and parking areas addressed here are outside of the CSO area. The proposed concept focuses on the approximately 2-acre parking lot on the southeast side of the site, along with drainage from the main portion of the high school building. It is likely that the proposed design would also intercept surface flow from the adjacent tennis courts further to the east.

The existing parking lot features extra-long, numbered bus parking spaces along the northeast and east perimeters of the lot. The parking layout maximizes available locations for bus parking, but in doing so, the layout creates two large dead spaces where parking is prohibited (see text box), both of which are located in the northeast corner of the lot. Each of these locations coincides with the location of existing catch basins. A double catch basin in the corner of the lot is the most downgradient collection point and outfalls directly to the Mill River approximately 10 feet below the parking lot grade. Roof drainage from the east side of the building appears to be connected into the drainage system at the catch basin located in the middle of the eastern edge of the parking lot.

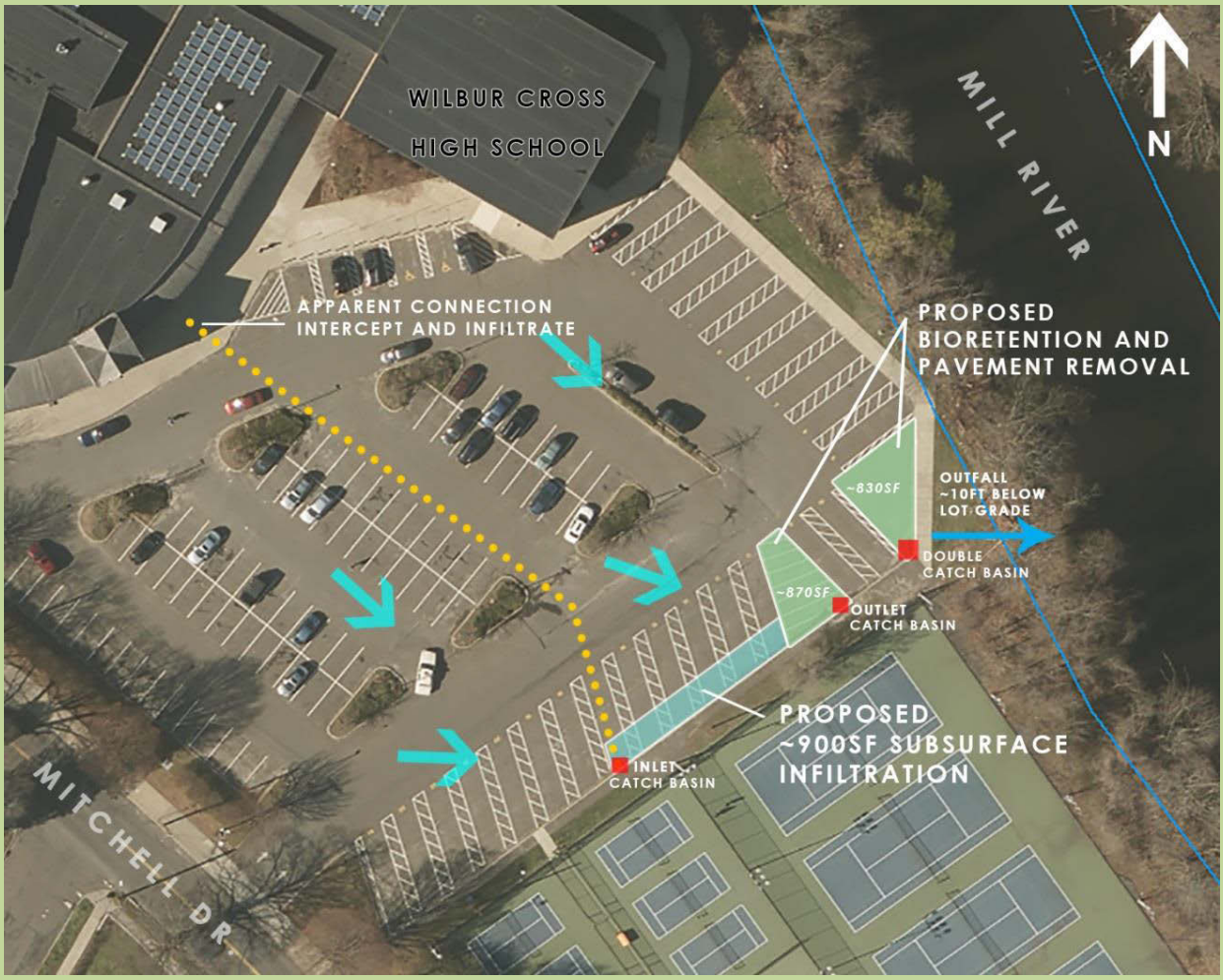
- **Parking Lot Bioretention**. Proposed retrofits include the removal of pavement from the two 'dead spaces' (approximately 830 square feet and 870 square feet) in the northeast corner of the lot and conversion to bioretention to accept surface flows across the parking lot. Of the 6,900 cubic feet WQV anticipated from the approximately 87,000 square feet parking lot, the two bioretention areas would treat up to up to 6,200 cubic feet (90%) of WQV.
  Estimated Cost: $79,000

- **Subsurface Infiltration.** An additional 900 square feet of subsurface infiltration along the eastern edge of the lot would utilize the existing mid-lot catch basin as an inlet to intercept roof drainage from the approximately 44,000 square feet of building footprint, infiltrating up to 3,400 cubic feet WQV out of the approximately 3,500 cubic feet WQV expected . The next catch basin downgradient would serve as an outlet to channel excess water back into the drainage system, and the existing double catch basin would serve as an overflow outlet to the Mill River for the entire retrofit system. *Estimated Cost: $89,000*

Total Estimated Cost: $168,000

Proposed Versus Existing Conditions: Wilbur Cross High School

Proposed green infrastructure retrofits for Wilbur Cross High School (top) utilize the "dead spaces" where parking is prohibited amidst bus parking spaces to create bioretention areas. Subsurface infiltration chambers are also proposed to capture redirected roof drainage. In the top graphic, red squares indicate existing catch basins and blue arrows indicate existing surface flow patterns.



4.5 Livingston Street at East Rock Road

East Rock Park begins just south of Lake Whitney and follows the Mill River for over 1.5 miles. On the east side of the river, the park provides a buffer for the river that is generally wooded and at least 0.2 miles wide. On the west side of the river, the park is much narrower and less heavily wooded; the proposed concept focuses on this side of the park, particularly the borders of the park that follow Livingston Street and East Rock Road.

An existing walking trail follows the park edge along Livingston Street. Scattered catch basins along Livingston Street intercept flow from the street and carry it north toward East Rock Road. At East Rock Road, storm drains from Livingston Street join with the storm drain under East Rock Road and carry runoff east to the Mill River. The outfall for this system is located north of the East Rock Road bridge.

While the park occupies the land east of Livingston Street, the west side of the street is residential. Many downspouts appear to be connected to the drainage system, though others were disconnected.

- **Vegetated Infiltration Swale.** A short wooden fence runs along the east side of Livingston Street beginning at the intersection with Cold Spring Street and following the road northward for approximately 850 feet. A vegetated swale is proposed to promote infiltration along this stretch of Livingston, using curb cuts spaced along the swale to accept approximately 1,200 cubic feet WQV of stormwater from approximately 15,000 square feet of drainage area consisting of the northbound lane of Livingston Street. *Estimated Cost: $61,000*

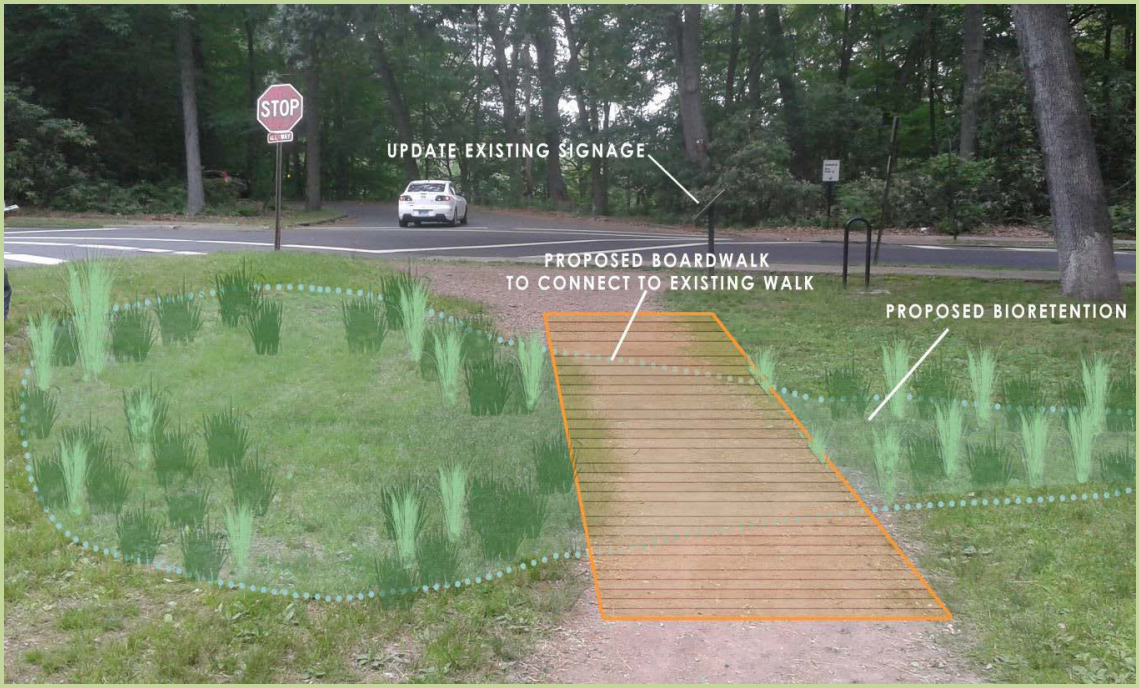
- **Bioretention Landscaping and Trail Enhancement.** A storm drain in the center of the intersection of Livingston Street and East Rock Road currently accepts stormwater flows from all four corners of the intersection, as well as flows from further west on East Rock Road. Two rain gardens/bioretention areas are proposed to accept stormwater from Livingston Street, East Rock Road, and East Rock Park Road via curbcuts located just upgradient of the existing catch basins.
    - One rain garden/bioretention area would be located on the northwest corner of the intersection (with approximate area of 250 square feet and capacity to capture and treat approximately 900 cubic feet WQV). The northwest rain garden/ bioretention area would serve a drainage area of approximately 10,000 square feet (800 cubic feet WQV), consisting of the north side of East Rock Road between Livingston Street and Everit Street, as well as a portion of the south side of East Rock Park Road. The BMP is proposed with an overflow structure that would carry excess stormwater back to one of the existing catch basins.
    - A second rain garden/ bioretention area on the southeast corner of the intersection (with approximate area of 300 square feet and capacity to capture and treat approximately 1,100 cubic feet WQV) would be located in existing open green space among trees to minimize root and tree impacts (see text box). Stormwater would enter the BMP from a curbcut located just south of the existing fire hydrant and upgradient of the existing catch basin on the east side of Livingston Road. The BMP would capture stormwater from the east side of Livingston Street from the mid-block catch basin to the curb cut, an area of approximately 14,000 square feet (1,100 cubic feet WQV). In order to preserve the existing trail, an ADA compliant boardwalk feature would allow pedestrians to connect from the corner sidewalk to the existing walking trail in the park, crossing over the rain garden/bioretention area. Additional interpretive signage would be added to the existing park sign already in place at the southeast corner of Livingston Street and East Rock Road to enable the stormwater features to serve as an

education and outreach site. The rain garden/bioretention area is proposed to contain an overflow structure that allows excess stormwater to sheetflow across vegetated land to the south and east.

- *Estimated Cost: $31,000 (consisting of $26,000 for bioretention areas and* $5,000 for trail enhancement)

Total Estimated Cost: $92,000

Livingston Street at East Rock Road: Existing Versus Proposed Conditions
Existing open space at the corner of Livingston and East Rock Road (top) is proposed for conversion to a raingarden/bioretention area with enhanced educational signage and an accessible boardwalk to connect the sidewalk with the existing pedestrian trail (bottom).



Green Infrastructure and Trail Enhancement: Livingston Street at East Rock Road

Proposed retrofits capture and treat stormwater drainage from portions of Livingston Street and East Rock Road, while simultaneously creating enhanced space for public outreach and education. In the graphic, red squares denote existing catch basins; blue arrows indicate existing surface flow patterns.

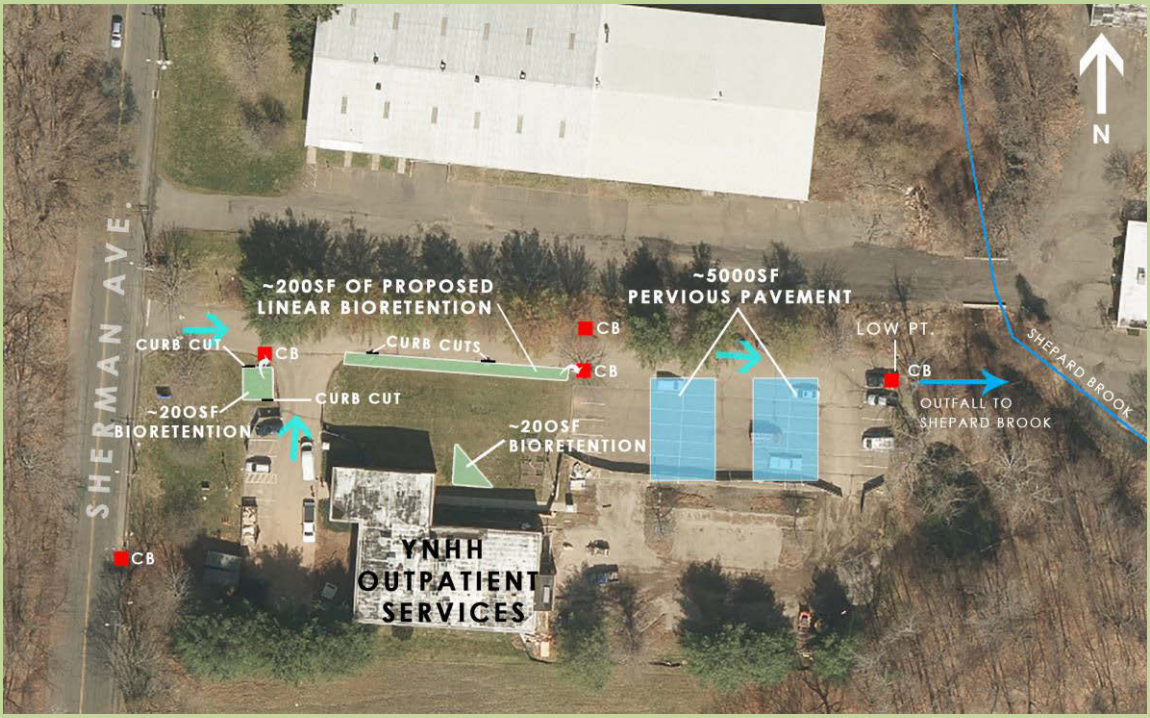
4.6 YNHH Outpatient Services

The Yale New Haven Health System (YNHH) Outpatient Services facility is located on Sherman Avenue in Hamden, CT, on an approximately 2-acre site. Shepard Brook runs along the northeast edge of the property, and drainage from the site enters the brook approximately 2 miles upstream of its confluence with the Mill River.

The site is largely covered by impervious surfaces, including approximately 28,000 square feet of parking lot space spread between two lots, an approximately 8,000 square feet building footprint, and an additional 7,500 square feet of paved driveway. Most of the remaining space within the parcel is occupied by maintained lawn. Trees border the north and south edges of the site, forming a buffer with adjacent parcels. A few large trees line the west edge of the parcel, along Sherman Avenue. A parking lot island in the rear lot features mature trees and shrubs as well and provides some shade on the site. This island could potentially be converted to bioretention, however existing trees, sidewalks, and underground electrical located in the island would pose conflicts for such a conversion.

A series of catch basins are connected in the parking lot and carry stormwater away from Sherman Avenue and toward Shepard Brook. External downspouts from the YNHH Outpatient facility are also connected to this storm drain system. The most downgradient catch basin was clogged with silt and debris during the field visit, indicating high sediment loads. Pooling in the vegetated area east of the site suggests a possible high water table, which may be contributing to pooling in the vicinity of the downgradient catch basin. Because of this, proposed BMPs are focused higher in the landscape, to ensure successful infiltration of stormwater.

Proposed Stormwater Retrofits at YNHH Outpatient Services Facility
A combination of bioretention areas and pervious pavement are proposed to decrease Stormwater runoff and serve as a green infrastructure demonstration site for the Shepard Brook subwatershed in Hamden.



- **Parking Lot Retrofits.** Approximately 5,000 square feet of pervious pavement is proposed for the 23,000 square feet rear parking area, focusing on the spaces in the center of the parking lot, where stormwater runoff could be infiltrated before reaching the most downgradient catch basin in the northeast corner of the site. In addition to reducing impervious area on this portion of the site by approximately 20%, the pervious pavement will also accept stormwater flows from more westerly sections of the parking lot, as water flows to the northeast across the site. *Estimated Cost: $20,000*

- **Front Lawn Retrofits.** The approximately 5,000 square feet front parking lot slopes toward the front lawn area, between Sherman Avenue and the front parking lot. This lawn area also appears to receive stormwater flows from an approximately 3,000 square feet area consisting of the northbound travel lane of Sherman Avenue as it approaches the driveway from the south, and the front portion of the YNHH driveway. This yields a total WQV for this portion of the site of approximately 630 cubic feet. An approximately 200 square feet bioretention area (with approximate treatment capacity of 735 cubic feet WQV) is proposed for the bumpout portion of the front lawn, with curb cuts allowing stormwater to enter from both the parking area and the driveway. *Estimated Cost: $10,000*

- **Main Lawn Retrofits.** Approximately 600 square feet of distributed bioretention/rain garden area is proposed for the main lawn. Approximately 400 square feet of linear bioretention (approximately 5 feet wide by 80 feet long) is proposed along the north edge of the lawn to capture stormwater from the approximately 4,500 square feet of driveway area between the two parking lots. An additional triangular rain garden/bioretention feature of approximately 200 square feet is proposed for the area adjacent to the sidewalk leading from the rear parking lot to the building. Downspouts from the north side of the 8,000 square feet building would be disconnected from the storm drain system and redirected to this area. Developing the bioretention area as a rain garden would provide a landscape feature on the site, and could be supplemented with interpretative signage for public education and outreach. This area could potentially be utilized as an outdoor gathering space, either for patients waiting for appointments or for staff on break. Lower maintenance bioretention designs are equally feasible on the site, and would require only periodic cleaning in addition to mowing, which is already occurring at the proposed location. *Estimated Cost: $28,000*

Total Estimated Cost: $58,000

4.7 Whitney High School North/West

Area Cooperative Educational Services (ACES) operates two special education programs out of its Whitney High School North and West campuses, located immediately west of the Mill River on Skiff Street in New Haven. The Whitney North/West campus is an approximately 5-acre site, which is nearly 100% impervious. Three buildings are located on the site, which slopes from Skiff Street down toward the south end of the site and also east toward the Mill River. Parking is terraced, as noted in the concept graphic below, creating three separate tiers along the north/south gradient.

Existing east-west oriented parking islands separate the tiers; these islands are narrow and steeply sloped, making them unlikely candidates for green infrastructure practices. Existing curb cuts at the ends of these islands carry water from one tier down to the next, with stormwater eventually flowing to catch basins along the southern edges of the parking areas. Downgradient catch basins are assumed to outfall directly to the Mill River, on the far side of a chain-link fence which follows the eastern edge of the parcel.

The southeast corner of the site, adjacent to the Staff Development Building, currently contains a raised bed garden area, picnic table, and composter. A gravel swale appears to carry excess stormwater from a low point in that area to the south edge of the site and toward the Mill River.

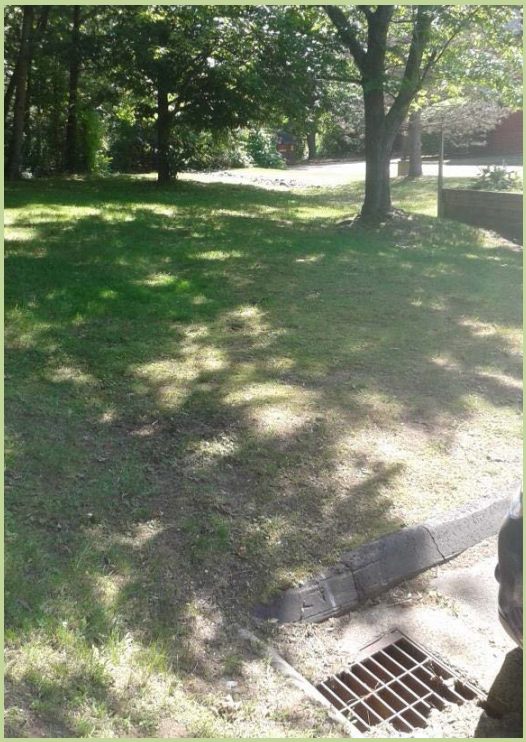
- **Parking Lot Retrofits and Bioretention.** A combination of subsurface infiltration, pervious pavement, and bioretention is proposed to reduce stormwater runoff from the extensive parking areas on the site and provide a variety of green infrastructure demonstration sites for curricular value.

    - Approximately 14,500 square feet of pervious pavement is proposed in the front parking lot and upper and middle tier parking areas of the main lot to reduce impervious cover on the site and infiltrate runoff from the upper two tiers of parking. *Estimated Cost: $58,000*

    - Approximately 500 square feet of subsurface infiltration is proposed to be located behind the Staff Development Building, intercepting flow from the existing catch basins at the low end of the parking lot, infiltrating approximately 1,800 cubic feet WQV, and returning excess stormwater to the existing drainage system at the east end of the practice. This practice would be designed to capture drainage from an approximately 20,000 square feet area including the parking area surrounding the Staff Development Building and redirected drainage from the building (approximately 1,600 cubic feet of WQV). *Estimated Cost: $47,000*

    - Approximately 800 square feet of bioretention is proposed in the southeast-most corner of the parking lot, requiring the removal of two parking spaces (see textbox at right). Existing catch basins in this location would be raised to serve as overflow structures. A sediment forebay is proposed for the first bioretention cell (to be located in the existing parking area) in order to minimize required maintenance of

Whitney High School North/West
A bioretention area is proposed in the open, grassed area (top) to connect an existing swale with a sediment forebay proposed for a down-gradient corner of the parking lot (middle). Tiered parking areas (bottom) will feature pervious pavement to reduce runoff volumes and decrease impervious cover.



Proposed Green Infrastructure: Whitney High School North/West

A suite of green infrastructure practices are proposed for the school campus, including approximately 16,500sf of pervious pavement, a bioretention area, and subsurface infiltration chambers. In the graphic, "CB" indicates existing catch basins and blue arrows represent existing surface flow patterns.

the downgradient bioretention area. From the sediment forebay, water would flow to a landscape feature that winds through the existing picnic/garden area, avoiding existing trees, and connecting to the existing gravel swale. The bioretention area would accept water flowing down the campus driveway, as well as flow from the lower tier parking area, including any overflow from the upper tiers (approximately 1 acre of drainage area or 3,500 cubic feet of WQV). The bioretention system would be designed to capture approximately 3,000 cubic feet WQV. Building on existing uses in this area which appear to emphasize environmentally-friendly practices (e.g., composting, raised bed gardening), the bioretention system could provide educational opportunities for students and staff in the form of signage and/or curricular connections. *Estimated Cost: $38,000*

Total Estimated Cost: $143,000

4.8 Counter Weight Brewery, Spring Glen Nursery, & Raccio Park Road

Counter Weight Brewery is located along the south side of Raccio Park Road, within approximately 500 feet of Shepard Brook. The building and lot occupy approximately 1-acre, with the adjacent portion of Raccio Park Road and circular turnaround adding 0.25-acres of additional drainage area. The parcel between the brewery and Shepard Brook is occupied by Spring Glen Nursery.

The roof drains on the brewery building are currently connected to the storm drainage system. A series of five catch basins in the circle and along the eastern and southern edges of the property transport stormwater away from the site, presumably to an outfall on Shepard Brook. Note that while most of this site is mapped as B soils (good infiltration), the southern edge of the site is indicated to be D soils, so additional soil testing will be especially necessary at this site in order to more precisely determine the infiltration capacity of the soils.

Existing plantings along Raccio Park Road between Counter Weight Brewery and Spring Glen Nursery.

Existing parking lots are in poor condition, and catch basins on site were clogged with silt and debris. Existing vegetated areas and parking islands on the brewery property do not appear to receive regular maintenance, whereas planting areas on the nursery property were obviously receiving regular care.

- **Bioretention Area/Rain Gardens.** A series of bioretention areas/rain gardens are proposed for the site:
    - A series of three distributed bioretention areas/rain gardens are proposed within Counter Weight Brewery's parking area. A 150 square feet bioretention area/rain garden is

proposed in the existing island bumpout at the northeast edge of the front parking lot; this practice would accommodate capture of approximately 550 cubic feet of WQV and would accept stormwater flows from a portion of the 7,500 square feet front parking lot (with associated 600 cubic feet of WQV). A second 100 square feet bioretention area is proposed in the existing island bump-out at the southeast edge of the front parking lot; this practice would accommodate approximately 370 cubic feet of WQV. In addition to accepting surface runoff from the front parking lot, this practice could potentially receive flow from redirected roof leaders. A third 75 square feet bioretention area/rain garden is proposed for the existing vegetated bumpout at the southeast corner of the building. This practice could accommodate approximately 275 cubic feet of WQV and would be designed to accept flow from redirected roof leaders, with a potential roof catchment area of approximately 4,500 square feet (354 cubic feet of WQV). Overflow from this bioretention area would be directed overland toward the existing catch basin and proposed pervious pavement (see below). *Estimated Cost: $16,000 (assuming all three areas); costs for individual practices range from $4,000 to $7,000*

Proposed Green Infrastructure Retrofits for Counter Weight Brewery and Raccio Park Road

A partnership between Counter Weight Brewery and Spring Glen Nursery is proposed to enhance the aesthetic appeal of the commercial park on Raccio Park Road and decrease Stormwater runoff and pollutant loads into Shephard Brook.

- A 200 square feet linear bioretention area along the southern edge of Raccio Park Road would accept stormwater runoff from the road via a curb cut on the western end of the feature, with the potential to capture and treat approximately 735 cubic feet of WQV. To increase the drainage area, the upgradient catch basin west of the practice should be closed off; this would direct approximately 5,500 square feet of drainage area to the practice (with corresponding 435 cubic feet of WQV). While the green space between the brewery and nursery driveways and the bumpout areas mentioned above are maintained with plantings, the existing green space between the road and the main brewery parking lot is unmaintained, so this feature could be designed either with landscape enhancement or minimal maintenance as the primary goal. The bioretention area would overflow to the existing downgradient catch basin adjacent to the Counter Weight Brewery driveway. *Estimated Cost: $10,000*

- **Parking Lot Retrofits.** Approximately 2,000 square feet of pervious pavement is proposed along the eastern edge of the parking lot to reduce impervious cover and intercept additional surface flows to the two existing catch basins at the edge of the lot. Approximately 28,000 square feet of impervious area drains toward this section of the parking lot, with corresponding 2,217 cubic feet WQV. The 7,500 square feet front parking area could also be converted to pervious pavement in the future if the lot is repaved. *Estimated Cost: $8,000 (assuming 2,000 square feet); an additional $30,000 would be required to convert the entire front lot to pervious pavement*

- **Maintain Existing Catch basins.** Some of the catch basins at the site were observed to be clogged with silt and other debris. Periodic clearing of this debris will maintain proper functioning of the existing system, decrease pollutant loads to the storm drain system, and reduce ponding in adjacent impervious areas. *Estimated Cost: minimal; use existing brewery staff labor or volunteers*

Total Estimated Cost: $34,000 ($64,000 including conversion of front lot to pervious pavement)

4.9 Bartlem Recreation Area

This large municipal park is located on CT 10 (South Main Street) in Cheshire, directly across from Cheshire High School. The site is owned by the Town of Cheshire and includes lacrosse, baseball, and soccer fields, as well as a covered swimming facility and multiple parking areas. Most of the stormwater from the site drains to an approximately 36-inch outfall at the southern end of the property. These parking areas and structures comprise approximately 5-acres of directly connected impervious cover on the site. An additional 1.75-acres of maintained athletic field area likely contributes surface flows to the storm sewer system during heavy rains. The proposed LID and Green Infrastructure elements may be incorporated as part of regular onsite maintenance and improvements and could be incorporated gradually as expansion opportunities and funding become available.

Existing catch basins are located behind the swimming pool and appear to capture overflows from the pool decks as well as stormwater runoff. Additional catch basins are located in the northern parking lot, on either side of the driveway, and in the lawn between the baseball field and swimming pool parking lot. The catch basin located at the southwest corner of the swimming pool parking lot appears to be the most downgradient catch basin before stormwater outfalls into the Mill River. An existing gravel swale carries additional overland runoff from the baseball diamond, along the south edge of the ball field, into a catch basin located in the grass adjacent to the parking lot, and ultimately through the parking lot catch basin to the outfall.

- **Linear Bioretention**. An existing short fence runs along the north edge of the baseball field, creating a lawn area approximately 15 feet wide between the fence and the curbed driveway of the recreation area. This space is currently utilized for event parking. Approximately 300 square feet of linear bioretention is proposed toward the east end of this space to treat stormwater runoff from the driveway while preserving as much parking as possible. A curb cut will allow stormwater to flow from the road (approximately 14,000 square feet of drainage area, with 1,100 cubic feet WQV) into the proposed bioretention before reaching the existing catch basin. As the landscape slopes slightly to the east, check dams are proposed as part of the design to slow the movement of water through the bioretention feature. The bioretention area can be designed to overflow either to the existing catch basin or the proposed water quality swale (below). *Estimated Cost: $14,000*

- **Vegetated Water Quality Swale.** A second linear feature (2,500 square feet) is proposed between the baseball field and the swimming pool parking lot, on top of the existing storm drainage pipes. Existing catch basins would be raised to serve as overflow structures during heavy rains, and a vegetated swale is proposed along the length of the parking lot to infiltrate surface runoff from the 44,000 square feet of uncurbed parking lot (with accompanying 3,500 cubic feet of WQV) and adjacent ball field (expected to generate, at minimum, an additional 350 cubic feet or more of WQV). Effectiveness of the swale could be further enhanced by re-grading the parking lot whenever it is next repaved to encourage stormwater to flow toward the swale. Drainage from the pool roof could potentially be directed toward the swale as well, although it was not clear from the site visit how pool roof drainage is currently handled. *Estimated cost: $36,000*

Existing Conditions: Bartlem Recreation Area
Existing catch basins at the edge of the swimming pool parking lot at Bartlem Recreation Area channel water to an outfall to the Mill River just east of the site (top). An approximately 15 foot wide strip of grass along the main driveway is used for parking during special events (bottom).

Pervious Pavement. 15,000 square feet of pervious pavement is proposed for the middle two rows of parking in the north parking lot. This conversion to pervious pavement would reduce the impervious surface of the 50,000 square feet lot by nearly 30% and decrease the volume of stormwater inputs to the existing drainage system. *Estimated Cost: $60,000*

- **Bioretention/Rain Garden.** A bioretention area/rain garden and native planting area of up to 1,500 square feet is proposed for the lawn area between the circular drive in front of the swimming pool and the swimming pool parking lot. A curb cut in the circle would allow stormwater to flow into the rain garden, with the existing catch basin serving as an overflow to direct excess stormwater back into the drainage system. A 300 square feet bioretention area is proposed to capture and treat runoff from the approximately 12,000 square feet of impervious drainage area (approximately 950

cubic feet of WQV) that would connect to the BMP via the proposed curb cut in the circle. Remaining area in this planting island should be converted to native plantings. Due to its location near the pool entrance, this would likely be the most visible location at which to include educational information about the full suite of proposed green infrastructure components suggested for the site. *Estimated Cost: $14,000 (assuming 300 square feet of bioretention; additional funds (or plant donations) may be required for native plantings to fill the entire island)*

Total Estimated Cost: $124,000

Proposed Conditions: Bartlem Recreation Area

Pervious pavement, bioretention/rain gardens, native plantings, and vegetated drainage swales are proposed to slow the flow of water across the site, decrease impervious area, and serve as demonstration sites for a variety of green infrastructure practices at a highly utilized community park. In the concept graphic, "CB" indicates existing catch basins; blue arrows depict existing surface flow patterns.

4.10 Strathmore Drive

Strathmore Drive is located in a residential subdivision in Cheshire that lies just east of the Mill River, across the river from the Bartlem Recreation Area and south of Wallingford Road. An unnamed tributary of the Mill River winds through the neighborhood.

Green spaces were required to be created during the development of the subdivision. Two such sites are located on Strathmore Drive, between the two ends of Buttonwood Circle. A playground occupies the green space to the west side of Strathmore Drive; on the east side of the street, the existing green space consists of a semi-circular lawn area bordered by bermed planting areas that include mature evergreen trees and shrubs. Beyond the berms is another area of lawn that backs up to residential lawns from homes on Buttonwood Circle. To the southeast, this area meets up with a wooded buffer through which the unnamed tributary stream passes through the neighborhood. The area, including the lawn and bermed planting areas, is currently maintained by the Homeowner's Association via a landscaping contractor.

- **Public Green Space Retrofit.** Although located adjacent to a high point on Strathmore Drive, the semi-circular lawn forms a natural bowl in the landscape, and could be converted to an approximately 500 square feet bioretention area to collect and infiltrate runoff from approximately 11,000 square feet of catchment area on Strathmore Drive and portions of Buttonwood Circle (with corresponding 900 cubic feet of WQV). Water could be redirected from catch basins on Strathmore Drive that are located at each end of the green space, through subsurface pipes, and directed into the bioretention area to either infiltrate or ultimately be released back into the tributary stream via an overflow swale. More detailed site survey is necessary to confirm feasibility, but available contour/elevation data indicates between a 5% and 8% slope from the catch basin locations to the depression/proposed bioretention area. It may also be possible to direct roof leaders from houses that back up to the green space into the bioretention area. If desired, the bioretention area could be designed as a rain garden to enhance the existing landscape features of this space. *Estimated Cost: $24,000*

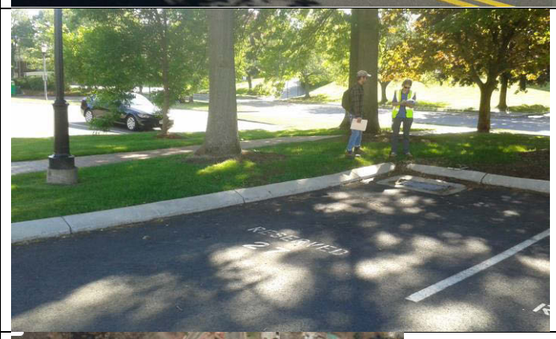
Existing public green space east of Strathmore Drive.

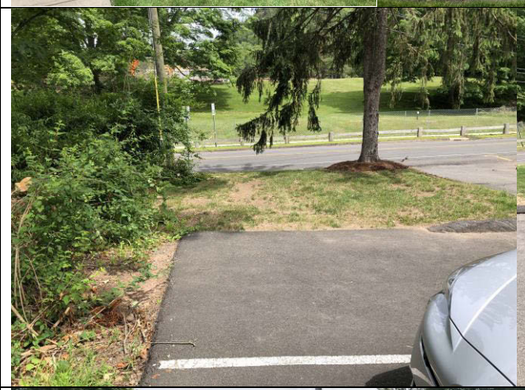
Total Estimated Cost: $24,000

Proposed Bioretention Area at Strathmore Drive

In the concept graphic, "CB" indicates existing catch basins; blue arrows represent existing surface flow patterns.

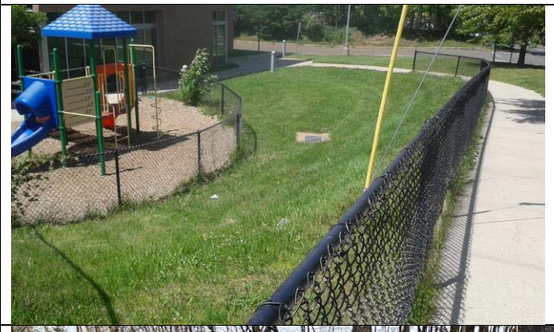
Table 4-1 Additional Potential Green Infrastructure Locations

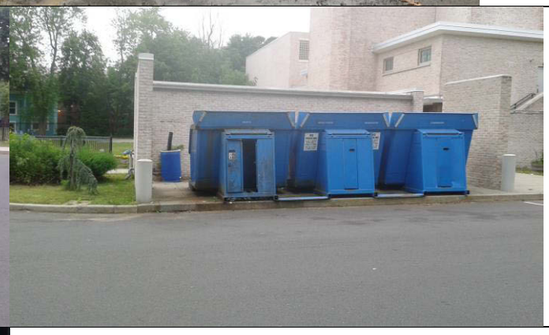
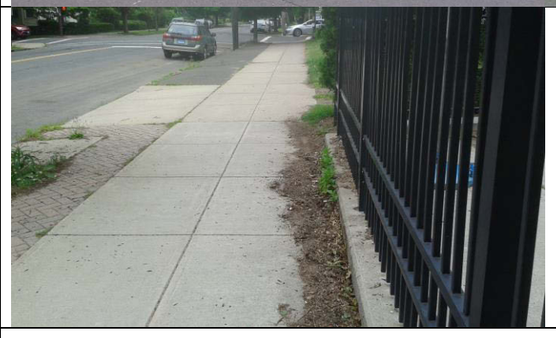
Site Location	Municipality	Existing Conditions	Recommendation	Photo
Cheshire HS	Cheshire	Large amount of impervious cover, multiple parking areas. Internal roof drainage from buildings.	Disconnect roof downspouts. Potential for infiltration or bioretention using existing landscaped areas in front lawn, just west of entrance, and/or under fire lane by gym. Replace impervious parking lots with pervious pavers. Low-lying area behind operations/maintenance building could also receive water.	 
Cheshire Public Works/Town Hall	Cheshire	Large parking lot, drains via catch basins. Catch basin in NE corner of parking lot was observed to have moderate flow, despite no rain in past 24h. Dumpsters without secondary containment adjacent were located adjacent to another catch basin.	Potential for subsurface infiltration under NE corner at catch basin.	
Route 10 Corridor	Cheshire	Large amount of impervious cover, multiple parking areas many of which back up to the Mill River with little or no Riparian Buffer	Decrease impervious cover throughout Route 10 Corridor.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Elim Park Retirement Community	Cheshire	Elim Park captures a good deal of their stormwater on site. A large bioretention feature was constructed as part of a larger redevelopment project. The site features several rain gardens capturing stormwater from the resident buildings and uses grass pavers at access points for the newest building.	Support ongoing efforts at Elim Park to retain and treat stormwater onsite and to increase accessibility to the river while promoting and restoring the natural landscape.	 
Quinnipiac University - Albert Schweitzer Institute	Hamden	Paved parking lots with no storm drains next to Mill River	Install educational rain garden to capture runoff from the front parking area.	 
Quinnipiac University – Bobcat Way parking areas	Hamden	Extensive parking areas with curbed planted islands	Potential for bioretention in existing landscaped area with catch basin adjacent to each island	

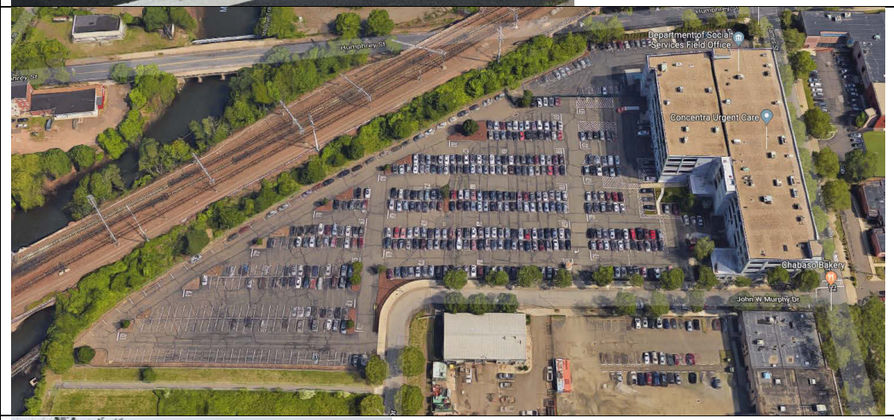
Site Location	Municipality	Existing Conditions	Recommendation	Photo
Alice Peck School	Hamden	Roof leaders and parking lot drain to paved open channel. Renovations to the school are expected during 2019.	Potential for bioretention and swale between parking lot and baseball field.	
Hamden Public Works	Hamden	Large parking lot drains to low point on south side of lot. Discharges to eroded channel into wet, wooded area south of site. No curbing or catch basins.	Bioretention or created wetland at south side of parking lot. Replace parking lot with pervious pavers.	
Whitney Washington ROW	Hamden	Bituminous island at intersection.	Potential to install bioretention cell or infiltration practice and/or remove impervious cover.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
USPS Whitney Ave	Hamden	Existing catch basins full of sediment. Roof leaders buried, discharge to catch basin on property.	Disconnect roof downspout. Potential for subsurface infiltration in parking lot, under pervious pavement. Bioswale or linear bioretention between parking lot and road.	
Washington Ave between Lincoln Street and Harding Street	Hamden	Wide ROW, no curb, sediment collecting at grass edge. On street parking.	Linear bioretention or bioswales along west side of street. Bioswales where practicable elsewhere on Washington Ave. Replace parking lanes on either side of street with pervious pavement.	
Dixwell Avenue/ Shepard Avenue/Skiff Street	Hamden	Busy intersection near many large parking lots and commercial center.	Potential for bioretention or infiltration in ROW island and linear practices in ROW. Paved ROW could, at minimum, be replaced with pervious cover.	 
Ridge Road Elementary	Hamden	Cracked pavement in parking lot, may be due for repaving.	Regrade parking lot, remove western curb and install bioretention or infiltration practice. Potential to replace parking lot with pervious pavers.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Hamden Municipal Campus	Hamden	Large parking lots at Hamden Senior Center, Library, Middle School, and Town Hall.	Develop a Municipal Campus Stormwater Masterplan.	
Spring Glen School	Hamden	Medium sized parking lot, recent pavement, trees in median.	Potential for bioretention in existing landscaped area with catchbasin adjacent to lower play area. Rain garden at SW corner of site.	
Town Center Park	Hamden	Town Park that receives runoff from 88 acres or surrounding urban land use (commercial and residential). Impervious cover is estimated to be 21%.	Installation of best management practices (BMPs) that slow, treat, capture, and filter the stormwater before it reaches the Pardee Brook diversion channel and Shepard Brook. The designs consist of reinforcing the existing plunge pool with a boulder overflow weir; installing a sediment filter riverbed, a stormwater treatment pond, constructed wetland and rain garden; and restoring the meadow area to create an emergent marsh. This series of engineered but natural stormwater management practices will reduce pollutant loading and erosion entering Pardee Brook **High Priority Project	 
RWA Water Center	Hamden	Hard packed access road with downspout discharging to access road	Install Rain barrel to capture roof runoff. Potential for demonstration bioretention.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Eli Whitney Museum	Hamden	Hard pack and paved parking area with catch basins discharging directly to river; curbed island and planters in the center of parking lot	Potential to retrofit curbing and islands in the center of the parking lot to be used for bioretention. Potential to install bioswales in grass areas along the paved driveway. Potential to install rain barrels to capture water from existing building and reuse onsite.	 
Hooker Middle School	New Haven	Church converted to school in 2009. Island in turnaround. Catch basins in parking lot, including beneath dumpsters. Former PTA constructed native habitat, but now is not maintained (invasives present). School has signage about native habitat and outdoor classroom.	Potential for green roof above main entrance, bioretention in island and at lower elevation on property in existing, unmaintained habitat garden. Recommend native plantings in bioretention. Rain garden by eastern gate Secondary containment around dumpsters.	 
Hooker Elementary School	New Haven	Moderately old street/sidewalk, possibly separated sewer/past CSO. Buried roof leaders to catchbasins.	Linear bioretention to subsurface infiltration along Canner, east of Livingston. Replace paved ROW area on Livingston, south of the school, with bioretention; connect to low points of playground via trench drain or replace with pervious pavers.	
Mill River Trail	New Haven	Access to Mill River is limited. Plans have been developed for a Mill River Trail system and the first phase is currently being implemented.	Prioritize public access and incorporation of green infrastructure where appropriate.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
John S. Martinez School Parking Lot	New Haven	Parking lot consists of impervious with parking islands and several existing catch basins.	Implement recommendations of the 2012 Green Infrastructure Feasibility Scan for Bridgeport and New Haven, CT, including bioretention in parking areas and curb cuts to divert runoff into vegetated median.	 
Jocelyn Square Park	New Haven	Broken 6' wide sidewalk on north side of park. Drainage existing along Humphrey Street. Leaching catch basin in private parking lot across Humphrey, at 175 Humphrey Street.	Bioswale in ROW between utility poles. Potential for subsurface storage/infiltration under paved park entrance.	 
Humphrey Street and Mill River Street	New Haven	Large parking area comprised of sand, gravel and pavement, which slopes towards the Mill River. The stream bank is eroded with no riparian area.	Potential for living shoreline	 

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Radiall America	New Haven	Large parking lot, buried roof leaders	Disconnect roof leaders, bioretention in existing landscaped areas.	
370 James Street	New Haven	Large parking area, landscaped islands.	Potential to incorporate bioretention islands throughout the side and rear parking lots. Work with property owner and Mill River Trail Advocates to utilize the western corner of the parking lot for bioretention and education.	
Haven Street	New Haven	Existing drainage along Haven Street captures private driveway.	Potential for bioretention to capture road runoff and stormwater from residential properties and to serve as connection to the Mill River Trail.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Fair P.A.C Housing	New Haven	Large parking lot and connected roof leaders	Potential for retention in the vegetated areas in the front and rear of the building	 
St James Unity Holiness Church	New Haven	Buried roof leaders, underutilized parking area.	Disconnect roof leaders, potential for pervious pavement.	
Yale Divinity School	New Haven	Buried roof leaders, potential evidence of gray water from building in catch basins along driveway between Divinity School buildings and adjacent conference center. Drainage system appears to drain east towards large landscaped area and potentially out to Whitney Avenue. Possible existing infiltration basins at conference center.	Potential for curb cuts to bioretention, potential for subsurface infiltration, disconnect roof leaders.	 
First Unitarian Church	New Haven	Buried roof leaders, compacted gravel. Paved play area sheet flow to parking lot.	Potential for subsurface infiltration.	

Site Location	Municipality	Existing Conditions	Recommendation	Photo
Orange Street/Edwards Street, Canner Street/Foster Street	New Haven	Cracking pavement. Possibly separated sewer/past CSO area. No Standing Anytime signs on all corners.	ROW bump-out bioretention or bioswale at intersection without removing on-street parking or infringing on bike lane. Potential for pervious pavers in parking/cycling lane.	
James and River Street	New Haven	Curbed bump out with gutter	Potential to retrofit bump out for use as bioswale. Location next to Criscuolo park also offers potential for education and outreach.	
Criscuolo Park	New Haven	Heavily used urban park and playing fields	Potential for riparian plantings and demonstration rain garden.	

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5 Pollutant Load Reductions

Pollutant load reductions were estimated for the watershed plan recommendations for which pollutant loads can be reasonably quantified. Load reductions were calculated using the Watershed Treatment Model (WTM), a screening-level land use pollutant loading model, and a loading calculation known as the Simple Method (Schueler, 1987), both of which are described in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b). Anticipated pollutant load reductions associated with ongoing and future CSO abatement efforts are based on the GNHWPCA 2015 *Hydraulic Model Update* (CH2MHILL 2015).

Annual pollutant loads were estimated for the management actions described below. Predicted load reductions were calculated relative to the existing, baseline pollutant loads, which are presented in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b).

- **CSO Abatement.** Existing conditions (2017) pollutant loads reflect recent and ongoing improvements to the overflow weirs at CSO 009 and 012, and completed sewer separation at CSO 011. Two future CSO abatement scenarios were considered, consistent with the phased implementation of the GNHWPCA Long Term Control Plan for CSO discharges to the Mill River. Improvements remaining to be made under the Long Term Control Plan include sewer separation at CSO 009, and installation of a CSO storage tank at CSO 011. These improvements are ultimately predicted to reduce annual CSO volumes and the number of CSO events in a typical year to a condition of zero discharge for up to the 2-year, 6-hour rainfall event . These improvements are expected to be completed by 2036 (i.e., Long Term Control Plan – 2036 Conditions). The following table summarizes the existing and modeled Mill River CSO volumes and number of CSO events for typical year conditions[7].

Table 5-1. Existing and Modeled CSO Conditions

Scenario	Mill River CSO Volume (Million Gallons)	Mill River CSO Events
2017 Existing Conditions (Based on Meter Data)	4.86	43
Short Term Control Plan – 2018 Modeled Conditions	4.82	12
Long Term Control Plan – 2036 Modeled Conditions	0.00	0

- **Green Infrastructure.** Continued implementation of green infrastructure is recommended throughout the watershed. Green infrastructure should continue to be implemented through retrofits of existing developed sites and roads (i.e., complete streets), and as part of new public and private development and redevelopment in the watershed, as required by existing and future land use regulations and policies. Potential pollutant load and runoff reductions were estimated for the following types of green infrastructure practices and land use settings:

    - Implementation of proposed green infrastructure projects detailed in this report
    - Roof leader disconnection and bioretention on commercial, institutional, and industrial land
    - Rain barrels and roof leader disconnection on residential properties

[7] Typical year conditions are defined as 40.63 inches of total rainfall per year, peak 15-minute intensity of 3.16 inches per hour, and 114 rainfall events per year (*Hydraulic Model Update*, CH2MHILL, 2015).

Multiple scenarios were modeled to estimate the effect of varying levels of green infrastructure implementation across the watershed, including estimates for retrofitting 10%, 25%, 50%, and 100% of the impervious area watershed-wide. The modeled effectiveness of the proposed retrofits was reduced to reflect system maintenance and design (system bypass during larger storms) factors.

- **Public Education.** Nonpoint source education programs can change behaviors that affect pollutant loads. Pollutant load reductions were estimated for pet waste education programs based on the number of dwellings, average fraction of pet-owners, pet-owners who already clean up after their pets, and average fraction willing to change their behavior. Conservative model assumptions were used to avoid over-estimating the load reduction benefits of these programs.

- **Illicit Discharge Detection and Elimination.** Illicit stormwater connection removal was considered in each subwatershed based on the existing estimated number of illicit connections associated with commercial and residential land uses. The illicit connection removal scenario conservatively assumes that 30% of the existing illicit discharges are detected and eliminated.

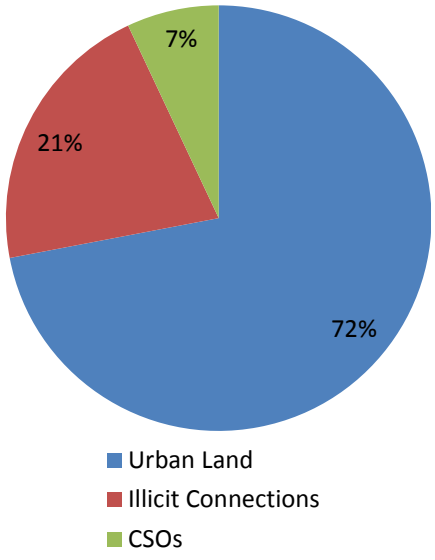
- **Septic System Repairs.** Septic system repairs were considered in each subwatershed based on the existing estimated number of households served by septic systems. The septic system repair scenario assumes that 20% of the failing septic systems are repaired. This scenario reflects short or mid-term recommendations to address existing failing or malfunctioning septic systems.

Other watershed management recommendations identified in this plan were not quantified due to the inherent limitations of screening-level pollutant load models and/or the lack of reliable information on the pollutant removal effectiveness of certain management measures.

Existing Pollutant Loads

Annual average pollutant loads for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), total fecal coliform (FC) bacteria, and average annual runoff volume were estimated for existing conditions and future conditions assuming implementation of the watershed based plan recommendations described in the above scenarios. Existing conditions pollutant loads are described in *Technical Memorandum 2—Pollutant Loading Model: Mill River Watershed-Based Plan* (Fuss & O'Neill, 2018b), a copy of which is provided as *Appendix A* of this plan.

Although pollutant loads were estimated for nutrients, sediment, and fecal indicator bacteria, the focus of discussion for the remainder of this section is on fecal indicator bacteria, which is the primary cause of water quality impairments in the Mill River watershed.



Relative composition of annual fecal indicator bacteria loads to the Mill River.

Nonpoint source runoff accounts for approximately 72% of the modeled existing annual bacteria load to the Mill River, CSOs account for approximately 7%, and estimated illicit connections account for approximately 21% (see chart at right). It is important to note that these percentages reflect *modeled* loads based on recent and

proposed CSO improvements in the Mill River watershed. As indicated in Section 3.2.2, continued CSO flow monitoring is recommended to verify modeled pollutant loads.

Pollutant Load Reductions

Table 5-2 summarizes the anticipated pollutant load reductions for the plan recommendations for which pollutant loads can be reasonably quantified. The load reduction values presented in *Table 5-2* are for the overall Mill River watershed. Load reduction summaries for individual green infrastructure projects are provided in *Appendix F*; larger projects are broken down into individual BMP recommendations.

As indicated in *Table 5-2*, the watershed plan recommendations are predicted to result in an approximately 17% reduction in annual fecal indicator bacteria loads for the entire Mill River watershed under the Long Term Control Plan 2036 CSO abatement scenario and assuming implementation of green infrastructure for 10% of the impervious area in the watershed as well as the project designs presented in this plan. Of this 17% reduction, approximately 7% is attributable to CSO abatement, approximately 3.5% to green infrastructure, approximately 6% to elimination of illicit discharges, and the remainder to other structural and non-structural nonpoint source pollution control measures.

Varying levels of green infrastructure implementation across the watershed were modeled, including the use of green infrastructure to manage runoff from 10%, 25%, 50%, and 100% of the impervious area in residential, industrial, commercial, institutional, and transportation land uses. The results for the 10% scenario, which is considered a reasonable likely future scenario, are included in *Table 5-2*. The results for all four scenarios are presented in *Table 5-3*. The 10% retrofit scenario is predicted to result in an approximately 3% reduction in annual fecal indicator bacteria loads and 4% reduction in annual runoff volume. Higher bacteria load reductions (up to approximately 33%) could potentially be achieved by implementing green infrastructure over a larger percentage of the watershed.

Table 5-2. Modeled Annual Pollutant Load Reductions

Watershed Management Recommendation	Fecal Coliform (billion/year)	Fecal Coliform (%)	Runoff Volume (acre-feet/year)	Runoff Volume (%)
CSO Abatement (2036 levels)	187,395	6.7%	--	--
Green Infrastructure (10% of impervious area)	112,834	5.6%	1,481	4.0%
Implement all 10 GI Concepts	5,322	0.3%	84	0.2%
Public Education	14,005	0.5%	--	--
Illicit Discharge Detection and Elimination (IDDE)	174,831	6.3%	--	--
Septic Repair	383	0.01%	--	--
Total	**473,621**	**17.0%**	**1,565**	**4.2%**

Illicit discharge detection and elimination (IDDE) is predicted to result in annual bacteria load reductions nearly twice that of the 10% green infrastructure scenario. Even the modest 30% removal rate assumed in the model is predicted to achieve an approximately 6% reduction in annual fecal indicator bacteria loads. IDDE is also significantly more cost-effective than implementing structural stormwater retrofits, and is supported through the requirements of the CTDEEP MS4 Permit. Dry weather sources of fecal indicator bacteria are the most likely to be identified and effectively managed and more likely to include human sources. Wet weather

bacteria sources are often very costly to address and stream standards can be difficult to attain, particularly with the presence of CSOs. IDDE and other source controls focusing on dry weather bacteria sources should be aggressively implemented through municipal stormwater management programs (as required by the MS4 permit) in conjunction with green infrastructure for wet weather sources.

Table 5-3. Modeled Annual Pollutant Load Reductions for Varying Levels of Green Infrastructure Implementation

Green Infrastructure Implementation Scenario	Fecal Coliform (billion/year)	Fecal Coliform (%)	Runoff Volume (acre-feet/year)	Runoff Volume (%)
Retrofit 10% of Impervious Area	112,834	5.6%	1,481	4.0%
Retrofit 25% of Impervious Area	282,084	14.1%	3,703	10.0%
Retrofit 50% of Impervious Area	564,169	28.2%	7,407	20.0%
Retrofit 100% of Impervious Area	1,128,337	56.4%	14,813	40.0%

How Much will the Watershed Plan Recommendations Improve Water Quality?

The primary objective of this watershed plan is to address the water quality impairments in the Mill River and thereby restore the recreational uses and aquatic habitat that have been affected by poor water quality. The pollutant load evaluation suggests that significant pollutant load and runoff reductions could be achieved by implementing the plan recommendations. Implementation of the watershed management recommendations is predicted to result in an approximately 17% to 47% reduction in annual fecal indicator bacteria loads to the Mill River.

However, even if the watershed plan recommendations are fully implemented, the 47% reduction in annual fecal indicator bacteria loads will not fully satisfy the Total Maximum Daily Load (TMDL) requirements for fecal indicator bacteria reductions prescribed to restore recreation and aquatic life uses in the impaired segments of the Mill River. The TMDL analysis for fecal indicator bacteria was completed for the impaired segment of the Mill River and for Shepard Brook as part of CTDEEP's Statewide Bacteria TMDL. A TMDL is a "pollution budget" that identifies the reductions in point and nonpoint source pollution that are needed to meet Connecticut water quality standards for a particular waterbody and a strategy to implement those reductions to restore water quality. The Statewide Bacteria TMDL calls for a 77% reduction in fecal indicator bacteria loads (based on the geometric mean) to the impaired segment of the Mill River, and a 71% reduction in fecal indicator bacteria loads for Shepard Brook. This suggests that additional controls or more aggressive control strategies will be needed, beyond the modeled recommendations of this plan, to fully achieve the load reductions specified in the TMDL. Additional load reductions may be achieved through reforestation and stream buffer restoration, increasing the public awareness in the watershed of certain programs, and increased detection and elimination of illicit discharges.

It is important to note several limitations of both the TMDL load reduction estimates and the pollutant load reduction modeling. The TMDL for the Mill River segment is based on limited wet and dry weather monitoring data – 2 samples collected at each of 2 sampling locations in 1998, 45 samples collected at a third sampling location in 2003, 2004, and 2006-2009, and 8 samples collected at a fourth sampling station in 2010. At Shepard Brook, the TMDL is based on 10 samples from a single sampling location during 2010-2011. The samples were also collected at locations upstream of the influence of CSOs. Furthermore, the TMDL and modeled load reductions are not directly comparable since the TMDL loads are daily, seasonal (i.e., worst-case) values, whereas the modeled pollutant loads are annual values. Lastly, the load reductions anticipated from CSO abatement efforts are not directly comparable to the TMDL load reduction goal since the TMDL was

developed prior to recent upgrades to the weirs at CSOs 009 and 012; those updates are reflected in the existing conditions. Therefore, the modeled future CSO abatement load reductions are conservatively low when compared to the TMDL load reduction goals.

As indicated in the TMDL, progress in achieving TMDL-established goals through implementation of this watershed plan may be most effectively gauged through continued fixed-station ambient water quality monitoring. Routine monitoring should be performed at the same sites used to generate the data for the TMDL calculations, as well as at additional sites along the Mill River (see the water quality monitoring recommendations in *Section 3.2* of this plan). Sampling should be scheduled at regularly spaced intervals during the recreational season to generate a data set for each season that will include ambient values for both "wet" and "dry" conditions in relative proportion to the number of "wet" and "dry" days that occurred during the monitoring period. The TMDL calculations can be updated over time to compare the percent reductions needed under "dry" and "wet" conditions to the percent reductions that were needed at the time of TMDL adoption.

6 Funding Sources

A variety of local, state, and federal sources are potentially available to provide funding for implementation of this watershed based plan, in addition to potential funds contributed by local grassroots organizations and concerned citizens. *Appendix G* contains a list of potential funding sources and mechanisms. The table is not intended to be an exhaustive list but can be used as a starting point to seek funding opportunities for implementation of the recommendations in this watershed plan. The table of potential funding sources is intended to be a living document that should be updated periodically to reflect the availability of funding or changes to the funding cycle, and to include other funding entities or grant programs.

7 References

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