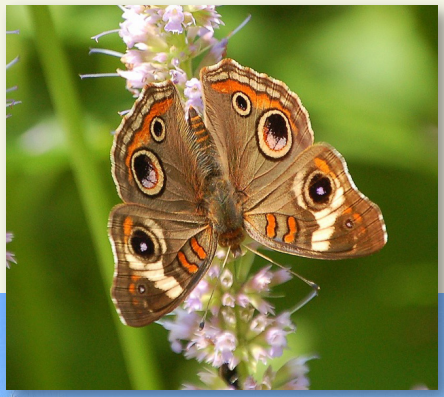
QUINNIPIAC RIVER
Watershed Based Plan

December 2013



Prepared by
FUSS & O'NEILL

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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Consultants

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Other Involved Stakeholders

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Executive Summary

The Quinnipiac River watershed is an approximately 166 square-mile, urbanized watershed in south-central Connecticut. The watershed consists of nine primary subwatersheds, which drain via the Quinnipiac River and its major tributaries to Long Island Sound. The four largest subwatersheds are the Quinnipiac River main stem, Eightmile River, Tenmile River, and Muddy River. The Quinnipiac River is the fourth largest river in Connecticut. Formed in a former glacial lakebed, the 38-mile Quinnipiac River originates in a 300-acre wetland called Deadwood Swamp on the border of Farmington and Plainville, and flows southward to its outlet at New Haven Harbor in Long Island Sound. The watershed contains portions of eighteen municipalities and is home to over 200,000 people. The municipalities that comprise most of the land area and population in the watershed include Plainville, Cheshire, Meriden, North Haven, Southington, Wallingford, and New Haven.

Issues Facing the Watershed

The Quinnipiac River has been impacted by historical development and land use activities in its watershed. Although advances and upgrades in wastewater treatment have improved water quality over the past several decades, the water quality of much of the Quinnipiac River and its tributaries remains poor as a result of elevated levels of bacteria and impairments to aquatic life.

Nonpoint sources such as stormwater runoff from developed areas and impervious surfaces are major contributors of bacteria, sediment, and nutrients. Agriculture and historical contamination of industrial sites are other sources of ongoing nonpoint source pollution. Landfills, site clearance associated with development and redevelopment, baseflow depletion from groundwater withdrawals, impacts from flow regulation and modification, and municipal wastewater discharges are among other sources of water quality impairments in the watershed.

Historical and ongoing development in the watershed and other factors are also responsible for loss of important habitats including inland wetlands, tidal marsh, riparian corridors, and forested areas. The Quinnipiac River supports a variety of cold water and warm water fisheries and was once an important habitat for anadromous fish species. The Quinnipiac River has been identified as a high priority for anadromous fish restoration.

A Total Maximum Daily Load (TMDL) (i.e., a "pollution budget") developed for the Quinnipiac River and its major tributaries by the Connecticut Department of Energy and Environmental Protection (CTDEEP) in 2008 indicates that bacteria loads must be reduced by over 90% for the impaired segments to meet water quality standards and once again support contact recreation.

Portions of the Quinnipiac River watershed also have a long history of flooding as a result of historical development of the watershed. Urban flooding is common in the more urbanized areas of the watershed where storm drainage systems are over-capacity during modest to intense storms. Riverine flooding is also a significant and frequent problem in some areas, particularly along Harbor Brook in Meriden from the area of Baldwin's Pond to Hanover Pond. The City of Meriden is implementing comprehensive flood control measures to address flooding along Harbor Brook. While water quality is the primary focus of

this watershed based plan, flooding is also addressed as a related issue, along with habitat protection and restoration.

Prior Watershed Planning

The Quinnipiac River has been at the forefront of water pollution control activities in Connecticut since construction of the state's first sewage treatment plant in Meriden in 1891 (Tyrrell, 2001). The Quinnipiac River has been the focus of numerous studies and grass-roots watershed management and water quality improvement efforts over the years, led by the Quinnipiac River Watershed Association (QRWA), the Quinnipiac Watershed Partnership, university research groups, state and federal resource protection agencies, the watershed municipalities, and other local and regional groups.

In 2004, the Quinnipiac Watershed Partnership developed the first comprehensive watershed management plan for the Quinnipiac River watershed, called the *Quinnipiac Watershed Action Plan*. The plan identified priority issues for the watershed and recommended actions to address them. The 2004 *Quinnipiac Watershed Action Plan* integrated various studies, research projects, and planning efforts within the Quinnipiac River watershed dating back to the 1980s.

The Need for an Updated Watershed Plan

Water quality in the Quinnipiac River watershed has benefitted from state and federal regulatory requirements to reduce point source pollution, efforts to restore impacted wetlands and other resource areas of the watershed, and the work of grassroots environmental advocacy groups to protect and restore the watershed through education, conservation, and recreation programs. Despite these accomplishments, the legacy of water quality problems remains as evidenced by the current impairments in the Quinnipiac River, its tributaries, and other water bodies in the watershed.

Since the previous *Quinnipiac Watershed Action Plan* was developed in 2004, EPA and CTDEEP have issued watershed planning guidance for impaired water bodies, placing greater emphasis on achieving quantifiable pollutant load reductions and water quality improvements through specific, measurable actions. This updated EPA and CTDEEP watershed planning process is also the recommended approach for achieving the pollutant load reductions outlined in the 2008 Quinnipiac River Bacteria TMDL.

The QRWA, CTDEEP and EPA recognize the need for an updated watershed management plan for the Quinnipiac River to address the remaining water quality issues of the Quinnipiac and its tributaries. Specifically, the reasons for updating the 2004 action plan are to:

- Update the 2004 plan recommendations to reflect current and emerging approaches for nonpoint source pollution management, building upon the previous 2004 action plan goals and recommendations
- Satisfy current EPA and CTDEEP required elements for watershed-based plans
- Incorporate various ongoing watershed stewardship efforts
- Incorporate water quality data collected since 2004 including the 2008 Quinnipiac River Bacteria TMDL
- Facilitate capacity building and re-engage the watershed municipalities

- Prioritize water bodies and implementation projects to reduce pollutant loads in the watershed
- Ultimately improve water quality and delist the impaired segments of the Quinnipiac River and its tributaries.

The QRWA worked collaboratively with the CTDEEP, EPA, the watershed municipalities, regional planning agencies, and other stakeholders to develop an updated, watershed based plan for the Quinnipiac River. This project was funded in part by the CTDEEP through an EPA Section 319 Nonpoint Source Grant, as well as by The Community Foundation for Greater New Haven through the Quinnipiac River Fund. Fuss & O'Neill, Inc. was retained to lead the development of the watershed based plan, working with a Project Steering Committee (QRWA, CTDEEP, and EPA) and a Watershed Stakeholders Group consisting of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed.

Plan Development Process

The watershed plan has been developed consistent with State and Federal guidance for the development of watershed-based plans. 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 plan consisted of the following major tasks.

- **Project Steering Committee and Watershed Stakeholders Group** – A project steering committee consisting of representatives from QRWA, CTDEEP, and EPA and a watershed stakeholders group, consisting of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed were formed to guide the plan development. A group of QRWA members and several other key stakeholders also formed an ad-hoc committee to interface with the CTDEEP and municipal leaders on a regular basis during development of the watershed plan.

- **State of the Watershed Assessment** – A baseline assessment was performed to update the information provided in the *2004 Quinnipiac Watershed Action Plan* and to develop an understanding of the current water resource conditions in the Quinnipiac River watershed. *Technical Memorandum #1: State of the Quinnipiac River Watershed* serves as a basis for the watershed plan recommendations and also provides a background reference document to support future implementation activities within the watershed.

- **Low Impact Development and Green Infrastructure Assessment** – A watershed assessment was performed to identify opportunities and develop concepts for site-specific Low Impact Development (LID) and green infrastructure retrofits. The site-specific project concepts are intended to serve as potential on-the-ground projects for future implementation 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 #2: Low Impact Development and Green Infrastructure Assessment.*

- **Plan Goals and Objectives** – The project team developed a series of goals and objectives for the watershed plan, building on the goals and objectives of the 2004 action plan and guided by the updated watershed assessments. The goals and objectives were further refined by the project steering committee and watershed stakeholders group and are presented in *Section 2* of this document.

- **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 stakeholders group through workshop meetings, culminating in the plan recommendations that are presented in this document.

- **Public Outreach** – Public outreach was conducted during the watershed planning process to increase public understanding of issues affecting the watershed and to encourage participation in the development of the watershed plan.

Watershed Management Goals

The watershed management goals for the Quinnipiac River watershed are:

- **Goal 1 – Capacity Building.** Build/strengthen capacity for successful implementation of the updated watershed plan by the watershed municipalities, non-governmental organizations (environmental groups and non-profits), residents, local businesses, and other stakeholders.

- **Goal 2 – Water Quality.** Improve the water quality of the Quinnipiac River and its tributaries so that impaired reaches of the river will consistently meet their designated uses for aquatic life, recreational use, and fish consumption, along with improving the downstream water bodies of New Haven Harbor and Long Island Sound. Protect and enhance the water quality of healthy water bodies (i.e., those that are not impaired).

- **Goal 3 – Habitat Protection and Restoration.** Protect and improve terrestrial, riparian, and aquatic habitat, including stream baseflow, in the watershed to maintain and increase the watershed's diversity of plant and animal species.

- **Goal 4 – Land Use and Public Access.** Encourage land use practices and policies that minimize adverse impacts on the Quinnipiac River watershed and increase public access to the Quinnipiac River and its tributaries for recreational and educational opportunities.

- **Goal 5 – Education and Outreach.** Promote stewardship of the Quinnipiac River watershed through education and outreach. Target appropriate messages to specific audiences, and promote stewardship opportunities through citizen involvement in science, conservation, and restoration activities.

Summary of Recommendations

A set of specific objectives and recommended actions were developed to satisfy the management goals for the watershed. The plan recommendations include watershed-wide recommendations that can be

implemented throughout the Quinnipiac River watershed, targeted recommendations that are tailored to issues within specific subwatersheds or areas, and site-specific recommendations to address issues at selected sites that were identified during the watershed field inventories. Recommendations are classified according to their timeframe and overall implementation priority.

- **Ongoing Actions** are actions that should occur annually or more frequently such as routine water quality monitoring, as well as actions that occur on an ongoing basis such as fundraising, education and outreach, and coordination between watershed stakeholders.

- **Short-Term Actions** are initial actions to be accomplished within the first one to 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. Such actions include adoption of the plan by the watershed municipalities and formation of a watershed organization; revising local land use regulations; outfall inventories and illicit discharge investigations; and stream walks to assess the condition of the streams and riparian corridors, identify retrofit opportunities and problem areas, and involve the public. Small demonstration projects could be completed during this phase, with volunteer service events. Construction of larger retrofits and restoration projects requiring extensive design, engineering, and permitting should be planned for later implementation.

- **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. Progress on land conservation, especially the protection of headwaters and unique landscapes, LID and green infrastructure implementation, and stream walk follow-up activities should be completed during this period, as well as project monitoring and tracking. A sustainable funding and maintenance program should also be established for watershed-wide green infrastructure programs and implementation of stormwater retrofits through regional collaboration.

- **Long-Term Actions** consist of continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed management plan. Long-term recommendations are intended to be completed between 5 and 10 years or longer after plan adoption. The feasibility of long-term project recommendations, many of which involve significant infrastructure improvements, depends upon the availability of sustainable funding programs and mechanisms.

Priority Actions for the Quinnipiac River Watershed

The actions in the following table are a subset of the overall recommendations that have been identified in this watershed management plan. These "priority" recommendations are actions that are most critical to the success of this watershed plan and will have the greatest benefit to water resource conditions in the watershed. The table lists the related plan goals and includes references to specific sections of the plan for more information on each recommendation.

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Priority Actions for the Quinnipiac River Watershed

Priority Action	Related Goal	For More Information
1. Adopt the plan through a formal agreement between the watershed municipalities and re-establish a formal watershed coalition or initiative such as the previous "Quinnipiac Watershed Partnership".	Capacity Building	Section 3.1.1
2. Seek funding for a watershed coordinator position.	Capacity Building	Section 3.1.1
3. Pursue grant funding and EPA Urban Waters designation.	Capacity Building	Section 3.1.2
4. Conduct stream walks and trackdown surveys, and prepare and implement subwatershed action plans for priority subwatersheds.	Capacity Building	Sections 3.1.4 and 3.1.5
5. Continue ongoing water quality (chemistry and biological assessments) monitoring in the watershed consistent with the bacteria TMDLs for the watershed,	Water Quality	Section 3.2.1
6. Eliminate the active CSO discharges within the Quinnipiac River watershed and reduce phosphorus loads from municipal Water Pollution Control Facilities through existing discharge permits and state-wide phosphorus reduction strategy.	Water Quality	Section 3.2.2
7. Strengthen municipal regulations to require upgrades to on-site sewage disposal systems.	Water Quality	Section 3.2.3
8. Implement the recommendations of the ongoing land use regulatory review for the watershed municipalities.	Water Quality Land Use	Section 3.2.4 Section 3.4.1
9. Require LID/GI for private development and municipal infrastructure.	Water Quality	Section 3.2.4
10. Pursue sustainable, long-term funding sources for municipal stormwater programs such as user fees, stormwater utility districts, infrastructure banking, public-private partnerships, etc.	Water Quality	Section 3.2.4
11. Implement priority stormwater retrofits.	Water Quality	Section 3.2.4 Section 4
12. Implement priority stream buffer and habitat restoration projects, and adopt local stream buffer regulations.	Water Quality Habitat	Section 3.2.6 Section 3.3.1
13. Implement improved illicit discharge detection and elimination programs with re-issued MS4 permit.	Water Quality	Section 3.2.8
14. Implement recommendations of the Trout Unlimited stream continuity survey for cold water fisheries. Evaluate the feasibility and cost of removing the remaining dams along the Quinnipiac River.	Habitat	Section 3.3.1
15. Develop an ecological master plan for the Quinnipiac River tidal marsh.	Habitat	Section 3.3.4
16. Evaluate possible restoration strategies for Hanover Pond.	Habitat	Section 3.3.5
17. Implement green infrastructure and other innovative techniques to address urban flooding problems in the watershed using an integrated, watershed-based approach.	Land Use	Section 3.4.2
18. Enhance recreational access to the Quinnipiac River along Lower Quinnipiac Canoeable Trail and Community Lake.	Land Use	Section 3.4.4
19. Enhance the QRWA website and continue targeted education/outreach programs for municipalities, businesses including residential builders, homeowners, and students.	Education and Outreach	Section 3.5

1 Introduction

1.1 Background

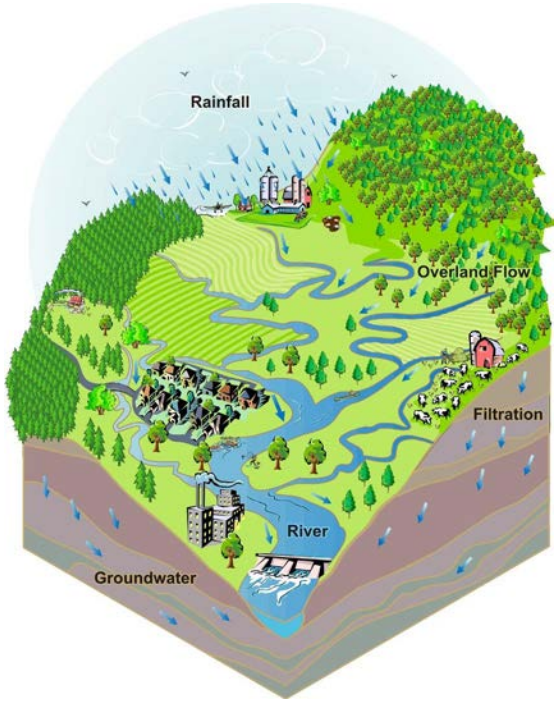
Watershed Overview

The Quinnipiac River watershed is an approximately 166 square-mile, urbanized watershed in south-central Connecticut (*Figure 1-1*). The watershed consists of nine primary subwatersheds, which drain via the Quinnipiac River and its major tributaries to Long Island Sound. The four largest subwatersheds are the Quinnipiac River main stem, Eightmile River, Tenmile River, and Muddy River.

What is a Watershed?

A watershed is the area of land that contributes runoff to a specific receiving water body such as a lake, river, stream, wetland, estuary, or bay.

The Quinnipiac River is the fourth largest river in Connecticut. Formed in a former glacial lakebed, the 38-mile Quinnipiac River originates in a 300-acre wetland called Deadwood Swamp on the border of Farmington and Plainville, and flows southward to its outlet at New Haven Harbor in Long Island Sound. The tidally-influenced river has nearly 913 acres of tidal marsh near its mouth on Long Island Sound. The total length of watercourses in the watershed is 522 miles, resulting in a stream network density of 3.1 miles of watercourse per square mile of watershed, which helps to explain the connection between water quality and land use in the watershed.



The watershed contains portions of eighteen municipalities and is home to over 200,000 people. The municipalities that comprise most of the land area and population in the watershed include Plainville, Cheshire, Meriden, North Haven, Southington, Wallingford, and New Haven. The Quinnipiac River watershed is located within a highly urbanized and developed area of the state. Interstate 91 and State Route 15 (Berlin Turnpike and Wilbur Cross Parkway) run north-south through the watershed, and Interstate 95 runs east-west through the southernmost portion of the watershed. Interstates 84 and 691 traverse the northern portions of the watershed (*Figure 2-2*). In addition to extensive residential and commercial development, several major industries and municipal wastewater treatment plants are also located in the watershed.

Issues Facing the Watershed

The Quinnipiac River, like many other urban rivers and streams in Connecticut, has been impacted by historical development and land use activities in its watershed. Although advances and upgrades in wastewater treatment have improved water quality over the past several decades, monitoring data indicate that the water quality of much of the Quinnipiac River and its tributaries (*Figure 1-3*) remains poor as a result of elevated levels of bacteria and impairments to aquatic life (CTDEEP, 2011).[1]

Nonpoint sources such as stormwater runoff from developed areas and impervious surfaces are major contributors of bacteria, sediment, and nutrients. Agriculture and historical contamination of industrial sites are other sources of ongoing nonpoint source pollution. Landfills, site clearance associated with development and redevelopment, baseflow depletion from groundwater withdrawals, impacts from flow regulation and modification, and municipal wastewater discharges are among other sources of water quality impairments in the watershed.

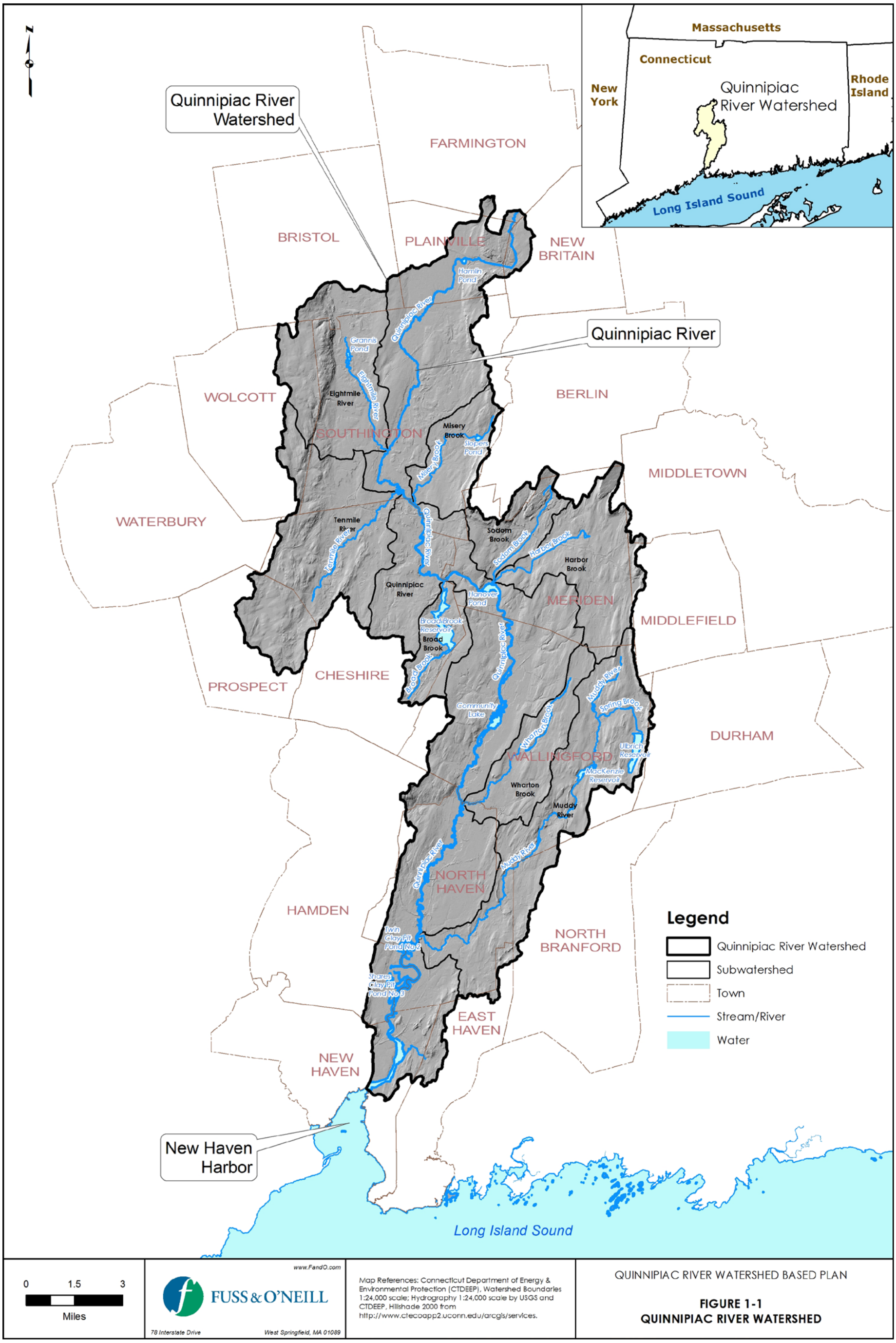
Historical and ongoing development in the watershed and other factors are also responsible for loss of important habitats including inland wetlands, tidal marsh, riparian corridors, and forested areas. The Quinnipiac River supports a variety of cold water and warm water fisheries and was once an important habitat for anadromous fish species. The Quinnipiac River has been identified as a high priority for anadromous fish restoration.

Quinnipiac River – Poor Water Quality

The water quality of the Quinnipiac River and its major tributaries is degraded due to elevated levels of bacteria and other pollutants resulting from wastewater treatment plants, industrial facilities, and nonpoint sources such as stormwater runoff from developed areas and impervious surfaces.

In 2008, the Connecticut Department of Environmental Protection (now called the Department of Energy and Environmental Protection) developed a Total Maximum Daily Load (TMDL) – essentially, a pollution budget - for indicator bacteria in the Quinnipiac River Regional Basin, including Harbor Brook, Misery Brook, Quinnipiac River, and Sodom Brook. The TMDL identified the reductions in indicator bacteria loads to each water body that are necessary for the water bodies to meet State water quality standards and once again support contact recreation. Point and nonpoint source stormwater runoff are the primary sources of indicator bacteria loadings identified in the TMDL.

[1] Not all segments of the Quinnipiac River or its tributaries have been assessed for uses such as support of aquatic life or recreation due to limited data; segments of the river that have not been formally assessed by the CTDEEP may also not meet Water Quality Standards.


Massachusetts
Connecticut
New York
Rhode Island
Quinnipiac River Watershed
Long Island Sound
Quinnipiac River Watershed
Quinnipiac River
New Haven Harbor
FARMINGTON
BRISTOL
PLAINVILLE
NEW BRITAIN
WOLCOTT
BERLIN
SOUTHINGTON
MIDDLETOWN
WATERBURY
MERIDEN
MIDDLEFIELD
PROSPECT
CHESHIRE
DURHAM
WALLINGFORD
HAMDEN
NORTH HAVEN
NORTH BRANFORD
EAST HAVEN
NEW HAVEN
Hamlin Pond
Grannis Pond
Eightmile River
Misery Brook
Slopers Pond
Tenmile River
Sodom Brook
Harbor Brook
Hanover Pond
Broad Brook Reservoir
Community Lake
Spring Brook
Ulbrich Reservoir
MacKenzie Reservoir
Twin Clay Pit Pond No 2
Shares Clay Pit Pond No 3
Legend
Quinnipiac River Watershed
Subwatershed
Town
Stream/River
Water
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Miles
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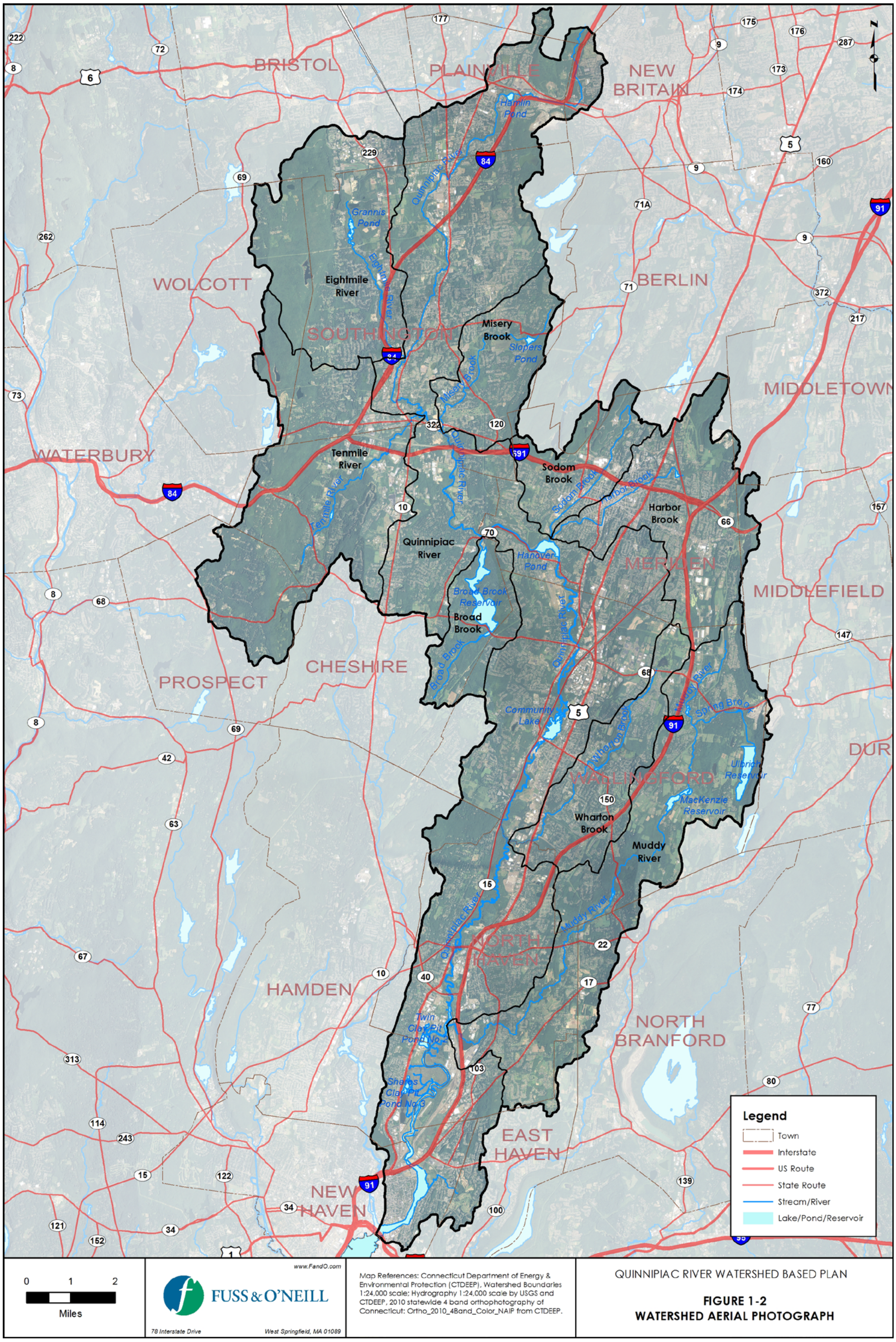
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Watershed Boundaries 1:24,000 scale; Hydrography 1:24,000 scale by USGS and CTDEEP, Hillshade 2000 from http://www.ctecoapp2.uconn.edu/arcgis/services.
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 1-1
QUINNIPIAC RIVER WATERSHED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SOUTHINGTON
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WATERBURY
MIDDLETOWN
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CHESHIRE
MERIDEN
MIDDLEFIELD
WALLINGFORD
DUR
HAMDEN
NORTH HAVEN
NORTH BRANFORD
EAST HAVEN
NEW HAVEN
Hamlin Pond
Quinnipiac River
Grannis Pond
Eightmile River
Eightmile River
Misery Brook
Sloopers Pond
Misery Brook
Tenmile River
Tenmile River
Quinnipiac River
Sodom Brook
Harbor Brook
Hanover Pond
Broad Brook Reservoir
Broad Brook
Quinnipiac River
Broad Brook
Community Lake
Wharton Brook
Muddy River
Spring Brook
Ulbrich Reservoir
MacKenzie Reservoir
Wharton Brook
Muddy River
Quinnipiac River
Muddy River
Twin Clay Pit Pond No. 2
Shares Clay Pit Pond No. 3
Eightmile River
Tenmile River
Quinnipiac River
Sodom Brook
Harbor Brook
Broad Brook
Wharton Brook
Muddy River
Legend
Town
Interstate
US Route
State Route
Stream/River
Lake/Pond/Reservoir
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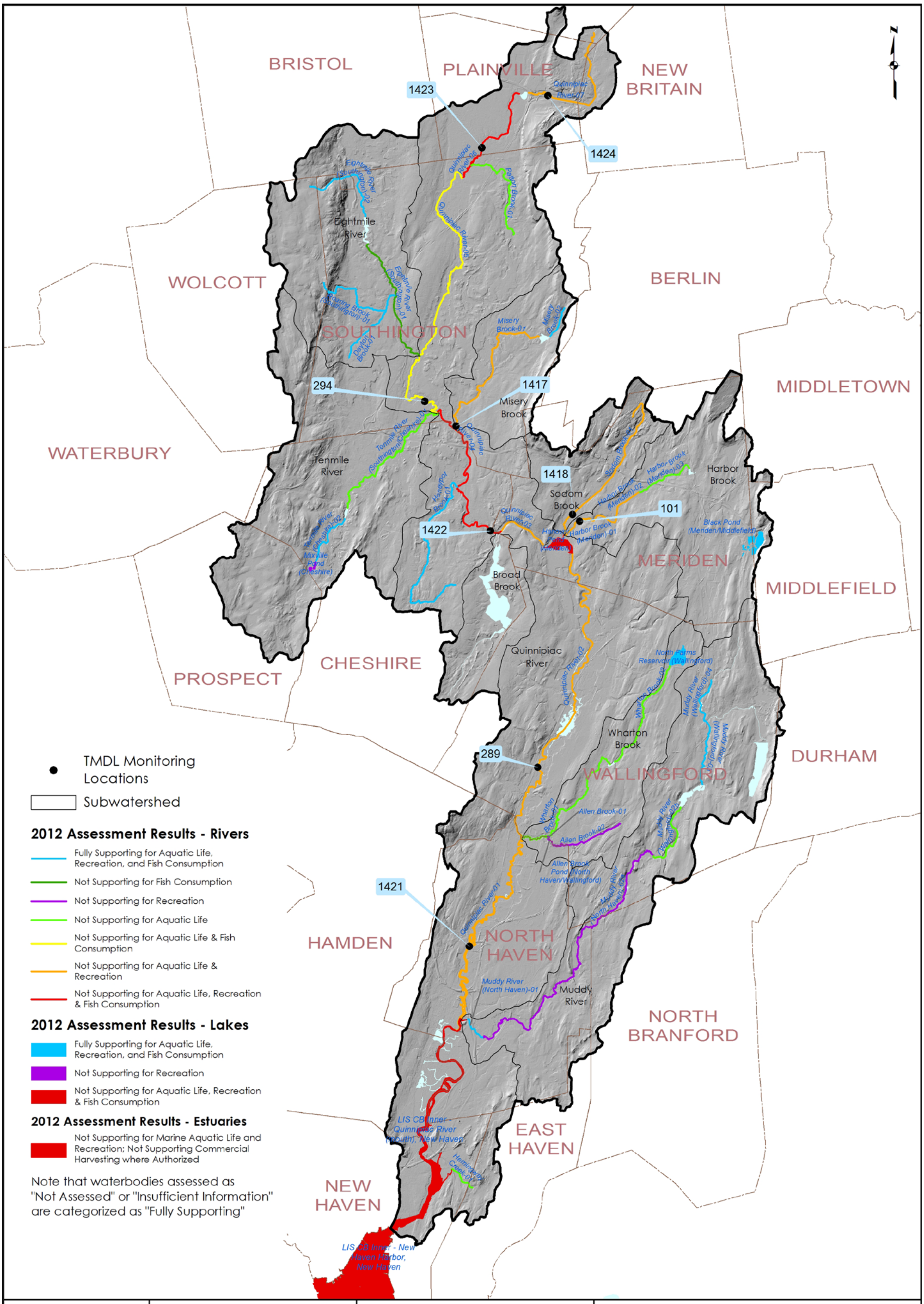
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Watershed Boundaries 1:24,000 scale; Hydrography 1:24,000 scale by USGS and CTDEEP, 2010 statewide 4 band orthophotography of Connecticut: Ortho_2010_4Band_Color_NAIP from CTDEEP.
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 1-2
WATERSHED AERIAL PHOTOGRAPH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NORTH HAVEN
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294
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101
289
1421
Eightmile River
Tenmile River
Misery Brook
Harbor Brook
Sodom Brook
Broad Brook
Quinnipiac River
Wharton Brook
Muddy River
Quinnipiac River-07
Quinnipiac River-06
Quinnipiac River-05
Quinnipiac River-04
Quinnipiac River-03
Quinnipiac River-02
Quinnipiac River-01
Eightmile River (Southington)-02
Eightmile River (Southington)-01
Pantry Brook-01
Misery Brook-01
Misery Brook-02
Roaring Brook (Southington)-01
Daylor Brook-01
Tenmile River (Southington/Cheshire)-01
Tenmile River (Cheshire)-02
Honeypot Brook-01
Harbor Brook (Meriden)-01
Harbor Brook (Meriden)-02
Harbor Brook (Meriden)-03
Sodom Brook-01
Mixville Pond (Cheshire)
Black Pond (Meriden/Middlefield)
North Farms Reservoir (Wallingford)
Muddy River (Wallingford)-01
Muddy River (Wallingford)-02
Muddy River (Wallingford)-03
Muddy River (Wallingford)-04
Wharton Brook-01
Wharton Brook-02
Allen Brook-01
Allen Brook-02
Allen Brook Pond (North Haven/Wallingford)
Muddy River (North Haven)-01
Muddy River (North Haven)-02
LIS CB Inner - Quinnipiac River (mouth), New Haven
Hemingway Creek-01
LIS CB Inner - New Haven Harbor, New Haven
TMDL Monitoring Locations
Subwatershed
2012 Assessment Results - Rivers
Fully Supporting for Aquatic Life, Recreation, and Fish Consumption
Not Supporting for Fish Consumption
Not Supporting for Recreation
Not Supporting for Aquatic Life
Not Supporting for Aquatic Life & Fish Consumption
Not Supporting for Aquatic Life & Recreation
Not Supporting for Aquatic Life, Recreation & Fish Consumption
2012 Assessment Results - Lakes
Fully Supporting for Aquatic Life, Recreation, and Fish Consumption
Not Supporting for Recreation
Not Supporting for Aquatic Life, Recreation & Fish Consumption
2012 Assessment Results - Estuaries
Not Supporting for Marine Aquatic Life and Recreation; Not Supporting Commercial Harvesting where Authorized
Note that waterbodies assessed as "Not Assessed" or "Insufficient Information" are categorized as "Fully Supporting"
0 1 2
Miles
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78 Interstate Drive West Springfield, MA 01089
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Watershed Boundaries 1:24,000 scale; Hydrography 1:24,000 scale by USGS and CTDEEP, "State of Connecticut Integrated Water Quality Report, Draft September 19, 2012.
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 1-3
WATER QUALITY IMPAIRMENTS

A primary focus of this watershed based plan is to address the poor water quality in the Quinnipiac River and its impaired tributaries in order to restore the recreation and aquatic life uses that have been lost due to degraded water quality. Similar to watershed based plans, TMDLs provide a quantitative framework to restore impaired waters by establishing the maximum amount of a pollutant that a water body can receive without adverse impact to aquatic life, recreation, or other public uses. For impaired waters, the TMDL also establishes pollutant load reduction targets for the water body to attain water quality standards.

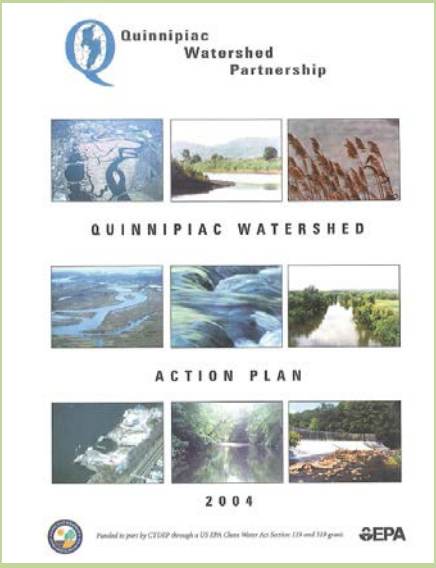
The Quinnipiac River Bacteria TMDL can be achieved by implementing specific actions that will reduce indicator bacterial loads using a watershed framework. This watershed based plan therefore provides a roadmap for implementing the TMDL. Ultimately, the goal of both the watershed based plan and the TMDL is to improve water quality of the impaired segments to meet water quality standards and remove the Quinnipiac River and its tributaries from the impaired waters list.

Portions of the Quinnipiac River watershed have a long history of flooding as a result of historical development of the watershed. Urban flooding is common in the more urbanized areas of the watershed where storm drainage systems are over-capacity during modest to intense storms. Riverine flooding is also a significant and frequent problem in some areas, particularly along Harbor Brook in Meriden from the area of Baldwin's Pond to Hanover Pond. The City of Meriden is implementing comprehensive flood control measures to address flooding along Harbor Brook. While water quality is the primary focus of this watershed based plan, flooding is also addressed as a related issue, along with habitat protection and restoration.

1.2 Prior Watershed Planning

The Quinnipiac River has been at the forefront of water pollution control activities in Connecticut since construction of the state's first sewage treatment plant in Meriden in 1891 (Tyrrell, 2001). The Quinnipiac River has been the focus of numerous studies and grass-roots watershed management and water quality improvement efforts over the years, led by the Quinnipiac River Watershed Association (QRWA), the Quinnipiac Watershed Partnership, university research groups, state and federal resource protection agencies, the watershed municipalities, and other local and regional groups. In 2004, the Quinnipiac Watershed Partnership developed the first comprehensive watershed management plan for the Quinnipiac River watershed, called the *Quinnipiac Watershed Action Plan*. The plan identified priority issues for the watershed and recommended actions to address them.

2004 Quinnipiac Watershed Action Plan



The 2004 *Quinnipiac Watershed Action Plan* integrated various studies, research projects, and planning efforts within the Quinnipiac River watershed dating back to the 1980s. The 2004 action plan reflected the major goals of the Quinnipiac Watershed Partnership, with planning recommendations organized around six work groups that focused on the following watershed issues – (1) Education and Outreach, (2) Habitat, (3) Land Use, (4) Tidal Marsh, (5) Water Allocation/Low Flow, and (6) Water Quality. Many of the recommendations identified in the 2004 action plan have been implemented, largely through the efforts of the Quinnipiac Watershed Partnership, QRWA, the watershed municipalities, and other stakeholder groups. *Table 1-1* summarizes the status of the major recommendations of the 2004 action plan.

2004 Action Plan – Major Accomplishments

- Municipal public works outreach and education
- Groundwater recharge/rain garden retrofit project with STS/CFE
- Grant-funded lower Quinnipiac Water Trail with 15 markers
- Increaed funding for phosphorus reduction legislation (increased grant to 50% for first 3 municipalities)
- Extensions of linear trails in Meriden and Wallingford
- Initiation of North Haven Trails Association
- Fishway installed at Wallace Dam
- Sign for Phase III Quinnipiac River Linear Trail (to be installed as part of Phase III)
- Urban River Stewardship signs installed at North Haven, Wallingford, and New Haven
- Marsh bird signs in design for New Haven Land Trust

Table 1-1. Status of the 2004 Action Plan Recommendations

Objective	Tasks/Recommendations	Status
Education and Outreach		
Objective 1: Expand the capacity of the Education and Outreach Working Group to assist other work groups.	Augment financial and human resources.	State/federal funding for Quinnipiac River watershed planning and implementation efforts has declined since the 2004 action plan. Human resources have also declined as the former Quinnipiac Watershed Partnership and work groups have dissolved. QRWA continues to lead watershed planning and implementation efforts in the watershed on a solely volunteer basis.
	Compile and categorize existing sources of educational material.	Existing sources of educational materials are available on the QRWA and www.thequinnipiacriver.com websites
Objective 2: Assist Habitat, Land Use, Tidal Marsh, and Water Quality work groups in their education and outreach tasks.	• Provide information on areas and habitat types of unique value and increase public knowledge of recreational opportunities related to the river. • Sponsor and/or publicize workshops and presentations on habitat, water quality (including MS4 regulations), regulations and open space acquisition. • Organize files of information resources relating to the restoration of impaired sites • Prepare restoration guidance packets for interested entities.	• QRWA stream buffer outreach and educational programming (e.g., buffer advocacy in Southington, public recognition program for cooperating landowners, and *Streamside Landowners' Guide to the Quinnipiac Greenway*). • Promoted Quinnipiac River Greenway • Municipal public works education and outreach • Safe lawns education and outreach campaign

Table 1-1. Status of the 2004 Action Plan Recommendations

Objective	Tasks/Recommendations	Status
Habitat		
Objective 1: Identify and publicize key habitat areas to be protected.	Identify key habitat areas in need of protection.	QRWA streamwalks conducted over a 5-year period, with a report generated in 2006. Areas of degraded habitat identified during streamwalks.
	Facilitate habitat protection initiatives in the watershed by disseminating information on key habitat areas and habitat types of unique value.	• Audubon Connecticut led a project to raise awareness among legislators, homeowners, and the general public about ways to reduce both non-point and point sources of pollution and to improve habitat for birds and other wildlife within the Quinnipiac River Watershed. • Biodiversity and Impacts of Drift Algae in New Haven Harbor study, University of New Haven, Department of Biology. • Landscape Structure & Dynamics in Lower Quinnipiac River Marshes, University of New Haven.
Objective 2: Identify and evaluate impaired sites for restoration.	• Compile existing information on degraded sites that would benefit from habitat restoration. • Review the preliminary annotated maps and fill in any information gaps. • Evaluate impaired sites for the feasibility and benefits of restoration, and produce a report on habitat restoration opportunities in the watershed.	QRWA streamwalks conducted over a 5-year period, with a report generated in 2006. Areas of degraded habitat identified during streamwalks.
Objective 3: Expand the capacity for implementing habitat protection and restoration projects.	• Recruit additional members for implementing the Habitat Action Plan. • Support implementation of habitat related projects through local capacity building, coordination, and technical assistance.	Fishway installed at Wallace Dam
Land Use		
Objective 1: Establish the Quinnipiac River Greenway.	• Determine and prioritize follow-up actions based on the Quinnipiac River Corridor Preservation - Recreation Action Plan. • Identify and secure additional access points and land acquisition opportunities along the river. • Coordinate efforts to promote the Quinnipiac River Greenway with the QRLTAC, CNVCOG, and the Trails Committee of SCRCOG. • Secure designation of the Quinnipiac River as a recreation corridor by the Connecticut Greenways Council.	The Quinnipiac River Greenway became a Connecticut Greenways Council Officially Designated Greenway in 2003 and the towns of New Haven, North Haven, Hamden, Wallingford, Cheshire, Meriden, Southington and Plainville have signed an inter-municipal compact which will provide public recreation, environmental education, and protection of natural resources in the Quinnipiac River watershed.
Objective 2: Prevent and Decrease Nonpoint Source Pollution.	Prevent further degradation from stormwater runoff by acquiring and/or requiring wide stream buffers and develop and facilitate land use strategies to prevent and decrease nonpoint source pollution.	QRWA stream buffer outreach and educational programming (e.g., buffer advocacy in Southington, public recognition program for cooperating landowners, and *Streamside Landowners' Guide to the Quinnipiac Greenway*).

Table 1-1. Status of the 2004 Action Plan Recommendations

Objective	Tasks/Recommendations	Status
Objective 3: Develop and facilitate the adoption of improved municipal regulations and ordinances for watershed protection.	Evaluate the regulatory tools for watershed protection in each municipality.	• Yale University conducted a regulatory review of the municipal land use policy and regulations of 10 Quinnipiac River watershed communities in 2002. • A similar review was undertaken by the Land Use Leadership Alliance in 2012 with a Quinnipiac River Fund grant. • The Mill River Watershed Association is conducting a regional review of local land use regulations and water discharge permits for municipalities in the Quinnipiac River, West River, and Mill River watersheds.
Objective 4: Increase public access for recreational and educational use of the river.	• Determine and prioritize follow-up actions based on the Quinnipiac River Corridor • Preservation - Recreation Action Plan. • Develop additional access points to and along the river.	• Grant-funded lower Quinnipiac Water Trail with 15 markers • Extensions of linear trails in Meriden and Wallingford • Initiation of North Haven Trails Association • Sign for Phase III QRLT (to be installed as part of Phase III) • Urban River Stewardship signs installed at North Haven, Wallingford, and New Haven • Marsh bird signs in design for New Haven Land Trust (IBA) • North Haven Trail Association is researching private property land titles and negotiating easements with property owners to continue trail through their land
Tidal Marsh		
Objective 1: Preserve and improve wildlife habitat.	• Monitor proposed development adjacent to the Quinnipiac tidal marsh in an effort to prevent adverse impacts to wildlife habitat. • Produce annotated maps and supporting documentation for the Quinnipiac tidal marsh. • Provide the data necessary to secure listing of the Quinnipiac marsh in the Important Bird Area (IBA) Program of the National Audubon Society. • Promote habitat restoration and remediation projects. • Formulate model ordinances, regulations, and practices for tidal marsh protection in New Haven, Hamden and North Haven.	• Quinnipiac River Tidal Marsh was listed as an Important Bird Area by the National Audubon Society in 2008. • 2002, 2012, and ongoing land use regulatory reviews • North Haven Trail Association is researching private property land titles and negotiating easements with property owners to continue trail through their land • Ongoing research by Yale University
Objective 2: Remove threats to the marsh from contamination and toxic materials.	• Work with CTDEEP and the mayors, selectman, town planners and agencies in New Haven, Hamden and North Haven to promote the enforcement and monitoring of remediation practices. • Meet with the management and staff of the Attorney General, CTDEP, and EPA, and brief them on marsh issues.	• Yale University has an ongoing study monitoring the Quinnipiac tidal marshes to support monitoring of sediment accretion, elevation change, and sea level rise. • Landscape Structure & Dynamics in Lower Quinnipiac River Marshes, University of New Haven • Elevation Change & Toxic Organics in the Quinnipiac Tidal Marshes, Yale University

Table 1-1. Status of the 2004 Action Plan Recommendations

Objective	Tasks/Recommendations	Status
Objective 3: Improve public access to the marsh for recreation and education.	Work with governmental, not-for-profit and private agencies, and local businesses to promote the construction of walkways, boardwalks, and observation platforms which are accessible to the public	• Urban River Stewardship signs installed at North Haven, Wallingford, and New Haven • Marsh bird signs in design for New Haven Land Trust
Objective 4: Inform the public and municipal officials about the marsh and its value to our communities.	• Develop public information materials showing the current marsh and its uses over time. • Conduct combination driving and walking tours of the Quinnipiac tidal marsh. • Maintain contacts and hold meetings with marsh stakeholders.	Informational materials developed and tours conducted
Water Allocation/Low Flow		
Objective 1: Assist CTDEEP and other state agencies with the content and design of a water diversion report form.	Provide a forum for CTDEEP to obtain input from stakeholders on the development of a reporting form.	• In 2011, the final Connecticut Stream Flow Standards and Regulations were adopted for maintaining minimum flows in rivers and streams. • Quinnipiac River Watershed Groundwater Restoration Project (ongoing)
Objective 2: Offer, and provide, assistance to the Water Planning Council to help them accomplish their mission mandated by the legislature.	Provide assistance to the Water Planning Council	
Objective 3: Complete the initial planning for a water budget pilot study in one or more subwatersheds in the Quinnipiac Watershed	• Establish the scope of the pilot study, and determine whether sufficient data are available to produce a first approximation of a water budget. • Determine the availability of data necessary to conduct a water budget pilot study in a limited number of subwatersheds.	
Water Quality		
Objective 1: Evaluate water quality data and trends and make this information available for action in terms of public education and changes to municipal regulations, policies, and procedures.	• Review of existing data and organize a GIS database format for the available data. • Make this data and analysis available to other work groups and partners.	Water quality analysis and database compilation now completed.
Objective 2: Establish a clearinghouse for water quality information for the Partnership and the public in the watershed.	Establish a clearinghouse	Not Completed

1.3 The Need for an Updated Watershed Based Plan

Water quality in the Quinnipiac River watershed has benefitted from state and federal regulatory requirements to reduce point source pollution, efforts to restore impacted wetlands and other resource areas of the watershed, and the work of grassroots environmental advocacy groups to protect and restore the watershed through education, conservation, and recreation programs. As described in the previous section, many of the 2004 *Quinnipiac Watershed Action Plan* recommendations have been implemented. Despite these accomplishments, the legacy of water quality problems remains as evidenced by the current impairments in the Quinnipiac River, its tributaries, and other water bodies in the watershed.

Since the previous *Quinnipiac Watershed Action Plan* was developed in 2004, EPA and CTDEEP have issued watershed planning guidance for impaired water bodies, placing greater emphasis on achieving quantifiable pollutant load reductions and water quality improvements through specific, measurable actions. This updated EPA and CTDEEP watershed planning process is also the recommended approach for achieving the pollutant load reductions outlined in the 2008 Quinnipiac River Bacteria TMDL.

The QRWA, CTDEEP and EPA recognize the need for an updated watershed management plan for the Quinnipiac River to address the remaining water quality issues of the Quinnipiac and its tributaries. Specifically, the reasons for updating the 2004 action plan are to:

- Update the 2004 plan recommendations to reflect current and emerging approaches for nonpoint source pollution management, building upon the previous 2004 action plan goals and recommendations
- Satisfy current EPA and CTDEEP required elements for watershed-based plans
- Incorporate various ongoing watershed stewardship efforts
- Incorporate water quality data collected since 2004 including the 2008 Quinnipiac River Bacteria TMDL
- Facilitate capacity building and re-engage the watershed municipalities
- Prioritize water bodies and implementation projects to reduce pollutant loads in the watershed
- Ultimately improve water quality and delist the impaired segments of the Quinnipiac River and its tributaries.

The QRWA worked collaboratively with the CTDEEP, EPA, the watershed municipalities, regional planning agencies, and other stakeholders to develop an updated, watershed based plan for the Quinnipiac River (referred to hereafter as the "Quinnipiac River Watershed Based Plan"). This project was funded in part by the CTDEEP through an EPA Section 319 Nonpoint Source Grant, as well as by The Community Foundation for Greater New Haven through the Quinnipiac River Fund. Fuss & O'Neill, Inc. was retained to lead the development of the watershed based plan, working with a Project Steering Committee (QRWA, CTDEEP, and EPA) and a Watershed Stakeholders Group consisting of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed.

1.4 Plan Development Process

This watershed plan is the culmination of desktop analyses and field assessments performed by the project team under the direction of the Project Steering Committee and with input from the Watershed Stakeholders Group. The plan synthesizes information and recommendations from the 2004 action plan and earlier studies on the watershed, updated Geographical Information System (GIS) mapping and analyses, and a field assessment of current restoration opportunities in the watershed.

EPA Nine Key Elements

1. Impairment
2. Load Reduction
3. Management Measures
4. Technical & Financial Assistance
5. Public Information & Education
6. Schedule
7. Milestones
8. Performance Criteria
9. Monitoring

The watershed plan has been developed consistent with EPA and CTDEEP guidance for the development of watershed-based plans. The guidance outlines nine key elements 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 major tasks.

- **Project Steering Committee and Watershed Stakeholders Group** – A project steering committee consisting of representatives from QRWA, CTDEEP, and EPA and a watershed stakeholders group, consisting of representatives from the watershed municipalities, government organizations, educational institutions, non-profit organizations, and others who live and work within the watershed were formed to guide the plan development. A group of QRWA members and several other key stakeholders also formed an ad-hoc committee to interface with the CTDEEP and municipal leaders on a regular basis during development of the watershed plan.

  A series of workshop meetings were held with the watershed stakeholders group to reach consensus on watershed planning goals and objectives and to discuss specific recommended actions. The steering committee and the stakeholders group guided the plan development process by providing review comments on draft deliverables. The watershed plan reflects the combined efforts of the QRWA, watershed municipalities, CTDEEP, other stakeholders, and the Fuss & O'Neill project team. Members of the project steering committee (including ad-hoc committee), stakeholders group, and other individuals involved in the plan development process are listed in the Acknowledgments section at the beginning of this document.

- **State of the Watershed Assessment –** A baseline assessment was performed to update the information provided in the *2004 Quinnipiac Watershed Action Plan* and to develop an understanding of the current water resource conditions in the Quinnipiac River watershed. The project team reviewed existing watershed data, studies, and reports; compiled and analyzed GIS

mapping of the watershed and various subwatersheds; and developed pollutant loading and impervious cover estimates for the watershed. *Technical Memorandum #1: State of the Quinnipiac River Watershed* 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 on CD in *Appendix A* of this plan.

- **Low Impact Development and Green Infrastructure Assessment** – A watershed assessment was performed to identify opportunities and develop concepts for site-specific Low Impact Development (LID) and green infrastructure retrofits. The site-specific project concepts are intended to serve as potential on-the-ground projects for future implementation 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 #2: Low Impact Development and Green Infrastructure Assessment.* A copy of the technical memorandum is also provided on CD in *Appendix A* of this plan.

- **Plan Goals and Objectives** – The project team developed a series of goals and objectives for the watershed plan, building on the goals and objectives of the 2004 action plan and guided by the updated watershed assessments. The goals and objectives were further refined by the project steering committee and watershed stakeholders group and are presented in *Section 2* of this document.

- **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 stakeholders group through workshop meetings, culminating in the plan recommendations that are presented in *Section 3* of this document. Management actions include ongoing, short, medium and long-term recommendation, as well as watershed-wide and site-specific actions.

1.5 Public Outreach

Public outreach was conducted during the watershed planning process to increase public understanding of issues affecting the watershed and to encourage participation in the development of the updated watershed plan. The following public outreach activities occurred during the watershed planning process:

- **August/September 2012 –** A project steering committee was formed, consisting of representatives from QRWA, CTDEEP, and EPA. A watershed stakeholders group was also formed, consisting of representatives from the watershed municipalities, government organizations, educational institutions, and non-profit organizations, including several individuals who had been involved in the development of the 2004 action plan. Specific groups that were formally invited to participate in the watershed plan update process included:
    - Municipal liaisons for each of the watershed municipalities
    - South Central Regional Council of Governments
    - Central Connecticut Regional Planning Agency
    - Council of Governments of the Central Naugatuck Valley

- Southwest Conservation District
- Connecticut Nonpoint Education for Municipal Officials (NEMO)
- Connecticut Fund for the Environment/Save the Sound
- United States Geologic Survey (USGS) (East Hartford, CT office)
- USDA, Natural Resources Conservation Service (NRCS)
- South Central Connecticut Regional Water Authority
- Trout Unlimited
- Yale University (School of Forestry and Environmental Studies)
- University of New Haven
- Industry representative(s) (3M, Cytec Industries, CBIA, etc.)

- **November 2012** – An initial stakeholders meeting was held on November 29, 2012 at the QRWA Headquarters building in Meriden. The purpose of the meeting was to present the project objectives and to review baseline watershed conditions. A watershed questionnaire was circulated to the stakeholders at this meeting to identify issues of concern and watershed planning priorities. Questionnaire responses are included in *Appendix B*.

- **July 2013 –** Two public workshop meetings were held on July 23, 2013 at the QRWA Headquarters building in Meriden. The workshops consisted of a presentation on the current watershed conditions and major issues facing the Quinnipiac River watershed, followed by group discussion of local issues of importance and desired outcomes of the watershed planning process.

- **November 2013** - A second stakeholders meeting was held on November 6, 2013 at the QRWA Headquarters building in Meriden. The purpose of the meeting was to review the findings and recommendations of the Low Impact Development and Green Infrastructure Assessment, and to review the proposed watershed plan goals, objectives, and action items.

- **December 2013** – The watershed plan was presented to the public at the QRWA Headquarters building on December 4, 2013. Questions and comments were received during and following the meeting. Public comments have been incorporated into the final watershed based plan.

- **QRWA Ad-hoc Committee Meetings** – Meetings between the QRWA Ad-hoc Committee, CTDEEP, and municipal leaders were held on a monthly or bi-monthly basis between November 2012 and the spring of 2013 to help guide development of the watershed plan priorities and recommendations.

2 Watershed Management Goals and Objectives

This section presents overall management goals for the watershed and specific objectives to achieve these goals. The goals and objectives were developed in conjunction with the project steering committee, building on the previous goals and objectives in the 2004 action plan. These updated goals and objectives reflect specific priorities identified by the watershed stakeholders based upon the watershed assessments and plan update process. Recommended actions to achieve these goals and objectives are presented in *Section 3* of this plan.

2.1 Watershed Management Goals

The watershed management goals for the Quinnipiac River watershed are:

- **Goal 1 – Capacity Building.** Build/strengthen capacity for successful implementation of the updated watershed plan by the watershed municipalities, non-governmental organizations (environmental groups and non-profits), residents, local businesses, and other stakeholders.

- **Goal 2 – Water Quality.** Improve the water quality of the Quinnipiac River and its tributaries so that impaired reaches of the river will consistently meet their designated uses for aquatic life, recreational use, and fish consumption, along with improving the downstream water bodies of New Haven Harbor and Long Island Sound. Protect and enhance the water quality of healthy water bodies (i.e., those that are not impaired).

- **Goal 3 – Habitat Protection and Restoration.** Protect and improve terrestrial, riparian, and aquatic habitat, including identified critical habitats and stream baseflow, in the watershed to maintain and increase the watershed's diversity of plant and animal species.

- **Goal 4 – Land Use and Public Access.** Encourage land use practices and policies that minimize adverse impacts on the Quinnipiac River watershed and increase public access to the Quinnipiac River and its tributaries for recreational and educational opportunities.

- **Goal 5 – Education and Outreach.** Promote stewardship of the Quinnipiac River watershed through education and outreach. Target appropriate messages to specific audiences, and promote stewardship opportunities through citizen involvement in science, conservation, and restoration activities.

2.2 Watershed Management Objectives

Specific objectives associated with the watershed management goals are described below. Recommended management strategies to achieve the plan objectives, including implementation priority, schedule, costs, funding sources, and implementation responsibilities, are presented in later sections of this plan.

2.2.1 Goal 1 – Capacity Building

- **Objective 1-1.** Promote inter-municipal coordination to formally adopt the watershed plan and coordinate and oversee watershed management plan implementation activities.
- **Objective 1-2.** Identify and secure funding to implement the recommendations outlined in this plan.
- **Objective 1-3.** Promote regional collaboration with other watershed organizations in Connecticut and around Long Island Sound to share ideas and strengthen regional watershed management efforts.
- **Objective 1-4.** Conduct stream walks 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.
- **Objective 1-5.** Prepare and implement subwatershed action plans for priority subwatersheds.

2.2.2 Goal 2 - Water Quality

- **Objective 2-1.** Continue water quality monitoring programs to identify pollution sources, follow long-term trends in water quality, and track the progress of the watershed based plan.
- **Objective 2-2.** Reduce or eliminate existing regulated point source discharges to the Quinnipiac River.
- **Objective 2-3.** Reduce the impacts of subsurface sewage disposal systems.
- **Objective 2-4.** Reduce the impacts of stormwater on hydrology and water quality through the use of Low Impact Development (LID) practices and Green Infrastructure approaches.
- **Objective 2-5.** Implement municipal stormwater management programs to comply with state and federal permit requirements.
- **Objective 2-6.** Protect existing and restore degraded riparian buffers.
- **Objective 2-7.** Reduce bacteria loads from nuisance waterfowl and pet waste.

- **Objective 2-8.** Identify and remove illicit wastewater and non-stormwater discharges into the Quinnipiac River and its tributaries.

- **Objective 2-9.** Promote good lawn care practices to reduce the use of water, fertilizer, and toxic chemicals.

- **Objective 2-10.** Reduce the threats to water quality from land uses with higher pollution potential and hotspot sites.

2.2.3 Goal 3 – Habitat Protection and Restoration

- **Objective 3-1.** Protect and restore in-stream and riparian habitat, including stream baseflow, along the Quinnipiac River, its tributaries, and the Quinnipiac River tidal marsh.

- **Objective 3-2.** Protect and restore forested areas and urban tree canopy within the watershed.

- **Objective 3-3.** Locate, control or diminish the prevalence of invasive species.

- **Objective 3-4.** Investigate, protect, and restore the Quinnipiac River tidal marsh and estuary.

- **Objective 3-5.** Restore water quality, aquatic habitat, and recreational opportunities in Hanover Pond.

2.2.4 Goal 4 – Land Use and Public Access

- **Objective 4-1.** Strengthen municipal land use policy and regulations.

- **Objective 4-2.** Address flooding issues through a watershed approach.

- **Objective 4-3.** Preserve and protect existing open space and continue to protect/acquire open space that meets resource protection and recreational goals in concert with development and redevelopment efforts within the watershed.

- **Objective 4-4.** Increase public access to the river corridor to improve public use, appreciation, and stewardship.

2.2.5 Goal 5 – Education and Outreach

- **Objective 5-1.** Consolidate and improve access to publicly-available resources about the Quinnipiac River.

- **Objective 5-2.** Advance local government and community business awareness of the Quinnipiac River through pollution prevention education and watershed restoration outreach activities.

- **Objective 5-3.** Build awareness of land stewardship and management practices and reduce nonpoint source impacts in residential areas.

- **Objective 5-4.** Enhance school education and stewardship programs.

3 Plan Recommendations

This section describes recommended actions to meet the watershed management goals and objectives outlined in *Section 2*. The recommendations include watershed-wide and targeted actions:

- **Watershed-wide Recommendations** are those recommendations that can be implemented throughout the Quinnipiac River watershed. These basic measures can be implemented in each of the watershed municipalities, are applicable in most areas of the watershed, and are intended to address nonpoint source pollution through municipal land use regulations and planning, green infrastructure and Low Impact Development, public education and outreach, urban watershed forestry, and watershed monitoring. The water quality and natural resource benefits of these measures are primarily long-term and cumulative in nature resulting from runoff reduction, source control, pollution prevention, and improved stormwater management for new development and redevelopment projects.

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

Site-specific watershed retrofit and restoration concepts are described in *Section 4* of this plan. Due to the large size of the overall Quinnipiac River watershed, additional targeted watershed assessment and planning is recommended for various subwatersheds to further characterize current conditions within specific reaches of the Quinnipiac River, its tributaries, and upland areas of the subwatersheds, with the goal of developing additional site-specific projects and action plans for each subwatershed. Implementation of site-specific actions is more effective at the subwatershed scale for large watersheds such as the Quinnipiac.

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

- **Ongoing Actions** are actions that should occur annually or more frequently such as routine water quality monitoring, as well as actions that occur on an ongoing basis such as fundraising, education and outreach, and coordination between watershed stakeholders.

- **Short-Term Actions** are initial actions to be accomplished within the first one to 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. Such actions include adoption of the plan by the watershed municipalities and formation of a watershed organization; revising local land use regulations; outfall inventories and illicit discharge investigations; and stream walks to assess the condition of the streams and riparian corridors, identify retrofit opportunities and problem areas, and involve the public. Small

demonstration projects could be completed during this phase, with volunteer service events. Construction of larger retrofits and restoration projects requiring extensive design, engineering, and permitting should be planned for later implementation.

- **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. Progress on land conservation, especially the protection of headwaters and unique landscapes, LID and green infrastructure implementation, and stream walk follow-up activities should be completed during this period, as well as project monitoring and tracking. A sustainable funding and maintenance program should also be established for watershed-wide green infrastructure programs and implementation of stormwater retrofits through regional collaboration.

- **Long-Term Actions** consist of continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed management plan. Long-term recommendations are intended to be completed between 5 and 10 years or longer after plan adoption. The feasibility of long-term project recommendations, 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 management plan. The recommended actions are categorized according to the five major goals of this plan – (1) capacity building, (2) water quality, (3) habitat protection and restoration, (4) land use and public access, and (5) education and outreach.

3.1 Capacity Building

Goal Statement: Build/strengthen capacity for successful implementation of the updated watershed plan by the watershed municipalities, non-governmental organizations (environmental groups and non-profits), residents, local businesses, and other stakeholders.

3.1.1 Promote Inter-Municipal Coordination

The success of the watershed management plan will depend on local adoption of the plan and active participation by the individual watershed municipalities, as well as cooperation between the municipalities during implementation. Many of the recommendations in this watershed management plan can benefit from a partnership among the watershed municipalities. 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 management plan by the watershed municipalities is an important first step in implementing the plan recommendations. During the planning process, the project steering committee and watershed stakeholders group provided

direction and local knowledge of the watershed in guiding the watershed assessments, determining priorities, and developing the watershed management recommendations. As the focus of the planning process moves towards implementation, the QRWA should seek to re-establish a formal watershed coalition or initiative such as the previous "Quinnipiac Watershed Partnership" to oversee implementation of the updated watershed plan.

Recommended Actions

- QRWA should seek adoption of the updated 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.

- QRWA should seek to re-establish a formal watershed coalition or initiative such as the previous "Quinnipiac Watershed Partnership" (or other successful watershed groups such as the Norwalk River Initiative and Pequonnock River Initiative) for the specific purpose of implementing the updated watershed plan. The organization should include representatives from regional, state, federal and local environmental organizations, businesses, institutions (e.g. Yale University, University of Connecticut, University of New Haven, Quinnipiac University, etc.), neighborhood groups, interested members of the public, and the watershed municipalities. The watershed coalition or initiative could be led or served by the QRWA, which currently provides a project website and administrative support for watershed protection efforts in the Quinnipiac.

- Re-establish subcommittees for implementation of the major goals of the watershed plan (Water Quality, Habitat Protection and Restoration, Land Use and Public Access, and Education and Outreach), similar to the previous Quinnipiac Watershed Partnership work groups.

- QRWA has limited capacity to implement the watershed plan without a funded watershed coordinator position. Secure funding for and hire a watershed coordinator to coordinate and oversee watershed management plan implementation activities such as:
    - Coordinating the efforts of the subcommittees or work groups.
    - Identifying funding sources, as well as pursuing grant funding for projects identified in the watershed plan.
    - 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.

3.1.2 Identify and Secure 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 based plan (see *Section 6*). High priority funding sources that QRWA should continue to reach out to include:
    - Community Foundation for Greater New Haven
    - Quinnipiac River Fund
    - Cuno Foundation
    - Meriden Foundation
    - Save the Sound/Connecticut Fund for the Environment
    - National Fish and Wildlife Foundation
    - CTDEEP/EPA
- Prepare and submit grant applications for projects identified in this plan on an ongoing basis.
- Each watershed community should seek its own funding for various projects.
- 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 Connecticut and around Long Island Sound.
- Pursue EPA designation of the Quinnipiac River watershed as an eligible geographic location (co-located with 18 existing Urban Waters Federal Partnership locations nation-wide) under the EPA Urban Waters Small Grants program. At some point in the future, eligible geographic location/Federal Partnership designation wil be re-evaluated by EPA.

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 can help to improve the effectiveness of this watershed based plan. This objective is to strengthen coordination of water quality planning activities with other watershed organizations to share ideas and strengthen regional watershed management efforts.

Recommended Actions

- Engage and involve the following local, state, and regional organizations with an interest in the Quinnipiac River watershed:

Local Groups	Regional Planning Agencies	Statewide Environmental Organizations
Meriden Linear Trail Committee New Haven Bird Club New Haven Environmental Justice Network	Central CT Regional Planning Agency South Central Regional Council of Government	CT Audubon Society The Nature Conservancy CT Forest and Park Association Trout Unlimited

Local Groups	Regional Planning Agencies	Statewide Environmental Organizations
Quinnipiac Audubon Society Conservation Commissions & Inland/Wetland Commissions Local Land Trusts Local Conservation Trusts	Council of Governments of the Central Naugatuck Valley	CTDEEP CT Coalition for Environmental Justice The Sierra Club Appalachian Mountain Club Bikewalk CT Solar Youth Conservation Districts CT NRCS

- Facilitate broad support of the plan from public and private economic and business sectors in the watershed.
- CTDEEP is in the process of updating the Connecticut Nonpoint Source Management Program Plan consistent with revised EPA Section 319 guidance. The revised plan will provide success stories and sources of information on current and emerging nonpoint source pollution management approaches, many of which could be applicable to the Quinnipiac River watershed based plan implementation.

3.1.4 Conduct Updated Stream Walks

Visual stream assessments or stream walks are an easy-to-use 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. Stream walks also provide an ideal opportunity to involve the public and volunteers as a form of outreach.

Formal visual stream assessments were last conducted in the Quinnipiac River watershed between approximately 2001 and 2006, the results of which are documented in the 2006 report *Quinnipiac River NPS Pollution Survey Phase 3* (QRWA, 2006). QRWA worked with NRCS to select representative sections of the watershed for assessment, recruited and trained volunteers, conducted stream walks, compiled the data into a usable database, conducted follow-up site visits where necessary, and initiated an education and outreach campaign. The previous QRWA and NRCS stream walks focused on the Eightmile River, Muddy River, Harbor Brook, Wharton Brook, Meetinghouse Brook, and Pine Brook, attempting to cover these subwatersheds in their entirety.

As reported in the *Quinnipiac River NPS Pollution Survey Phase 3* (QRWA, 2006), although the data generated by the previous stream walks was limited in its rigor and representativeness due to the variability in the observational and reporting skills of the volunteers, the stream walks proved to be a valuable educational and outreach tool and helped to identify areas of concern and problems on which to focus conservation efforts. The major areas of concern and problems identified by the previous stream walks are summarized in *Table 3-1*, including initial survey findings by volunteers and confirmed areas of concern by more experienced agency staff and volunteers during follow-up site visits.

Table 3-1. Summary of Findings of Previous Quinnipiac River Watershed Stream Walks (QRWA, 2006)

Subwatershed	Key Findings
Eightmile River (12 units out of 12 surveyed in 37 segments)	**Initial Survey Findings:** Eightmile River and its tributaries flow through suburban, rural and natural areas and seem to be in relatively good shape. Discharge pipes with associated discharge were reported with significantly higher frequency than any other potential impairment. Visually impaired water and excess algae, followed by channelization/channel manipulation, barriers to fish passage and impoundments, and then by exposed stream banks and insufficient buffers were reported with descending frequency. **Confirmed Areas of Concern:** The major areas of concern appear to be near the golf course north of Grannis Pond, and around North and South branches of Hamlin Brook. The golf course is associated with lawns, insufficient buffer, excess algae, discharge pipes with outflow, trash and oil. The brooks have sections of lawn and insufficient buffer, excess algae near a farm on the south branch, and dumping on the north branch.
Muddy River (7 units out of 7 surveyed in 27 segments)	**Initial Survey Findings:** Excess algae was reported with the highest frequency for the Muddy River watershed, followed by insufficient buffers and impoundments. **Confirmed Areas of Concern:** Impoundments include the dams forming McKenzie and Spring Brook Reservoirs, Spring Lake and Scards Pond. Eightmile Brook is impacted by the farmland through which it flows, and sediment buildup was reported by a stormwater outfall. On the Muddy River south of McKenzie Reservoir the walkers reported a high volume of bulk trash. Heavy illegal dumping was reported near Spring Lake. Insufficient buffers, often associated with lawn were confirmed at sites along the north (where the Muddy flows along Interstate 91), central and southern reaches of the Muddy River.
Wharton Brook (15 units out of 18 surveyed in 55 segments)	**Initial Survey Findings:** Wharton Brook flows through a much more urban portion of the Quinnipiac watershed than do Eightmile and Muddy Rivers. The most frequently reported concerns here were discharge pipes with associated outflow, followed by excess algae and exposed streambanks. Insufficient buffers, lawns and illegal dumping were also reported several times. **Confirmed Areas of Concern:** Insufficient streamside buffers appear to be a real issue in this subwatershed, typically associated with lawns. Upper Wharton Brook appeared to be in better condition than first reported. Possible explanations include the difference in volunteer experience - the follow-up walker is an experienced outdoorsman, unlike the initial surveyor - and climatic variation - the first survey was performed during a drought, and the follow-up completed during a relatively wet year. Farther downstream, erosion from a high bank near East Main Street suggests a bank stabilization project may be needed, and there was plenty of trash in this middle section of the Brook. The second look at Caitlin Brook confirmed the oil oozing from the left bank upstream of the pump house and the sewage smell. Allen Brook is impacted by Interstate 91 and a golf course.
Harbor Brook (9 out of 13 units surveyed in 23 segments)	**Initial Survey Findings:** Stream channelization and manipulation was reported much more frequently than any other problem, followed by lawns along the waterways and impoundments to flow, than by algae, dumping and notable discharge through pipes. **Confirmed Areas of Concern:** Lawns do appear to describe the biggest concern, aligned however with insufficient riparian buffers. Stream channelization, other than culverts under roadways, and the problem of downtown Meriden (which we did not bother to assign, as the entire river goes underground beneath downtown) was reported as a major concern where Harbor Brook runs through an artificially lined channel in Meriden's Brookside Park. Impoundments to flow and excess algae were also reported across the watershed. The surveyor reported an illegal diversion east of

Table 3-1. Summary of Findings of Previous Quinnipiac River Watershed Stream Walks (QRWA, 2006)

Subwatershed	Key Findings
	Black Pond, with no associated streamside pond.
Meetinghouse Brook (2 units out of 5 surveyed in 4 segments)	**Initial Survey Findings:** Channelization and manipulation were closely followed by fish barriers. Here, reports of fish barriers outnumbered those of impoundments because a natural looking ledge or dam was not reported as a barrier to fish movement. Discharge pipes with visible outflow, barriers to fish passage and excessive algae followed. In this basin, nearly all discharge pipes were reportedly associated with notable discharge. **Confirmed Areas of Concern:** Channel manipulation, impoundments/barriers to fish passage and discharge pipes were confirmed as the most significant concerns, as was insufficient buffer and illegal dumping. To a lesser extent, algae and erosion were noted.
Pine Brook (1 unit out of 1 surveyed in five segments)	**Initial Survey Findings:** Pine Brook flows a short distance, and has no significant tributaries. Stream channelization and manipulation was by far the biggest problem with Pine Brook, followed by impoundments and discharge pipes, from which runoff was observed. Apparently, residents had both changed the course of about 1500 yards of Pine Brook to define their property boundaries, and have dammed four ponds, two of which cover at least an acre. The stream passes though many culverts under driveways and roadways. **Confirmed Areas of Concern:** The original volunteer walker is an environmental scientist who was thorough in his data collection, so we felt no need to question his data.

Recommended Actions

Updated stream walks are recommended in Quinnipiac River subwatersheds with impaired water bodies given the passage of time (10 or more years) since the previous stream walks, the limited usefulness of the previously collected data, and the renewed emphasis on addressing water quality impairments. Specific recommendations include:

- Review the previous stream walk findings and plan/conduct another round of stream walks in impaired subwatersheds using the Natural Resource Conservation Service (NRCS) "Stream Visual Assessment Protocol" or similar method for citizen stream walks such as the Center for Watershed Protection's Unified Stream Assessment method. Higher priority subwatersheds are those watersheds containing water bodies with bacterial impairments listed in the 2008 Quinnipiac River Regional Basin TMDL or the 2006 TMDL for Allen Brook and Allen Brook Pond. Lower priority subwatersheds include other major Quinnipiac River tributaries with listed aquatic life impairments or for which TMDLs have not yet been developed. Where possible, select the same reaches and segments as the previous stream walks for comparison to the 2006 data.

- Recruit volunteers from QRWA, the watershed municipalities, and local schools and universities to assist with the effort and as a form of education/outreach. However, each stream team should be led by an individual trained and experienced in stream assessment methods to avoid the data deficiencies that resulted from the use of many teams consisting solely of inexperienced volunteers during the previous stream walks.

- Enlist the technical assistance of NRCS or a consultant to provide training for volunteers.

- Following the stream walks and evaluation of the assessment results, plan and conduct subwatershed visual track down surveys of identified or suspected pollution sources. Visual trackdown 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 trackdown survey are to collect information on all the possible causes of impairment and recommend and implement solutions in an effort to have the stream removed from the US EPA's impaired waters list.

- Subwatershed stream assessments and trackdown surveys should be updated every five to ten years to monitor changing watershed conditions and the progress of plan implementation.

Updated Quinnipiac River Watershed Stream Walks and Trackdown Surveys

Updated stream walks and associated trackdown surveys using teams of volunteers and individuals experienced in stream assessment methods are recommended in the following subwatersheds to help identify conditions responsible for water quality impairments and recommended solutions to reduce pollutant loads:

Higher Priority (bacteria impairments):
- Quinnipiac River mainstem (where walkable)
- Misery Brook
- Sodom Brook
- Harbor Brook
- Allen Brook

Lower Priority (other impairments):
- Patton Brook
- Hemingway Creek
- Eightmile River
- Tenmile River
- Wharton Brook
- Muddy River

3.1.5 Prepare and Implement Subwatershed Action Plans

Development and implementation of site-specific restoration and protection strategies is most effective at the subwatershed scale for large watersheds such as the Quinnipiac. Although this watershed plan identifies a number of site-specific and targeted recommendations that can also serve as 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 various Quinnipiac River tributaries and subwatersheds, such as the stream walks and trackdown surveys described in the previous section. Additional targeted watershed assessment and planning is recommended for various subwatersheds to further characterize current conditions within specific reaches of the Quinnipiac River, its tributaries, and upland areas of the subwatersheds, with the goal of developing additional site-specific projects and action plans for each priority subwatershed.

Recommended Actions

- Prepare and implement more detailed subwatershed action plans for priority subwatersheds to reflect the baseline information contained in the overall Quinnipiac River Watershed Based Plan, previous subwatershed-specific evaluations[2], and the findings of new stream walks and associated trackdown surveys (see recommendations in previous section).

- Target subwatersheds, including major tributaries and municipalities located within each subwatershed, are summarized in *Table 3-2*. The municipalities located within each subwatershed should be encouraged to participate in development and implementation of the respective subwatershed action plans. *Table 3-2* also includes the average percent reductions in bacterial loads to meet water quality standards, as reported in the 2008 *Quinnipiac River Bacteria TMDL*. Higher priority subwatersheds are those watersheds containing water bodies with bacterial impairments listed in the 2008 Quinnipiac River Regional Basin TMDL or the 2006 TMDL for Allen Brook and Allen Brook Pond. Lower priority subwatersheds include other major Quinnipiac River tributaries with listed aquatic life impairments or for which TMDLs have not yet been developed.

- Subwatershed action plans could be maintained as an appendix to the overall Quinnipiac River Watershed Based Plan, relying on watershed background information, goals, and objectives contained in the Quinnipiac River Watershed Based Plan. A recommended framework for the subwatershed action plans is as follows:
    - Subwatershed Characteristics and Pollutant Sources
    - Load Reductions Needed
    - Management Goals and Measures
    - Implementation Schedule, Milestones, and Evaluation Criteria
    - Technical and Financial Assistance Needed

[2] Previous subwatershed-specific evaluations include the 2001-2006 QRWA stream walks as documented in *Quinnipiac River NPS Pollution Survey Phase 3* (QRWA, 2006) and *Quinnipiac Watershed Data Integration Report - A Study of the Quinnipiac River Watershed's Nine Sub-Basins* prepared by Yale University School of Forestry and Environmental Studies Center for Coastal and Watershed Systems (Anisfeld and Zajac, 2004).

- APPENDIX - Potential Site-Specific Retrofit/Restoration Projects with Load Reduction and Cost Estimates

Table 3-2. Subwatersheds Recommended for Development of Subwatershed Action Plans

Subwatershed	Major Tributaries	Municipalities Located within Subwatershed	Required Percent Reduction in Bacterial Loads (TMDL)
Higher Priority (Bacteria Impairment with TMDL)			
Quinnipiac River (mainstem)	Honeypot Brook, Patton Brook, Meetinghouse Brook, Spruce Glen Brook, Waterman's Brook, Hemingway Creek	Farmington, New Britain, Plainville, Southington, Cheshire, Meriden, Wallingford, North Haven, Hamden, East Haven, New Haven	64% to 84%
Misery Brook	Un-named tributaries	Meriden, Southington	65%
Sodom Brook	Crow Hollow Brook	Meriden, Berlin	92%
Harbor Brook	Spoon Shop Brook, Willow Brook, North Brook	Meriden, Berlin, Wallingford, Middletown, Middlefield	95%
Allen Brook	Un-named tributaries	Wallingford, North Haven	22% (From mouth at confluence with Wharton Brook upstream to Allen Brook Pond dam) 68% (From inlet to Allen Brook Pond upstream to headwaters)
Lower Priority (Aquatic Life Impairment or No TMDL Yet Established)			
Patton Brook	Un-named tributaries	Southington	Not Applicable
Hemingway Creek	Un-named tributaries	East Haven, New Haven	Not Applicable
Eightmile River	Cussgutter Brook, Hamlin Brook (north and south branches), Dayton Brook, Roaring Brook	Southington, Bristol, Wolcott	Not Applicable
Tenmile River	Cuff Brook, Mountain Brook, Judd Brook, Humiston Brook	Southington, Wolcott, Cheshire, Prospect	Not Applicable
Wharton Brook	Catlin Brook, Allen Brook	Wallingford, North Haven	Not Applicable
Muddy River	Eightmile Brook, Pine River, Fivemile Brook	Wallingford, North Haven, Hamden, North Branford	Not Applicable

3.2 Water Quality

Goal Statement: Improve the water quality of the Quinnipiac River and its tributaries so that impaired reaches of the river will consistently meet their designated uses for aquatic life, recreational use, and fish consumption, along with improving the downstream water bodies of New Haven Harbor and Long Island Sound. Protect and enhance the water quality of healthy water bodies (i.e., those that are not impaired).

3.2.1 Continue Water Quality Monitoring

Ongoing water quality monitoring is recommended for the Quinnipiac River watershed to refine the understanding of water quality impacts from potential point and non-point pollution sources in the watershed, to continue developing a water quality database for the watershed to guide environmental decision-making, to measure the progress toward meeting watershed management goals and TMDL pollutant load reductions, and ultimately support removal of the impaired segments of the Quinnipiac River and its tributaries from the CTDEEP and EPA impaired waters list.

Recommended Actions

- Perform an analysis of critical data gaps at high-priority monitoring sites, including limited data collection at those sites, and make recommendations for future data collection activities. The analysis would support implementation and future updates of the Quinnipiac River Watershed Based Plan, as well as help inform discussions on appropriate permit limits for the wastewater treatment plants that discharge to the Quinnipiac River and inform potential revisions to the state's phosphorus reduction strategy.

- Continue the QRWA volunteer participation through the state-wide Rapid Bioassessment in Wadeable Streams & Rivers by Volunteer Monitors (RBV) program. Involve students and faculty from local schools and universities.

- Continue ongoing water quality (chemistry and biological assessments) monitoring in the watershed, with potential modifications to the programs informed by the gap analysis described above. Coordinate the monitoring efforts of the QRWA, University of New Haven, and Yale School of Forestry and Environmental Studies with the ongoing CTDEEP and USGS water quality monitoring programs.

- Consistent with the bacteria TMDLs for the watershed, the monitoring program should be designed to accomplish two objectives: (1) source detection to identify specific sources of bacterial loading and (2) direct BMP implementation efforts with fixed station monitoring to quantify progress in achieving TMDL established goals.

Continue Water Quality Monitoring

Continue ongoing water quality (chemistry and biological assessments) monitoring in the watershed. Consistent with the bacteria TMDLs for the watershed, the monitoring program should include bacteria source detection to identify specific sources of bacterial loading and fixed station bacteria monitoring to direct BMP implementation efforts and quantify progress in achieving TMDL established goals.

- Bacteria Source Detection – Source detection monitoring may include such activities as 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 subwatershed stream walks and trackdown 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 the 9 previous CTDEEP TMDL monitoring sites 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 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.

- Pursue dedicated funding to finance future monitoring efforts and routine (annual or biennial) water quality monitoring summary reports (similar to the report *Water Quality in the Quinnipiac River Watershed: An Analysis of Water Quality Data for the Period 1989-1999* by Mary L. Tyrrell).

- Incorporate monitoring recommendations of the "Science Workgroup" associated with the state-wide phosphorus reduction strategy (Public Act 12-155). The Act requires CTDEEP to collaborate with chief elected officials (or their designees) of Danbury, Meriden, Waterbury, Cheshire, Southington and Wallingford, and any other municipality impacted by the state-wide strategy to reduce phosphorus, and to collaboratively evaluate and make recommendations regarding a state-wide strategy to reduce phosphorus in order to comply with EPA standards. The Science Workgroup is charged with developing methods to measure current phosphorus levels and to make future projections.

- Consider reviving the successful QRWA turbidity monitoring program that was conducted between 1997 and 2000. Water samples were collected by volunteers from 10 to 15 stream/river stations 6 to 8 times per year, at the end of a rain event. Samples were analyzed using an optical turbidimeter. After each sampling event, results were faxed to the town enforcement officers, who followed-up on high turbidity results, resulting in many effective corrective erosion control measures. CTDEEP is now requiring turbidity measurements at construction sites under the current General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities.

3.2.2 Reduce or Eliminate Point Source Discharges

The watershed's wastewater treatment plants are a potential source of bacteria and nutrients (nitrogen and phosphorus) to the Quinnipiac River and Long Island Sound. Excessive levels of indicator bacteria are a leading cause of water quality impairments in the Quinnipiac River and its major tributaries. When present in excessive amounts, phosphorus contributes to a process called "eutrophication" that can impair both aquatic life and recreational use of Connecticut's inland water resources. Excessive loading of phosphorus to surface waters as a result of discharges from industrial and municipal WPCFs or nonpoint sources such as runoff from urban and agricultural lands, can lead to algal blooms, including blooms of noxious blue green algae, reduction in water clarity, and in extreme cases depletion of oxygen, fish kills, and other impairments to aquatic life (CTDEEP, 2011).

EPA Region 1 has mandated that all New England states establish limitations on phosphorus in wastewater discharge permits where the potential exists for the discharge to contribute to eutrophication and impair designated uses in downstream waters. In response, CTDEEP has adopted an interim strategy to establish water quality based phosphorus limits in non-tidal freshwater for industrial and municipal WPCF National Pollutant Discharge Elimination (NPDES) permits until numeric nutrient criteria are established in the Connecticut Water Quality Standards. Seasonal phosphorus permit loads and performance levels have been established for four municipal wastewater treatment plants (Cheshire WPCF, Meriden WPCF, Southington WPCF, and Wallingford WPCF) and one industry (Cytec Industries Inc.[3]) that discharge to the Quinnipiac River. As discussed in *Technical Memorandum #1: State of the Quinnipiac River Watershed*, CTDEEP is working collaboratively with several of the Quinnipiac River watershed communities to reduce phosphorus and to make recommendations regarding a state-wide strategy to reduce phosphorus to comply with EPA standards.

The Cheshire, Meriden, Southington, and Wallingford WPCFs and Cytec Industries Inc. have indicator bacteria limits in their NPDES Permits. Disinfection required under the NPDES Permit is sufficient to reduce indicator bacteria densities to below levels of concern in the effluent when in use and functioning properly. The current NPDES permits for these four municipal wastewater treatment plants and Cytec Industries Inc. require disinfection from May 1 - September 30 to meet permit limits for indicator bacteria (CTDEEP, 2008).

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. These discharges are referred to as Combined Sewer Overflows (CSOs). Four active CSO discharge locations are within the Quinnipiac River watershed – the James Street siphon, Poplar Street at River Street, Pine Street at North Front Street, and Quinnipiac Avenue at Clifton Street. The City continues to implement CSO abatement projects to eliminate CSO discharges, including sewer separation, CSO storage tanks, and the use of green infrastructure techniques along with new stormwater regulations. New Haven is also in the process of

[3] NPDES-permitted industrial facilities that discharge to the Quinnipiac River include Cytec Industries, Inc., Evonik-Cyro Industries, LLC, Nucor Steel Connecticut, Inc., and Allegheny Ludlum Corporation (Wallingford); Pharmacia & Upjohn Company and United Aluminum Corporation (North Haven), Tilcon Connecticut, Inc. (Plainville), (Source: DEEP database of NPDES permitted facilities, 2011).

establishing a stormwater authority and fee system, based on impervious cover, to provide a dedicated funding source for its stormwater management program and to provide further incentive for the use of green infrastructure approaches.

Recommended Actions

- Reduce or eliminate the four active CSO discharge locations within the Quinnipiac River watershed through the City of New Haven's CSO Long-Term Control Plan.
- Continue reduction in phosphorus loads from municipal Water Pollution Control Facilities (WPCFs) in the watershed through existing NPDES permits and the CTDEEP's ongoing state-wide strategy to reduce phosphorus discharges in non-tidal freshwater streams. Provide funding to help implement the necessary WPCF upgrades to meet the phosphorus permit load limits.
- Extend disinfection at WPCFs through October (to the end of the paddle season).

3.2.3 Reduce Impacts of Subsurface Sewage Disposal systems

Approximately 34 percent of the population within the Quinnipiac River watershed is served by on-site subsurface sewage disposal systems, also referred to as septic systems. Many of these systems are old and not inspected frequently or maintained properly. Failing or malfunctioning systems can impact surface water and groundwater quality. An objective of this plan is to reduce the water quality impacts of failing or malfunctioning on-site wastewater disposal systems in the watershed.

Recommended Actions

- Strengthening municipal regulations to require upgrades to on-site sewage disposal systems following a phased approach, such as requiring systems to pass an inspection or be upgraded upon the sale of a property.

- Conduct public education and outreach programs, especially with Inland Wetlands Commissions and town officials, addressing on-site wastewater disposal system care, maintenance, and repairs. Emphasize that larger setbacks from septic systems (buffers) to sensitive wetlands (e.g., headwater stream, seep, bog) may be needed to prevent adverse impacts and that site- and soil-specific nitrogen dilution studies may be warranted.

- Coordinate efforts with nonpoint source phosphorus load reduction recommendations of the CTDEEP's ongoing state-wide strategy to reduce phosphorus discharges in non-tidal freshwater streams and CTDEEP's Statewide Nonpoint Source Plan update.

3.2.4 Promote Low Impact Development and Green Infrastructure

Since much of the watershed was developed prior to the adoption of stormwater quality regulatory requirements, most of the existing drainage infrastructure consists of traditional storm drains/catch basin and storm pipes that discharge directly to surface waters without treatment, other than detention to maintain peak rates of discharge. Urban stormwater runoff, in the form of point discharges from stormwater collection systems and nonpoint sources such as diffuse runoff from parking lots and other impervious surfaces, is a significant cause of water quality impairments in the Quinnipiac River watershed. An important objective of this watershed management plan is to reduce the impacts of stormwater runoff on hydrology and water quality through the use of Low Impact Development and Green Infrastructure (LID/GI).

The use of LID/GI is the preferred approach by EPA and CTDEEP for stormwater management in urban and suburban areas. The two terms are often used interchangeably, but are generally used in different contexts.

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.

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.

Grey Infrastructure refers to traditional stormwater management systems that quickly dispose of stormwater, such as pipes, pumps and lined ditches, or use of detention ponds.

While LID is generally used to describe development approaches and practices at the site level, the term "green infrastructure" is typically used in a broader range of contexts and scales. At the largest scale, the preservation and restoration of natural landscape features (such as forests, floodplains and wetlands) are components of green infrastructure. On a smaller scale, green infrastructure practices also include rain gardens, permeable pavement, green roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting for non-potable uses such as toilet flushing and landscape irrigation (EPA Green Infrastructure Website, Accessed December 2, 2013).

Table 3-3 summarizes various types of green infrastructure practices and the scales at which they are typically applied. Many of the site and neighborhood-scale practices are also considered LID techniques. Examples of LID/GI practices are highlighted in *Section 4* of this watershed plan.

Table 3-3. Green Infrastructure Practices

Scale	Green Infrastructure Practices
Site	Green Roofs and Blue Roofs Green Walls Rain Harvesting Downspout Disconnection Planter Boxes Rain Gardens/Bioretention Permeable Pavement Vegetated Swales Stormwater Wetlands Stormwater Infiltration Systems Brownfield Redevelopment Infill and Redevelopment
Neighborhood	Green Parking Green Streets & Highways Trees & Urban Forestry
Watershed	Wetland/Riparian Buffers Urban Forests

Source: Adapted from EPA Green Infrastructure Website, Accessed December 2, 2013.

Examples of the Potential Environmental, Financial, and Social Benefits of LID/GI (EPA, 2013)

Environmental Benefits

- Improved water quality
- Improved air quality from trees
- Improved groundwater recharge
- Energy savings from reduced air conditioning
- Reduced greenhouse gas emissions
- Reduced urban heat stress
- Reduced sewer overflow

Financial Benefits

- Reduced construction costs compared with all-grey infrastructure, or compared with upsizing grey infrastructure for increased runoff

Other Social Benefits

- Improved aesthetics
- More urban greenways
- Increased public education on their role in stormwater management
- Reduced flash flooding
- Green jobs
- Potential increase in economic development from improved aesthetics

Recommended Actions

Recommended actions relative to the implementation of LID/GI in the watershed municipalities include:

- Continue to implement LID and green infrastructure projects within the watershed. Watershed municipalities should incorporate LID/GI into municipal projects, including roadway projects using "green streets" approaches. Municipalities should take a leadership role by incorporating LID/GI into high-profile demonstration projects at publicly-owned facilities. Private development projects that implement LID or green infrastructure should also be highlighted through a recognition program that could consist of public awards, websites, meetings, media, and other methods.

- Watershed municipalities should incorporate LID and GI stormwater requirements, including runoff reduction standards (e.g., zero net increase in runoff) into their local land use regulations to: (1) satisfy existing and future municipal (MS4) Stormwater Permit Program regulatory requirements, (2) require LID practices and GI approaches to be implemented for new development and redevelopment projects, and (3) address other local drainage and natural resource protection issues identified by the municipalities.

- Implement the LID/GI recommendations of the updated regional land use regulatory review conducted by the Mill River Watershed Association for municipalities in the Quinnipiac River, West River, and Mill River watersheds. The regulatory review will guide the revision of local land use regulations to require the use of LID and green infrastructure and to remove barriers to the use of such techniques in the current regulations.

Green Infrastructure in New Haven
The City of New Haven is implementing a green infrastructure (GI) program to address combined sewer overflows and upgrades to its stormwater system. Program elements include a GI feasibility study, a proposed stormwater utility, GI demonstration projects, LID/GI regulations, and an on-line GI atlas.
http://reducerunoff.org/newhaven.htm

Residential Rain Gardens in Southington
Save the Sound's Rain Garden Program was responsible for the installation of 9 residential rain gardens in Southington in June 2013. Several larger bioretention systems are planned for municipal or commercial sites in Southington to help reduce runoff and recharge groundwater aquifers in the Quinnipiac.
http://reducerunoff.org/quinnipiac.htm

- Construct LID/GI retrofits (municipal, state, and private outfalls and/or sites) for water quality improvements based on the site-specific projects identified in *Technical Memorandum #2: Low Impact Development and Green Infrastructure Assessment* and future projects identified from stream walks, trackdown surveys, and subwatershed action plans. The best opportunities for retrofits include sites located on public land in close proximity to impaired water bodies, including:

- Parking lot upgrades (bioretention, pervious pavement, vegetated buffers, water quality swales)
- Municipal and institutional properties (bioretention, pervious pavement, green roofs, blue roofs, tree planting, stormwater harvesting)
- Athletic fields and other open spaces at parks and educational institutions (water quality swales, vegetated buffers, infiltration, bioretention, stormwater reuse for irrigation)
- Road repair/upgrades (green streets – bioretention, water quality swales, tree planters, below-ground infiltration chambers)
- Vacant or underutilized parcels owned by the watershed municipalities
- Infiltration-type LID practices within Aquifer Protection Areas (APAs) and areas with stratified drift.

- Encourage riparian commercial property owners along the Quinnipiac River and its tributaries to provide proportioned or phased stormwater detention and recharge facilities as a retrofit to existing building and parking areas when new tenants are accepted. Stormwater retrofits should be required for any additions or new development on these properties. Drainage from commercial or industrial sites should not be directed into old street drainage systems but rather managed on-site using LID/GI techniques. For example, riparian buffers and LID/GI stormwater controls should be incorporated into the design of the "Outlets at Cheshire" mixed use development proposed along the Ten Mile River in Cheshire. A recent study by the Natural Resources Defense Council illustrates the benefits of GI to the commercial real estate sector (go.nrdc.org/greenedge).

- Provide education and outreach for designers, land use commissioners, municipal staff, and the public. Emphasize neighborhood stormwater retention through campaigns to add rain barrels, rain gardens, disconnect downspouts, and replace pavement with pervious surfaces for parking.

- Pursue sustainable, long-term funding sources to move beyond the demonstration phase. Pursue alternative funding sources for green infrastructure projects (user fees, stormwater utility districts, infrastructure banking, public-private partnerships, etc.). New Haven, Bridgeport, and several other CT communities are in the process of implementing stormwater utilities.

Innovative Financing for Green Infrastructure – Prince George's County Watershed Protection and Restoration Program

Innovative financing mechanisms are being explored at the national level, particularly tapping into the resources of the private sector through public–private partnerships (P3s). Traditionally, water and wastewater infrastructure has been funded through municipal bonds, with help from EPA State Revolving Loan funds, while stormwater is typically funded either through its limited share of local general funds or stormwater utilities. The Chesapeake Bay states are exploring P3s to meet TMDL obligations for nutrients and sediment. A 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 launching a P3 pilot program in the fall of 2013 to retrofit 2000 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. This program is part of the County's Watershed Protection and Restoration Program.

3.2.5 Implement 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. Each of these entities is a regulated small Municipal Separate Storm Sewer System (MS4) under the CTDEEP General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4 Permit).

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. The municipalities have also begun to address historical development and nonpoint source pollution impacts in the watershed by identifying potential sites for stormwater retrofits.

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.

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. The CTDEEP is currently in the process of revising and reissuing the MS4 General Permit, which represents an opportunity for the watershed municipalities to review and update their municipal stormwater management programs relative to the MS4 Permit requirements and to achieve meaningful pollutant reductions relative to the bacteria TMDL. Specific recommendations include:

- The watershed municipalities should work cooperatively to cost-effectively address the public education and outreach, monitoring, mapping, and illicit discharge detection and elimination requirements of the revised MS4 General Permit, which is expected to be re-issued by CTDEEP by January 2015.

Reissuance of CTDEEP MS4 Permit

The CTDEEP is currently in the process of revising and reissuing the MS4 General Permit, which represents an opportunity for the watershed municipalities to review and update their municipal stormwater management programs relative to the MS4 Permit requirements and to achieve meaningful pollutant reductions relative to the bacteria TMDL for the Quinnipiac River.

The reissued permit is anticipated to contain more stringent requirements relative to:

- Storm system mapping
- Illicit discharge detection and elimination
- Monitoring
- Discharges to impaired waters
- Expanded legal authority

- The watershed municipalities should consider forming a regional coalition of regulated MS4s in the watershed to facilitate sharing of resources to comply with the re-issued MS4 General Permit.

- The municipalities should consider requesting approval from CTDEEP for an alternative MS4 Permit monitoring program to more effectively address the bacteria impairments in the Quinnipiac River watershed. Monitoring may be performed by municipal staff, citizen volunteers, or contracted to an environmental consulting firm. The program must include sampling to address both objectives (source detection and progress quantification). Source detection monitoring may include such activities as 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.

- Municipalities and CTDEEP should increase inspection and enforcement of erosion and sediment controls at construction sites within the watershed for compliance with local and state requirements. Education of construction supervisors is also recommended.

- Municipalities should follow CTDEEP best practices for snow disposal from plowed streets and parking lots and street sweepings disposal to reduce sedimentation and other water quality impacts.

3.2.6 Protect Existing and Restore Degraded Riparian Buffers

Riparian buffers are naturally vegetated areas adjacent to streams, ponds, and wetlands. Vegetative 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. The naturally vegetated buffer filters out pollutants, captures sediment, regulates stream water temperature and processes many contaminants through vegetative uptake. The vegetative community of riparian buffers provides habitat for plants and animals, many of which are dependent on riparian habitat features for survival. Riparian buffers are needed to sustain the stream insect/invertebrates at the base of the aquatic food chain, and the insect populations that support wildlife on stream banks. Since, in many areas, riparian buffers are becoming reduced in size and impacted by roadways and development, many species of plants and animals that are dependent on the unique blend of characteristics that buffers provide are threatened or endangered species.

As discussed in *Technical Memorandum #1: State of the Quinnipiac River Watershed*, development along the stream corridors in the watershed has resulted in substantial loss of riparian vegetation. The high degree of stream buffer encroachment along the watercourses in the Quinnipiac River watershed has a significant impact on overall stream and habitat conditions.

A study funded by the Long Island Sound Study and conducted by the University of Connecticut Center for Land Use Education and Research (CLEAR) characterized Connecticut's watersheds and their riparian areas through the use of remotely-sensed land cover during the 1985 to 2006 time period. Results of this study indicate that the Quinnipiac River watershed experienced a 4 to 6 percent loss of forested land within the 300-foot riparian corridor (i.e., within 300 feet on either side of the streams and rivers in the watershed) between 1985 and 2006 (CLEAR, 2011).

An objective of this plan is to protect and restore degraded riparian buffers in the watershed to protect and improve water quality. Related recommendations for protection and restoration of riparian habitat, including in-stream habitat, are addressed in *Section 3.3* of this plan.

Recommended Actions

- Implement priority buffer restoration projects identified during stream walks and watershed field inventories. Focus efforts on publicly-owned, high-profile sites such as existing parks along the Quinnipiac River corridor and tributaries, as well as smaller headwater tributaries, ponds, and lakes. *Section 4* identifies several potential buffer restoration candidates based on limited field inventories. Site-specific concepts for several of these potential opportunities are presented in *Section 4*. Future stream walks and trackdown surveys will help to identify additional stream buffer restoration candidates.

- 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. Consider implementing buffer restoration projects by identifying "seed" funding for the initial design phases, followed by the development of subwatershed plans with more detailed designs, which will increase the chances of state and federal funding for these projects.

- In general, riparian buffers are most effective along smaller, headwater streams, although larger streams, ponds, and areas along the lower Quinnipiac River could also benefit from buffer enhancements. Potential buffer restoration approaches for the watershed include:
    - Installation of new buffers
    - Widening existing buffers

Quinnipiac River Stream Buffer Initiative

In 2006, QRWA led a Stream Buffer Initiative to encourage land use practices that minimize adverse impacts on the watershed and increase public access to the river and its tributaries. The project included buffer advocacy in Southington, a public recognition program for cooperating landowners, and an abbreviated *Streamside Landowners' Guide to the Quinnipiac Greenway* to help landowners reduce pollution and use tax credits to conserve watershed land. A full-length guide was also developed for municipal officials.

  - Invasive species removal/management
  - Tree planting/reforestation

- Pending enabling state legislation, adopt local riparian buffer protection regulations that would establish a regulated riparian zone on both sides of the Quinnipiac River and its tributaries.

- Adopt or modify local land use regulations to incorporate site design credits or other similar incentives for developers to restore or establish vegetative buffers as part of new development or redevelopment.

- Engage volunteers in riparian buffer implementation projects.

- Educate developers, designers, municipal staff, and homeowners about the value and importance of riparian buffers by building on previous QRWA stream buffer outreach and educational programming (e.g., buffer advocacy in Southington, public recognition program for cooperating landowners, and *Streamside Landowners' Guide to the Quinnipiac Greenway*). The education/outreach could incorporate results from the CLEAR study on the status of riparian corridors in Connecticut and build on the recent success creating riparian corridor programming in the Niantic River Watershed towns of Waterford, East Lyme, Salem and Montville.

- Preserve and enhance riparian buffers for projects that provide public access to the Quinnipiac River and its tributaries.

- Preserve and protect endangered and/or threatened species habitat identified by CTDEEP Natural Diversity Database Areas and Critical Habitat Areas within buffers.

- Conservation easements for wetland and watercourse buffers should have enforceable provisions with regard to pesticide use.

3.2.7 Reduce Nuisance Waterfowl and Pet Waste

Fecal material from nuisance waterfowl such as mute swans and Canada geese and pet waste is a source of nonpoint source pollution, particularly pathogens and nutrients. Reducing these populations could improve water quality by reducing bacterial and nutrient loadings to the Quinnipiac River, particularly in the public parks, golf courses, and cemeteries along the river and stream corridors.

Many of the watershed communities have existing bans on feeding of waterfowl and pet waste (i.e., "pooper scooper") ordinances. However, enforcement of such regulatory controls is difficult. 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.

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 is the preferred deterrent method since it also provides value as a riparian buffer.

- Existing regulatory controls prohibiting the feeding of waterfowl should be augmented through additional signage in public parks and other educational tools, in addition to the potential for fines.

- Adopt local pet waste regulatory mechanisms and programs in the watershed communities and local/state parks in the watershed that currently do not have such controls.

Canada 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.

3.2.8 Identify and Eliminate Illicit 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 and illegal dumping are among the types of illicit discharges that may exist in residential and commercial areas within the watershed. Approximately 66 percent of the population of the Quinnipiac River watershed is served by municipal sanitary sewers. Depending on the source, an illicit discharge may contain a variety of pollutants that can impact both human health and the aquatic environment. Identifying and eliminating these discharges is an important means of pollution source control for the watershed.

All of the watershed municipalities are subject to the requirements of the NPDES Phase II stormwater program, which is regulated under 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 program 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 an Illicit Discharge Detection and Elimination (IDDE) Plan to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.

The CTDEEP is currently in the process of revising and reissuing the MS4 General Permit, which represents an opportunity for the watershed municipalities to review and update their municipal stormwater management programs relative to current and future MS4 Permit requirements, including IDDE efforts.

Recommended Actions

- The watershed municipalities should implement IDDE programs as required by the existing and future re-issued MS4 General 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 Plan to detect and eliminate existing and future non-stormwater discharges, including illegal dumping.
- Educate municipal staff and the public.
- Implement priority stream cleanups identified by stream walks and trackdown surveys.
- Conduct follow-up illicit discharge investigations at priority outfalls identified during stream walks and trackdown surveys.

Other sources of information on performing illicit discharge investigations include:

- *Illicit Discharge Detection and Elimination Manual - A Handbook for Municipalities,* New England Interstate Water Pollution Control Commission (2003) http://www.neiwpcc.org/neiwpcc_docs/iddmanual.pdf
- *Illicit Discharge Detection and Elimination - A Guidance Manual for Program Development and Technical Assessments*, Center for Watershed Protection (2004)

3.2.9 Promote Good Lawn Care Practices

Lawns account for approximately 15% of the land area within the Quinnipiac River watershed, including residential lawns, parks and public facilities, cemeteries, and golf courses. The use of fertilizers and pesticides on lawns contributes nutrients and toxic chemicals to surface waters and groundwater. Organic lawn and turf care can maintain attractive lawns and turf without the use of excessive nutrients or toxic pesticides.

Connecticut's new law regulating the use of phosphorus on established lawns went into effect on January 1, 2013. Golf courses and agricultural land are exempt from this regulation. Connecticut was also the first state to ban toxic lawn pesticides on the grounds and athletic fields of all public and private elementary and middle schools, which was spearheaded by the Quinnipiac Watershed Partnership.

Good Lawn Care Practices

- Test soil to determine if fertilizer is needed. The UCONN Soil Nutrient Analysis Laboratory and the CT Agricultural Station have soil testing programs.
- Reduce lawn area by creating more/larger planting beds.
- Overseed or mulch bare soils to prevent erosion and reduce weed growth.
- Aerate soil to promote water infiltration and deep root growth. It also helps keep down weeds.
- Keep grass 3" tall. Shorter grass has weaker roots that allow more weed growth.
- Water no more than 1x a week, about 1". Frequent watering encourages shallow root growth.
- Leave grass clippings on lawn for a natural fertilizer.
- Do not apply nutrients or organic matter during Nov - Feb.
- Avoid fertilizing before heavy rain or during long, dry spells
- Avoid spreading onto walks, drives and other hard surfaces
- Avoid fertilizing close to water's edge

Recommended Actions

- Promote good lawn care practices and organic lawn care techniques through education and outreach (see text box).
- Develop incentive-based programs (e.g., certificate programs) for environmentally friendly lawn and grounds care
- Promote organic lawn/land care and non-lawn alternatives to the landscaping industry within the watershed.
- Work with the Watershed Partnership, Inc. (formerly Quinnipiac Watershed Partnership) to decrease and eliminate the use of toxic lawn pesticides in the Quinnipiac River watershed.
- Work with municipalities to transition to pesticide-free athletic fields and other municipal properties such as town greens. Plainville is home to the pesticide-free Paderewski Park, one of only nine in the nation that does not use any pesticides.
- Follow the lead of Plainville, and help the watershed municipalities pass resolutions asking their citizens to voluntarily stop using toxic lawn pesticides and synthetic fertilizers.
- 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

Other sources of information on organic lawn care practices include:

- 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/

3.2.10 Reduce Impacts from Hotspot Land Uses

Hotspot land uses are land uses with higher potential pollutant loads due to the nature of the activities and pollutant sources associated with these land uses. Hotspot land uses within the Quinnipiac River watershed include commercial land use, existing and former industrial sites, gas stations and automotive repair facilities, and high-use parking lots.

An objective of this watershed management plan is to reduce the threat to water quality from land uses with higher potential pollutant loads through good housekeeping and pollution prevention, improved compliance at regulated facilities, and cleanup and sustainable re-use of contaminated (i.e., brownfield) sites. Related education and outreach recommendations are addressed in *Section 3.5* of this plan.

Recommended Actions

- Improve housekeeping programs and stormwater compliance at public works facilities and parks building on the recent municipal public works outreach program conducted by QRWA and CTDEEP.
- Develop a watershed-specific outreach program to dovetail with CTDEEP industrial stormwater permitting requirements, showing facility operators the impacts of their activities on the Quinnipiac River and its tributaries.
- Develop strategies and/or regulations to pursue parcels that contribute higher pollutant loads.
- Ensure that reissued NPDES industrial water discharge permits contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection.
- Incorporate source controls, green infrastructure, and LID practices into brownfield redevelopment projects to reduce pollutant loads and runoff volumes.
- Cleanup and promote sustainable re-use of contaminated sites (including re-vegetation and incorporation of stormwater retrofits), which present an opportunity to cleanup historic contamination posing a long-term threat to water quality.
- Give priority to hotspot sites and activities within Aquifer Protection Areas.

3.3 Habitat Protection and Restoration

Goal Statement: Protect and improve terrestrial, riparian, and aquatic habitat, including identified critical habitats and stream baseflow, in the watershed to maintain and increase the watershed's diversity of plant and animal species.

As described in *Technical Memorandum #1: The State of the Quinnipiac River Watershed*, the Quinnipiac River watershed is highly urbanized but also contains diverse physical settings and natural resources. The watershed is characterized by a mosaic of forests, urban/suburban developments and agricultural land, providing a variety of fisheries and wildlife habitats. The following objectives and recommended actions are intended to protect and restore the various habitats that exist within the watershed.

3.3.1 Protect and Restore In-Stream and Riparian Habitat

The Quinnipiac River and its tributaries provide a variety of habitats for cold and warm water fish species. The Quinnipiac River watershed was once an important habitat for anadromous[4] fish species. CTDEEP has identified the Quinnipiac River as a high priority for anadromous fish restoration, particularly for the Alewife, American Shad, and Blueback Herring.

Several fish passage restoration projects have been completed along the Quinnipiac to restore anadromous and freshwater fish migration along the river including the fishways installed at Hanover Pond and Wallace Dam. Community Lake Dam is completely breached, and three other dams remain on the mainstem of the Quinnipiac.

The entire length of the Eightmile River in Southington is a Class 1 wild trout management area and is catch and release only. Class 1 wild trout management areas are not stocked. The Eightmile River has also been targeted by CTDEEP for potential fisheries restoration. Providing fish passage at the outlet of Grannis Pond combined with additional fish passage restoration along the upper Quinnipiac River could provide spawning habitat for diadromous fish in the Eightmile River.

Wallace Dam Fishway

A fishway was installed at Wallace Dam in April 2012, which opened up more than 17.3 miles of river and 171 acres of lake and pond habitat to migratory fish foraging and spawning. Save the Sound and project partners also installed software used by CTDEEP to monitor fish passage through the fishway.

A number of problems affecting fisheries exist on many streams in the Quinnipiac River watershed. Lack of shade along the stream banks results in increased stream temperature, which can affect cold water fish species. Elevated stream temperature from warm, summer stormwater runoff can be harmful to cold water fish. Sediment from stormwater runoff and stream bank erosion can harm fish and smother the

[4] Anadromous fish begin life in freshwater, migrate to the sea to reach maturity, and return to freshwater to spawn.

eggs of fish and invertebrate larvae. Abnormally low flows during dry weather are common in some areas of the Quinnipiac River watershed due to development and loss of groundwater recharge. Remaining dams in the upper portion of the watershed and numerous culverts on smaller streams impede fish migration in the upstream tributaries of the Quinnipiac River watershed (QWP, 2004). Trout Unlimited is currently conducting a survey of culverts and other barriers to fish migration in the upstream tributaries within the Quinnipiac River watershed.

The Connecticut Department of Public Health and the CTDEEP have also published an advisory for fish caught within the Quinnipiac River, above the Quinnipiac Gorge to Hanover Pond, and within the Eightmile River. These fish are assumed to be contaminated with polychlorinated biphenyls (PCBs). According to the advisory, no one should eat any fish caught above the Quinnipiac Gorge or from the Eightmile River, and only one meal per month should be consumed of fish caught between the Quinnipiac Gorge/Hanover Pond (CTDPH and CTDEEP, 2012).

Recommended Actions

- Implement the recommendations of the Trout Unlimited stream continuity survey for cold water fisheries to identify and prioritize barriers to fish passage throughout the watershed and opportunities for restoring fish passage and aquatic habitat. Implement fish passage projects at identified barriers or impediments, including at the outlet of Grannis Pond on the Eightmile River.

- Set lower temperature limits on warm water discharge permits at permit renewal.

- Revise local storm drainage design standards and regulations such that new or modified stream crossings are designed following the Connecticut Stream Crossing Guidelines.

- Work with the U.S. Fish and Wildlife Service and CTDEEP to evaluate the feasibility and cost of removing the remaining dams along the Quinnipiac River:
    - Partially-breached dam behind the Britannia Spoon building in Wallingford
    - Partially-breached Carpenter's Dam at the upper end of Quinnipiac Gorge in Meriden
    - Clarks Brothers Dam in Southington

  Connecticut Fund for the Environment is currently negotiating an agreement with U.S. Fish and Wildlife Service for the removal of Carpenter's Dam and the Clarks Brothers Dam.

- Implement priority stream and wetland restoration projects identified during stream walks and trackdown surveys to replenish stream baseflow and improve riparian habitat. Address areas of stream erosion and sedimentation using appropriate bioengineering and habitat-sensitive measures.

- Implement stream daylighting projects for priority culvertized segments in the watershed and restore riparian vegetation (e.g., Harbor Brook).

- Municipal water utilities should follow the lead of state-regulated utilities and change the rate structure to promote water conservation in low-flow seasons.

- Educate wetlands commissioners, municipal officials, and engineers about wetland and stream dewatering by constructing utility trenches deeper than an adjacent wetland water table and to include physical barriers, such as clay stops, as needed.

- The U.S. Fish and Wildlife Service, working with the CTDEEP, should implement habitat restoration projects in the Quinnipiac River watershed associated with the Solvents Recovery Service Site and Old Southington Landfill.

3.3.2 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). Traditional approaches to restoring urban watersheds that have relied on structural solutions have failed to protect and restore urban streams. Through green infrastructure approaches, vegetation and natural systems are now considered a key tool in the protection and restoration of urban watersheds.

The Quinnipiac River watershed is characterized by roughly equal amounts of developed and forested land cover. The following actions are recommended to protect and enhance forested areas and tree canopy within the watershed.

Recommended Actions

- Protect existing forested land through land acquisition and conservation easements. Priority should be given to protection of the very large and minimally fragmented forests on the traprock ridges, such as Beseck Mountain, Cathole Mountain, and the Hanging Hills. Conservation of traprock ridge forests conserves the quality of clean headwater streams that flow into the Quinnipiac River, and major drinking water reservoirs, as well as associated traprock critical habitats.

- Amend site development regulations and zoning to encourage tree retention and maintenance, restrict tree removal, and require landscaping and parking lot shading.

- Reforest public lands, beginning with priority sites.

- Encourage reforestation of private land by developing education, stewardship and incentive programs. For larger parcels, contact a state forester or private consulting forester to developing specific goals and objectives for that property.

- Consider developing a tree ordinance, especially for canopy protection along the river corridor.

- Establish municipally-based Urban Tree Canopy or developed land cover goals for Harbor Brook, Sodom Brook, and the Quinnipiac River mainstem subwatersheds and develop a plan to achieve those goals.

- Identify and convert former industrial sites to forest or vegetated open space.

- 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.

3.3.3 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 also prevalent throughout the watershed. The common reed and purple loosestrife are common along the sides of highways, on lake shores and in tidal marsh areas. These species have the greatest tendency to become dense, homogenous stands which offer little wildlife support. Bittersweet, multiflora rose, and knotweed are often found along transitions between developed and undeveloped areas. Winged euonymous, garlic mustard, and barberry typically dominate the understory of woodlands where the forest's perimeter has been disturbed (QWP, 2004).

Invasive species management efforts should focus on site-specific and targeted stream corridor improvements, and properties that are actively maintained with opportunity and interest for control, given the impracticality of successfully controlling or eradicating invasive plant species on unmaintained sites.

Recommended Actions

- Implement priority invasive species management projects identified during stream walks and trackdown surveys.
- Develop an invasive species management plan for targeted and accessible areas of the watershed, including prevention and education efforts to preempt arrivals, early detection and citizen monitoring efforts, rapid response measures for successful eradication, and when a species cannot be eradicated, continued control efforts that are necessary to minimize ecological and economic impacts.
- Early detection and removal of invasive species is important even in largely pristine open space areas. Develop control protocols and identify the major invasive threats for riparian open space areas, and also for the critical habitats in the Quinnipiac River watershed.
- 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.

3.3.4 Investigate, Protect, and Restore the Quinnipiac River Tidal Marsh and Estuary

The Quinnipiac River is tidally influenced for approximately 14 miles upstream from its mouth at New Haven Harbor. Tidal marshes span approximately six of these miles, starting near the river's mouth and extending up through the towns of Hamden and North Haven (Linn & Anisfield, 2002). The Quinnipiac tidal marsh is an approximately 900-acre tidal marsh owned by the State of Connecticut and managed by the CTDEEP as a Wildlife Management Area. The marsh is flooded twice a day by tidal action and is characterized by salt marsh cordgrass, salt meadow cordgrass, and phragmites or common reed (QWP, 2004). Despite the encroachment of industrial and commercial development on the Quinnipiac tidal marsh over the years, the remaining portion of the marsh provides a unique ecological and recreational resource in a highly developed area. The Quinnipiac tidal marsh supports both estuarine and coastal zone species and offers a variety of opportunities for outdoor recreation.

Since the 1970s, extensive areas of marsh vegetation have been replaced by mud flats. The cause of this change is the subject of ongoing study. Possible causes include changes in the flow regime of the Quinnipiac River, changes in nutrients, sinking of the marsh, sea level rise, or a combination of these and other potential factors (QWP, 2004). Yale University has an ongoing study monitoring the Quinnipiac tidal marsh relative to sediment accretion, elevation change, and sea level rise.

Recommended Actions

- Develop an ecological master plan for the Quinnipiac River tidal marsh modeled after the master plan developed for the Ash Creek estuary in Fairfield and Bridgeport. The ecological master plan should integrate and build upon the previous research and restoration efforts focused on the marsh.
- Continue investigations by Yale University researchers into the causes and implications of marsh drowning (areas of marsh vegetation replaced by mud flats).
- Many rare marsh bird species were tallied in the 1990s, but no call-back surveys have been done since then. Update the bird survey that was conducted in the 1990s to assess the existing

Ash Creek Estuary Ecological Master Plan

The Ash Creek Conservation Association, working with a project advisory committee consisting of representatives from the Town of Fairfield, the City of Bridgeport, and neighborhood groups, completed Phase 1 of a comprehensive ecological restoration plan for the Ash Creek Estuary in 2012. The plan identifies specific recommendations for restoration of the Ash Creek Estuary. Phase 2 of the master plan is anticipated to result in more detailed site-specific restoration designs and cost estimates. http://www.ashcreekassoc.org/categories/ecological-master-plan

populations of listed and uncommon species, compare them to the 1990s survey, and find current nesting areas.

- Monitor development and redevelopment projects adjacent to the tidal marsh to prevent adverse impacts to wildlife habitat. Work with Hampden, New Haven, and North Haven land use boards and commissions.

- Continue to improve public access to the marsh by continuation of the public access recreation and educational trail along the tidal marsh section of the Quinnipiac River (North Haven Trail Association).

3.3.5 Restore Hanover Pond

Hanover Pond, located at the confluence of the Quinnipiac River and Harbor Brook in Meriden, has been the focus of grassroots restoration efforts for approximately the past decade. The Hanover Pond Dam was rebuilt in 2006 as part of the City of Meriden's flood control strategy, complete with a fish ladder to facilitate the fish returning upstream. Other accomplishments include completion of the Quinnipiac River Gorge Trail, the Phase II trail extending the linear trail system along the pond to Platt High School, and the renovations of the Quinnipiac River Watershed Association's headquarters at Dossin Beach.

Despite these successes, sediment loads carried by the Quinnipiac River, Sodom Brook, and Harbor Brook are contributing to the gradual infilling of Hanover Pond, affecting water quality, aquatic habitat, and recreational opportunities, as evidenced by the center island that has formed behind the QRWA headquarters. The Meriden Linear Trail Advisory Committee, working with representatives from QRWA, Meriden Neighborhood Associations, Meriden Flood Control, and City Council Liaison, have created a subcommittee ("Hanover Pond Initiative") focused on restoring Hanover Pond and addressing the upstream sources of sediment that continue to plague the pond.

Recommended Actions

- Conduct an evaluation of Hanover Pond, including current conditions, sediment sources, and alternatives for restoring the water quality, aquatic habitat, and recreational opportunities in the pond. Possible restoration strategies that should be considered include pond dredging, habitat restoration, and stormwater retrofits to address watershed sediment sources.

3.4 Land Use and Public Access

Goal Statement: Encourage land use practices and policies that minimize adverse impacts on the Quinnipiac River watershed and increase public access to the Quinnipiac River and its tributaries for recreational and educational opportunities.

3.4.1 Strengthen 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 wetland 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.

Because a watershed management 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.

Yale University conducted a regulatory review of the municipal land use policy and regulations of 10 Quinnipiac River watershed communities in 2002. The purpose of the review was to assess provisions that are protective of water quality and other natural resources and opportunities for strengthening land use regulations. A similar review was undertaken by the Land Use Leadership Alliance in 2012 with a Quinnipiac River Fund grant. The Mill River Watershed Association is also conducting an updated regional review of local land use regulations for municipalities in the Quinnipiac River, West River, and Mill River watersheds.

Recommended Actions

- Implement the recommendations of the updated regional land use regulatory review by the Mill River Watershed Association for the Quinnipiac River watershed municipalities.

- Develop and adopt revised land use regulations including zoning, subdivision, and inland wetlands and watercourses regulations. Projects recently completed by a number of Connecticut communities (Plainville, Newington, Tolland, Vernon, and East Granby) to remove barriers to and implement Low Impact Development (LID) regulations can serve as a model for implementation of similar LID recommendations in the Quinnipiac River watershed municipalities.

- The watershed municipalities should reference the Quinnipiac River Watershed Based Plan in their updated municipal Plans of Conservation and Development. 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.

3.4.2 Address Flooding Through a Watershed Approach

As described in *Technical Memorandum #1: State of the Quinnipiac River Watershed*, the Quinnipiac River watershed has a long history of flooding as a result of historical development of the watershed. For example, Harbor Brook floods with frequency from the area of Baldwin's Pond to Hanover Pond, through the City of Meriden.

Urban flooding occurs when rain overwhelms drainage systems and waterways and makes its way into the basements, backyards, and streets of homes, businesses, and other properties. Urban flooding in the watershed occurs both as a result of overflow from the Quinnipiac River and its tributaries and from the generation of excessive quantities of stormwater on properties and in public rights-of-way.

Urban Flooding in the Quinnipiac River Watershed – Harbor Brook

Urban flooding in the watershed occurs both as a result of overflow from the Quinnipiac River and its tributaries (e.g., Harbor Brook) and from the generation of excessive quantities of stormwater on properties and in public rights-of-way. Despite the history of flood control projects along Harbor Brook and other tributaries, flooding still remains a significant issue for many areas of the watershed. The City of Meriden is implementing comprehensive flood control measures to address flooding in Harbor Brook.

Water quality is the primary focus of this watershed management plan, although water quality and quantity (i.e., flooding) issues are closely related in terms of watershed resource management. This watershed based plan, although not intended as a flood mitigation plan, also addresses flooding due to the prevalence of flooding and 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 supplement 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 systems, which is a change from past, conventional approaches to watershed development. The recommended approaches include elements of the traditional FEMA 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 implementing Meriden's flood control plan, which provides a model for other municipalities.
- Adopt a policy of no-net-loss of flood storage capacity or flood conveyance within the watershed.
- Restore floodplain storage by excavating fill and removing flood-prone structures.
- Emphasize infiltration using LID and green infrastructure techniques, restore detention capacity, no-net-loss of flood storage capacity or flood conveyance due to floodplain encroachment, and removal of fill and restoration of floodplain and natural channel meanders.
- Remove, redesign and reduce in-channel and in-floodway structures and restore channels, floodways and floodplains.
- Develop integrated water quality and flood mitigation recommendations, including consideration of green infrastructure approaches as an alternative to conventional flood mitigation measures.
- 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) to climate change and increased frequency of extreme storms, sea level rise, etc. Develop adaptation strategies for the watershed communities.
- Evaluate municipal policies, plans, and regulations that may adversely affect the river system, such as increased development and density without concomitant improvements in stormwater runoff and water quality, detention, groundwater recharge and flood mitigation.
- Engage federal and state agencies on available assistance and resources in order to develop and implement engineering solutions to address current flood problems.

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 watershed development.

Updated Design Storm Rainfall Amounts

The National Oceanic and Atmospheric Administration National Weather Service is updating precipitation frequency data (i.e., design storm rainfall amounts). 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 this web tool offer significant advantages over previous products (e.g., "Rainfall Frequency Atlas of the United States", Technical Paper No. 40, U.S. Department of Commerce, Weather Bureau and NOAA Technical Memorandum "NWS Hydro-35", June 1977, U.S. Department of Commerce, National Weather Service) since the design storm rainfall amounts are based on a much longer period of record, including future updates as new rainfall data is available.

3.4.3 Preserve and Protect Open Space

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 includes preserved natural areas as well as lightly developed parks and playgrounds. In addition, the watershed has large unfragmented forests on the traprock ridges such as Beseck Mountain and Cathole Mountain, which are important to preserve for water quality and habitat.

There are several common methods that undeveloped land can be preserved and protected as open space. These include outright purchase, conservation easements, restrictive covenants, purchase or transfer of development rights, tax lien procedures, and land donations. 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.

Approximately 9% of the watershed consists of protected open space, composed primarily of state and municipally-owned parks, public water supplies, cemeteries, golf courses, and playgrounds. This land is protected against future development or is unlikely to be developed in the future. Another 3% of the watershed consists of uncommitted public and private open space (QWP, 2004). A key 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. The watershed communities have identified open space protection goals and priorities within the watershed primarily through their Plans of Conservation and Development.

Recommended Actions

- 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. Update open space planning documents at least every five years.

- 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.

- 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.

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

- Prioritize protection of undeveloped privately-owned critical habitats as open space, including sand plain habitats around industrial parks in North Haven and Wallingford, kettle bogs in Southington, and traprock ridge forest habitats including lower slopes with especially rich flora

and fauna and, often, vernal pools. Also strive to protect the privately-owned portions of the remaining areas with known robust eastern box turtle habitats, such as Fresh Meadows in Wallingford, Beseck Mountain, and the Panthorn Park/Wonx Springs habitat block.

- Work with property owners to permanently protect more sensitive portions of their properties with conservation easements and/or the purchase/donation of development rights. A variety of open space preservation techniques should be pursued. Financing for open space acquisitions should be leveraged through a coordinated effort between the public and private sectors. Seek alternative funding sources and approaches for open space acquisition such as 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, transferring development rights from sensitive locations to locations better suited for development.

- 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 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 of CTDEEP Critical Habitat or areas of special importance, such as traprock critical habitat, kettle bog habitats, sand plain habitats, and silver maple floodplain 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.

- Perform an evaluation of 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.

3.4.4 Increase Public Access to the River

An objective of this watershed management plan is to increase public access to the Quinnipiac River and its tributaries to enhance recreational opportunities as well as public appreciation and stewardship of the river, while balancing the interests of competing uses.

Recommended Actions

- Coordinate efforts with the regional planning agencies and watershed municipalities for the continued construction of the Quinnipiac River Greenway in New Haven, North Haven, Hamden, Wallingford, Cheshire, Meriden, Southington and Plainville to provide public recreation, environmental education, and protection of natural resources in the Quinnipiac River watershed. Connect inter-municipal segments of linear trails along the Quinnipiac River throughout the watershed (e.g., Meriden, Wallingford, and North Haven).

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

- Resurrect the USDA canoe launch project (i.e., finish canoe launches). Complete additional launch at North Haven municipal-owned parcel and add a launch at Tolles Road.

- The Lower Quinnipiac Canoeable Trail at the location of Tolles Road and Banton Street in North Haven requires further investigation. This area of the Quinnipiac River is beyond the maintenance of the QRWA volunteers and will require sustained funding to maintain the removal of log jams and debris if this section of the river if it is to be considered a permanent source for public access.

- Re-shape the water body in the Community Lake basin adjacent to Wallingford Senior Center. Provide water-based recreational access at the old Community Lake basin in the reshaped water body east of the river.

- Enhance or provide river access at existing public open spaces, focusing on areas where the river corridor is currently inaccessible.

Lower Quinnipiac Canoeable Trail

In 2010 and 2011, QRWA staff and volunteers created the Lower Quinnipiac Canoeable Trail, which allows canoeists and kayakers to travel from Wallingford to North Haven through the Quinnipiac River State Park. The project, supported by a grant from CTDEEP, is designed to increase public access to this varied section of the river, which includes a passage through an industrial area into a forest full of wildlife. However, this water trail is continually difficult to keep open due to the thick forest and the Quinnipiac's tendency to rise and fall rapidly, undercutting the river banks and toppling trees, resulting in frequent log jams.

- Target acquisition of new access points or areas at locations that are underserved by open space or access to the river and with dense residential development 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 (Quinnipiac River Linear Trail, Quinnipiac Water Trail, Quinnipiac Marsh, etc.). Build on previously installed Urban River Stewardship signs installed at North Haven, Wallingford, and New Haven.

3.5 Education and Outreach

Goal Statement: Promote stewardship of the Quinnipiac River watershed through education and outreach. Target appropriate messages to specific audiences, and promote stewardship opportunities through citizen involvement in science, conservation, and restoration activities.

An overarching 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 critical role they have in protecting water resources. Public education is critical to the long-term success of watershed management because it raises awareness of both personal responsibilities and the responsibilities of others relative to environmental protection and teaches people about individual actions they can take to protect and improve water resource conditions 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.

Four primary target audiences have the greatest potential to affect long-term change and improve water resource conditions in the Quinnipiac River watershed:

- Municipalities
- Businesses including residential builders
- Homeowners
- Students (K-12)/higher education

Education and outreach recommendations that are tailored to each of these audiences are described in the following sections. Watershed public outreach and educational programs should build upon the extensive programs that already exist in the watershed, many of which were developed previously by QRWA and other cooperating stakeholder groups.

3.5.1 Enhance the QRWA Website

Recommended Actions

- Create a webpage on the QRWA website for the Quinnipiac River Watershed Based Plan to disseminate materials and updates on progress in implementing the plan recommendations.
- Expand the QRWA website to include downloadable educational materials on organic lawn care, stream buffers, and green stormwater practices.
- Create a working library of technical and outreach materials to be categorized and made available through the QRWA website.
- Include prominent links on the QRWA website to the other major web sources of information on the Quinnipiac River Watershed including the Quinnipiac River Fund "Quinnipiac River" website.

3.5.2 Advance Local Government and Business Community Awareness

Recommended Actions – Outreach and Education for Local Government

A key objective of this plan is to advance local government awareness, understanding, and stewardship of the watershed through pollution prevention, best management practices education, regulatory enhancements, and involvement in watershed restoration activities. Municipal operations and facilities such as public works yards, street and bridge maintenance, winter road maintenance, stormwater system maintenance, vehicle and fleet maintenance, parks and open space maintenance, and municipal building maintenance can impact water quality by contributing pollutants to the storm drainage system or directly to surface waters or groundwater. Improving the awareness of municipal employees about the potential impact of their operations on water quality and environmental resources in the watershed is an important objective.

The science of watershed protection, including management and regulatory mechanisms that promote and protect watershed resources, has advanced significantly over the past decade. For example, many communities in Connecticut have adopted regulations promoting or requiring the use of LID and green infrastructure techniques. Volunteer members of land use commissions within the watershed should be provided educational opportunities to learn about advancements in watershed science and protection, and the regulatory enhancements being implemented in other communities in Connecticut. Recommendations include:

- 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 riparian buffer protection, LID and green infrastructure, and construction erosion and sediment controls.

- Build on previous QRWA stream buffer outreach and educational programming (e.g., buffer advocacy in Southington, public recognition program for cooperating landowners, and Streamside Landowners' Guide to the Quinnipiac Greenway).

- Juliana Barrett of Connecticut Sea Grant (a program of the University of Connecticut and the National Oceanic and Atmospheric Administration) and other staff with the Connecticut Nonpoint Education for Municipal Officials (NEMO) program have developed municipal training materials on the importance of riparian buffers and their protection. Juliana and the NEMO program are excellent local resources to provide training for land use commissioners in the watershed communities. Successful riparian corridor programming has also occurred in the Niantic River Watershed towns of Waterford, East Lyme, Salem and Montville. As a buffer outreach tool, borrow from recent successful consciousness-raising by the media regarding the vulnerability of the insect community (including honeybees) and invertebrates in riparian corridors to insecticide use.

- The Watershed Management Program of the CTDEEP has been recently involved with ten grant projects under the Municipal Land Use SEP fund from towns in the Farmington River Watershed. The final product for these grant projects are revisions to local land use regulations and ordinances that incorporate and remove barriers to LID. Staff from the CTDEEP Watershed Management Program has led workshops for municipal public works and other staff on topics ranging from municipal facility pollution prevention to LID and green infrastructure. It is recommended that the QRWA and watershed municipalities coordinate a workshop inviting CTDEEP Watershed Management Program staff to provide a presentation for the land use commission members of the watershed municipalities, as well as designers from the greater watershed area.

- Additionally, the Connecticut NEMO Program and the Southwest Conservation District are excellent local resources to provide educational programming for municipal reviewers and designers.

- Provide targeted workshops for municipal parks and recreation employees on how to maintain riparian buffers on public property, invasive plant management, and organic lawn care practices.

- 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 commission members in upcoming Quinnipiac River restoration projects, outreach events, and clean-ups.

Recommended Actions – Outreach and Education for the Business Community

Various businesses are located within the watershed. Whether located directly adjacent to the river or in upland areas of the watershed, all businesses contribute in some way to stormwater runoff that ultimately reaches the Quinnipiac River. An objective is to advance local business awareness, understanding, and stewardship of the Quinnipiac River watershed through pollution prevention and best management practices education, and involvement in watershed restoration activities. Recommendations include:

- Conduct targeted outreach to residential builders in the watershed on Low Impact Development (LID) methods including environmental site design and LID Best Management Practices, including runoff reduction techniques for new construction and redevelopment projects.

- Conduct targeted business outreach for other types of businesses in the watershed whose activities have the potential to impact water quality (e.g., heavy and light industry, commercial retail centers, landscaping companies, and restaurants). The education and outreach programs could consist of a variety of printed and electronic media, seminars and workshops, and training opportunities such as a training and certification program for local landscapers in the use of environmentally-sensitive lawn care practices. The City of Bridgeport provided training for area landscapers in 2010 using resources from the EPA GreenScapes program.

- Involve businesses in restoration activities to continue to invite and involve businesses in upcoming Quinnipiac River restoration projects, outreach events, and clean-ups.

Recommended Actions – Outreach and Education for Institutional Land 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. Large institutional land owners, therefore, play an important collective role in protecting water quality. Recommendations include:

- QRWA should sponsor workshops on best practices and local resources regarding management and maintenance practices at parks and institutional facilities. Topics could include:
    - Integrated Pest Management (IPM)
    - Turf management and low fertilizer usage
    - Grass clippings management and leaf/brush waste management
    - Restoration of riparian buffer areas
    - Parking lot and road maintenance (deicing, snow management)
    - Drainage system maintenance (catch basins, storm drains, stormwater BMPs)
    - Water quantity and flooding issues
    - Low Impact Development and green infrastructure approaches

- A wealth of local, state, and national resources and educational materials already exists on many of these topics, including the organic lawn care initiatives led by the Watershed Partnership, Inc. (formerly Quinnipiac Watershed Partnership), the Town of Plainville, and the City of Middletown's Project Green Lawn to encourage residents and businesses to eliminate lawn chemicals (see *Section 3.2.9* of this plan).

3.5.3 Conduct Homeowner Outreach and Education

An objective of the watershed plan is to build awareness of land stewardship and management practices and reduce nonpoint source impacts associated with residential land use, which comprises approximately 42% of the watershed land area. Homeowner education and outreach efforts should be tailored to the most common types of residential activities in the watershed that pose a risk to water quality. These activities include lawn and landscape maintenance, fertilizer and pesticide use, alteration of backyard riparian areas, rooftop runoff connections to the storm drainage system, and pet waste.

Promote Rooftop Disconnection

Residences in some areas of the watershed contribute significant quantities of rooftop runoff to the storm drainage system. Opportunities exist to disconnect residential rooftop runoff from the storm drainage system and reduce the quantity of runoff by redirecting the runoff to pervious areas or through the use of rain barrels or rain gardens.
Downspout disconnection (also referred to as "roof leader disconnection") is a cost-effective on-site option for reducing the volume and cost of stormwater that requires public management. Downspout disconnection has a number of economic and environmental benefits to the municipality and the property owner. The major benefits include:

- Reduces volumes of flows conveyed and resulting loads to watercourses
- Reduces the volume of flow to the municipal storm drainage system (MS4) and combined sewer systems
- Increases infiltration and groundwater recharge
- Provides options to reuse rainwater

Individual rooftop retrofits target a small area, requiring the participation of many homeowners to make a measurable difference across a watershed. As a result, 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 or the business community. Examples of effective local downspout disconnection programs are presented in *Urban Stormwater Retrofit Practices* (CWP, 2007).

Recommended actions include:

- 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 areas, through the use of dry wells, compost-amended soils (in areas with poorly-drained soils), or through the use of rain barrels or rain gardens.
- Disseminate educational materials on designing, constructing or 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/tools/stormwater/rain_garden.htm

- Consider rain barrel incentive program options for residents and business owners for those who purchase a rain barrel, such as monetary credit toward a utility bill or subsidized give-away programs, through grant funding or other revenue sources.

Promote Good Lawn Care Practices

As discussed in *Section 3.2.9*, 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.

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/
- Southwest Conservations District http://conservect.org/southwest/Education/tabid/267/itemid/121/Default.aspx

Connecticut's new law regulating the use of phosphorus on established lawns went into effect on January 1, 2013. Golf courses and agricultural land are exempt from this regulation. A law is summarized at: http://www.cga.ct.gov/2012/ACT/PA/2012PA-00155-R00SB-00440-PA.htm

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/index.html

Also work with and provide outreach to local landscapers regarding alternative landscaping and lawn care practices. Potential outreach programs, which can 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", and their brochure and program can be found at: http://www.milfordecc.com/freedom_lawn/info.html. Another successful homeowner incentive program has been developed by Lake Champlain International called the BLUE® Certification Program, which can be found at: http://www.mychamplain.net/blue-program

Promote Backyard Habitat

Encourage the creation of backyard habitat 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. Take advantage of existing programs, such as the QRWA *Streamside Landowners' Guide to the Quinnipiac Greenway,* Audubon's backyard program, and programs from the EPA- Long Island Sound Study and Connecticut Sea Grant.

Continue Watershed Stewardship Signage Efforts

Stewardship signage can be an effective way of educating the public on the importance of preserving natural resources and common ways in which they may be impacting these resources. The general public is often unaware of the cumulative effects of their every-day activities. Signage can play an important role in making the connection between every-day activities and their sometimes harmful results. Educational 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).

Storm drain stenciling and other watershed stewardship signage is already present in many areas of the watershed. Stewardship signage could be expanded to other areas of the watershed, targeting commercial and additional residential areas that are currently under-served. Interpretive educational signage is also recommended in highly-visible public areas of the watershed such as municipal facilities (schools, town offices, parks, libraries, etc.) and public access areas along the river.

3.5.4 Enhance School Education and Stewardship Programs

- Work with the local school districts to identify specific schools and grade levels that would benefit from new or expanded watershed or related environmental education programs.

- Implement a watershed-based 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.

- Establish a formal program for high school and college students to participate in watershed stewardship efforts such as beach and stream cleanups, invasive species removal, trail and park maintenance, and ecological restoration projects.

4 Site-Specific Project Concepts

Site-specific restoration or retrofit concepts were developed for selected sites using a two-step approach. First, a desktop screening-level review was performed to initially identify potential areas of the watershed that are potential candidates for stormwater retrofits. This screening-level review considered watershed characteristics such as soils, land use, land ownership, proximity to surface waters, identified surface water impairments, and Aquifer Protection Areas. Field inventories were then conducted in May 2013 within areas identified by the screening-level review, and retrofit concepts were developed for the most feasible sites *(Figure 4-1)*.

The site-specific project 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. Property owners and other affected parties are responsible for evaluating the ultimate feasibility of these and similar site-specific concepts.

Preliminary, planning-level costs were estimated for the site-specific restoration concepts presented in this section. These estimates are based upon unit costs derived from published sources and the proposed concept designs. Capital (construction, design, permitting, and contingency) and operation and maintenance costs were included in the estimates, and total annualized costs are presented in 2013 dollars based on the anticipated design life of each restoration concept. A range of likely costs is presented for each concept, reflecting the inherent uncertainty in these planning-level cost estimates. A more detailed breakdown of the cost estimates is included in *Appendix C*.

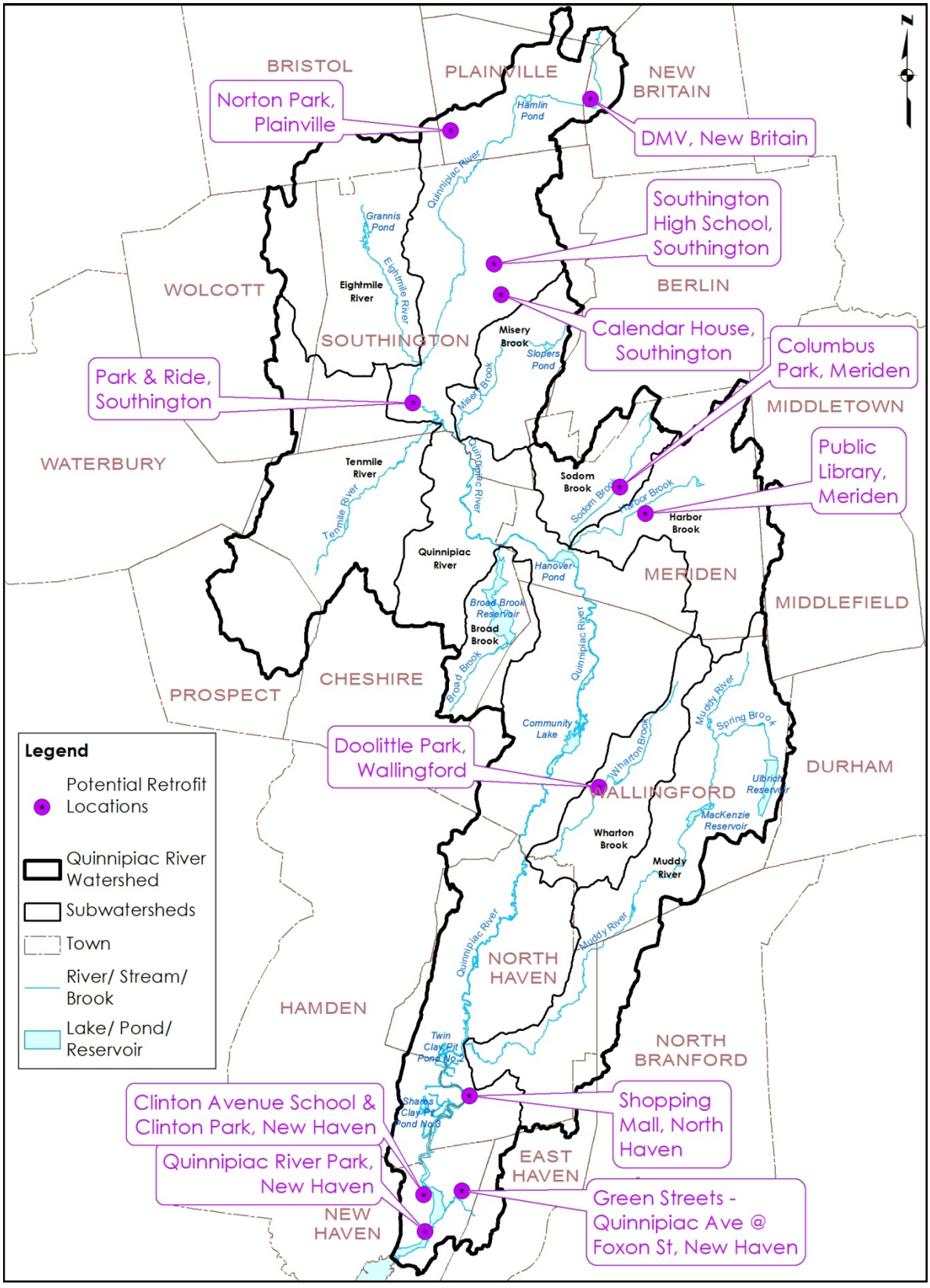


Figure 4-1. Site-Specific Project Locations

4.1 Quinnipiac River Park, New Haven

Quinnipiac River Park Retrofit

Location:
Front Street, New Haven
Objectives:
Improve water quality by treating stormwater discharge from residential areas using bioretention for infiltration and pollutant reduction; restore and improve stream bank armoring; and provide educational elements for the public at a highly visible park adjacent to the river.
Essential Elements:
Series of bioretention cells, removal of existing 24" pipe, armored outflow channel, and bank restoration
Estimated Cost: $116,000–$249,000

Quinnipiac River Park is located along Front Street in the Fair Haven area of New Haven, and is bounded approximately by the Quinnipiac River, Front Street, East Grand Avenue, and the Bottling Works Condominiums on Brewery Street. Quinnipiac River Park provides an ideal opportunity for green infrastructure retrofits given its location adjacent to the Quinnipiac River. Several 24-inch concrete storm drainage pipes that are believed to be conveying stormwater from the upgradient neighborhoods to the west were observed in the park. Stormwater retrofits in the park would not require significant grading since drainage from developed areas near the park drain toward the river. Shoreline erosion along the river at Quinnipiac Park is shown in *Figure 4-2,* and is likely caused by wave action from Hurricane Sandy and is being exacerbated by stormwater runoff from Front Street and upland areas.

Figure 4-2. Shoreline Erosion and Erosion on Walkways at Quinnipiac River Park

The proposed concept for this site, shown in *Figures 4-3 and 4-4,* involves treating a portion of the stormwater that is generated in the upgradient neighborhoods prior to discharging it to the Quinnipiac River. Since the drainage area to the 24-inch underground pipes is significant (estimated to be approximately 30 acres), the green infrastructure concept includes a serpentine, step pool design to

maximize residence time within the bioretention areas. The bioretention areas will infiltrate and treat the stormwater prior to discharging to the Quinnipiac River. As part of the retrofits, the walkways and shoreline areas could be stabilized to mitigate further erosion. The proposed concept includes the following elements:

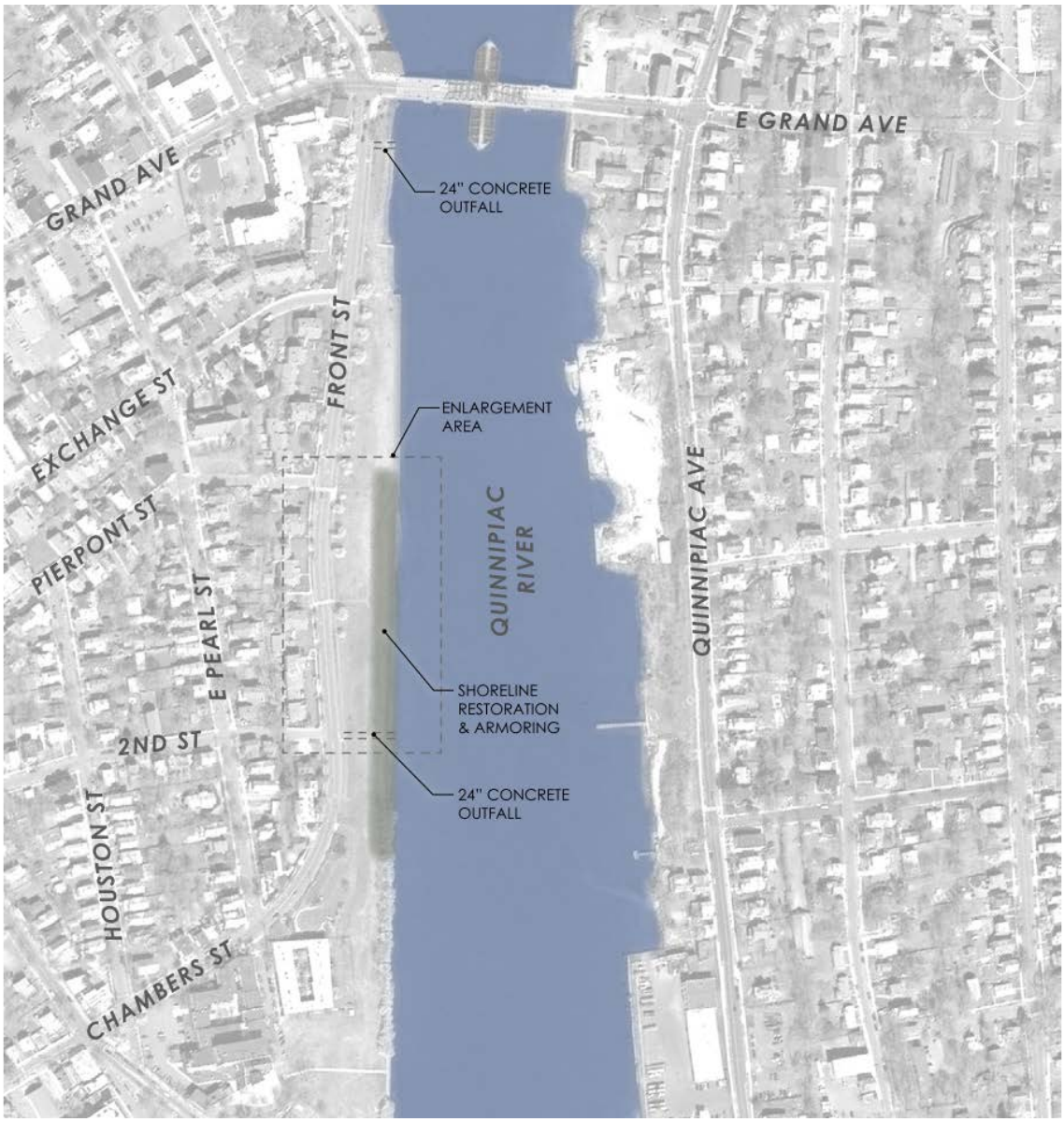


Figure 4-3. Quinnipiac River Park Green Infrastructure Retrofit Concept

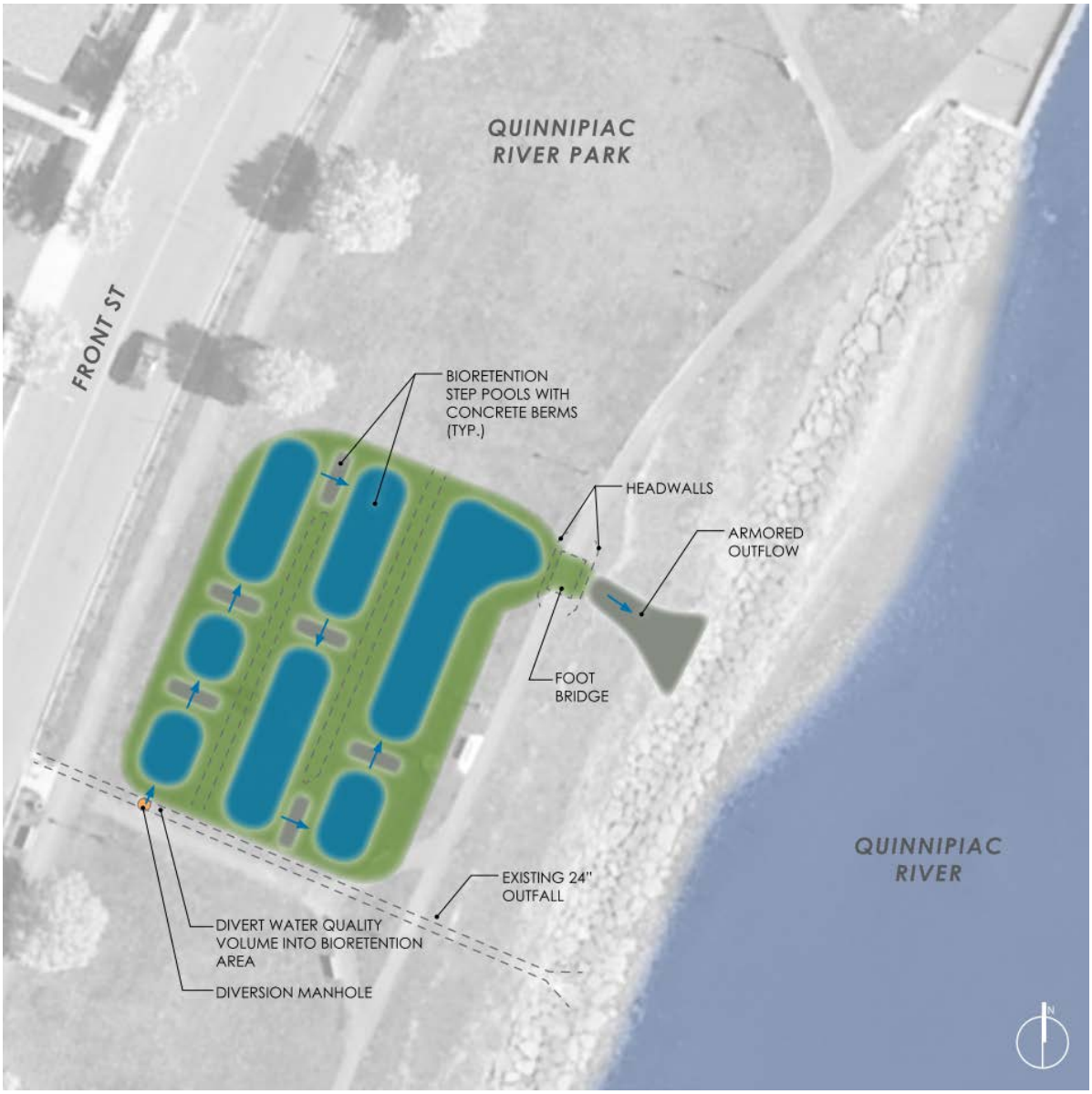
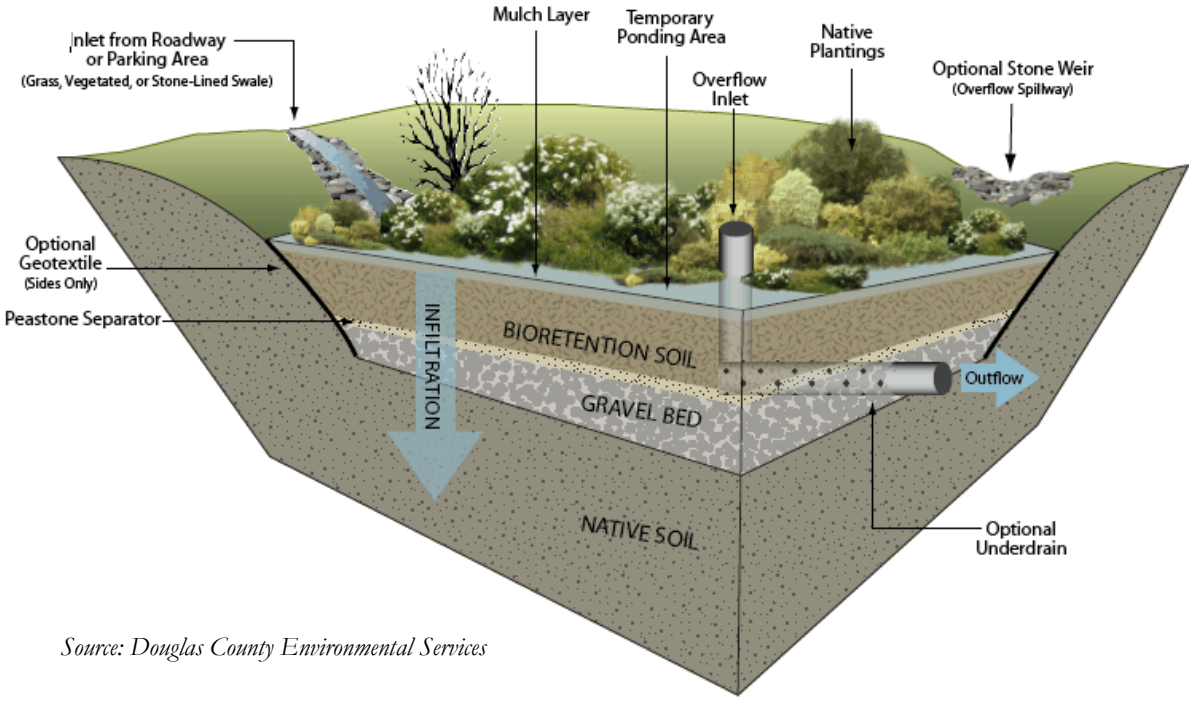


Figure 4-4. Enlargement Area for Quinnipiac River Park Green Infrastructure Retrofit Concept

Bioretention Areas with Armored Outflow Channel. A series of bioretention areas could be installed to treat stormwater from the upgradient residential areas. A diversion manhole would be installed to divert the water quality volume into the bioretention system, while bypassing flows from larger storms. The bioretention system would consist of a series of step pools separated by gravel or concrete berms. This area would capture, treat, and infiltrate runoff prior to discharging it through an armored channel to the river. The design should consider the flood-prone nature of this site. A schematic of a typical bioretention area is shown in *Figure 4-5*. A visualization of several step pools of the proposed system is shown in *Figure 4-6*.



Source: Douglas County Environmental Services

Figure 4-5. Typical Bioretention Design

Figure 4-6. Existing and Proposed Visualization of the Quinnipiac River Park Retrofit

Bank Restoration and Armoring. The bank of the river is currently armored with riprap, although as shown in *Figure 4-6*, the riprap was not sufficient to withstand damage from Hurricane Sandy in October 2012, and erosion is continuing due to stormwater runoff. The bank restoration could include the placement of additional riprap along the shoreline on a combination of large stones and tidal wetland plantings for enhanced habitat value.

4.2 Southington High School, Southington

Southington High School is located at 720 Pleasant Street in Southington on a 54-acre parcel with more than half of the parcel containing recreational fields. An approximately 6-acre, 5-tier parking lot is located on the north side of the school. The lot has parking islands between each tier, making it an ideal location for an LID retrofit. Drainage on the site flows primarily from east to west on the north of the site and primarily flows south on the southern half of the site. The school building is large, contributing approximately 5-acres of impervious area; therefore, it is a good potential candidate for a green and/or blue roof retrofit.

Southington High School

Location:
720 Pleasant Street, Southington

Objectives:
Reduce parking lot runoff and improve water quality; provide educational benefits to students and the public

Essential Elements:
Bioretention areas, vegetated swales, permeable pavement, tree boxes, green and blue roofs

Estimated Cost:

Bioretention Islands	$122,000 - $261,000
Vegetated Swales	$14,000 - $30,000
Green Roof	$415,000 - $890,000
Blue Roof	$36,000 - $77,000
Tree Boxes	$17,000 - $36,000
Porous Asphalt	$43,000 - $92,000
Total Cost	$647,000 - $1,386,000

The site is located within the Southington Water Departments Well 1A, Well 3 and Patton Aquifer Protection Areas; therefore, infiltration-type LID practices are preferred, such as bioretention. A proposed concept for improving stormwater management at the school is shown in *Figures 4-7 and 4-11,* and includes the following elements:

Bioretention and Vegetated Swales. Construct bioretention areas and vegetated swales in the traffic islands between parking rows to capture, treat, and infiltrate stormwater. Typical bioretention design is discussed in *Section 4.1*. Vegetated swales are shallow, vegetated channels which treat and convey stormwater runoff. Unlike typical stormwater conveyance structures, such as pipes, concrete channels or drainage channels, vegetated swales slow runoff velocity, filter out stormwater pollutants, and reduce runoff temperatures. The swales will direct stormwater to tree box filters which will provide infiltration.

Sidewalk tree box filters. Tree box filters could be installed to capture and treat runoff discharging from the vegetated swales in the parking islands. Tree box filters are a form of bioretention, consisting of precast concrete planters with tops that install flush with the curb. The majority of the device is below ground and includes a soil media to support tree growth and for pollutant removal via filtration. The curb inlet allows stormwater to enter the tree box filter. Trash and debris is deposited on top of the soil media and can be removed, while stormwater is treated as it passes through the soil media. The system can be configured to infiltrate the treated stormwater depending on soil and groundwater conditions. A typical schematic of a tree box filter is shown in *Figure 4-8*.

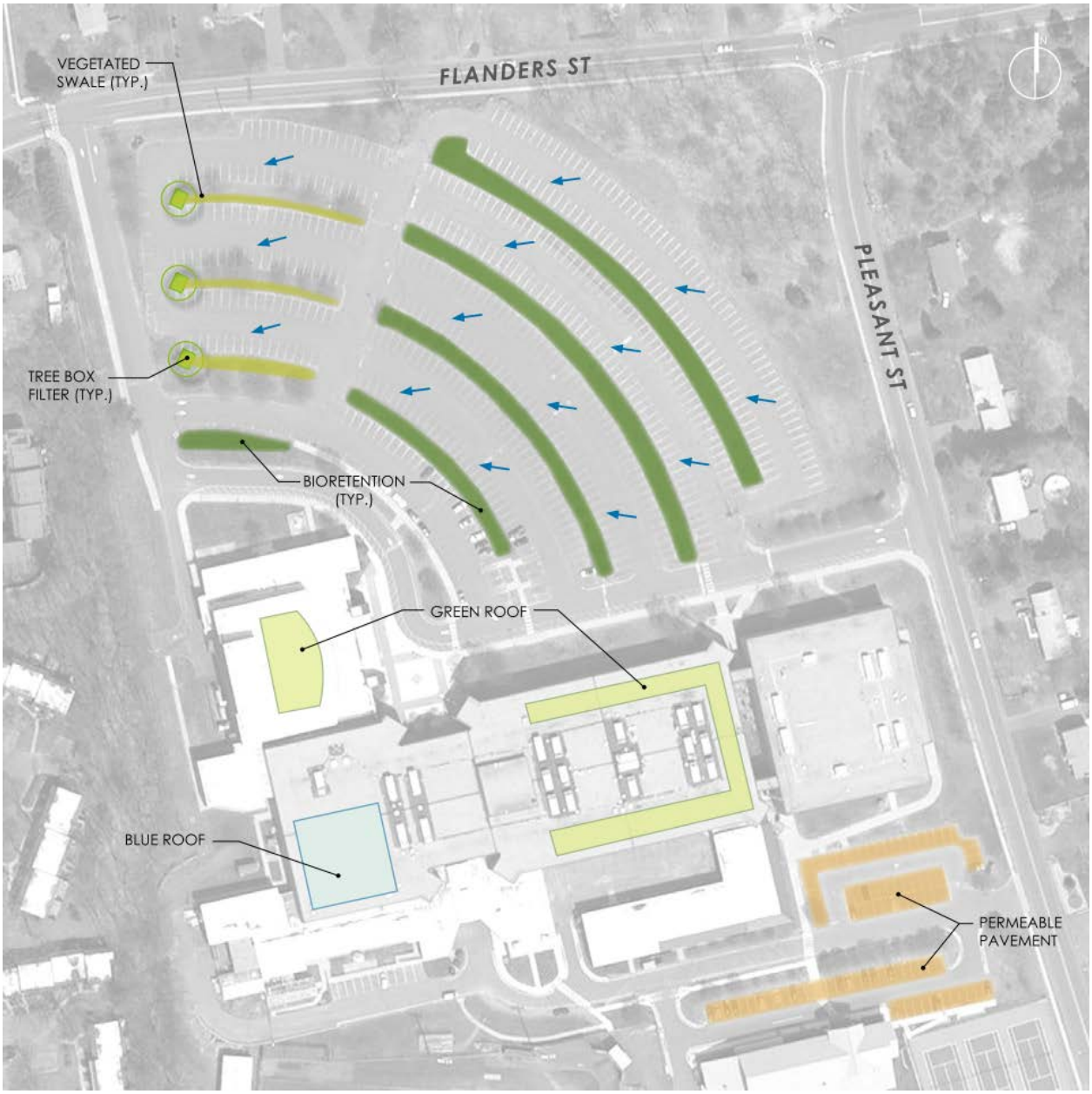


Figure 4-7. Southington High School Green Infrastructure Retrofit Concept

Green or Blue Roof. Public buildings with large flat roofs are potential candidates for green or blue roof retrofits. Green roofs are engineered planting systems that can be installed on buildings to absorb and retain rainwater, reducing peak stormwater flows and runoff volumes. Green roofs are more costly than conventional roofs but they are capable of absorbing and retaining large amounts of stormwater. In addition, green roofs provide sustainability benefits such as absorbing air and noise pollution, rooftop cooling by reducing ultraviolet radiation absorption, creating living environments for birds, and increasing the quality-of-life for residents.

Blue roofs are non-vegetated rooftop source controls that detain stormwater. Weirs at the roof drain inlets and along the roof can create temporary ponding and gradual release of stormwater. Blue roofs are less costly than green roofs. Coupled with light-colored roofing material, they can provide energy savings through rooftop cooling. New York City has begun to use blue roofs as part of its green infrastructure strategy for addressing CSOs and stormwater management.

A portion of the school building's roof could be converted to a green roof or blue roof.

Permeable Pavement. The smaller rear parking lots are good candidates for permeable pavement in the parking stalls because they are relatively small areas and do not receive any stormwater run-on from off-site areas. These lots do not receive heavy traffic. Different types of permeable pavement are discussed in *Section 4.3*. Porous asphalt could be used at this site to reduce installation costs.

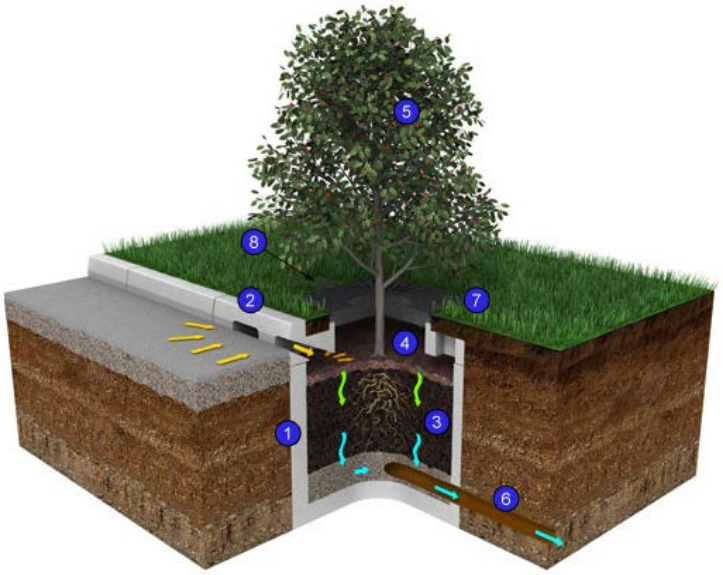


Figure 4-8. Typical Tree Box Filter (Source: Hydro International, Inc.)

Figure 4-9. Modular Green Roof System Installation

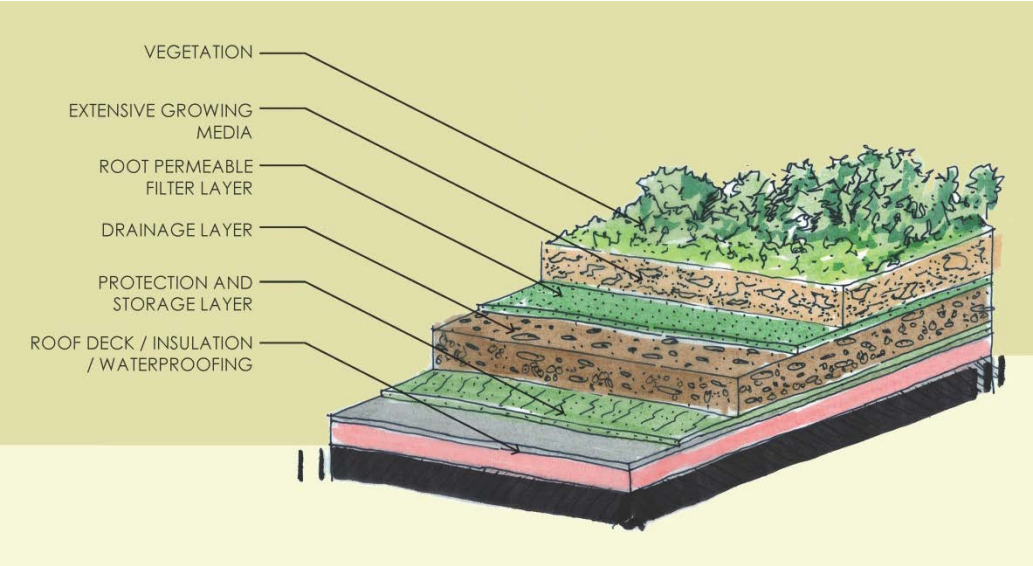


Figure 4-10. Typical Green Roof Design

Figure 4-11. Existing and Proposed Visualization for the Parking Island Bioretention Areas

4.3 Clinton Avenue School and Clinton Fields, New Haven

Clinton Avenue School and Clinton Fields Retrofit

Location:
293 Clinton Avenue, New Haven
Objectives:
Improve water quality by infiltrating and treating stormwater; provide educational elements for the public.
Essential Elements:
Bioretention and rain gardens, infiltration trenches, a blue roof, and permeable pavement
Estimated Cost: $198,000–$424,000

Clinton Avenue School and Clinton Fields are located adjacent to Interstate 91 on Clinton Avenue in the Fair Haven area of New Haven. Clinton Fields are managed by the City on New Haven Department of Parks, Recreation and Trees. The school is located on an approximately 5 acre site, with approximately half of the school grounds consisting of impervious areas. Clinton Fields consists of approximately 8 acres of turf fields. The site is located less than a quarter mile from the Quinnipiac River, making it a good candidate for LID retrofits. A variety of LID practices could be used on this site including bioretention and rain gardens, infiltration trenches, a blue roof, and permeable pavement for the parking stalls.

Bioretention Area. A bioretention area is proposed in an existing grass area downgradient of the parking lot. An existing catch basin adjacent to the proposed bioretention area could be modified to an inlet for the bioretention system. Since the drainage system is already installed in this area, overflow from the bioretention area could be directed back into the existing piped underground drainage system.

Rain Gardens. Small-scale bioretention applications for residential yards, median strips, or parking lot islands are commonly referred to as rain gardens. A rain garden is proposed in front of the school building along Clinton Avenue, which could include educational signage for the students and the public. Two other rain gardens are proposed near a side entrance to the school and at the corner of Clinton Fields where there are depressed areas in the grass with existing catch basins or yard drains. The rain garden could be excavated/constructed around the catch basin, using the existing catch basing/yard drain as an overflow.

Blue Roof. A blue roof is proposed for the school rooftop to detain rain water and release it up to a 24 hour period to attenuate peak flows.

Infiltration Trenches. An infiltration trench is proposed on the downgradient sides of the paved basketball and play courts to capture and infiltrate stormwater. An infiltration trench is an excavated trench back-filled with stone to form a subsurface collection area. Stormwater runoff is diverted into the trench where it is detained until it can be infiltrated into the soil. Infiltration trenches are very adaptable and the availability of many practical configurations makes them ideal for small urban drainage areas with sufficiently permeable soils.

Permeable Pavement. A variety of materials are available to replace conventional paved surfaces (roadway, driveway, and parking) with permeable pavement *(Figure 4-13)*. Permeable pavement material should be selected based on the characteristics of the site and the application, as well as cost and maintenance considerations.

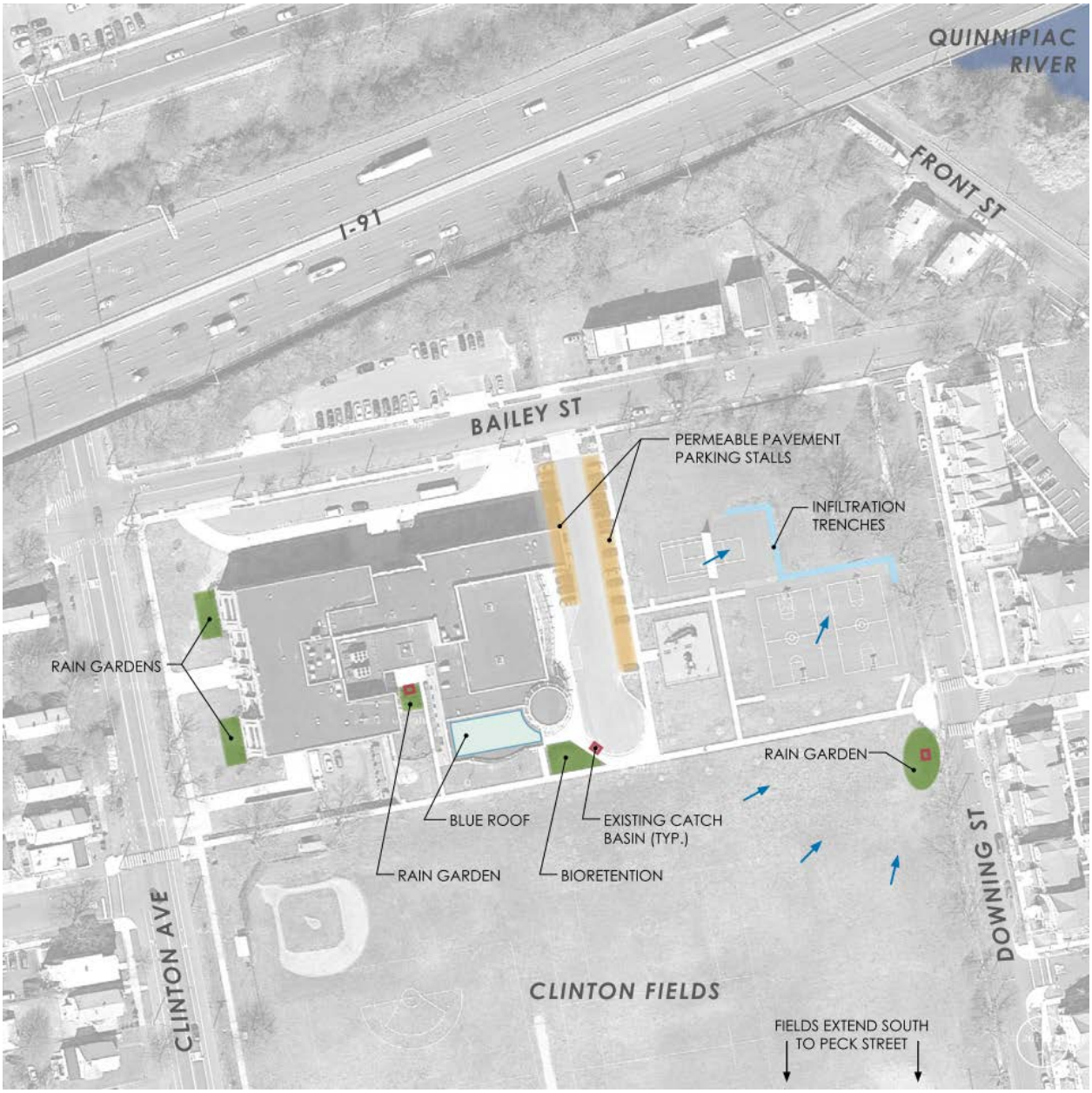


Figure 4-12. Clinton Avenue School and Clinton Fields Green Infrastructure Retrofit Concept

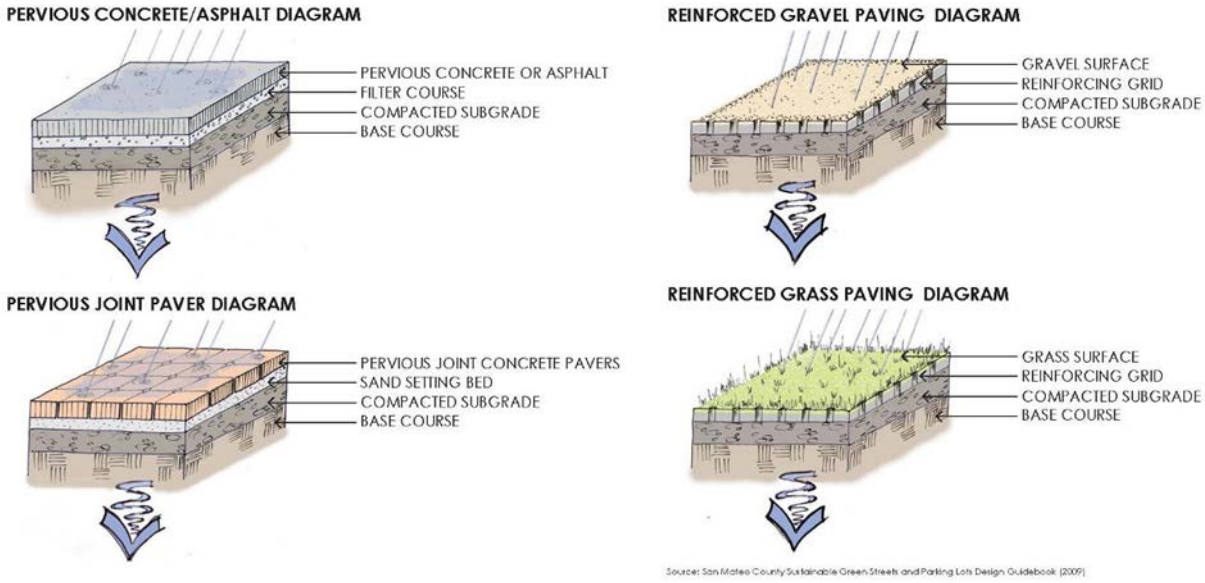


Figure 4-13. Diagrams of Selected Permeable Pavement Systems

Block pavers are easy to install and relatively inexpensive, but are suitable for applications where vehicle traffic is relatively light. Parking spaces in urban areas can be paved with open-jointed block pavers, which are more attractive than pervious asphalt or concrete, but provide a smoother surface and are somewhat more suited to constant vehicle use, although at slow speeds. For areas where heavier traffic loads are anticipated, pervious asphalt or pervious concrete may be more appropriate. These pavements are similar to common asphalt and concrete but contain voids to make them permeable and can be used for roadway surfaces. Pervious pavers could be used for this application since traffic is light in this employee lot.

4.4 Green Streets – Quinnipiac Avenue at Foxon Street, New Haven

A "green street" retrofit of Quinnipiac Avenue near Foxon Street in New Haven would address stormwater management and streetscape improvement objectives. Quinnipiac Avenue is typical of urban residential streets in New Haven and throughout the watershed; it is wider than necessary, and provides for parking on both sides of the street, which is under-utilized since most homes have driveways and off-street parking. Many urban and suburban streets, sized to meet code requirements for emergency service vehicles and provide a free flow of traffic, are oversized for their typical everyday functions. The Uniform Fire Code requires that streets have a minimum 20 feet of unobstructed width. The width on Quinnipiac Avenue is approximately 32 feet.

Green Streets Design for Quinnipiac Avenue

Location: Quinnipiac Avenue, New Haven
Objectives:
Improve streetscape, traffic calming, reduce runoff volumes, pollutant loads, and peak flow rates
Essential Elements:
Pervious pavement in on-street parking stalls and bioretention bulb-outs at intersections and driveways
Estimated Cost: $111,000 –$239,000

One potential concept (*Figure 4-14)* consists of reducing the amount of effective impervious cover along Quinnipiac Avenue to reduce runoff volumes, pollutant loads, and peak flow rates, as well as infiltrating and treating stormwater through the use of green infrastructure practices such as bioretention areas and tree boxes. This concept maintains on-street parking and integrates stormwater management and streetscape improvements using green infrastructure approaches within the right-of-way, while providing an aesthetic benefit and traffic calming. This concept could be applied to many residential streets within the watershed.

Figure 4-14. Quinnipiac Avenue Green Streets Retrofit Concept

The proposed concept for Quinnipiac Avenue includes the following elements, which can be implemented on other low to medium-traffic volume residential streets:

Pervious pavement in on-street parking stalls. Quinnipiac Avenue is approximately 32 feet wide with one travel lane in each direction and the remainder used for on-street parking, which is not fully utilized. On-street parking could be limited by providing bulb-outs, which would allow construction of

pervious pavement, such as pervious concrete, pervious asphalt, or open-jointed block pavers. These areas would be available for parking but, unlike conventional asphalt pavement, would infiltrate stormwater and reduce roadway runoff volumes and pollutant loads. *Figure 4-15* shows a typical detail of a green street parking bay.

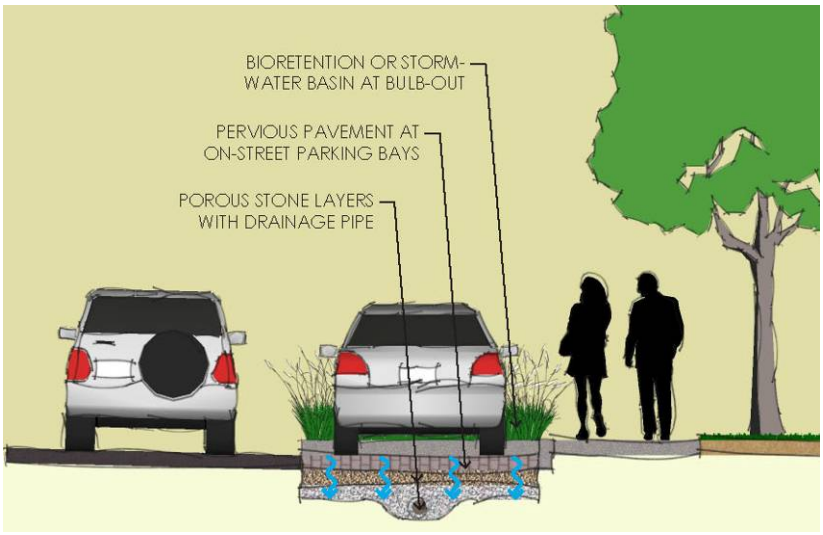


Figure 4-15. Typical Green Street Parking Bay

Bioretention Bulb-outs. Near intersections and driveways, where on-street parking is discouraged to maintain site distance for turning vehicles and turning radius for driveway access, bioretention bulb-outs could be used to capture, treat, and infiltrate or filter stormwater. Bulb-outs at intersections can also serve to provide traffic calming. A typical bioretention bulb-out detail is presented in *Figure 4-16*. These bioretention areas would have a soil media layer to temporarily store and treat runoff prior to infiltration into underlying soils or discharge to the storm drainage system in areas with high groundwater or poor soils. The bulb-outs could be planted with attractive, low-growing and low-maintenance native landscape plants with a mulch layer.

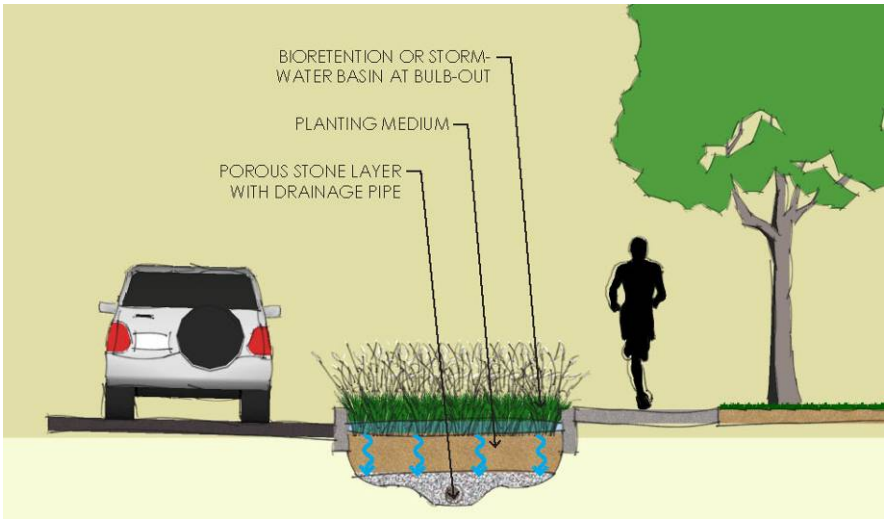


Figure 4-16. Typical Green Street Bioretention Bulb-out

4.5 Calendar House, Southington

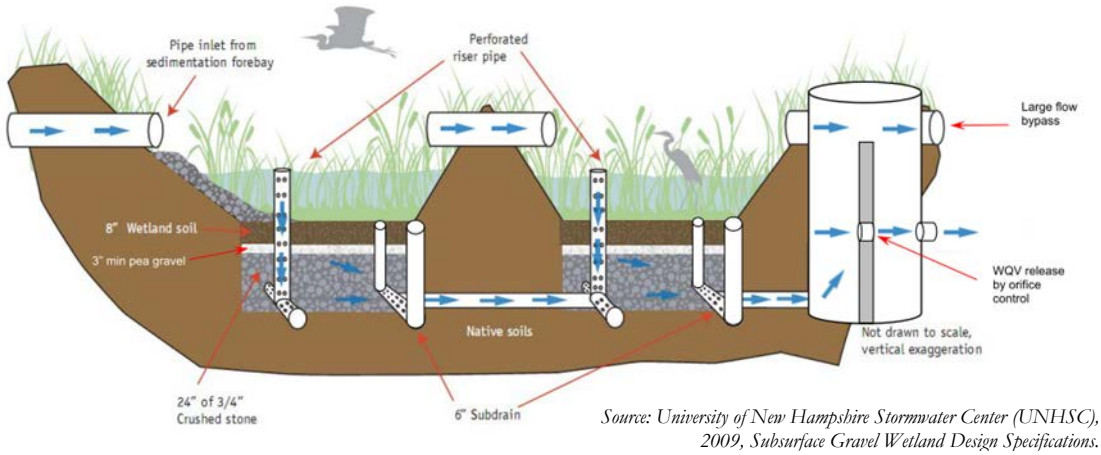
The Calendar House is home to the Southington Senior Center located at the corner of Pleasant Street and Hobart Street in Southington. The parking lot was recently reconstructed and consists of traditional drainage structures including catch basins and piped drainage that are believed to drain to a dry detention basin at the southern edge of the property. The detention basin provides only minimal stormwater treatment or infiltration prior to being discharged from the basin.

Calendar House Detention Basin Retrofit

Location:
388 Pleasant Street, Southington
Objectives:
Peak flow attenuation and pollutant load reduction
Essential Elements:
Subsurface gravel wetland
Estimated Cost: $113,000 –$239,000

The Calendar House is located within the Well #1 and #3 APA for the Southington Water Department. The proposed green infrastructure improvements are to retrofit the existing dry detention basin in the rear of the building to create a subsurface gravel wetland *(Figure 4-18)*. The native soils in the area are in Hydrologic Soils Group B, meaning they have moderately low potential for runoff and water transmission through the soil would be uninterrupted.

Subsurface Gravel Wetland. A subsurface gravel wetland could be constructed to replace the existing dry detention basin for treating runoff from the site *(Figure 4-17)*. The subsurface gravel wetland uses a series of horizontal flow-through treatment cells, preceded by a sedimentation forebay and provides sedimentation, filtration, physical and chemical sorption, and treatment of bacteria (UNHSC, 2009).



Source: University of New Hampshire Stormwater Center (UNHSC), 2009, Subsurface Gravel Wetland Design Specifications.

Figure 4-17. Typical Subsurface Gravel Wetland Design

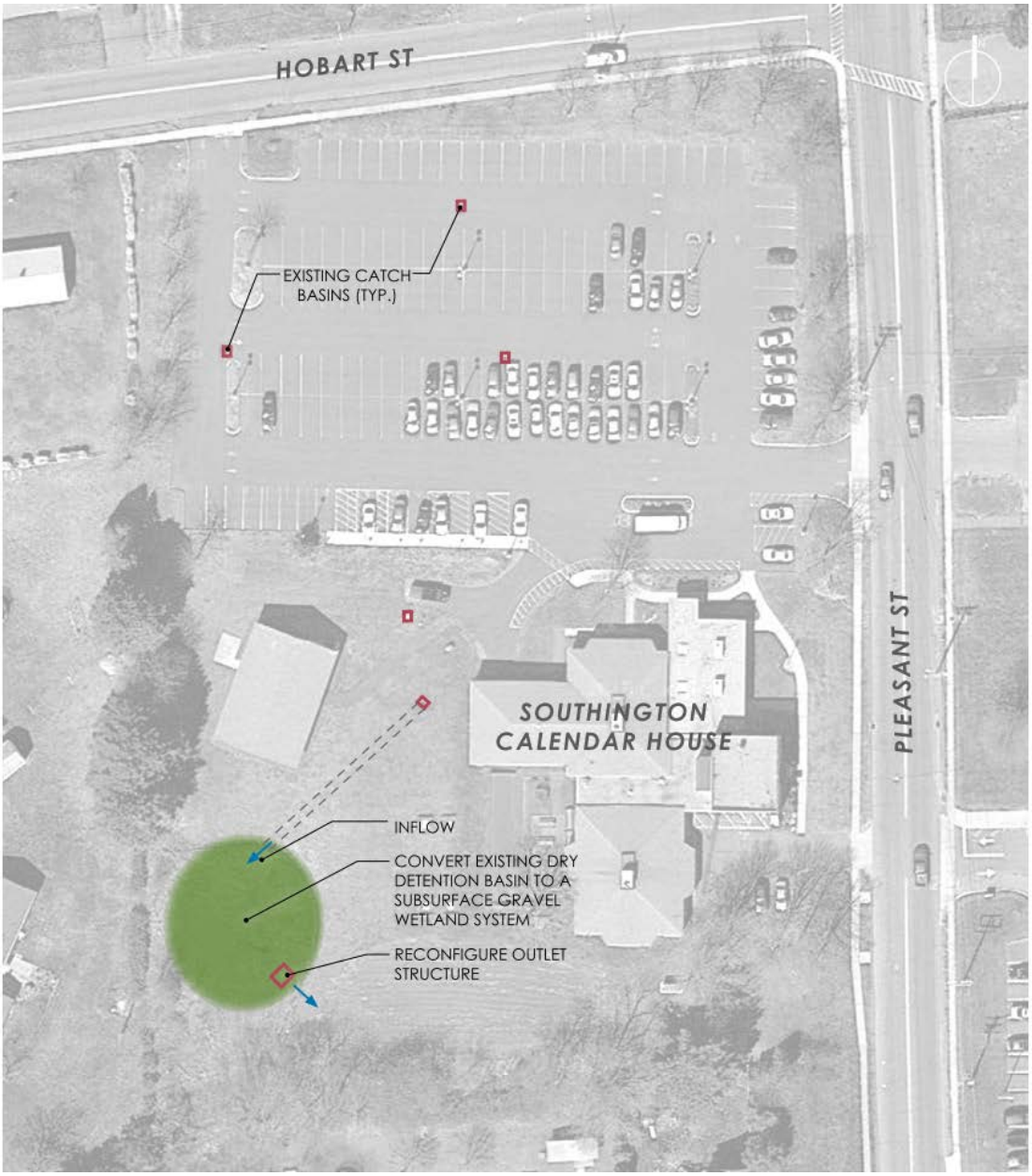


Figure 4-18. Calendar House Green Infrastructure Retrofit Concept

4.6 Columbus Park, Meriden

Columbus Park Retrofit

Location:
208 Lewis Avenue, Meriden
Objectives:
Habitat improvement and public outreach
Essential Elements:
Stream restoration and invasive species removal
Estimated Cost: $61,000–$131,000

Columbus Park is located on approximately 12 acres in Meriden on Lewis Avenue just south of Interstate 691 within the Mule and Columbus Park APA of the Meriden Water Division. The park consists of recreational fields, including 3 baseball fields and a soccer field. Stormwater runoff discharges to Sodom Brook, which forms the western boundary of the site. Sodom Brook flows from north to south in this area and the park is located just downstream of the road crossing of Interstate 691. The restoration of Columbus Park could include stream restoration and invasive species removal.

Invasive Species Control: The riparian buffer is degraded in this area and has invasive species growing along the banks, including Japanese knotweed *(Fallopia japonica)* which was also identified in others areas of the Quinnipiac River watershed. This and other invasive species such as multiflora rose, purple loosestrife, and oriental bittersweet, are common in Connecticut and have displaced native species and threaten local biodiversity and ecosystem function in the watershed. Japanese knotweed is a herbaceous plant that has hollow stems with distinct raised nodes that give it the appearance of bamboo, as shown in *Figure 4-19*, a photo taken of Sodom Brook in Columbus Park. An invasive species management plan could be developed for eradication and control methods within the watershed including planting plans for native vegetation. Other areas within the watershed with invasive species issue may be identified through watershed-wide invasive species surveys.

Figure 4-19. Invasive Species Japanese Knotweed at Columbus Park

Stream Restoration: Stream restoration of the bank and riparian areas would likely include replacing degraded areas with dense plantings of native shrubs and herbaceous plants that would stabilize the bank's soils with a network of roots and eventually shade the stream *(Figure 4-20)*. Japanese knotweed is

considered shade intolerant and is therefore unlikely to grow under closed tree canopy, mititgating the growth of future knotweed vegetation.

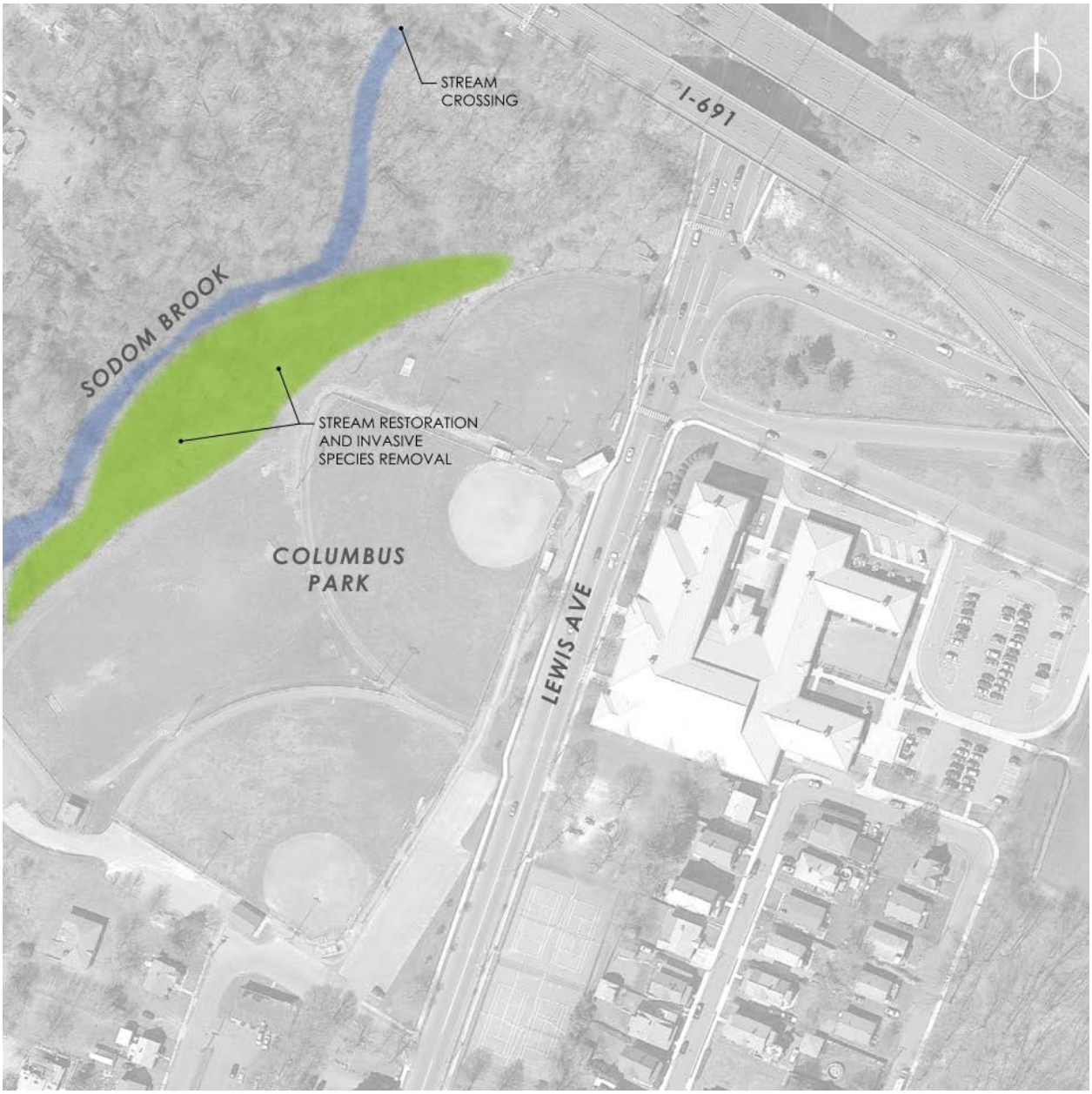


Figure 4-20. Columbus Park Stream Restoration Concept

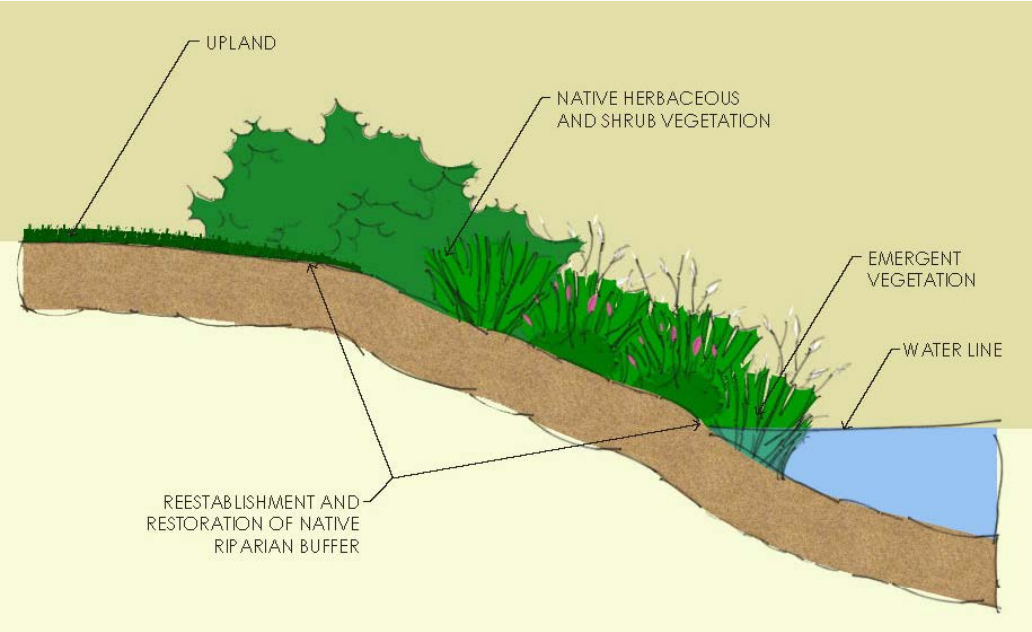


Figure 4-21. Typical Bank Restoration Planting for Small Streams

A typical bank restoration planting for small streams is shown in *Figure 4-21*. While plants are establishing, coir fiber rolls staked to the banks would prevent erosion on steeper slopes. Upslope from the bank, a riparian buffer of native trees and shrubs could replace the existing grass to better slow direct stormwater runoff and provide improved stormwater treatment and infiltration.

4.7 Department of Motor Vehicles Office, New Britain

New Britain DMV Retrofit

Location:
85 North Mountain Road, New Britain
Objectives:
Reduce parking lot runoff and improve water quality and reconfigure the existing detention basin to enhance pollutant removal
Essential Elements:
Bioretention areas, rain gardens, retrofit existing basin to an extended wet pond
Estimated Cost: $68,000–$146,000

The Connecticut Department of Motor Vehicles (DMV) office in New Britain is located at the top of a steep hill on North Mountain Road. The site is located within the Woodford Avenue APA of operated by Valley Water Systems, Inc. The site is located just east of Interstate 84 near Exit 36. Stormwater from the site discharges to the Quinnipiac River approximately 2 miles south of its headwaters in Farmington. The topography of the site generally slopes toward the southwest, with the DMV office located at the high point of the site. There are many tiered parking lanes that have grasses islands in between, providing adequate space for bioretention islands. There is also an existing dry detention basin that received stormwater runoff from the majority of the site. A green infrastructure retrofit on the site could include the following elements *(Figure 4-22):*

Bioretention Areas and Rain Garden. Bioretention areas and a rain garden are proposed in existing parking lot islands to capture, treat, and infiltrate stormwater. The existing catch basins could be modified as inlets to the bioretention/rain garden systems.

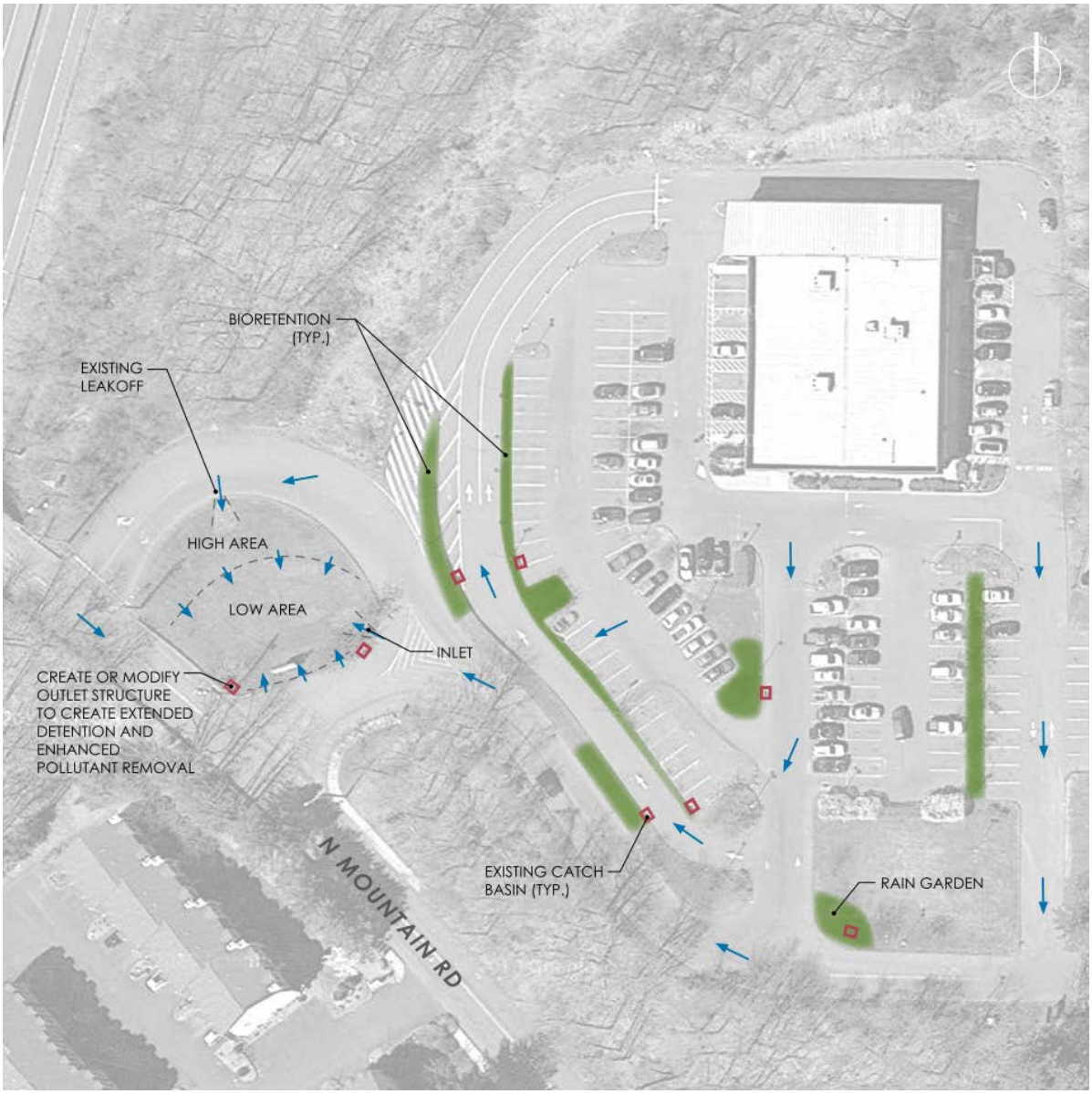
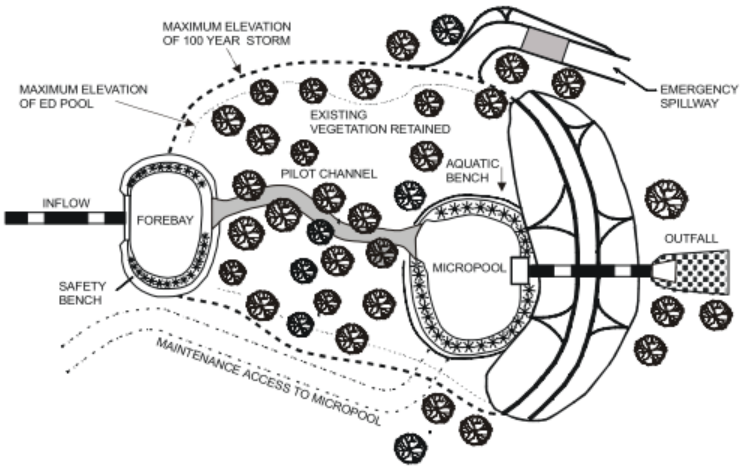


Figure 4-22. New Britain DMV Green Infrastructure Retrofit Concept

Detention Basin Retrofit: The site drains to a common detention basin near the driveway entrance which provides a small detention area, but no water control structure to detain any water within the basin for an extended period of time. The control outlet structure could be modified to improve the existing detention pond. Conventional detention ponds temporarily store stormwater runoff, thereby reducing the peak rate of runoff to a stream or storm sewer. They help to prevent localized flooding although they do not provide water quality benefits since there is no permanent pool. A micropool can be provided in an

extended detention pond to prevent re-suspension of previously settled sediments and prevent clogging of the low flow orifice *(Figure 4-23)*.



Source: Center for Watershed Protection. (2000). Maryland Stormwater Design Manual.

Figure 4-23. Micropool Detention Pond Typical Design

4.8 Doolittle Park, Wallingford

Doolittle Park Retrofit

Location:
South Elm Street, Wallingford
Objectives:
Improve water quality, stream habitat restoration, and fish and amphibian passage improvement
Essential Elements:
Permeable pavement, infiltration trenches, riparian buffer restoration, and dam removal
Estimated Cost: $103,000–$220,000

Doolittle Park is a 15.4 acre town-owned facility located on South Elm Street in Wallingford and includes ball fields, three-lighted tennis courts, two basketball courts, and a playscape. Stormwater from the fields drains via overland flow to Wharton Brook, which constitutes the eastern boundary of the park. There are several catch basins on-site to drain water from the parking lot and tennis courts directly to Wharton Brook. The banks along the brook have eroded potentially due to a lack of riparian buffer along the stream and upstream development increasing peak flows. The fields are mowed almost entirely to the bank, leaving no brush or trees to provide canopy cover or nutrient removal. The proposed restoration concept includes permeable pavement in the parking lot, infiltration trenches around the tennis courts, restoring the riparian buffer around the stream, and removing a small dam on Wharton Brook *(Figure 4-24)*:

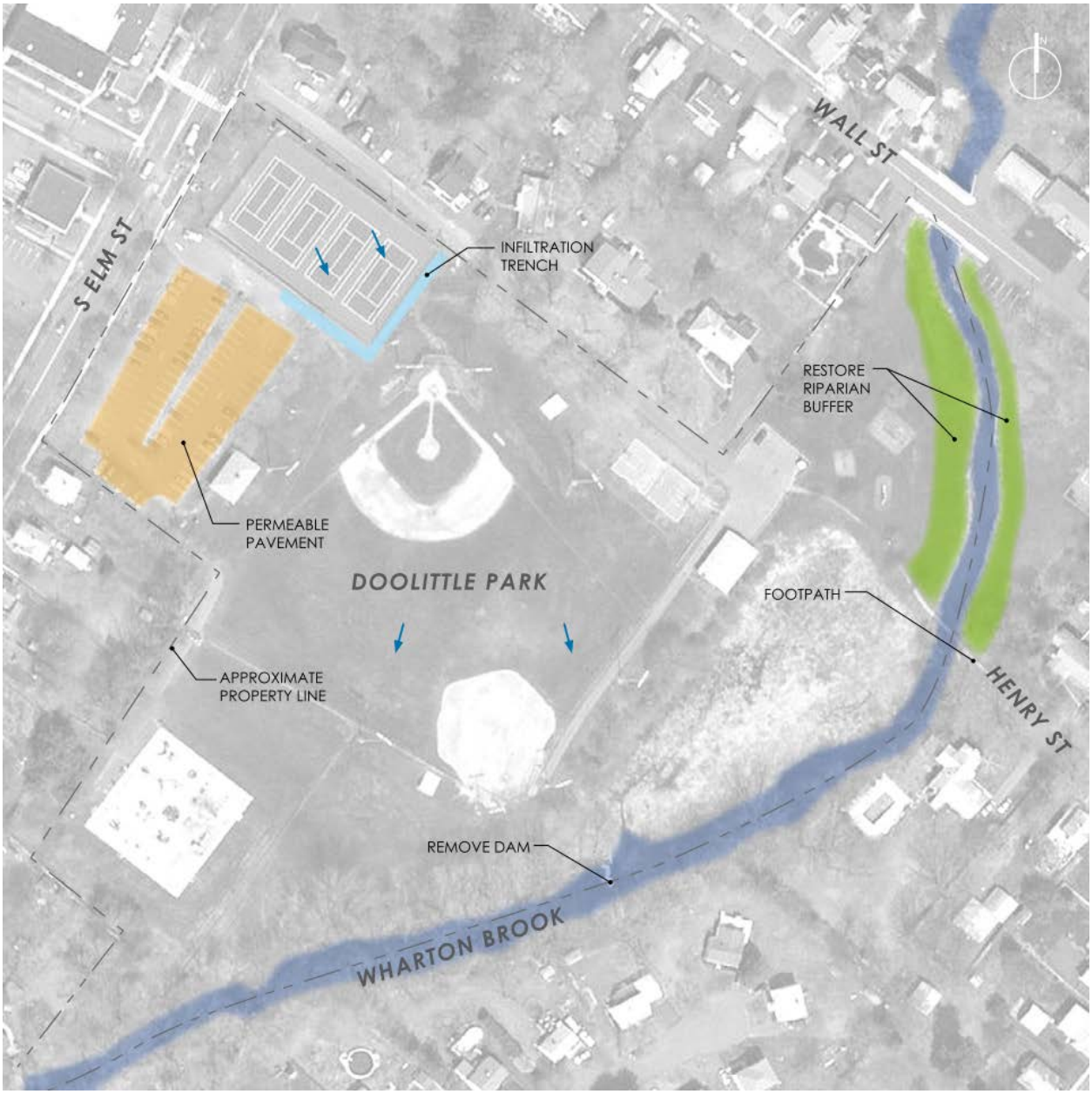


Figure 4-24. Doolittle Park Green Infrastructure Retrofit Concept

Reinforced Gravel Parking: Reinforced gravel parking (a type of permeable pavement, see *Section 4.3)* or other types of permeable pavement could be used for the parking lot area to reducing runoff and pollutant transport through direct infiltration. The entrance driveway and could remain as conventional asphalt pavement since it has higher traffic volumes.

Infiltration Trenches: Infiltration trenches could be installed around the tennis courts, to infiltrate the clean runoff.

Riparian Buffer Restoration: The riparian buffer along a 400 foot section of Wharton Brook from the Wall Street crossing to the walking bridge that crosses near Henry Street has encroachments from mowing up to the stream bank. Vegetative buffers help encourage infiltration of runoff, filter pollutants, and provide absorption for high stream flows, which helps mitigate flooding and drought. *Figure 4-25* shows a conceptual visualization of the proposed buffer restoration along the stream. The addition of trees would help shade the stream, decrease water temperatures, and serve as permanent buffer markers to protect the restored buffer from being mowed.

Figure 4-25. Existing and Proposed Visualization for Riparian Buffer Restoration of Wharton Brook in Doolittle Park

Dam Removal: A small dam is located within Doolittle Park on Wharton Brook, which does not appear to serve a current purpose and is in disrepair *(Figure 4-26)*. Although the dam is small, approximately 2-3 feet in height, obstructions such as this limit or prevent passage of fish and other aquatic organisms. The dam could be removed to improve in-stream habitat and fish passage.

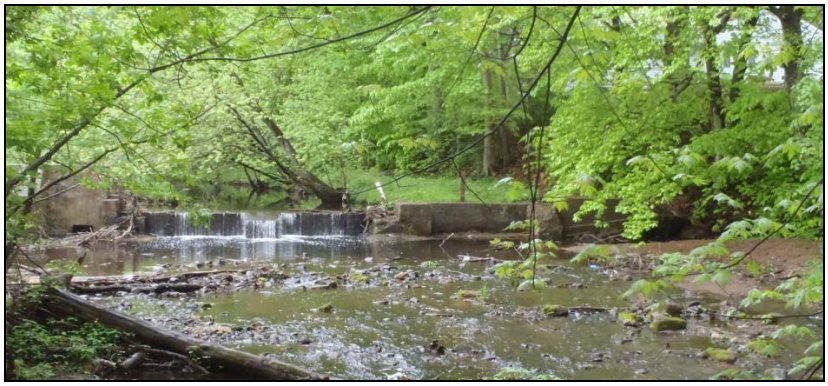


Figure 4-26. Small Dam on Wharton Brook

4.9 Public Library, Meriden

The Meriden Public Library is situated in a densely developed urban neighborhood on Miller Street in Meriden. The library property consists primarily of impervious surfaces including the library building and associated parking lot. There are several small impervious underutilized lawn area areas around the building that could accommodate bioretention retrofits. The turf areas on the edge of the property adjacent to Liberty Street would be ideal locations for LID practices; however, the parking lot drainage predominantly flows toward the building away from Liberty Street. Therefore, a subsurface infiltration galley is proposed at the northern edge of the parking lot to maintain the existing parking spaces and infiltrate stormwater runoff (*Figure 4-27)*. The proposed retrofit elements include:

Meriden Public Library Retrofit

Location: 105 Miller Street, Meriden
Objectives: Reduce parking lot runoff and improve water quality, reduce roof runoff, and provide educational benefits to school children and the public
Essential Elements: Green Roof, Permeable Pavers, Tree Boxes, Bioretention, and Subsurface Infiltration
Estimated Cost:

Green Roof	$43,000 – $284,000
Porous Asphalt	$52,000 - $111,000
Rain Garden and Signage	$31,000 - $68,000
Subsurface Infiltration	$88,000 – $189,000
Tree Boxes	$11,000 - $24,000
Total Cost:	**$314,000 – $676,000**

Rain Garden with Educational Signage. There is an approximately 2,100 sf grass area near the rear of the building between the parking lot and the building that could be converted to a rain garden to capture, treat, and infiltration runoff from the building and adjacent areas during small storms. The grass area has an existing catch basin/yard drain which could serve as an overflow during larger storms. Educational signage could be provided for the public to understand stormwater issues in the Quinnipiac watershed and the benefits of rain gardens. A conceptual design for the rain garden is shown in *Figure 4-28*.

Figure 4-27. Meriden Public Library Green Infrastructure Retrofit Concept

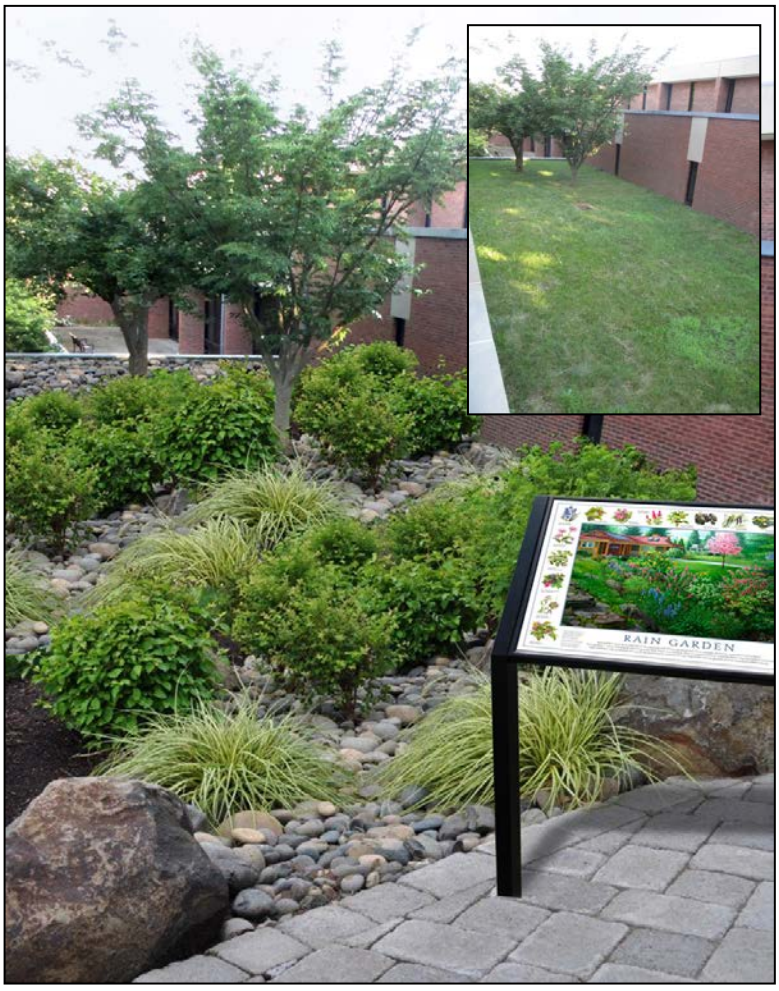


Figure 4-28. Existing and Proposed Visualization for the Meriden Public Library Rain Garden

Subsurface infiltration System. A subsurface infiltration system is proposed to receive stormwater runoff from the parking area and infiltrate it through a subsurface galley such as the one shown in the picture to the right. The stormwater infiltrates through the stone bottom. The outlet would tie into the existing piped drainage system to avoid water backup into the parking area. The soils at the site consist of Urban Land, which could have variable infiltration values. Site-specific investigations should be conducted during preliminary design.

Permeable Pavement & Tree Boxes. A variety of materials are available to replace conventional paved surfaces (roadway, driveway, and parking) with permeable pavement. Permeable pavement material should be selected based on the characteristics of the site and the application, as well as cost and

maintenance considerations. Block pavers are easy to install and relatively inexpensive. They may be suitable for this application where vehicle traffic is relatively light. Tree boxes could be installed at the end of the parking rows to infiltrate stormwater that is not intercepted by the permeable pavement.

4.10 Park & Ride, Southington

Southington Park & Ride Retrofit

Location:
South Main Street, Southington
Objectives:
Improve water quality and restore a degraded stormwater treatment area for upland runoff
Essential Elements:
Vegetated swale and constructed wetland
Estimated Cost: $21,000–$46,000

The Park & Ride lot near Interstate 84, Exit 29 in Southington is operated by the Connecticut Department of Transportation. The Park & Ride was approximately half utilized during the site visit on a weekday. The parking lot is an approximately 1 acre paved area located approximately 550 feet from the main stem Quinnipiac River. Stormwater runoff from the parking lot drains to the west toward a degraded swale with some wetland vegetation *(Figure 4-29)*. The swale also receives runoff from other areas, possibly from South Main Street or other properties in the vicinity via a 24-inch drainage pipe. The proposed retrofit elements include an improved vegetated swale to capture runoff from the parking lot and direct flow to a constructed wetland area that would replace the existing vegetated swale.

Figure 4-29. Southington Park & Ride Green Infrastructure Retrofit Concept

Grassed Channel. A grassed channel could be constructed around the perimeter of the parking area to convey stormwater runoff to a constructed wetland on the northwestern side of the lot. The grassed channel provides sediment removal, which is a typical pollutant from traffic areas. Other pollutants would be removed in the constructed wetland.

Constructed Wetland. The existing degraded wetland area inside the conveyance channel could be upgraded to function as a pocket constructed wetland system containing native species and engineered drainage layers. The constructed wetland would be designed for enhanced treat of runoff from the Park & Ride area and the upland area that drains through the 24" outfall pipe.

Figure 4-30. Existing Conveyance Channel at the Park & Ride

4.11 Commercial Development, North Haven

Commercial Development (Target) Retrofit

Location:
Universal Drive, North Haven
Objectives:
Reduce runoff and improve water quality from commercial parking areas and large commercial roofs
Essential Elements:
Bioretention parking islands
Estimated Cost: $223,000–$477,000

Numerous commercial plazas and "big box" stores are located in an approximately 150 acre area on either side of Universal Drive and North Universal Drive in North Haven. These commercial areas provide hundreds of parking spaces, most notably Target, BJ's, Michaels, Home Depot, and Rave Cinemas. The buildings and parking on the western side of Universal Drive drain directly to the Quinnipiac tidal marsh system. It appears that several of the newer facilities and site have some degree of modern stormwater management systems, including the North Haven Commons, which was formerly a brownfield site and was redeveloped in 2009.

A potential stormwater retrofit concept is proposed for the Target store located on the southern end of the shopping development, although the principles could be applied to other commercial sites within the watershed. The Target store is located on an approximately 26 acre site that has shared parking with other commercial stores. The retrofit concept for Target is to improve water quality by treating the parking lot runoff using bioretention in the parking islands and to attenuate peak flows by infiltrating stormwater and detaining water on the roof in a blue roof system, as described below and shown in *Figure 4-31*:

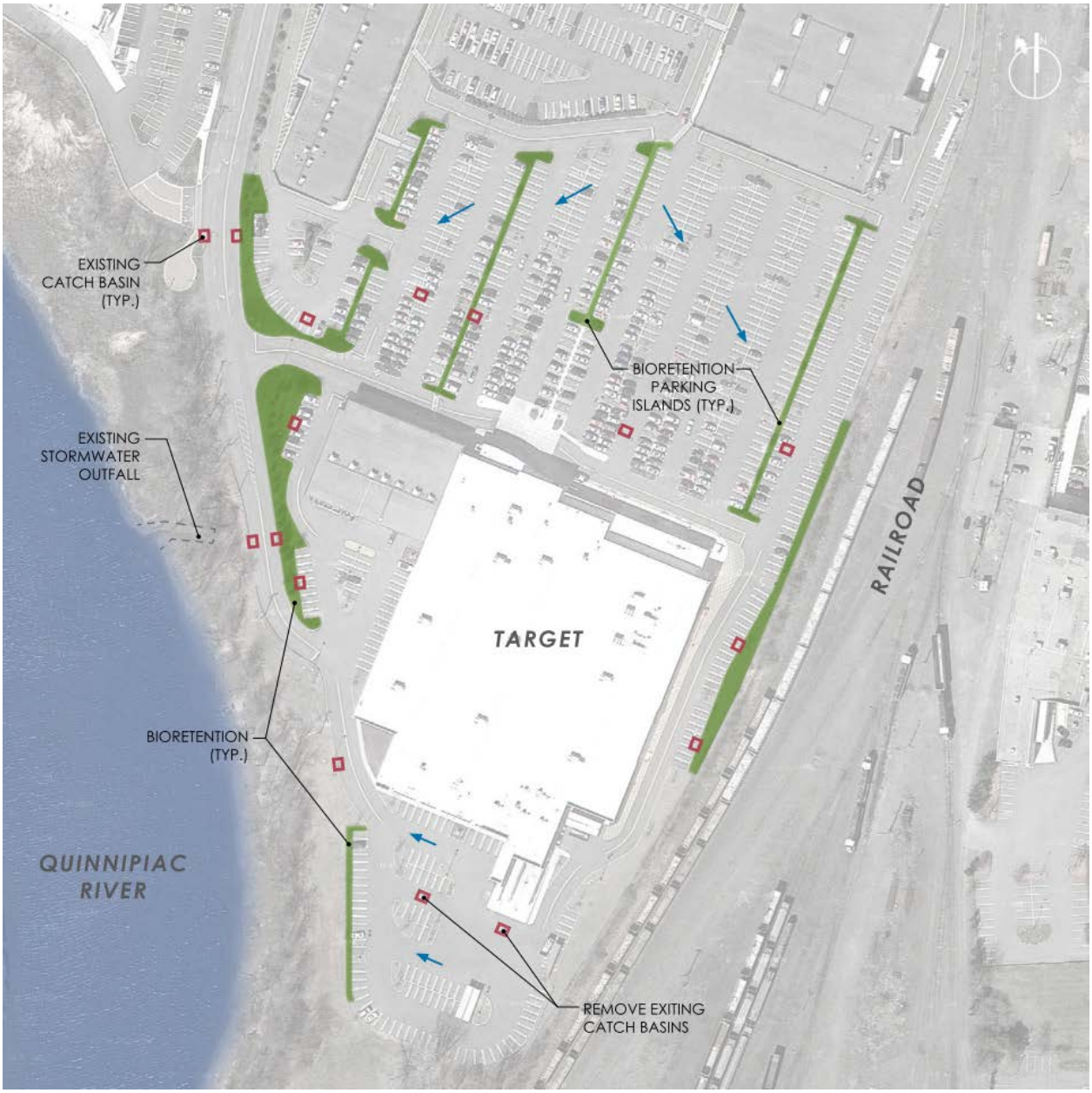


Figure 4-31. North Haven Shopping Mall Green Infrastructure Retrofit Concept

Bioretention Parking Islands. Bioretention areas are proposed throughout the parking lot within existing grass areas in the parking islands. Areas for bioretention were selected near existing catch basins to avoid regrading the parking lot. Since the drainage system is already installed in this area, overflow from the bioretention areas would tie into the existing site drainage system.

4.12 Other Potential Green Infrastructure Retrofits

Opportunities for stormwater retrofits exist throughout the Quinnipiac River watershed. The most promising retrofit opportunities are generally located on publicly-owned land and include:

- Parking lot upgrades (bioretention, pervious pavement, vegetated buffers, water quality swales)
- Municipal and institutional properties (bioretention, pervious pavement green roofs, blue roofs, tree planting, stormwater harvesting)
- Athletic fields at parks and educational institutions (water quality swales, vegetated buffers, infiltration, bioretention, stormwater reuse for irrigation)
- Road repair/upgrades (green or "complete" streets – bioretention, permeable pavement, water quality swales, tree planters, below-ground infiltration chambers)
- Roadway stormwater outfalls, particularly at or near roadway stream crossings
- Vacant or underutilized parcels owned by the watershed municipalities

Residential lots offer opportunities for small-scale LID retrofits such as roof leader and downspout disconnection, rain barrels, and rain gardens, but typically require homeowner incentives and outreach/education for widespread implementation. Several of these have been implemented by the Save the Sound's Rain Garden Program. Commercial and industrial facility retrofits can also be effective as these sites are typically characterized by high impervious cover and pollutant sources. However, commercial and industrial retrofits also require incentives and cooperation of private land owners if they are not regulated through a local, state, or federal permit program.

Two community workshops were held in Meriden on July 23, 2013 that focused on soliciting input from residents, municipal staff, and land use commissions in the major watershed communities. *Table 4-1* summarizes potential green infrastructure retrofit sites, in addition to the concepts presented in *Section 4-1 through 4-11,* that were identified during the desktop screening-level review, field inventories, and during the community workshops.

Table 4-1. Other Potential Green Infrastructure Retrofits

Site	Land Use	Town	Description/Potential Retrofits
Gulf Gas Station, Route 322	Commercial	Cheshire	Gas station adjacent to Quinnipiac River; non-infiltration LID practices could be implemented to treat stormwater runoff from parking lot.
Castle Heights	Residential	Cheshire	Construction was underway during site visits (May 2013); confirm stormwater treatment is being provided.
Custom & Precision Products	Industrial	Hampden	Site located along the Quinnipiac River east of State Street. Based on aerial imagery, the site appears to be used for material storage and has large areas of exposed soil. The site is likely registered under the Industrial Stormwater General Permit in Connecticut.
Centennial Plaza Shopping Center	Commercial	Meriden	Within Lincoln-Platt APA for Meriden Water Division and adjacent to Crow Hollow Brook, tributary to Hanover Pond. Potential LID infiltration practices as retrofits or during site redevelopment.
Westfield Mall	Commercial	Meriden	The approx. 60-acre site is almost entirely impervious. LID elements could include infiltration since the site is within Mule and Columbus Park APA of Meriden Water Division. Potential LID includes bioretention parking islands, blue and green roofs, permeable pavement in underutilized or overflow parking, and extended wet ponds around the perimeter of the site.
Ben Franklin School	Institutional	Meriden	Site is almost entirely impervious and discharges to Sodom Brook. Potential LID elements include green roof and subsurface infiltration.
Midstate Medical Center	Institutional	Meriden	Within Mule and Columbus Park APA of Meriden Water Division, LID practices could include infiltration for parking lot and roof runoff.
Wilcox Tech School & Orville High School	Institutional	Meriden	Schools are located next to each other and could share larger stormwater retrofits or LID features could include infiltration-type BMPs.
Bronson Avenue Park	Recreational	Meriden	Adjacent to Harbor Brook; improve riparian buffer.
Hardware City Shopping Center	Commercial	New Britain	Adjacent to Quinnipiac River, restore riparian buffer. Could be restored in conjunction with the West Main Street & Stanwood Drive retrofit.

Table 4-1. Other Potential Green Infrastructure Retrofits

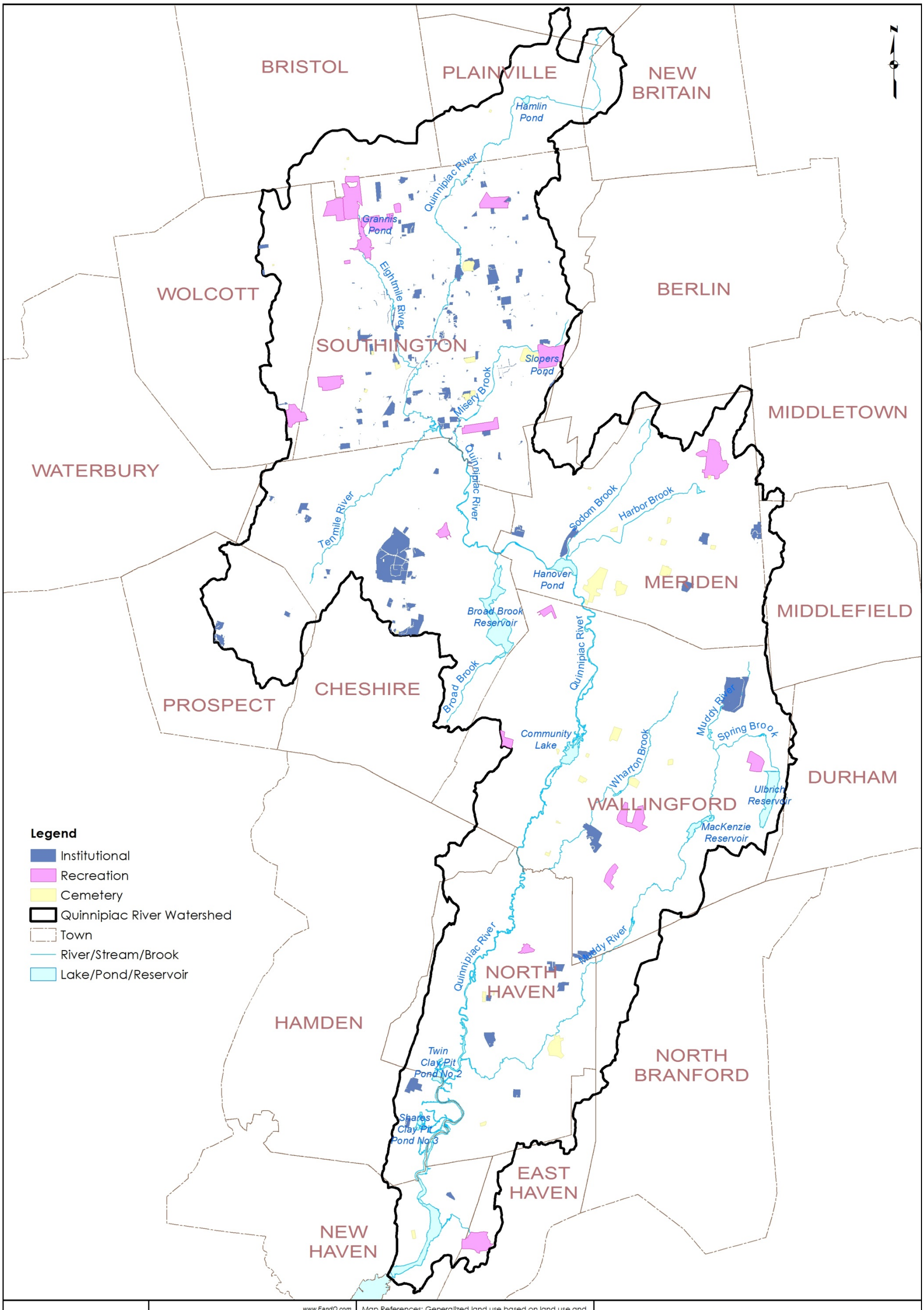
Site	Land Use	Town	Description/Potential Retrofits
West Main Street & Stanwood Drive	Commercial	New Britain	Stream currently flows under parking lot for former grocery store. Potential retrofit could consist of daylighting the stream and parking lot stormwater retrofits when the site is redeveloped.
Interstate 84 Right-of-Way	Transportation	New Britain	Roadway drainage improvements along I-84.
Quinnipiac River Park	Recreation	New Haven	As a lower-maintenance natural alternative to the retrofit concept presented in this section, consider the creation of restored salt marsh over a portion of the park, including a boardwalk to provide pedestrian access and views of the rvier.
Betsy Ross School and New Haven Schools Central Kitchen	Institutional	New Haven	Create stormwater basin and extend on-site wetland area next to the Central Kitchen building.
Fair Haven Middle School	Institutional	New Haven	Little space on-site for bioretention or rain gardens; potentially include green roof, subsurface infiltration.
Lenox Street & Aner Street	Transportation	New Haven	Potential green streets opportunity.
Wharton Brook State Park	Recreation	North Haven	Remove invasive species, stream cleanup (trash in stream), restore riparian buffer; restore eroded banks.
Plainville High School	Institutional	Plainville	Site is highly impervious with little room for surface LID practices; however, Quinnipiac Park is located adjacent to the site downgradient with pervious areas to implement stormwater treatment or LID.
Trumbull Park	Recreational	Plainville	Located adjacent to the Quinnipiac River. Retrofits could include bioretention at end of access driveway inside cul-de-sac and on the southern edge of the property to intercept and treat runoff prior to discharge to the river.
Connecticut Commons Shopping Center	Commercial	Plainville	Commercial shopping plaza with significant parking, located just upstream of Hamlin Pond. Retrofits would be very visible, however, they would require private buy in. Retrofits may include converting the raised parking islands into bioretention swales, retrofitting the existing stormwater pond for additional detention and enhanced sediment removal. Other measures could include bioretention, permeable pavement in parking areas.

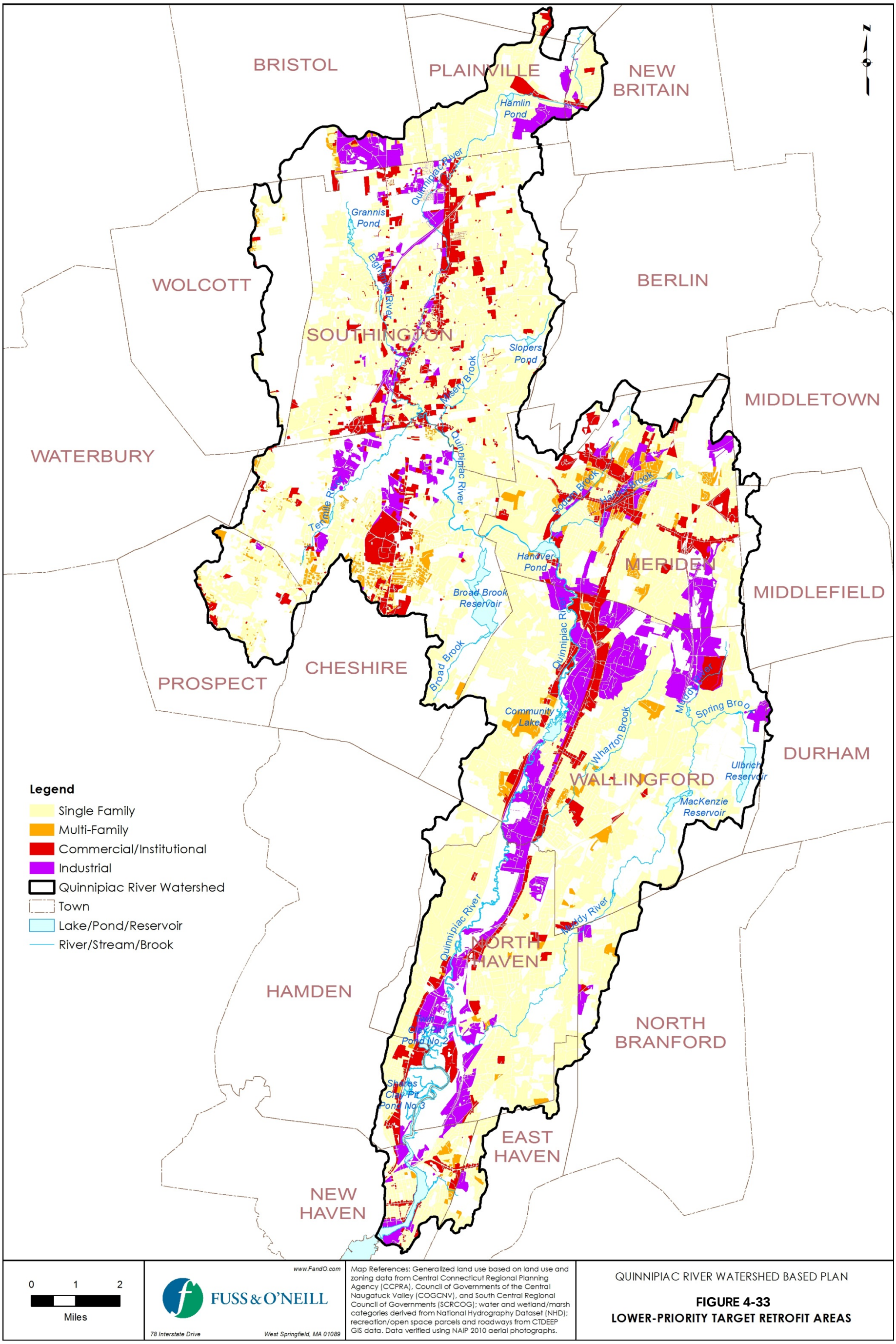
Table 4-1. Other Potential Green Infrastructure Retrofits

Site	Land Use	Town	Description/Potential Retrofits
Southington Shopping Center & Plaza	Commercial	Southington	Located along Route 10 commercial corridor. LID retrofits to provide water quality treatment.
Yarde Metals	Industrial	Southington	Quinnipiac River flows around the north side of the site, observed riparian buffer encroachments. Implement LID retrofits around the site and possibly a larger-scale detention basin to treat stormwater runoff from the site.
Flanders School	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
Hatton Elementary School	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
JFK Middle School	Institutional	Southington	Use existing pervious areas on-site for bioretention, rain gardens, and potentially constructed wetlands or wet detention pond.
Joseph A DePaolo Middle School	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
North Center School	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
South End School	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
Southington Fire Department Headquarters	Institutional	Southington	Infiltration-type BMPs since site is within the Southington Water Department APA.
Farmington Canal Greenway	Recreational	Southington	Remove invasive species including Japanese knotweed along the greenway.
Jennings Trailer Park, Aircraft Road	Residential	Southington	Stream restoration and riparian buffer improvements to replace existing lawn/turf along stream corridor.
Wallingford Train Station	Commercial	Wallingford	Bioretention retrofit of parking lot on west side of railroad tracks
Colony Shopping Park Shopping Center	Commercial	Wallingford	Commercial mall with moderate-sized parking lot. There are pervious areas around the building that could provide opportunities for LID and stormwater detention. Within the Oak Street APA of the Wallingford Water Department.
Dag Hammarskjold Junior High School	Institutional	Wallingford	Near Lyman High School; significant impervious areas with pervious space in between for LID. A regional stormwater basin could be combined with the Lyman High School site since this site drains generally to the same area as Lyman.

Table 4-1. Other Potential Green Infrastructure Retrofits

Site	Land Use	Town	Description/Potential Retrofits
James H Moran Middle School	Institutional	Wallingford	Infiltration of parking lot and roof runoff.
Lyman High School	Institutional	Wallingford	Pervious area around school for bioretention and infiltration-type LID elements. Large parking lot could be retrofitted with bioretention islands.
Masonicare Health Center	Institutional	Wallingford	Grounds are well-maintained and likely have fertilizer application. Pervious areas around buildings and parking around the campus to implement LID such as bioretention, permeable pavement, and tree box filters.
Parker Farms Elementary	Institutional	Wallingford	Site within Wallingford Water Department APA; Stormwater could be infiltrated using bioretention, tree box filters, and permeable pavement.
Sheehen High School	Institutional	Wallingford	Parking lot retrofit with bioretention; large roof could be retrofitted with green or blue roof.
Interstate 95 Right-of-Way	Transportation	Wallingford	Improve infiltration and stormwater treatment from roadways using median and other open areas around I-95.


BRISTOL
PLAINVILLE
NEW BRITAIN
Hamlin Pond
Quinnipiac River
Grannis Pond
Eightmile River
WOLCOTT
SOUTHINGTON
BERLIN
Slopers Pond
Misery Brook
MIDDLETOWN
WATERBURY
Tenmile River
Quinnipiac River
Sodom Brook
Harbor Brook
Hanover Pond
MERIDEN
MIDDLEFIELD
Broad Brook Reservoir
Broad Brook
Quinnipiac River
PROSPECT
CHESHIRE
Muddy River
Community Lake
Wharton Brook
Spring Brook
DURHAM
Ulbrich Reservoir
WALLINGFORD
MacKenzie Reservoir
Legend
Institutional
Recreation
Cemetery
Quinnipiac River Watershed
Town
River/Stream/Brook
Lake/Pond/Reservoir
Quinnipiac River
Muddy River
NORTH HAVEN
HAMDEN
Twin Clay Pit Pond No. 2
NORTH BRANFORD
Shares Clay Pit Pond No. 3
EAST HAVEN
NEW HAVEN
0 1 2
Miles
www.FandO.com
FUSS & O'NEILL
78 Interstate Drive
West Springfield, MA 01089
Map References: Generalized land use based on land use and zoning data from Central Connecticut Regional Planning Agency (CCPRA), Council of Governments of the Central Naugatuck Valley (COGCNV), and South Central Regional Council of Governments (SCRCOG); water and wetland/marsh categories derived from National Hydrography Dataset (NHD); recreation/open space parcels and roadways from CTDEEP GIS data. Data verified using NAIP 2010 aerial photographs.
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 4-32
HIGHER-PRIORITY TARGET RETROFIT AREAS


BRISTOL
PLAINVILLE
NEW BRITAIN
Hamlin Pond
Quinnipiac River
Grannis Pond
Eightmile River
WOLCOTT
SOUTHINGTON
BERLIN
Slopers Pond
Misery Brook
MIDDLETOWN
WATERBURY
Tenmile River
Quinnipiac River
Sodom Brook
Jarvis Brook
Hanover Pond
MERIDEN
MIDDLEFIELD
Broad Brook Reservoir
Broad Brook
Quinnipiac River
CHESHIRE
PROSPECT
Community Lake
Muddy River
Spring Brook
Wharton Brook
DURHAM
Ulbrich Reservoir
WALLINGFORD
MacKenzie Reservoir
Quinnipiac River
Muddy River
NORTH HAVEN
HAMDEN
Shaffer Chip Pit Pond No. 2
Shaffer Chip Pit Pond No. 3
NORTH BRANFORD
EAST HAVEN
NEW HAVEN
Legend
Single Family
Multi-Family
Commercial/Institutional
Industrial
Quinnipiac River Watershed
Town
Lake/Pond/Reservoir
River/Stream/Brook
0
1
2
Miles
www.FandO.com
FUSS & O'NEILL
78 Interstate Drive
West Springfield, MA 01089
Map References: Generalized land use based on land use and zoning data from Central Connecticut Regional Planning Agency (CCPRA), Council of Governments of the Central Naugatuck Valley (COGCNV), and South Central Regional Council of Governments (SCRCOG); water and wetland/marsh categories derived from National Hydrography Dataset (NHD); recreation/open space parcels and roadways from CTDEEP GIS data. Data verified using NAIP 2010 aerial photographs.
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 4-33
LOWER-PRIORITY TARGET RETROFIT AREAS

5 Pollutant Load Reductions

Pollutant load reductions were estimated using the Watershed Treatment Model (WTM) pollutant loading model described in *Technical Memorandum #1: State of the Quinnipiac River Watershed.* Anticipated pollutant load reductions were modeled using WTM for the following watershed management plan recommendations. Other recommended actions identified in this plan could not be quantified due to inherent limitations of WTM and/or the lack of reliable input data or information on the pollutant removal effectiveness of certain practices.

1. **CSO Abatement.** The City of New Haven Water Pollution Control Authority is implementing a Long-Term Control Plan that will eliminate the four active CSO discharge locations within the Quinnipiac River watershed – the James Street siphon, Poplar Street at River Street, Pine Street at North Front Street, and Quinnipiac Avenue at Clifton Street.

2. **Point Source Reductions.** Efforts are ongoing by the watershed municipalities to reduce point source discharges of nitrogen and phosphorus from wastewater treatment plants. The CTDEEP Nitrogen General Permit regulates the discharge of nitrogen from 79 Publicly Owned Treatment Works in Connecticut. Point source reductions of nitrogen were estimated assuming that the municipal wastewater treatment plants in the watershed meet their Nitrogen General Permit goals. Currently the North Haven and Wallingford treatment plants do not meet their permit goals. Treatment plants that meet their nitrogen permit goals are assumed to remain at their nitrogen discharge limit in the future.

   CTDEEP has adopted an interim strategy to establish water quality based phosphorus limits in non-tidal freshwater for industrial and municipal wastewater treatment plant discharge permits until numeric nutrient criteria are established in the Connecticut Water Quality Standards. Seasonal phosphorus permit loads and performance levels have been established for four municipal wastewater treatment plants (Cheshire WPCF, Meriden WPCF, Southington WPCF, and Wallingford WPCF) and one industry (Cytec Industries Inc.) that discharge to the Quinnipiac River. CTDEEP is also working collaboratively with several of the Quinnipiac River watershed communities to make recommendations regarding a state-wide strategy to reduce phosphorus to comply with EPA standards. Point source phosphorus reductions were estimated using the seasonal phosphorus limits in the current permits, which are based on the interim strategy, as well as the current phosphorus loadings during the other months of the year.

3. **Green Infrastructure/Low Impact Development (LID) Retrofits.** Stormwater retrofits are recommended throughout the watershed on public land (municipal, institutional, and transportation land uses), identified or potential hotspots (commercial and industrial land uses), and residential properties. Potential pollutant load and runoff reductions were estimated for a variety of green infrastructure and LID retrofit practices, including:

   - Roof disconnection and bioretention on commercial, institutional, and industrial land
   - Rain barrels and roof disconnection on residential properties
   - Vegetated filter strips and bioretention for transportation land use (roadways)

Multiple scenarios were modeled to estimate the effect of varying levels of retrofit implementation across the watershed, including estimates for retrofitting 5%, 10%, 50%, and 100% of the watershed impervious area. The modeled effectiveness of the proposed retrofits was reduced to reflect system maintenance and design (system bypass during larger storms) factors. These scenarios assume that the retrofits in the watershed would most likely be implemented as the watershed is redeveloped over time. The watershed plan promotes effective stormwater management for future development and redevelopment throughout the watershed through land use regulatory mechanisms and the local site plan review process.

4. **Riparian Buffer Restoration.** Potential pollutant load reductions were estimated for restoration of impacted riparian buffers in the watershed. The total length of streams within each subwatershed with impacted buffers was estimated from land cover data. Under the modeled restoration scenario, a 100-foot vegetative riparian buffer was assumed for those areas currently with impacted buffers.

5. **Reforestation.** The watershed plan promotes preservation and enhancement of tree canopy through various urban watershed forestry approaches. Potential pollutant load reduction benefits were estimated for a watershed reforestation scenario using recommended tree canopy goals. Based on a recommendation of American Forests, 40% forest cover is a reasonable overall threshold goal for urban areas (American Forests, 2009). The amount of land conversion required to achieve the recommended tree canopy goal was modeled by converting existing developed land uses to a forested condition.

6. **Public Education.** Pet waste, lawn care, and other nonpoint source education programs can change behaviors that affect pollutant loads. Pollutant load reductions were estimated for pet waste and lawn care 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. Residential lawn care education accounts for fertilizer reduction, using organic fertilizers, and adherence to the recent Connecticut law restricting the application of fertilizers that contain phosphate.

7. **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 assumes that 15% of the existing illicit discharges are detected and eliminated.

8. **Street Sweeping and Catch Basin Cleaning.** Municipalities are required to sweep all streets and clean catch basins and other stormwater structures that accumulate sediment at least once a year in accordance with the *General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems*. A revised General Permit is anticipated in 2015, which may include more stringent requirements for street sweeping and catch basin cleaning. In anticipation of these requirements, future street sweeping and catch basin cleanouts are modeled semi-annually.

9. **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.

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 proposed watershed management plan recommendations described in the above scenarios. Existing conditions pollutant loads are described in *Technical Memorandum #1: State of the Quinnipiac River Watershed*, a copy of which is provided as *Appendix A* of this plan.

Nonpoint source runoff and pollutant sources other than wastewater treatment plants account for approximately 74% of the TN load, 25% of the TP load, 99% of the TSS load, and nearly 100% of the FC load for the entire watershed. The wastewater treatment plants in the watershed are estimated to contribute approximately 26% of the TN load, 75% of the TP load, and less than 1% of the TSS and FC loads for the entire watershed. CSOs account for approximately 4% of the total FC loading in the watershed.

Pollutant Load Reductions

Table 5-1 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 5-1* are for the entire Quinnipiac River watershed. Load reduction summaries by subwatershed are provided in *Appendix D*.

As indicated in *Table 5-1*, eliminating the remaining four CSOs in the watershed under the City of New Haven Water Pollution Control Authority's CSO Long Term Control Plan is estimated to result in an approximately 4.1% reduction in fecal coliform loading to the Quinnipiac River, compared to existing conditions.

Varying levels of stormwater retrofit implementation across the watershed were modeled, including estimates for retrofitting 5%, 10%, 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 5-1*. The results for all four scenarios are presented in *Table 5-2*. The 10% retrofit scenario is predicted to result in approximately 1.5 to 5.9% reductions in annual TN, TP, TSS, FC, and runoff volume watershed-wide. Significantly higher reductions (15% to 59%) could potentially be achieved by retrofitting a much greater percentage of the watershed, although the level of retrofits required to achieve these reductions would likely be cost-prohibitive.

The effectiveness of the watershed management recommendations varies by pollutant. Watershed-wide reductions in TP of 33.9% could be possible by meeting the seasonal phosphorus load limits in the

interim phosphorus reduction strategy for the WPCFs in the watershed. Nonpoint source pollution control measures could account for an additional 5% reduction in phosphorus loads.

Reforestation, WPCF point source reductions (assuming the Nitrogen General Permit goals are met at all WPCFs) , and enhanced street sweeping and catch basin cleaning are anticipated to yield the greatest TN load reductions. A watershed-wide load reduction of approximately 16.5% is anticipated through implementation of all the watershed management recommendations.

Fecal coliform load reductions of up to 34.7% are anticipated through the implementation CSO abatement and nonpoint source controls. Stormwater retrofits, public education, IDDE, reforestation and riparian buffer restoration are the most effective management plan recommendations for reducing bacteria loads. Runoff volume is anticipated to decrease by approximately 10.4% overall, with green infrastructure and reforestation predicted to provide the greatest potential reductions in runoff volume.

Table 5-1. Anticipated Annual Pollutant Load Reductions

Watershed Management Recommendation	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	FC (billion/yr)	Runoff Volume (ac-ft/yr)	TN (%)	TP (%)	TSS (%)	FC (%)	Runoff Volume (%)
CSO Abatement	1,124	52	2,938	428,414	0	0.1%	0.0%	0.0%	4.1%	0.0%
WPCF Point Source Reductions	33,945	71,141	0	0	0	2.2%	33.9%	0.0%	0.0%	0.0%
Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	78,846	3,088	3,412,588	536,717	8,112	5.1%	1.5%	5.5%	5.1%	5.9%
Riparian Buffer Restoration	17,931	732	0	795,541	0	1.2%	0.3%	0.0%	7.6%	0.0%
Reforestation	62,200	2,535	3,668,784	639,414	6,275	4.1%	1.2%	5.9%	6.1%	4.5%
Public Education	17,931	732	0	795,541	0	1.2%	0.3%	0.0%	7.6%	0.0%
Illicit Discharge Detection and Elimination (IDDE)	985	90	8,043	400,785	0	0.1%	0.0%	0.0%	3.8%	0.0%
Street Sweeping and Catch Basin Cleaning	28,398	3,166	2,060,640	0	0	1.9%	1.5%	3.3%	0.0%	0.0%
Septic Repair	11,646	446	77,641	35,597	0	0.8%	0.2%	0.1%	0.3%	0.0%
Total	**253,006**	**81,981**	**9,230,633**	**3,632,009**	**14,387**	**16.5%**	**39.1%**	**14.8%**	**34.7%**	**10.4%**

Table 5-2. Anticipated Annual Pollutant Load Reductions for Varying Levels of Green Infrastructure/LID Retrofits

Green Infrastructure/LID Retrofits	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	FC (billion/yr)	Runoff Volume (ac-ft/yr)	TN (%)	TP (%)	TSS (%)	FC (%)	Runoff Volume (%)
Retrofit 5% of Impervious Area	39,423	1,544	1,706,294	268,359	4,056	2.6%	0.7%	2.7%	2.6%	2.9%
Retrofit 10% of Impervious Area	78,846	3,088	3,412,588	536,717	8,112	5.1%	1.5%	5.5%	5.1%	5.9%
Retrofit 50% of Impervious Area	394,231	15,440	17,062,939	2,683,585	40,558	25.7%	7.4%	27.4%	25.6%	29.4%
Retrofit 100% of Impervious Area	788,462	30,879	34,125,878	5,367,170	81,116	51.4%	14.7%	54.9%	51.3%	58.7%

Table 5-3 summarizes the anticipated combined effectiveness for all of the watershed management recommendations considered. The pollutant loadings and load reductions presented in *Table 5-3* reflect a comparison of modeled natural background conditions, existing conditions, and future pollutant loadings with implementation of the watershed management recommendations for the entire Quinnipiac River watershed. The natural background pollutant loads reflect a fully-forested condition in the entire watershed, which represents the lowest, realistically-achievable pollutant loads for the watershed. The last column in *Table 5-3* contains anticipated "effective load reductions" with implementation of the watershed management recommendations. These effective load reductions are realistically-achievable reductions that account for the natural background pollutant load. Overall, a 43.9% reduction in TP and a 36.3% reduction in FC loads is anticipated, with smaller reductions anticipated for TN (22.8%), TSS (19.0%), and runoff volume (22.2%).

Table 5-3. Summary of Modeled Pollutant Loads and Load Reductions

Pollutant	Natural Background Conditions	Existing Conditions	Future Conditions with Controls	Load Reduction with Controls (From Existing Conditions)	Effective Load Reduction with Controls (Accounting for Natural Background Load)
TN (1,000 lb/yr)	422	1,534	1,281	16.5%	22.8%
TP (1,000 lb/yr)	23	210	128	39.1%	43.9%
TSS (1,000 lb/yr)	13,475	62,163	52,933	14.8%	19.0%
FC (trillion/yr)	453	10,471	6,839	34.7%	36.3%
Runoff Volume (1,000 acre-ft/year)	73	138	124	10.4%	22.2%

Figures 5-1 through *5-5* depict the existing and anticipated future pollutant loads for the watershed, with and without implementation of the watershed plan recommendations. The pie charts in *Figures 5-1* through *5-5* show the relative contribution of the management plan recommendations to the predicted effective load reductions.

Pollutant Load Reductions and Water Quality Impairment Status

The primary objective of this watershed plan is to address the water quality impairments in the Quinnipiac River in order to restore the recreation and habitat uses that have been lost due to degraded 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 included in *Table 5-1* is predicted to result in an approximately 36.3% reduction in annual bacteria loads to the Quinnipiac River. Additional load reductions may be achieved by implementation of stormwater controls over a larger portion of the watershed, as shown in *Table 5-2*, additional tree cover and reforestation, increasing the public awareness in the watershed of certain programs, and increased detection and elimination of illicit discharges.

However, a key question that arises from this evaluation is – will the pollutant load reductions that are anticipated to result from the watershed plan recommendations enable the impaired water bodies to meet their designated uses?

A TMDL analysis was completed for indicator bacteria in the Quinnipiac River (CTDEEP, 2008). The waterbodies included in the analysis are Harbor Brook, Misery Brook, Quinnipiac River, and Sodom Brook. The TMDL calls for overall reductions in daily loads of indicator bacteria in the Quinnipiac River segments as indicted in *Table 5-4*. *Table 5-4* also summarizes the predicted reductions in annual indicator bacteria loads for the Quinnipiac River segments assuming implementation of the watershed plan recommendations. A comparison of the two values indicates that the watershed plan recommendations can partially meet the TMDL load reduction targets, but additional controls are necessary to achieve the full load reductions required by the TMDL. However, the limitations of both the TMDL load reduction estimates and the pollutant load reduction modeling should be noted. The TMDL is based on limited wet and dry weather data. 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.

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 site(s) used to generate the data used to perform the TMDL calculations (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. Therefore, the data set at the end of each season 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.

Table 5-4. Average TMDL Percent Reductions to Meet Water Quality Standards

Waterbody	Segment ID	Average Percent Reduction to Meet Water Quality Standards			Percent Reduction with all Management Recommendations
		TMDL	WLA[1]	LA[2]	
Harbor Brook	CT5206-00_01	95	95	95	**Total Reduction: 60.7%** GI/LID Retrofits: 7.6% Riparian Buffer Restoration: 18.7% Reforestation: 14.1% Public Education: 18.7% IDDE: 1.3% Septic Repair: 0.3%
	CT5206-00_02				
Misery Brook	CT5203-00_01	65	74	59	**Total Reduction: 20.2%** GI/LID Retrofits: 5.4% Riparian Buffer Restoration: 5.7% Public Education: 5.8% IDDE: 2.9% Septic Repair: 0.2%
Quinnipiac River	CT5200-00_01	68	73	64	**Total Reduction: 34.7%** CSO Abatement: 4.1% GI/LID Retrofits: 5.1% Riparian Buffer Restoration: 7.6% Reforestation: 6.1% Public Education: 7.6% IDDE: 3.8% Septic Repair: 0.3%
	CT5200-00_02	64	73	58	
	CT5200-00_02	84	88	80	
	CT5200-00_02				
	CT5200-00_05	75	80	71	
	CT5200-00_06	82	85	80	
	CT5200-00_07	78	83	75	
Sodom Brook	CT5205-00_01	92	92	91	**Total Reduction: 30.2%** GI/LID Retrofits: 4.8% Riparian Buffer Restoration: 9.8% Public Education: 9.8% IDDE: 5.4% Septic Repair: 0.3%

Notes:
(1) WLA - Wasteload Allocation is the portion of the total loading which is allocated to point source discharges
(2) LA - Load Allocation is the portion of the total loading attributed to nonpoint sources

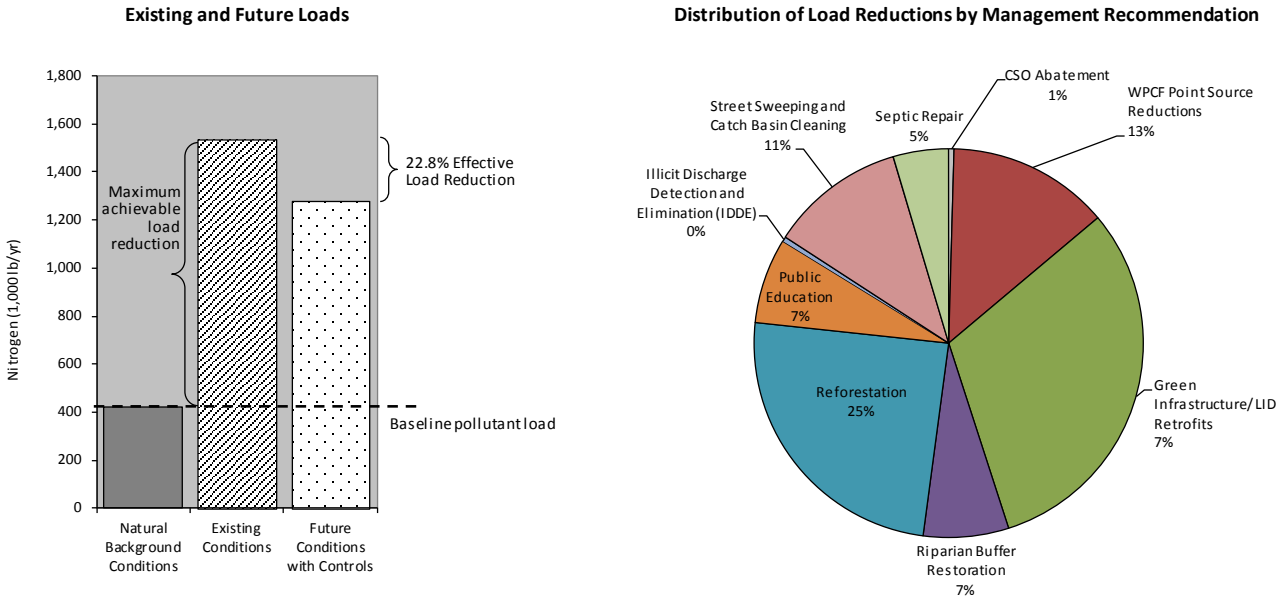


Figure 5-1. Anticipated Nitrogen Loads and Load Reductions

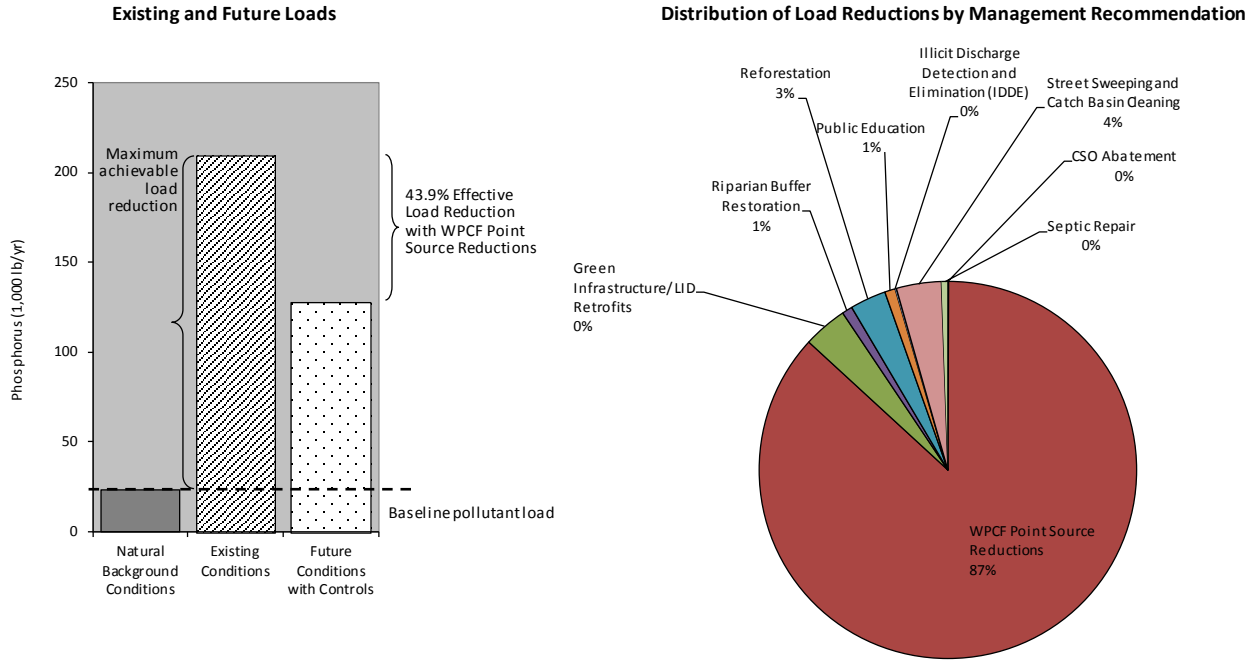


Figure 5-2. Anticipated Phosphorus Loads and Load Reductions

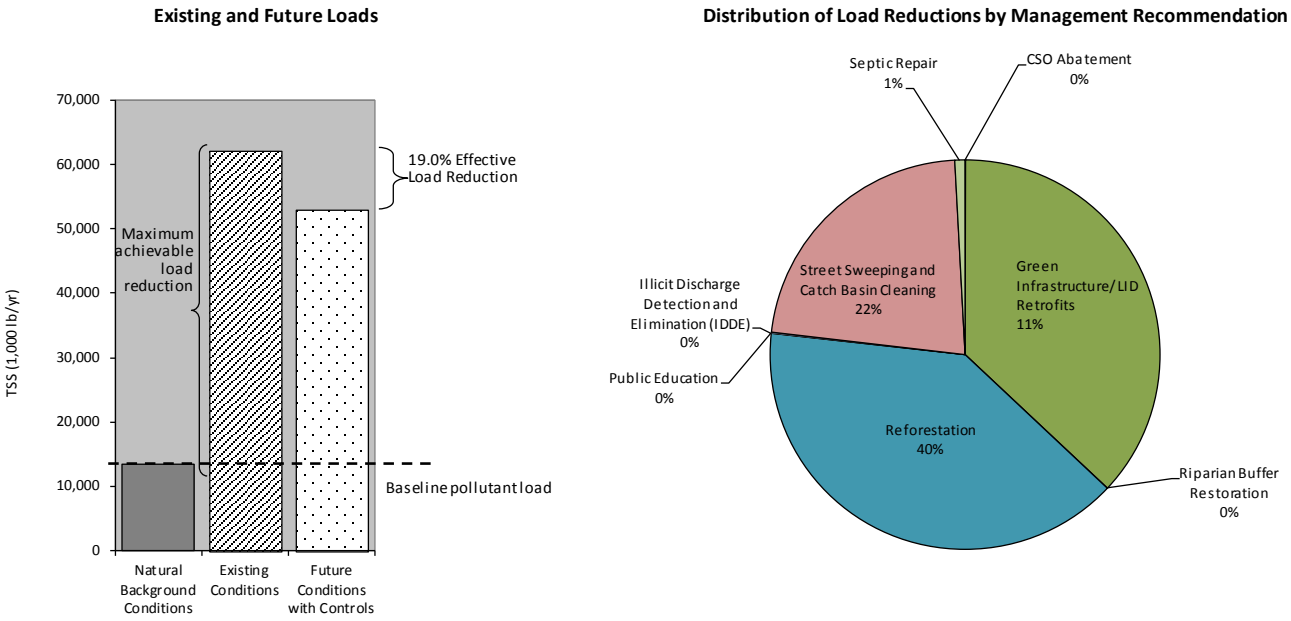


Figure 5-3. Anticipated Sediment (TSS) Loads and Load Reductions

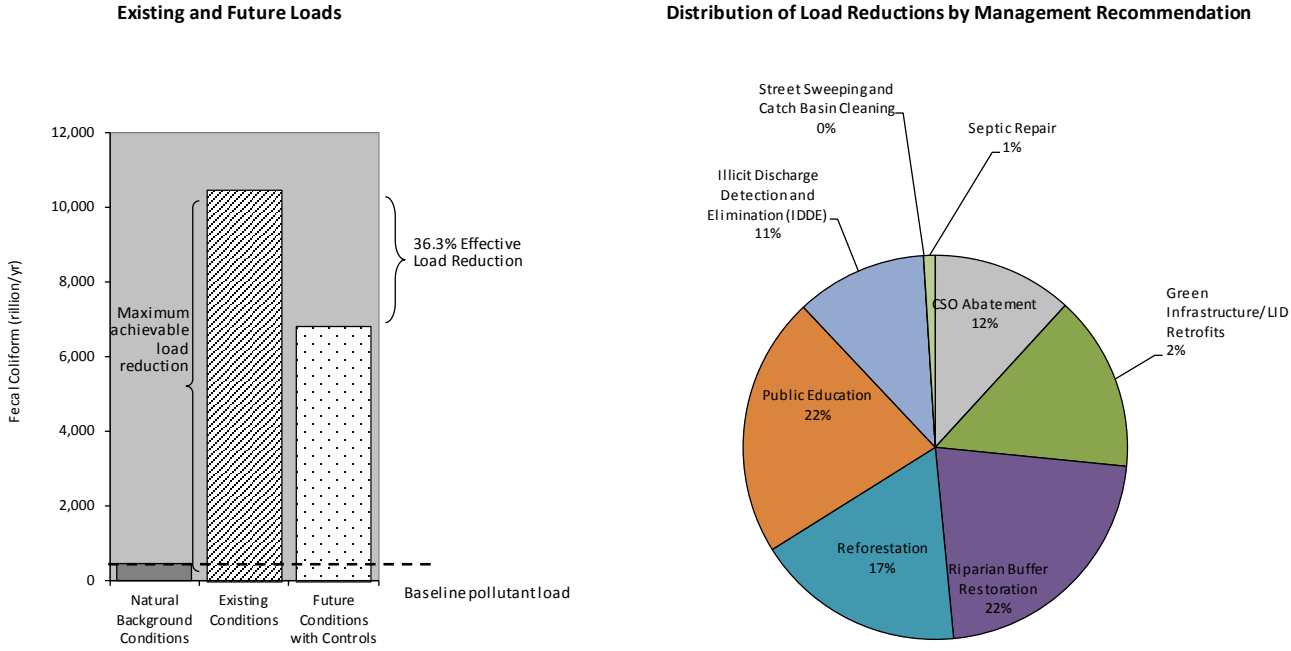


Figure 5-4. Anticipated Fecal Coliform Loads and Load Reductions

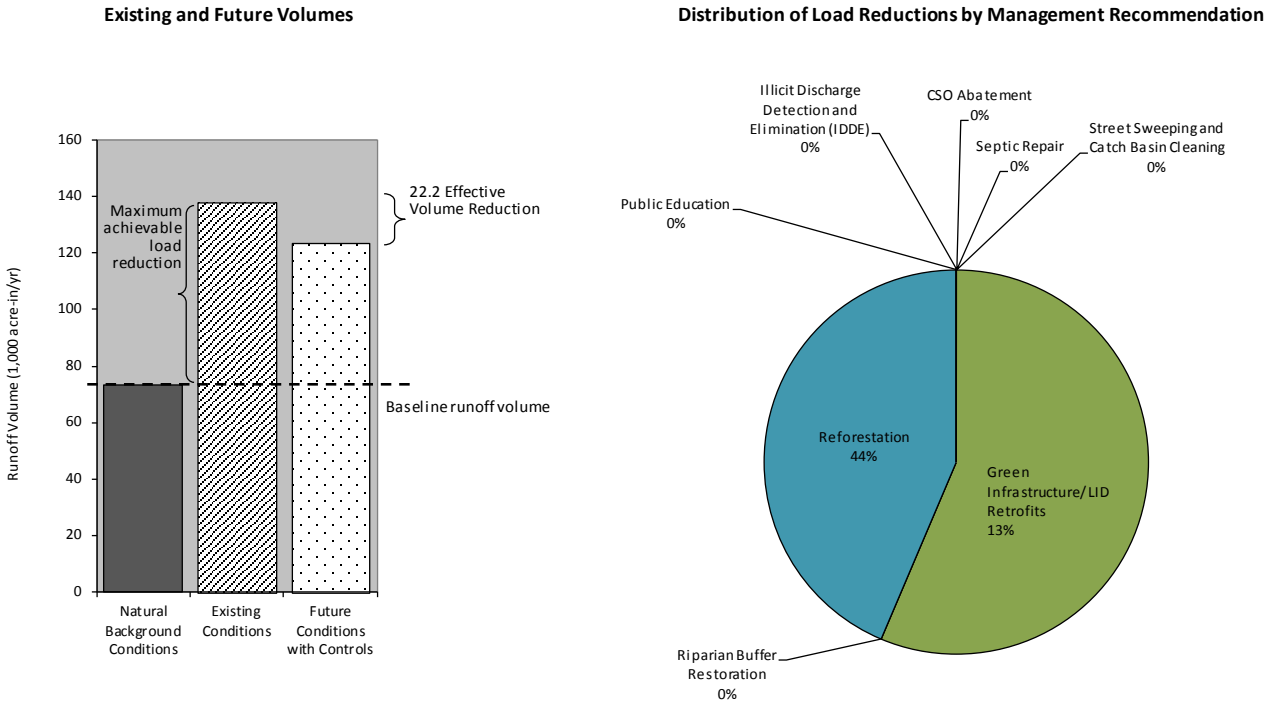


Figure 5-5. Anticipated Runoff Volumes and Volume Reductions

6 Schedule, Milestones, and Evaluation Criteria

Appendix E contains a proposed implementation schedule, including action items and associated lead entity, timelines, products, and evaluation criteria. This table should be revised as necessary to reflect future changes to the watershed plan and implementation activities.

Many different groups will need to participate and collaborate to successfully implement the recommendations identified in this plan. The table in *Appendix E* identifies a designated lead group(s), which will initiate, obtain the necessary funding for, and organize the necessary resources to implement an action. The lead group is assigned based on the organization or entity whose mission or responsibilities best align with the action and, in the case of a government entity, have jurisdiction over the action or associated geographic area.

7 Funding Sources

A variety of local, state, and federal sources are potentially available to provide funding for the implementation of this watershed management plan, in addition to potential funds contributed by local grassroots organizations and concerned citizens. *Appendix F* contains a list of potential funding sources for implementation of this watershed plan. 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 information presented in this watershed management plan and the supporting study documentation will support future grant proposals by demonstrating a comprehensive, scientifically-based approach for addressing identified concerns consistent with the recommended watershed-based approach. 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.

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