Appendix A

Technical Memorandum #1:
State of the Quinnipiac River Watershed (on CD)

Technical Memorandum #2:
Low Impact Development &
Green Infrastructure Assessment (on CD)

Technical Memorandum #1: State of the Quinnipiac River Watershed

Quinnipiac River Watershed Based Plan

December 2012
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Prepared For:

Quinnipiac River Watershed Association

In Cooperation With:

Connecticut Department of Energy & Environmental Protection
U.S Environmental Protection Agency

FUSS & O'NEILL

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Technical Memorandum #1: State of the Quinnipiac River Watershed

Appendices

1 Introduction

The Quinnipiac River Watershed Association (QRWA), working with the Connecticut Department of Energy and Environmental Protection (CTDEEP) and the U.S. Environmental Protection Agency (EPA), is seeking to revise the 2004 *Quinnipiac Watershed Action Plan.* This project will transform the 2004 Action Plan for the Quinnipiac River watershed into a CTDEEP and EPA-approved watershed based plan. The revised plan will incorporate recent water quality data and the bacteria Total Maximum Daily Load (TMDL) for the Quinnipiac River, facilitate capacity building and re-engage the watershed municipalities, and prioritize water bodies and implementation projects to reduce pollutant loads in the watershed and improve water quality in the Quinnipiac River.

This project is 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.

The watershed planning process includes the preparation of the following documents:

1. Technical Memorandum #1 – State of the Quinnipiac River Watershed,
2. Technical Memorandum #2 – Low Impact Development and Green Infrastructure Assessment,
3. Watershed Based Plan.

Technical Memorandum #1 serves as a "State of the Watershed" report, summarizing existing water quality and land use conditions in the Quinnipiac River watershed. Technical Memorandum #1 also identifies the major water quality and related water resources issues to be addressed by the revised watershed action plan. The second project deliverable, Technical Memorandum #2, will document a stormwater retrofit assessment of the watershed, identifying site-specific Low Impact Development and Green Infrastructure retrofit concepts to serve as future implementation projects and examples of projects that could be implemented at other locations in the watershed. Lastly, the watershed based plan will identify prioritized action items to protect and improve water quality and water resource conditions in the Quinnipiac River and its watershed, guided by the Project Steering Committee and Watershed Stakeholders Group. The watershed based plan will also incorporate the nine watershed management planning elements required by CTDEEP and EPA for future funding of plan recommendations through the 319 Nonpoint Source Grant program and similar state and federal grant programs.

1.1 Background

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 New Haven Harbor and Long Island Sound. The four largest subwatersheds are the Quinnipiac River main stem, Eightmile River, Tenmile River, and Muddy River.

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, like many other urbanized 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 remains degraded as a result of elevated levels of bacteria and impairments to aquatic life (CTDEEP, 2011). 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.

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.

In 2008, the Connecticut Department of Environmental Protection developed a Total Maximum Daily Load (TMDL) 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. TMDL implementation activities are therefore focused on corrective actions that will reduce bacterial loads in stormwater runoff. The TMDL can be achieved by implementing specific actions that will reduce indicator bacterial loadings using a watershed framework. The revised watershed based plan for the Quinnipiac River will therefore provide a roadmap for implementing the TMDL.

1.2 Development of Technical Memorandum #1

The following tasks were completed in developing Technical Memorandum #1:

- Reviewed the 2004 *Quinnipiac Watershed Action Plan,* as well as existing data, studies, and reports for the watershed.
- Compiled, reviewed and summarized water quality monitoring data collected within the watershed since the 2004 *Quinnipiac Watershed Action Plan*.
- Identified and delineated subwatersheds within the overall Quinnipiac River watershed.
- Consulted with the Project Steering Committee, the watershed municipalities, the regional planning agency, and other governmental entities regarding available land use information and mapping.
- Developed an updated description of existing watershed conditions and updated Geographic Information System (GIS) mapping of the watershed.

- Developed a surface runoff pollutant loading model for the Quinnipiac River watershed to guide the development of the revised watershed plan recommendations and to quantify the anticipated load reductions associated with the recommendations.

Technical Memorandum #1 documents watershed conditions for the following topics:

- Watershed description including watershed municipalities, demographics, and a brief history of the watershed (Section 2).
- Water quality conditions of the Quinnipiac River and its tributaries based on available monitoring data (Section 3).
- Natural resources including geology, topography, wetlands, fish and wildlife resources, and vegetation (Section 4).
- Water infrastructure including dams, water supply, wastewater, stormwater, and flooding (Section 5).
- Land use and land cover, including an analysis of impervious cover in the watershed (Section 6).
- Pollutant loading (Section 7).

1.3 Prior Watershed Studies and 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 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. Many of the recommendations identified in the 2004 action plan have been implemented, largely through the efforts of the QRWA, the watershed municipalities, and other stakeholder groups. Additional water quality monitoring data has been collected within the Quinnipiac River watershed since 2004, resulting in the 2008 Quinnipiac River bacteria TMDL and identification of the current water quality impairments in the watershed, as discussed in Section 3 of this document.

Technical Memorandum #1 and the subsequent revised watershed based plan for the Quinnipiac River will build upon and update information presented in the 2004 *Quinnipiac Watershed Action Plan* to reflect water quality studies, watershed planning efforts, and other related stewardship activities that have occurred in the watershed since the release of the 2004 action plan.

1.4 Watershed Stewardship Efforts

The QRWA and its partners have been addressing water resource issues facing the Quinnipiac River and its watershed for many years, as reflected in the 2004 action plan and subsequent implementation of that plan. Notable recent, ongoing and planned water quality restoration and related stewardship efforts within the Quinnipiac River watershed are highlighted below.

- **Quinnipiac River Watershed Groundwater Restoration Project** – Save the Sound, a program of Connecticut Fund for the Environment, is working to expand drinking water supplies in the Quinnipiac River watershed through the use of green infrastructure techniques. Funding is provided by the Connecticut Department of Energy and Environmental Protection (CTDEEP) through the Quinnipiac River Groundwater Natural Resources Damages Fund. Save the Sound and its partners, which include the University of Connecticut NEMO Program, the United States Geological Survey (USGS), and the towns of Southington and Meriden, are proposing to construct bioretention rain gardens at sites throughout the Quinnipiac River watershed. These green infrastructure projects would absorb stormwater run-off and thereby "recharge" the groundwater aquifers, providing some replenishment of the drinking water resource. The goal is to capture and infiltrate stormwater runoff from rooftops that would otherwise end up in the municipal stormwater system, pick up pollution, and flow into nearby streams. This project will also provide an integrated approach to public outreach and education about groundwater resources within the region that will have long-term benefits within those communities (Save the Sound, http://reducerunoff.org/quinnipiac.htm).
- **Outreach to Municipal Public Works Departments** – The QRWA received a grant from the Greater New Haven Green Fund in support of Department of Public Works (DPW) informational meetings. The purpose of the grant is to meet with various DPWs in the watershed (targeted are New Haven, North Haven and Wallingford) to educate and inform the workers about water related topics such as stormwater discharge, importance of vegetative buffers, and low impact developement. In cooperation with the CTDEEP and the Natural Resource Conservation Service as speakers, the QRWA provides the opportunity for open discussion and face-to-face meetings. The DPWs are informed about the ongoing watershed planning effort for the Quinnipiac River.
- **Quinnipiac River Water Trail** – QRWA received a grant from CTDEEP to provide enhanced access to the Quinnipiac River Water Trail system. QRWA's role is to make the waterway passable by removing log jams in the lower river, placing 13 markers (signage) along the way, provide laminated guides to the public and to ensure that the launch area ramp is accessible to the public.
- **State-Wide Phosphorous Reduction Strategy** – CTDEEP is working with the EPA on a statewide nutrient control strategy that includes reductions in the discharge of phosphorus from point and nonpoint sources. Public Act 12-155 requires CTDEEP to collaborate with several of the Quinnipiac River watershed communities including Meriden, Cheshire, Southington and Wallingford to reduce phosphorus and to collaboratively evaluate and make recommendations regarding a state-wide strategy to reduce phosphorus to comply with EPA standards.

- **Green Infrastructure Feasibility Scan** – Connecticut Fund for the Environment and Save the Sound recently completed a project to assess the feasibility of green infrastructure implementation in New Haven and Bridgeport (. A feasibility scan was conducted for both cities to evaluate opportunities to incorporate green infrastructure into ongoing wet weather management efforts. Results of the feasibility scan indicate that green infrastructure can serve as an effective approach to managing Combined Sewer Overflows (CSOs) and other wet weather issues within Bridgeport and New Haven. The study is intended to serve as a foundation for future detailed planning and design efforts within these communities. It also demonstrates the applicability of green infrastructure approaches in similar urban communities including those within the Quinnipiac River watershed (Save the Sound, http://reducerunoff.org/newhaven.htm).
- **Habitat Restoration, Solvents Recovery Service Site and Old Southington Landfill** – The U.S. Fish and Wildlife Service, working with the CTDEEP, is conducting a Natural Resource Damage Assessment planning process to identify and implement priority projects in the Quinnipiac River watershed to restore migratory birds and fish affected by historical contamination from these sites. Potential projects may include wetland restoration and protection; river restoration projects to provide fish passage, improve water quality, and alleviate flooding in the Quinnipiac River; and habitat restoration focused on improving habitat for birds and fisheries in the watershed.
- **University Research and Non-profit Advocacy** – continuing their long-standing focus on issues in the Quinnipiac River watershed, colleges, universities and non-profit advocacy groups in and around the watershed are actively involved in projects focused on water quality and natural resources of the Quinnipiac River watershed. Examples of ongoing research and related projects include:
    - A study on the impacts of wastewater from municipal waste water treatment plants on fish health in the Quinnipiac River (University of Connecticut, College of Agriculture and Natural Resources)
    - A continuing study about assessing the extent and characteristics of macroalgal blooms in New Haven Harbor and the impacts such blooms have on benthic communities (University of New Haven, Department of Biology)
    - To support water testing of the Quinnipiac estuary and New Haven Harbor for contaminants and evaluation of abnormal reproductive development of the blue mussel by endocrine disrupting compounds (Yale University)
    - Education of fishers on safe consumption of fish from the Quinnipiac River (Connecticut Coalition for Environmental Justice)
    - Review of Cytec's National Pollutant Discharge Elimination System (NPDES) water permit for discharges into the Quinnipiac River (Connecticut Urban Legal Initiative, Inc.)
    - Municipal regulation review of the Quinnipiac River watershed towns in order to collect and assess provisions that are protective of water quality (Land Use Leadership Alliance)

- Continuation of a public access recreation and educational trail along the tidal marsh section of the Quinnipiac River, behind the Universal Drive shopping areas, in North Haven (North Haven Trail Association)
- Signage which will include a trail map and information about the natural history and historical aspects of the area for the Phase III section of the Quinnipiac River Linear Trail (Quinnipiac River Linear Trail Advisory Committee of Wallingford Corporation)
- Recruitment and training for residents in each of the river municipalities to become advocates on behalf of the Quinnipiac River in order to participate in public meetings on the Quinnipiac Watershed Action Plan Update of 2012 and to support the completion of the Lower Quinnipiac River Canoeable Trail and the Town of North Haven canoe launch to access the new trail (Quinnipiac River Watershed Association)
- Surve of the Quinnipiac River for polyaromatic hydrocarbons and phthalate plasticizers in an effort to characterize contamination from industrial and municipal sources (Quinnipiac University)
- Safe Grounds Campaign to reduce and ultimately eliminate the use of toxic lawn pesticides in the Quinnipiac River watershed and throughout Connecticut (The Watershed Partnership, Inc.)
- New Haven Harbor Data Project which will create and maintain an online catalog of data about New Haven Harbor and will be accessible on Schooner's website (Schooner, Inc.)
- Continuation of homeowner workshops which will initiate educational outreach on organic land care to inland/wetland and conservation commissions, including installation and assisting in the development and related outreach of an online turf forum geared towards Connecticut school groundskeepers (Northeast Organic Farming Association of Connecticut, Inc.)
- Continuation of investigations into the causes and implications of marsh drowning in the Quinnipiac River (Yale University)
- Biodiversity and Impacts of Drift Algae in the New Haven Harbor study, which will continue to assess habitat structure and species diversity in New Haven Harbor, and to investigate the dynamics and potential impacts of extensive drift algal mats that have been found in portions of the harbor (University of New Haven, Department of Biology)
- Quinnipiac Urban River Stewardship project, which will install several river stewardship signs in prominent locations to promote human links to the river and foster stewardship of the shared resource (Quinnipiac River Watershed Association)

2 Watershed Description

2.1 Quinnipiac River Watershed

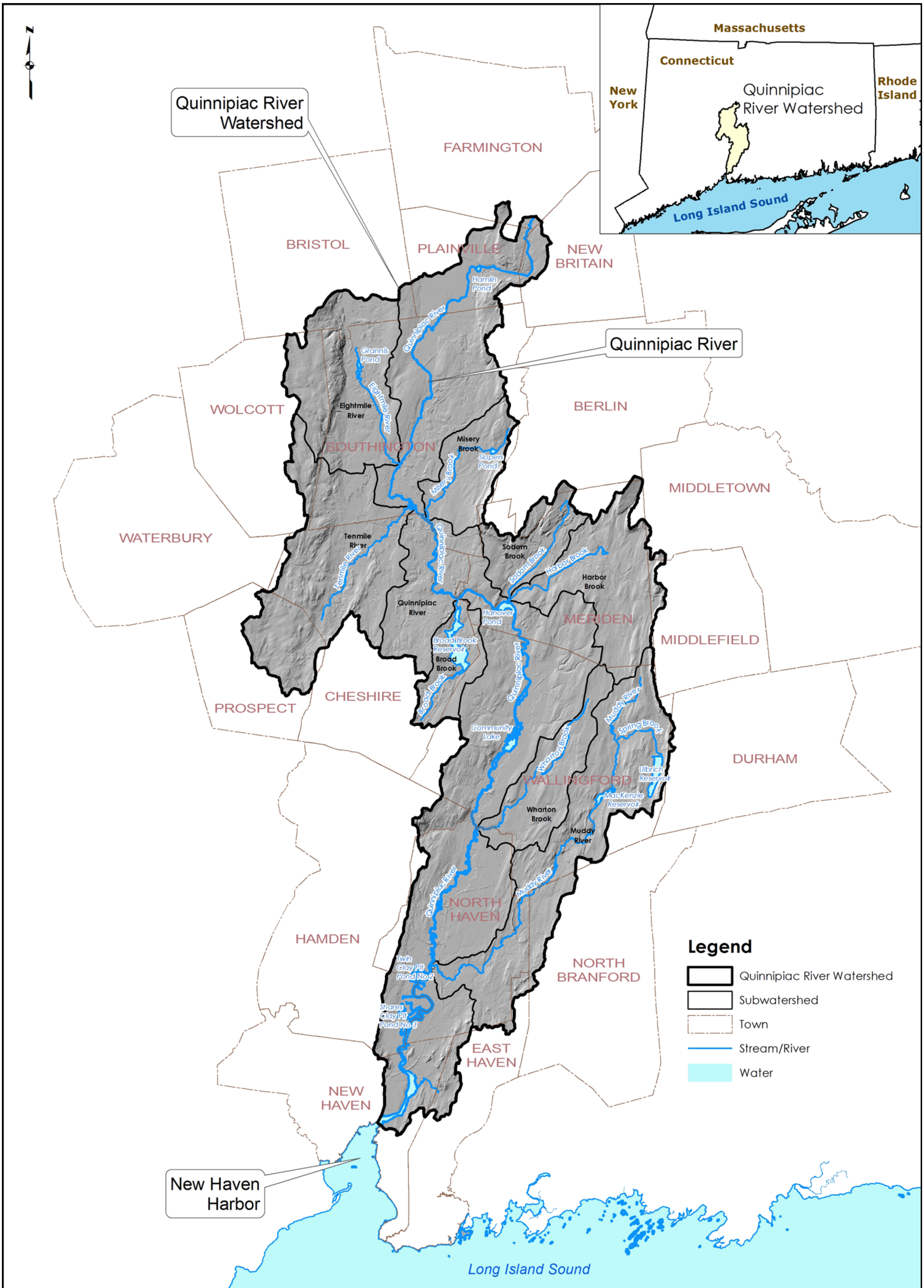
The Quinnipiac River watershed is an approximately 166 square-mile (106,200 acre) coastal watershed in south central Connecticut. The basin includes eight additional subwatersheds that drain to the Quinnipiac River, the fourth largest river in Connecticut (*Figure 2-1*). Formed in a former glacial lakebed, 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 Quinnipiac River watershed is located within a highly urbanized and developed area of the state, with a watershed-wide population of approximately 240,000. 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*). European settlement along the river began in 1614 and farms, homes, and businesses were established in the Quinnipiac River corridor. Growing development and industrialization in the 1800s impacted water quality in the Quinnipiac River and its tributaries through both point sources discharges of pollutants, like sewage, and nonpoint source discharges from stomwater runoff. Today, there are six wastewater treatment plants in the watershed.

The water quality impairments identified in the watershed reflect the watershed's industrial past combined with its overall level of development (approximately 65% of the watershed). For example, in the latest reporting to the EPA in 2010 (CTDEEP, 2012), approximately 75 miles of rivers and streams and 18.2 acres of waterbodies in the watershed were impacted by bacterial pollution (E.coli and/or Enterococcus). Polychlorinated Biphenyls (PCBs) are listed as causes of impairment for 20.8 miles of watercources and 70.5 acres of waterbodies. Landfills, site clearance associated with development and redevelopment, baseflow depletion from groundwater withdrawals, impacts from flow regulation and modification, and municipal point source discharges are the top five identified probable sources of impairment for assessed watercourses in the watershed.

The Quinnipiac Watershed is made up of nine subregional basins called subwatersheds (*Figure 2-1*). *Table 2-1* lists the land area and miles of streams within each subwatershed. The Quinnipiac River subwatershed, which is the largest of the subwatersheds, follows the length of the main stem Quinnipiac River from the headwaters in Famington to its outlet into New Haven Harbor. Other subwatersheds include:

- Eightmile River flows southeast from Grannis Pond in the northern portion of Southington, under Interstate 84, to the confluence with the Quinnipiac River.



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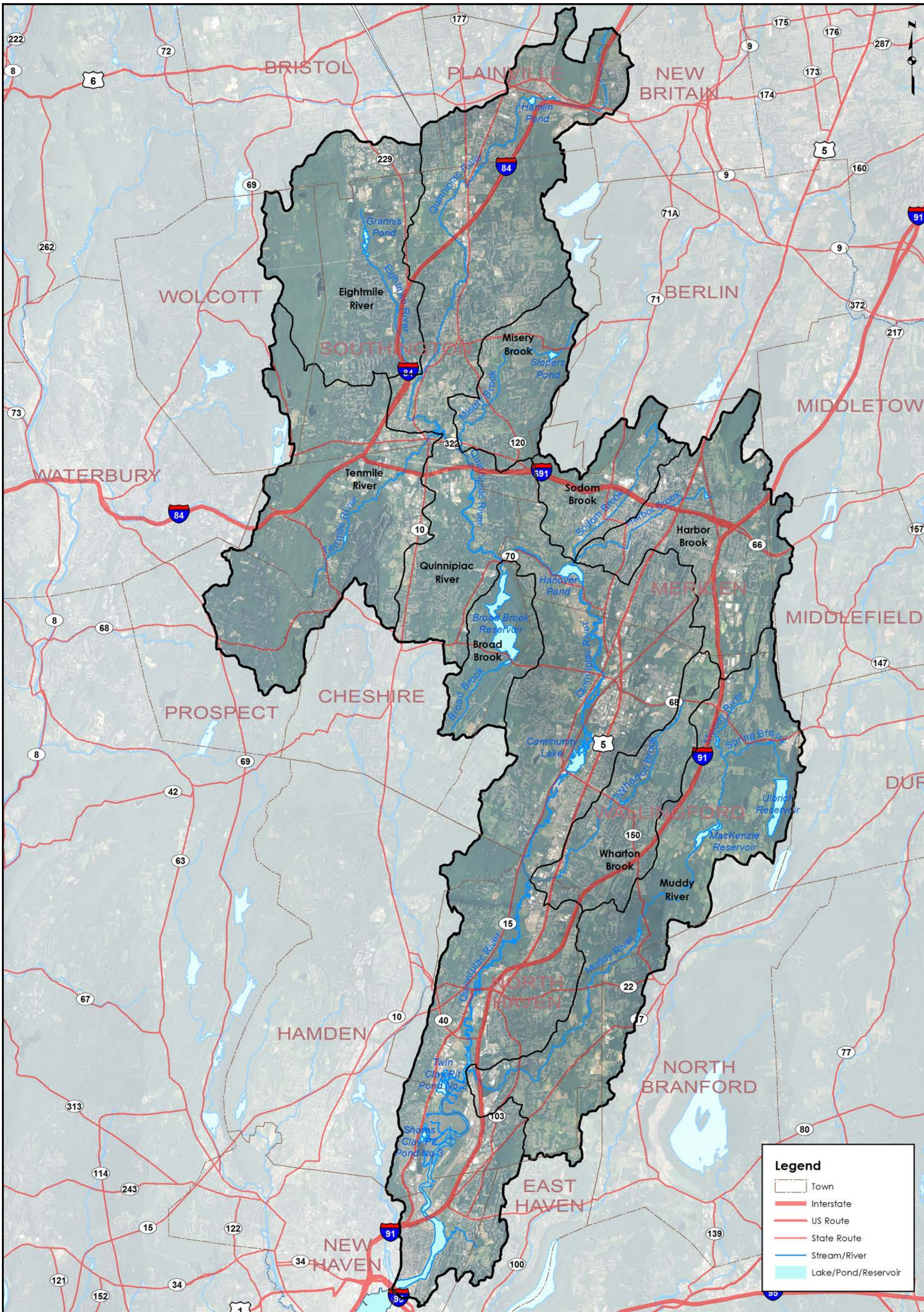
78 Interstate Drive West Springfield, MA 01089

Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Watershed Boundaries 1:24,000 scale; Hydrography 1:24,000 scale by USGS and CTDEEP, Hillshade 2000 from http://www.ctecoapp2.uconn.edu/arcgis/services.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 2-1
QUINNIPIAC RIVER WATERSHED



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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 2-2
WATERSHED AERIAL PHOTOGRAPH

Table 2-1. Quinnipiac River Subwatersheds

Subwatershed	Acronym	Area (acres)	Area (square miles)	Length of Stream (miles)[1]
Quinnipiac River (Main Stem)	QR	46,500	72.7	152.8
Muddy River	MR	13,947	21.8	47.6
Tenmile River	TR	12,967	20.3	44.7
Eightmile River	ER	9,441	14.8	33.1
Harbor Brook	HB	7,751	12.1	21.7
Wharton Brook	WB	4,895	7.6	17.2
Misery Brook	MB	3,993	6.2	11.7
Sodom Brook	SB	3,377	5.3	7.4
Broad Brook	BB	3,080	4.8	10.2
Watershed (Total)		**105,952**	**165.5**	**346.4**

Notes:
(1) Only includes the main stem of mapped rivers and streams in each subwatershed

- Tenmile River begins near the Prospect/Cheshire town line and flows northeast, under Interstate 691, Connecticut Route 10 and Connecticut Route 322, to its confluence with the Quinnipiac River just north of the Southington/Cheshire town line.
- Misery Brook begins near the Berlin/Southington town line and flows southwest through Slopers Pond, under Connecticut Route 120 and Connecticut Route 322 to its confluence with the Quinnipiac on the Cheshire/Southington town line, just south of the confluence of Tenmile River with the Quinnipiac River.
- Broad Brook begins in Cheshire and flows northeast to Broad Brook Reservoir, which empties into the Quinnipiac near the Cheshire/Meriden town line.
- Sodom Brook begins in Meriden and first flows northeast, and then turns to flow southwest toward the Quinnipiac River. Sodom Brook flows southeast under Interstate 691 and Connecticut Route 70 before entering the Quinnipiac River at Hanover Pond.
- Harbor Brook begins in Meriden and flows southwest under Connecticut Route 5, Interstate 691 and Connecticut Route 70 to Hanover Pond in Meriden, located along the Quinnipiac River. The Harbor Brook watershed also contains Connecticut Route 66, Interstate 91 and Connecticut Route 15.
- Wharton Brook begins in Wallingford near Connecticut Route 68 and flows southwest under Connecticut Route 150 and US Route 5 to where it meets the Quinnipiac River on the Wallingford/North Haven town line.
- Muddy River begins in the northern end of Wallingford and flows southwest under Connecticut Route 68, through the MacKenzie Reservoir, and under Route 150, Route 22 and US Route 5 to its confluence with the Quinnipiac River just north of the North Haven/Hamden town line. The Muddy River watershed is also fed by Spring Brook, which originates from the Ulbrich Reservoir near the Wallingford/Durham town line.

The United States Geological Survey (USGS) has several stream flow gage stations within the Quinnipiac River watershed. Gage station 01196561 is located on Muddy River near East Wallingford. The highest stream flow generally occurs in April, while low-flow typically occurs August through October. Gage station 01196500 is located on the Quinnipiac River in Wallingford. The highest stream flow generally occurs March through April, while the lowest flow occurs August through October. Gage station 01195490 is also located on the Quinnipiac River in Southington. The highest stream flow generally occurs in March and April and the seasonal low-flows typically occur July through September.

2.2 Watershed Municipalities and Demographics

Table 2-2 lists each municipality in order of the percent of watershed within their boundary. Twenty Connecticut municipalities contain some portion of the watershed. However, in the following tables, only municipalities with more than 1 percent of the watershed area are shown. The towns of Wallingford, Southington, Meriden, Cheshire, and North Haven contain over 80 percent of the watershed. The remaining municipalities listed in *Table 2-2* have a total of 17.9 percent of the watershed within their boundaries. The municipalities with less than 1 percent of the watershed within their political boundaries are New Britain, Berlin, Middlefield, Farmington, Middletown, Durham, Waterbury, and are not listed in the table. The majority of the watershed communities are located in New Haven County, with only Southington, Plainville, and Bristol located in Hartford County.

Table 2-2. Distribution of Municipalities in the Quinnipiac River Watershed

Municipality	Total Acreage of Municipality	Acreage in Watershed	% of Municipality in Watershed	% of Watershed
Wallingford	25,821	23,423	90.7%	22.1%
Southington	23,377	21,487	91.9%	20.3%
Meriden	15,325	13,889	90.6%	13.1%
Cheshire	21,165	13,609	64.3%	12.8%
North Haven	13,510	12,656	93.7%	11.9%
Plainville	6,309	3,582	56.8%	3.4%
Wolcott	13,539	3,292	24.3%	3.1%
Prospect	9,238	3,047	33.0%	2.9%
New Haven	12,288	2,512	20.4%	2.4%
Hamden	21,278	2,247	10.6%	2.1%
Bristol	17,168	1,786	10.4%	1.7%
North Branford	17,231	1,418	8.2%	1.3%
East Haven	8,047	1,120	13.9%	1.1%
Watershed (Total)	**102,528**	**18,639**		**100%**

Population and demographic information for the watershed was analyzed using data from the Connecticut Economic Resource Center (CERC, 2012) and the Connecticut Department of Economic and Community Development (DECD, 2012). The watershed population is estimated at approximately 240,000, which is based on the population densities within the five communities that make up the majority of the watershed land area. Of the total population in the watershed, it is estimated that 25% live in Meriden, 18% in Southington, and 18% in Wallingford. New Haven, which has the largest municipal population of all the watershed communities, is estimated to have approximately 11% of the watershed population.

Table 2-3. Population Densities in the Quinnipiac River Watershed

Municipality	Watershed Population	Watershed Population Density (Population / Square Mile)	Town Population	Town Population Density (Population / Square Mile)
New Haven	26,434	6,736	161,279	8,400
Meriden	58,384	2,690	81,011	3,383
East Haven	3,943	2,252	54,531	4,337
Plainville	11,452	2,046	40,490	4,108
Hamden	4,892	1,393	91,343	2,747
Bristol	3,651	1,308	84,469	3,149
Southington	41,822	1,246	70,546	1,931
Wallingford	43,004	1,175	141,243	3,501
North Haven	21,292	1,077	48,881	2,316
North Branford	1,858	838	38,014	1,412
Cheshire	16,644	783	55,929	1,691
Prospect	2,996	629	24,755	1,715
Wolcott	2,169	422	34,520	1,632
Watershed (Total)	**238,539**		**927,011**	

Population in the watershed communities, with the exception of New Haven, has increased steadily since 1900. The population decline in New Haven in the 1950s-1980s corresponds to some of the most rapid growth in the suburban communities, reflecting the movement from cities to suburbs that occurred across the state during that time period. Since 1990, population growth in the suburban towns of the watershed has leveled, but continues to show minor growth (*Figure 2-3*). New Haven County, in which the majority of the watershed communities are located, has experienced steady growth over the past decade. Since 1990, the region's population has grown by 67,000 and is projected to reach 905,825 by 2016, an average annual growth rate of 0.8% of the period 2011-2016, which is the same as the projected state population growth rate (CERC, 2012). By 2016, approximately 24% of the State's population is expected to live in New Haven County.

In the three communities with the largest populations in the watershed – Southington, Wallingford, and Meriden – the population growth rate is expected to meet or exceed the 0.8% growth rate. Meriden, which has both the highest percentage of population and the second highest population density in the watershed (*Table 2-2*), is anticipated to experience an average annual population growth of 1.4%, nearly double the surrounding communities and the state. Although Bristol and Hamden have similar overall populations, Meriden's relatively large population in 1990 reflects the age of development in that portion of the watershed, as does the fact that approximately 36% of the housing stock in Meriden was construction before 1950.

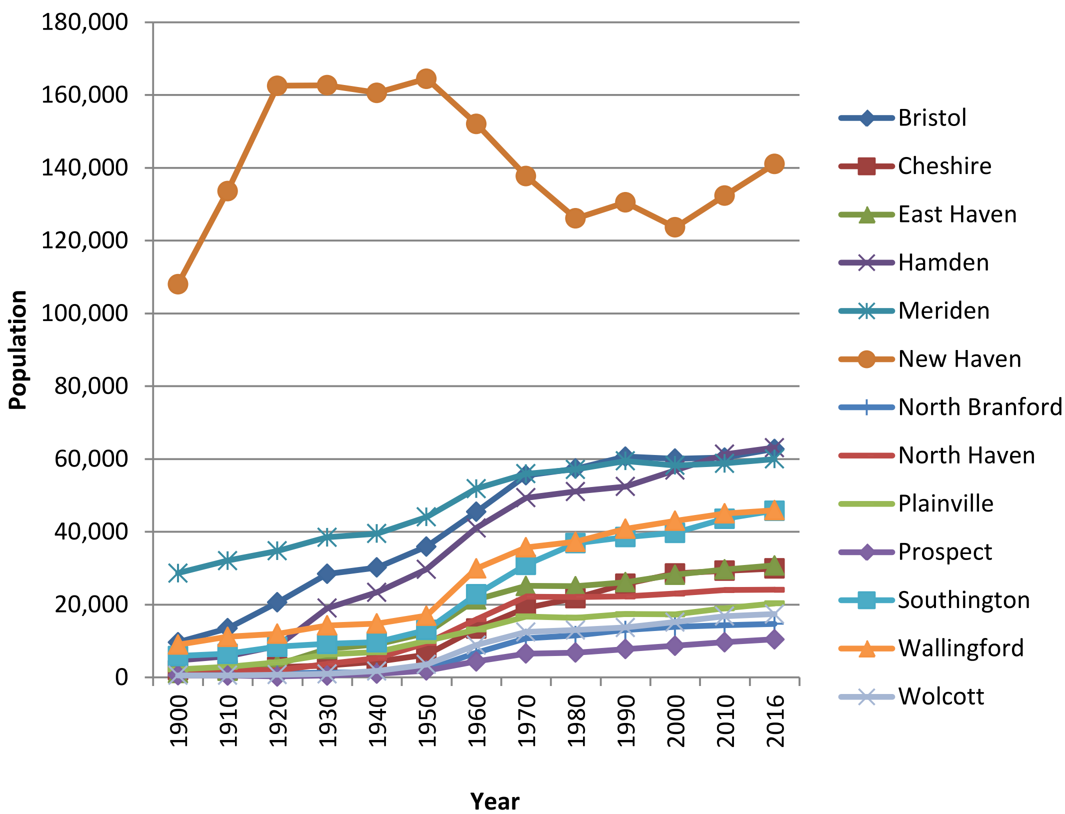


Figure 2-3. Population Trends of the Quinnipiac River Watershed Communities

2.3 Historical Perspective

European settlers in 1614 were attracted to the river that Native Americans had named Quinnipiac, meaning "long water land," because of its abundant supply of fish and oysters. By the early 1800s, the oyster industry was flourishing, but other industries were also establishing in the river valley. Brickmaking, textiles, machinery, firearms and metalworking industries were established in the Quinnipiac watershed. Meriden became known as The Silver City during that era, illustrating the prominence of the metal industry in the region.

Although the types of industries changed in the 20th century, with electronics, chemical and plastics manufacturing coming to prominence in the region, the Quinnipiac River continued to provide transportation, hydropower, and waste disposal. Since the Industrial Revolution, the river had been a primary means of waste disposal, carrying industrial waste from manufacturing and sewage from residential and commercial areas in the population centers of Meriden, Southington, Wallingford, and North Haven downstream to Long Island Sound. By the 1880s, the state of the river led to the first water pollution control legislation, prohibiting Meriden from discharging raw sewage into the Quinnipiac River and resulting in the construction of the state's first water pollution control facility. By 1914, when the State Board of Health declared the Quinnipiac River polluted, 71 businesses and several municipalities were discharging to the river (Tyrrell, 2001). By 1952, that number had decreased, but industrial discharges directly to the river continued into the 1990s.

The enactment of the state and federal environmental laws in the 1960s and 1970s resulted in regulation and reduction of pollution discharges into the Quinnipiac River. However, the legacy of hundreds of years of use of the river for waste disposal is still evident in the water quality of watercourses and waterbodies in the watershed. A 2001 report (Tyrrell) on water quality in the Quinnipiac estimated that there are over 5,000 locations in the watershed where pollutant releases have occurred, regulatory enforcement actions that taken place, or there is the potential for pollution to reach rivers and streams. More than one half of these sites are estimated to be within a quarter mile of a stream or river. In addition, the river continues to receive treated wastewater discharges and stormwater runoff from urban and suburban areas. As discussed in *Section 3* (Water Quality), in addition to the main stem Quinnipiac River, Harbor Brook, Sodam Brook, Eightmile River, and Tenmile River are among the most impacted subwatersheds from a water quality perspective.

Over the past several decades, water quality in the Quinnipiac River watershed has benefitted from the combination of 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. However, the legacy of water quality impacts remains as evidenced by the current impairments in the main stem river, its tributaries, and waterbodies in the watershed.

3 Water Quality

Water quality is a primary indicator of the ecological health of a river and its ability to support specific uses such as water supplies, recreation, habitat, and industrial uses. Water quality is also inherently linked to the activities that take place in its watershed.

The Quinnipiac River and its tributaries have been monitored and studied extensively over the past several decades given the focus on improving water quality in the river since the 1960s and 1970s. This section reviews previous water quality studies and monitoring efforts in the Quinnipiac River watershed by the Connecticut Department of Energy and Environmental Protection (CTDEEP), the U.S. Geological Survey (USGS), and other organizations. The monitoring data are reviewed in the context of the Connecticut Water Quality Standard (CWQS) and the Draft 2012 Integrated Water Quality Report to assess current water quality conditions in the watershed.

3.1 Classification, Standards, and Impairments

The Federal Clean Water Act (CWA) was established to protect the nation's surface waters. Through authorization of the CWA, the United States Congress declared as a national goal "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water wherever attainable." The CWA requires states to:

1. Adopt Water Quality Standards,
2. Assess surface waters to evaluate compliance with Water Quality Standards,
3. Identify those waters not currently meeting Water Quality Standards, and
4. Develop Total Maximum Daily Loads (TMDL) and other management plans to bring water bodies into compliance with Water Quality Standards.

Connecticut Water Quality Standards are established in accordance with Section 22a-426 of the Connecticut General Statutes and Section 303 of the CWA. The Water Quality Standards are used to establish priorities for pollution abatement efforts. Based on the Water Quality Standards, Water Quality Classifications establish designated uses for surface, coastal and marine and ground waters and identify the criteria necessary to support these uses. The Water Quality Classification system classifies inland surface waters into three different categories, Class AA, Class A and Class B and coastal and marine surface waters into two categories, Class SA and SB (*Table 3-1*).

Figure 3-1 depicts the Water Quality Classifications of surface water and groundwater in the Quinnipiac River watershed. There are several water supply subwatersheds designated as Class AA waters in the Quinnipiac River watershed, including areas in Wolcott, the entire Broad Brook subwatershed, and a majority of the Muddy River subwatershed. Most of the tributaries to the Quinnipiac River are designated as Class A surface water bodies that have the following designated uses: potential drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other uses, including navigation. The main stem Quinnipiac River, Eightmile River, Tenmile River, and Harbor

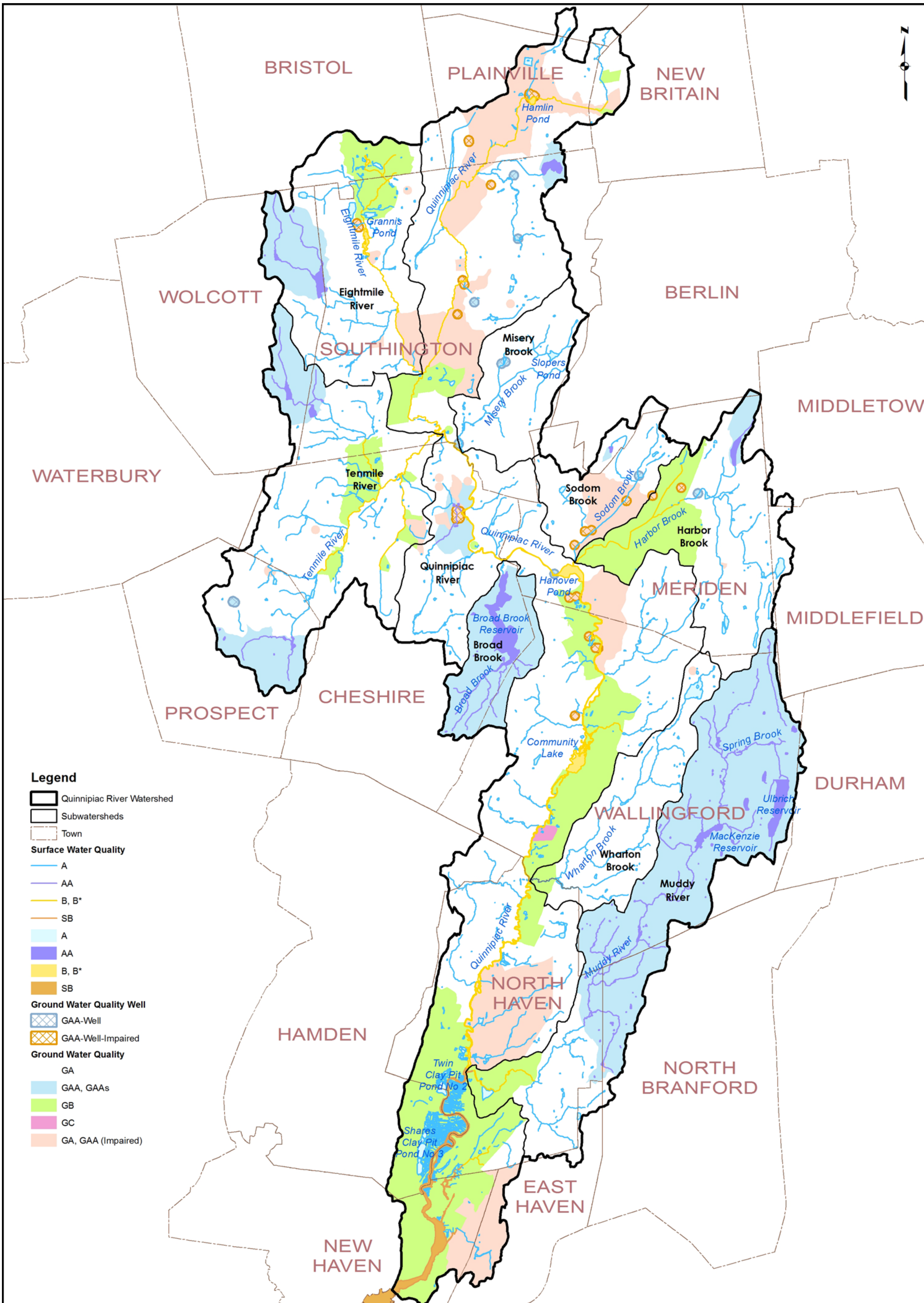
Brook are designated Class B water bodies, with the following designated uses: fish and wildlife habitat; recreational use; agricultural, industrial supply and other uses, including navigation.

Table 3-1. Connecticut Surface Water Quality Classifications

Designated Use	Inland Surface Waters			Coastal and Marine Surface Waters	
	Class AA	Class A	Class B	Class SA	Class SB
Existing or proposed drinking water supply	●				
Potential drinking water supply		●			
Habitat for fish, other aquatic life, and wildlife habitat	●	●	●	●	
Shellfish harvesting for direct human consumption				●	
Commercial shellfish harvesting					●
Recreation	●	●	●	●	●
Industrial and/or agricultural supply	●	●	●	●	●
Navigation	●	●	●	●	●

The CWA requires each state to monitor, assess and report on the quality of its waters relative to attainment of designated uses established by the State's Water Quality Standards. When waters are not suitable for their designated use, they are identified as "impaired." Each year, the State of Connecticut assesses watercourses and water bodies in the state and provides to EPA a list of impaired waters. *Table A-1* in *Appendix A* summarizes the impaired designated uses for water bodies in the Quinnipiac River watershed from the Draft 2012 Integrated Water Quality Report, including the causes and potential sources of the impairments. *Table A-2* in *Appendix A* summarizes the water quality classifications of various segments, or reaches, and tributaries of the Quinnipiac River that do not meet their Water Quality Criteria designated uses. *Figure 3-2* depicts the locations of the impaired water bodies.

Currently, 22 of the 32 assessed stream segments, 3 of 5 assessed lakes, and both of the assessed estuary areas are impaired for one or more of their designated uses. Several streams are impaired for habitat for fish, other aquatic life, and wildlife, as determined by a combination of information on the benthic macroinvertebrate community, fish community, physical/chemical data, toxicity, and records of water quantity. The suitability of surface waters for recreation is determined using the *Enterococci* group bacteria in salt (estuarine) water, and *Escherichia coli (E. coli)* in fresh water as indicators of fecal pollution. Several stream segments in the watershed are not meeting their designated use for fish consumption, based on contaminated fish tissue. There is currently a statewide advisory for mercury in freshwater fish and for polychlorinated biphenyls (PCBs) in migratory saltwater fish. The Eightmile River has a fish consumption advisory due to a PCB spill that occurred in the Plainville section of the Quinnipiac River in 1996 and 1997, which has since been remediated; however, affected fish in the Quinnipiac River have migrated to the Eightmile River. These impairments are described further in *Section 3.1*.



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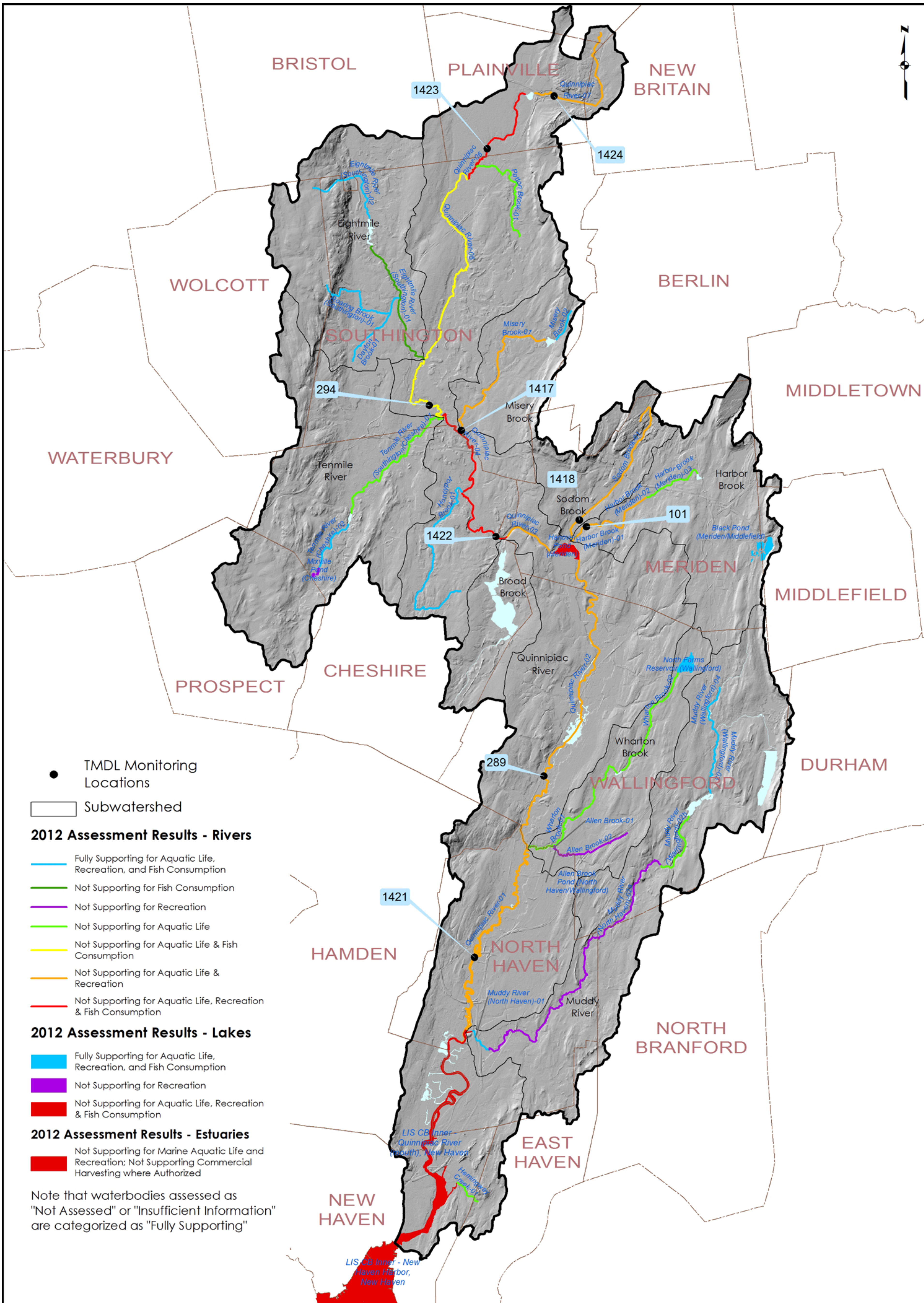
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP),
Water Quality Standards 1:24,000-scale;
Surface Water Quality Standards Effective February 25, 2011,
Groundwater Quality Standards Effective April 12, 1996.
Aquifer Protection Areas 1:24,000-scale.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 3-1
WATER QUALITY CLASSIFICATIONS



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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, "State of Connecticut Integrated Water Quality Report, Draft September 19, 2012.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 3-2
WATER QUALITY IMPAIRMENTS

Several tributaries that drain off the forested slopes of traprock ridges (e.g., upper Tenmile River) and Southington Mountain (e.g., Dayton Brook) are fully supporting for all designated uses, or have not been assessed by CTDEEP. Honeypot Brook is another high quality stream segment within Broad Brook since its watershed is largely protected as a drinking water supply.

The tidal sections of the river at New Haven Harbor are also listed as impaired. The identified impairments in the tidal portions of the river (i.e., the mouth of the Quinnipiac River and New Haven Harbor) include commercial shellfish harvesting; recreational uses; and habitat for fish, other aquatic life, and wildlife; and industrial water supply; and navigation (CTDEEP, 2011).

Total Maximum Daily Loads (TMDLs) provide the framework to restore impaired waters by establishing the maximum amount of a pollutant that a water body can assimilate without adverse impact to aquatic life, recreation, or other public uses. *Table A-2* in *Appendix A* lists the priority year for TMDL development for Category 5[1] waters, where available data and/or information indicate that one or more designated uses are not being supported and a TMDL is needed.

A TMDL analysis was completed for indicator bacteria in the Quinnipiac River watershed. The waterbodies addressed by the TMDL include Harbor Brook, Misery Brook, Quinnipiac River (main stem), and Sodom Brook. In the Quinnipiac River Regional Basin TMDL, loadings are expressed as the average percent reduction from current loadings that must be achieved to meet water quality standards. The TMDL calls for overall reductions in indicator bacteria in the Quinnipiac River, Harbor Brook, Misery Brook, and Sodom Brook of between 64% and 95%, with 73% to 95% reductions in point source discharges and 58% to 95% reductions in nonpoint source discharges.

A TMDL document was approved by the EPA in 2007 for Gay City Pond (Gay City State Park), Allen Brook Pond (Wharton Brook State Park), and Schreeder Pond (Chatfield State Hollow). Allen Brook segment 01 and 02 and Allen Brook Pond (North Haven. Wallingford) are within the Quinnipiac River watershed. The TMDL was prepared as a result of beach closures due to an exceedance of indicator bacteria *E. coli* levels in designated swimming areas. Geese and pet waste are believed to be the primary causes of elevated *E. coli*. Using the same approach as the Quinnipiac River Regional Basin TMDL, the Gay City Pond, Allen Brook Pond and Schreeder Pond TMDL loadings are also expressed as the average percent reduction from current loadings that must be achieved to meet water quality standards. The TMDL calls for a nonpoint source reduction of 3% in dry weather and 21% during wet weather conditions in *E. coli* loadings to Allen Brook Pond and 64% reduction in *E. coli* loadings during dry weather conditions.

[1] Category 5 waterbodies are defined as having available data and/or information that indicate that one or more designated uses are not being supported and a TMDL is needed.

3.2 Water Quality Monitoring

The Quinnipiac River watershed has been the focus of many water quality studies over the years conducted by a variety of academic institutions, government agencies, private industry, and volunteer groups. Several documents summarize the monitoring efforts of these groups, including an extensive review of water quality data from 1989 to 1999 that was conducted by Mary Tyrell (2001) for the Yale School of Forestry and Environmental Studies Center for Coastal and Watershed Systems (CCWS). The Yale study focused on pollution from metals and carbon-based chemical compounds. Another compendium of water quality data was also compiled by CCWS and the University of New Haven Department of Biological and Environmental Science in March 2000. Within the last 10 years, the CTDEEP, USGS, and volunteer monitoring groups have collected water quality data throughout the watershed for the purposes of identifying impairments under the CWA and quantifying the progress that watershed stewardship efforts have had on water quality in the watershed.

A variety of indicators have been used to assess the water quality of the Quinnipiac River and its tributaries. These indicators include metals, nutrients, dissolved oxygen, total suspended solids, turbidity, and aquatic biodiversity. Due to the large amount of data available, boxplots are used throughout the following sections to graphically summarize water quality data. Boxplots provide a succinct, graphical summary of water quality data to allow comparison of water quality conditions in different subwatershed or between stations along the main stem Quinnipiac River. A boxplot consists of a box, whiskers, and outliers. As shown in *Figure 3-3*, the top of the box is the 75th percentile, the bottom of the box is the 25th percentile, the line dividing the box is the median value (50th percentile), and the diamond is the average. The vertical lines above and below the box are called whiskers and represent the minimum and maximum values of the observed data.

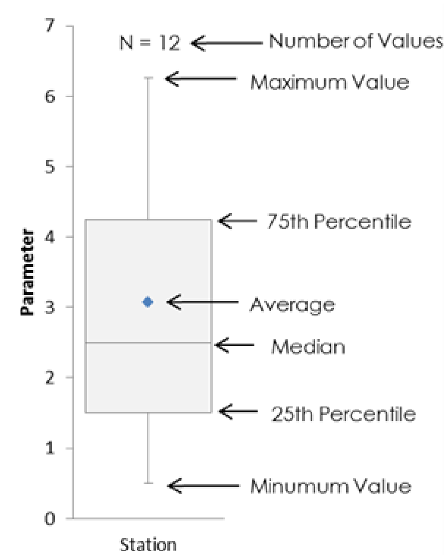


Figure 3-3. Boxplot Elements

3.2.1 CTDEEP Ambient Water Quality Monitoring Program

Monitoring Program

The determination of the supported uses in rivers across the state relies on the collection of physical, chemical and biological monitoring data of stream water quality. In 2005, a new Comprehensive Ambient Water Quality Monitoring Strategy was adopted. The strategy incorporates a composite of targeted and probabilistic sampling designs to assess aquatic life use support. The monitoring includes a mix of sites visited every five years, two-years, and annually.

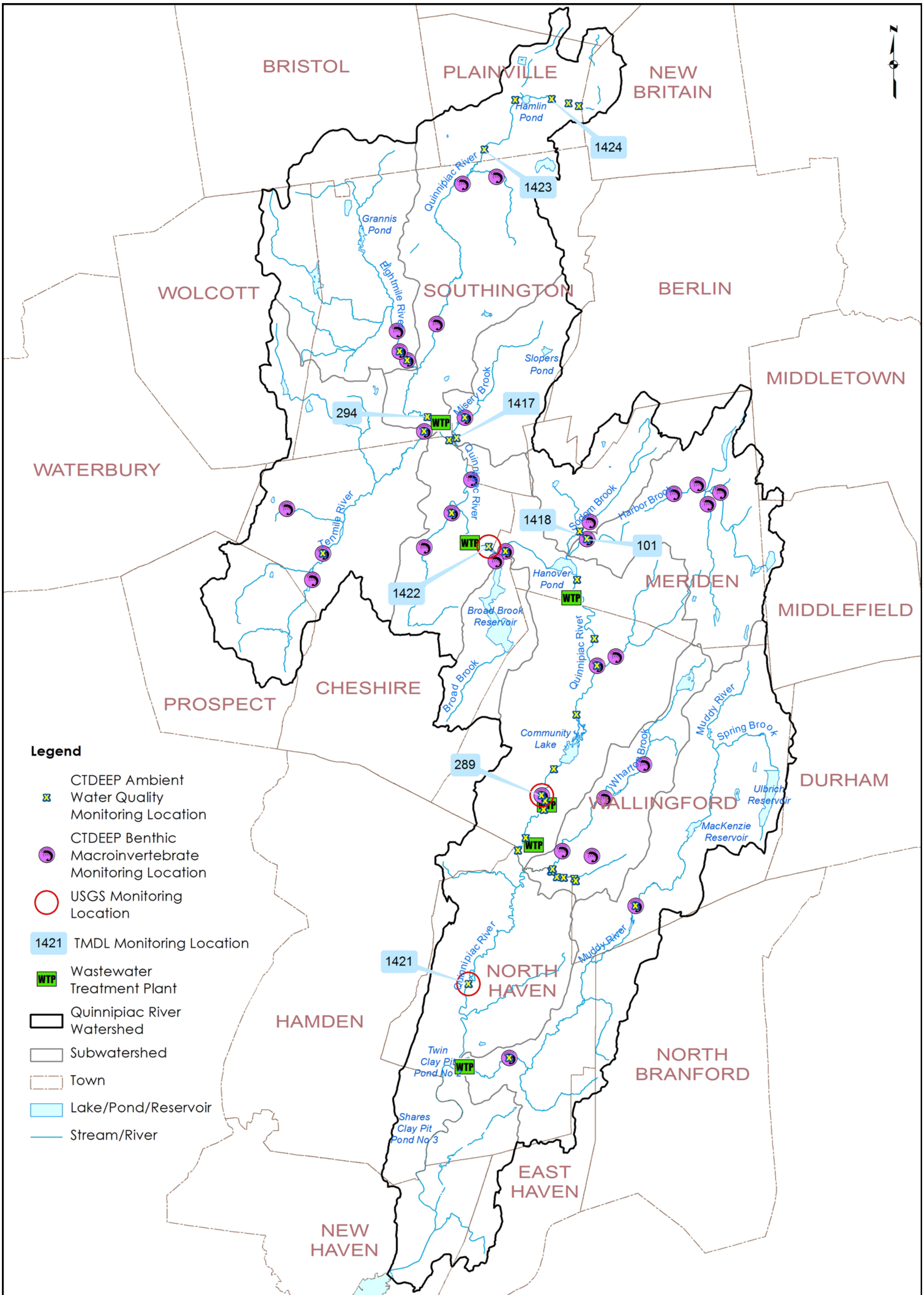
The CTDEEP has conducted water quality monitoring within the Quinnipiac River watershed since 1996 at approximately 67 stations throughout the watershed for a wide variety of chemical and physical parameters (*Figure 3-4*). Only data collected within the last 10 years (2002 – 2012) is considered in this review since it reflects the most current conditions in the watershed. Due to the large number of stations within the watershed, the data is analyzed in the following sections by subwatershed, with more detail on the spatial distribution of data along the main stem Quinnipiac River (Quinnipiac River subwatershed). The Quinnipiac River subwatershed has the most water quality monitoring stations (30) since the main stem of the Quinnipiac River is completely contained within the subwatershed. In addition, three of the stations along the Quinnipiac River in Meriden, Wallingford, and North Haven are USGS cooperative stations and the data collected by the USGS is shown with the CTDEEP data in boxplots, where appropriate. The Eightmile River, Tenmile River, Misery Brook, Harbor Brook, Sodom Brook, Wharton Brook, and Muddy River subwatersheds have between one and 11 water quality monitoring stations each. The Broad Brook subwatershed does not have any water quality monitoring stations.

Benthic macroinvertebrates and fish survey stations are also located throughout the Quinnipiac River watershed. Benthic macroinvertebrates surveys were conducted from 1976 to the present, and fish surveys were conducted from 1969 to the present. Again, data analysis in this report is restricted to the past 10 years. Since 2002, 27 benthic macroinvertebrate surveys have been conducted in the Quinnipiac River, 16 in the Eightmile River, 9 in the Muddy River, and between 1 and 6 total surveys in Harbor Brook, Tenmile River, Willow Brook, Wharton Brook, Cuff Brook, Misery Brook, Honeypot Brook, Patton Brook, and Meetinghouse Brook. There were 9 fish surveys in the Quinnipiac River, 6 in the Muddy River and the remaining 24 surveys at other various locations throughout the watershed tributaries.

Metals

Metals occur naturally in the environment, but human activities can alter their distribution. When metals are released into the environment in higher than natural concentrations, they can be toxic and disrupt aquatic ecosystems. Metals in their dissolved form are typically more harmful (i.e., bioavailable) to aquatic organisms. Copper, zinc, and lead are most often used as relevant indicators of impaired water quality conditions. Boxplots summary statistics for copper, lead, and zinc concentrations along the main stem Quinnipiac River are presented in *Figure 3-5* with the stations ordered upstream to downstream reading left to right in the plots. The Water Quality Criteria for chemical constituents in freshwater for chronic conditions in Class AA, A & B in the Connecticut Water Quality Standard (CWQS) are as follows: copper = 4.7 μg/L; lead = 1.2 μg/L; and zinc = 65 μg/L, which are shown as dashed reference lines in *Figure 3-5*. The 75th percentile for all stations for copper is below the CWQS, with the exception of station #1423, which is located in Plainville downstream of Hamlin Pond. This exceedance may be due to historic discharges of metals into the Quinnipiac River.

Heavy loads of toxic metals (cadmium, chromium, copper, silver, and nickel) were discharged from industrial facilities from about 1840 until at least the late 1950s. The facilities were concentrated in Meriden (Harbor and Clark Brooks) and Southington (Quinnipiac River). Metals are conservative, meaning they don't break down or decay, and when dissolved metals are introduced into a river in a waste stream, they tend to attach to sediments and settle out of the water column into the river bottom sediments. Other studies of Quinnipiac River sediments have confirmed this pattern, with elevated levels of metals found in the sediments of Hanover Pond, Hamlin Pond, Community Lake, the North Haven marshes and a floodplain near the North Haven/Wallingford border (Tyrrell, 2001).



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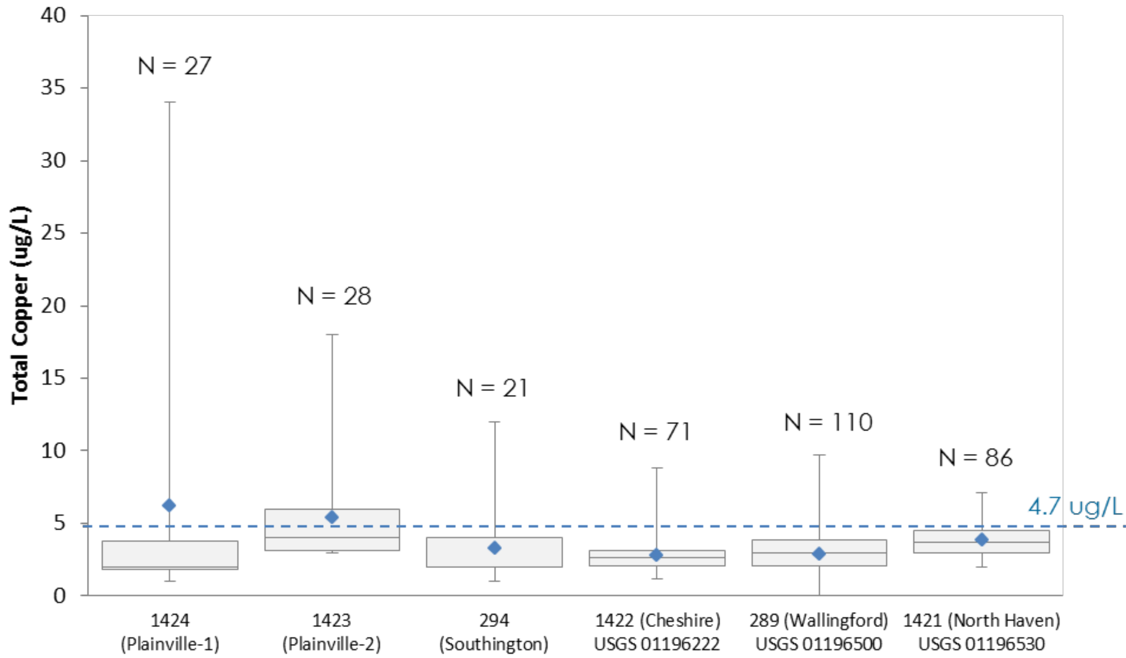
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Watershed Boundaries 1:24,000 scale; National Hydrography Dataset, and USGS.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 3-4
WATER QUALITY MONITORING LOCATIONS



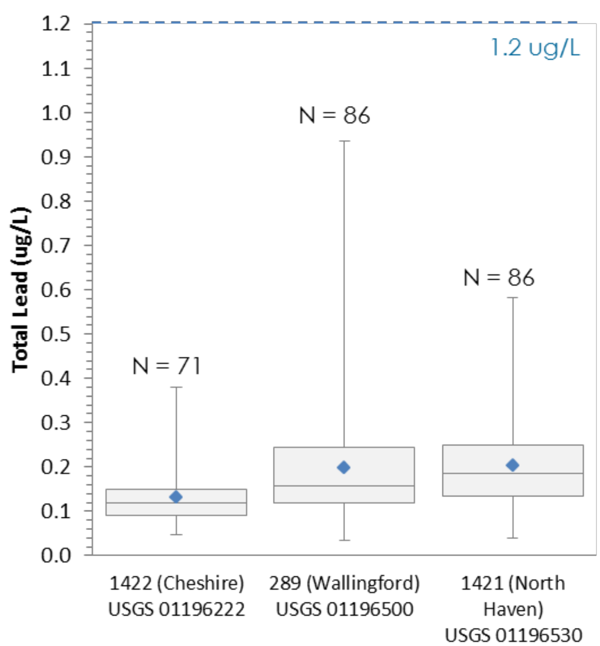
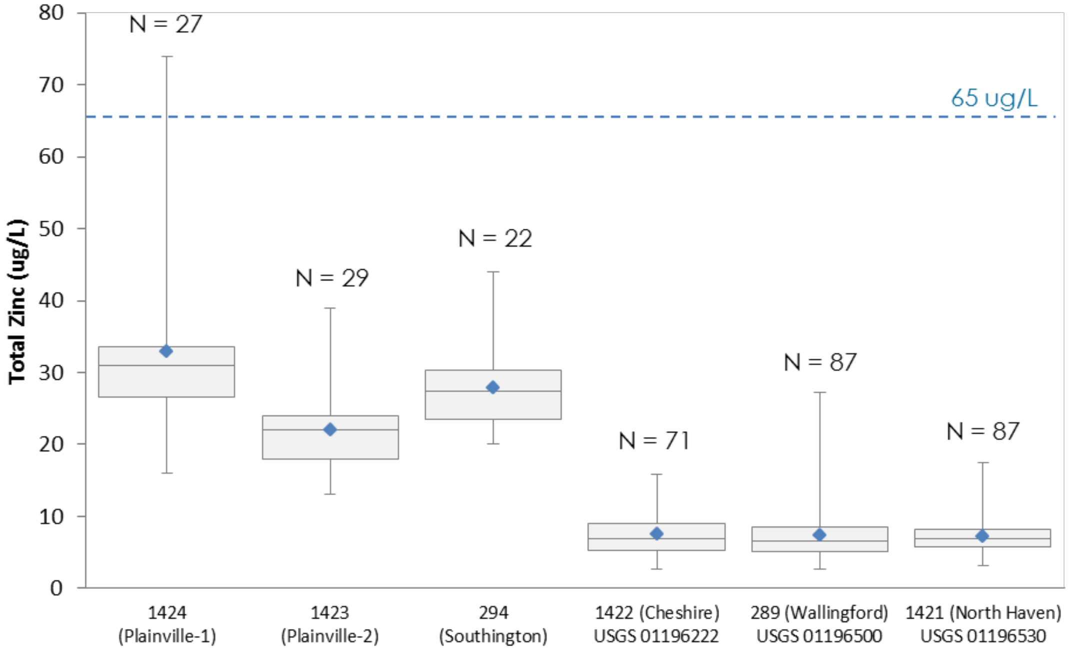


Figure 3-5. Copper, Lead, and Zinc Boxplots for the Main Stem Quinnipiac River



Numerical Water Quality Criteria for Chemical Constituents Freshwater Chronic Class AA, A & B - Copper = 4.7 µg/L; Lead = 1.2 µg/L; Zinc = 65 µg/L.

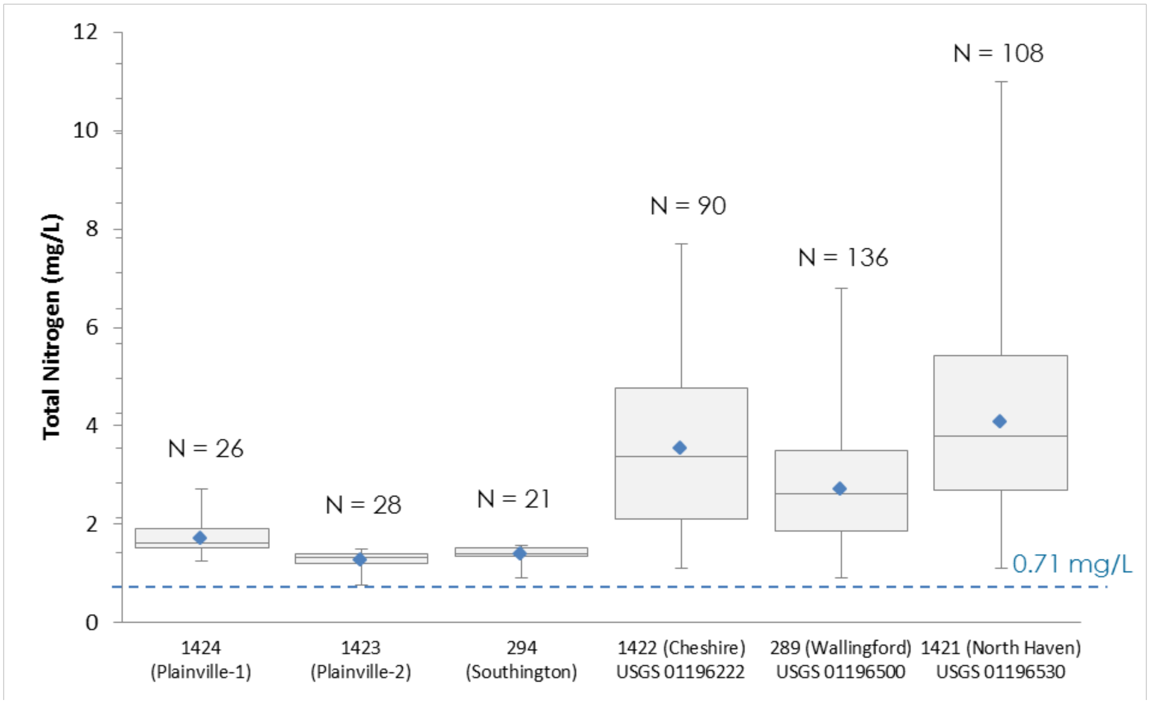
Figure 3-5. Copper, Lead, and Zinc Boxplots for the Main Stem Quinnipiac River

There are generally fewer than 5 monitoring events conducted in the tributary subwatersheds for copper, lead, and zinc. The data is highly variable and no clear pattern is evident; therefore, the tributary data is not presented.

Nutrients

Nitrogen and phosphorus are the primary nutrients that enrich streams and rivers and cause nuisance levels of algae and aquatic weeds. Nutrients, especially phosphorus, are frequently the key stimulus to increased and excessive algal biomass in many freshwaters. Nitrogen is more of a concern in marine systems and estuaries, such as Long Island Sound to which the Quinnipiac River discharges.

Total nitrogen and phosphate were routinely monitored throughout the Quinnipiac River watershed over the last 32 years. The three stations in the upper portion of the watershed have between 21 and 28 measurements for nutrients, and the three downstream stations have between 92 and 136 measurements over the past 10 years. The averages of total nitrogen measured within the last 10 years at the eight stations with data are above the EPA reference criterion of 0.71 mg/L for rivers in southern New England (EPA, 2000). In addition, the average of total phosphate concentrations was also above the total phosphorus EPA reference criterion of 0.03125 mg/L at all six stations. This reflects the contribution of nitrogen and phosphorus from sources in the watershed, such as precipitation and atmospheric deposition, urban stormwater runoff, wastewater treatment plant effluent, septic system effluent, and sewer overflows. The nutrient concentrations along the main stem of the Quinnipiac River increase significantly at stations #1422, #289, and #1421, which are located downstream from one or more of the WPCFs located within the watershed, including the towns of Southington, Cheshire, Meriden, and Wallingford, as shown on *Figure 3-6*.



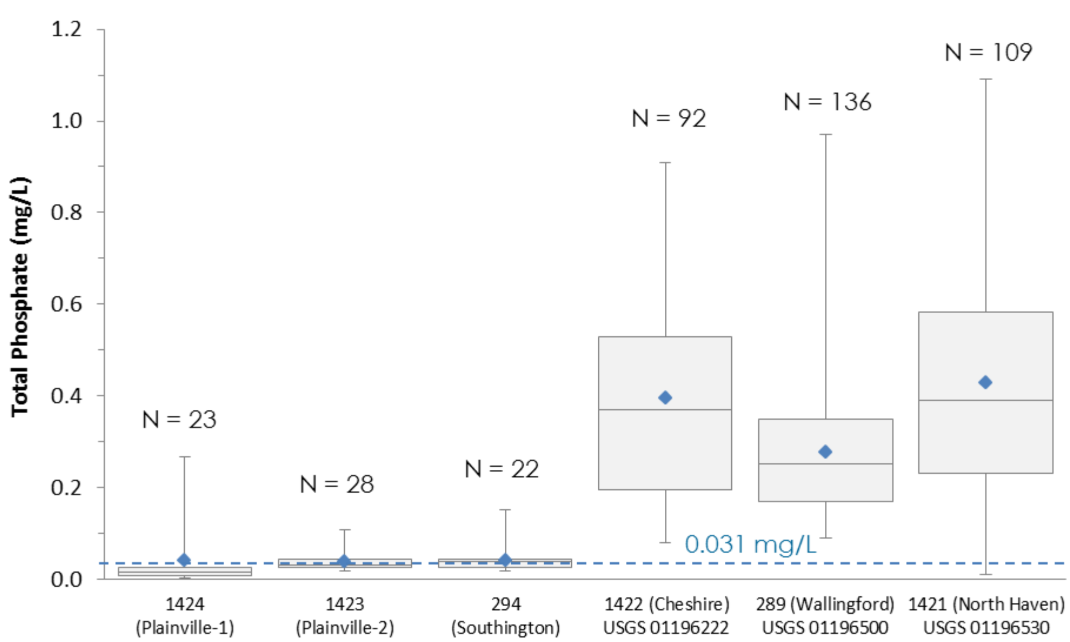
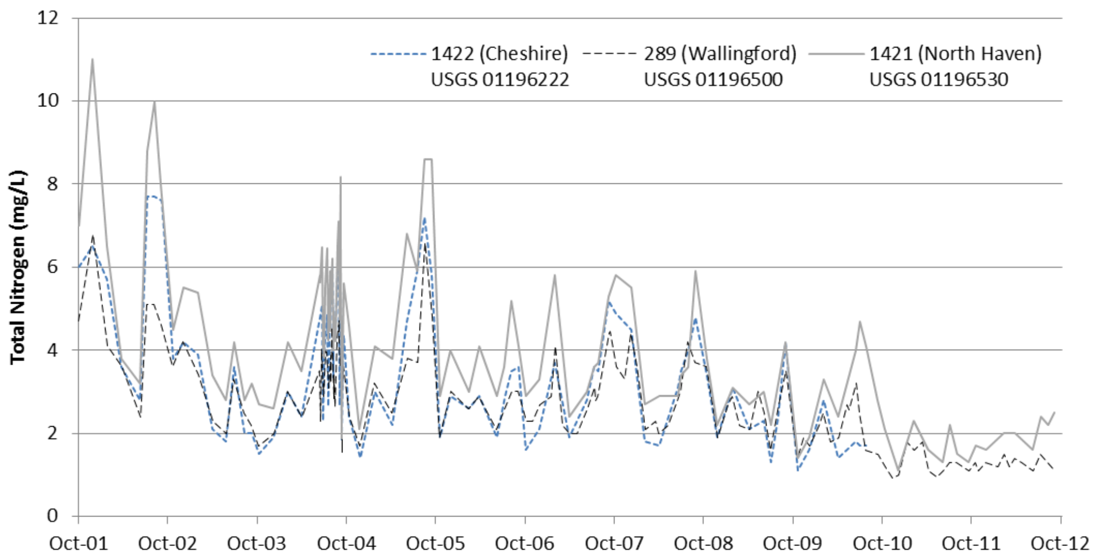


Figure 3-6. Total Nitrogen and Phosphate Boxplots for the Main Stem Quinnipiac River

Figure 3-7 shows the nitrogen and phosphate concentrations from 2002 to 2012 for the 3 stations in the lower portion of the watershed, which have historically had the highest nutrient concentrations of the stations in the watershed. As discussed further in *Section 5.3*, some of the municipal wastewater treatment plants in the watershed have begun to implement denitrification or advanced treatment for nitrogen removal. A downward trend in nitrogen concentrations in the Quinnipiac River downstream of the WPCFs has occurred over the past 10 years. This trend may be the result of treatment process optimization to meet lower nitrogen discharge standards. Phosphorus reductions/limitations in wastewater discharges is also an ongoing concern for CTDEEP, which has adopted an interim strategy to establish water quality based phosphorus limits in non-tidal freshwater for industrial and municipal WPCF NPDES permits until numeric nutrient criteria are established in the CWQS. Currently, CTDEEP is working collaboratively with several of the Quinnipiac River watershed communities including Meriden, Cheshire, Southington and Wallingford to reduce phosphorus and to make recommendations regarding a state-wide strategy to reduce phosphorus to comply with EPA standards.



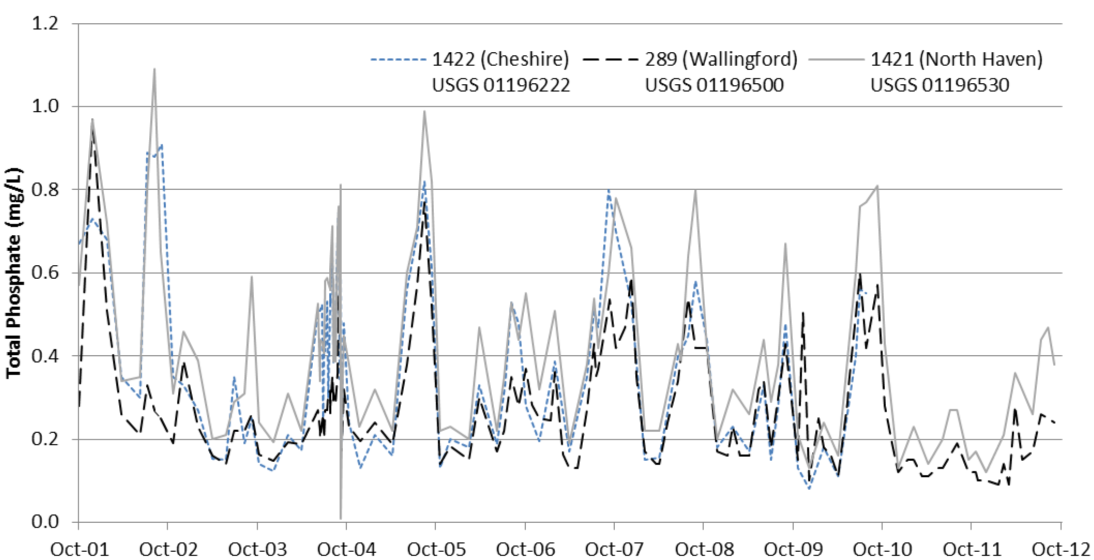


Figure 3-7. Total Nitrogen and Phosphate Trends for the Lower Quinnipiac River

As shown in *Figure 3-7,* there has been a slight reduction in phosphorus over the past 10 years. However, there is likely to be a more significant reduction in phosphorus loading following the implementation of CTDEEP's statewide plan.

The nutrient levels in the subwatershed tributaries are similar to those in the upper portions of the main stem Quinnipiac River (*Figure3-8*). The average of total nitrogen measured is above the EPA reference criterion of 0.71 mg/L for all of the subwatersheds with data. The average of the total phosphate concentrations is also above the total phosphorus EPA reference criterion of 0.03125 mg/L in tributaries in the Misery Brook, Sodom Brook, Harbor Brook, and Wharton Brook subwatersheds. The average of the total phosphate concentrations in the tributaries in the Eightmile River, Tenmile River and the Muddy River were below the reference criterion. These three subwatersheds are primarily undeveloped and have protected forested land for water supply.

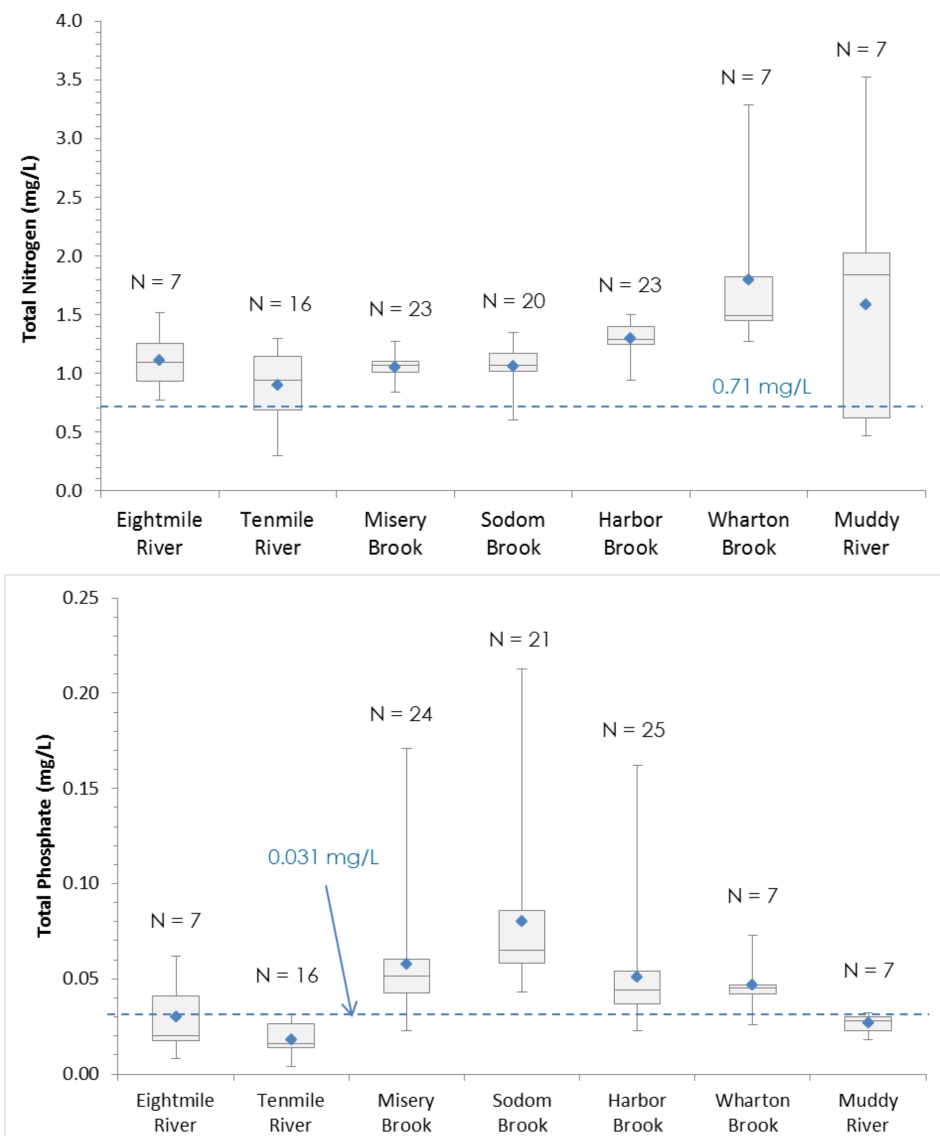


Figure 3-8. Total Nitrogen and Phosphate Boxplots for Tributary Subwatersheds

Bacteria

Connecticut's adopted water quality criteria for the indicator bacteria *E.coli* in the CWQS include a geometric mean and upper confidence limit (i.e., single sample maximum) for three recreational use categories. The standard for all recreational use categories is a geometric mean of less than 126 colony forming units per 100 milliliters (CFU/100 mL) and a single sample maximum of 256 CFU/100 mL for designated swimming; 410 CFU/100 mL for non-designated swimming; and 576 CFU/100 mL for all other recreational uses. A TMDL analysis was completed in 2008 for indicator bacteria in the Quinnipiac River Regional Basin. The streams addressed in the TMDL analysis include the Harbor Brook, Misery Brook, Quinnipiac River, and Sodom Brook. These streams are included on the List of Connecticut Waterbodies Not Meeting Water Quality Standards due to exceedances of the indicator bacteria criteria contained within the CWQS. The data collected to support the TMDL development is shown in *Figure 3-9*. The Sodom Brook and Harbor Brook subwatersheds have slightly elevated levels of bacteria compared to the other subwatersheds, likely due in part to higher nonpoint source pollution in Meriden where density of development is higher than in the other subwatersheds.

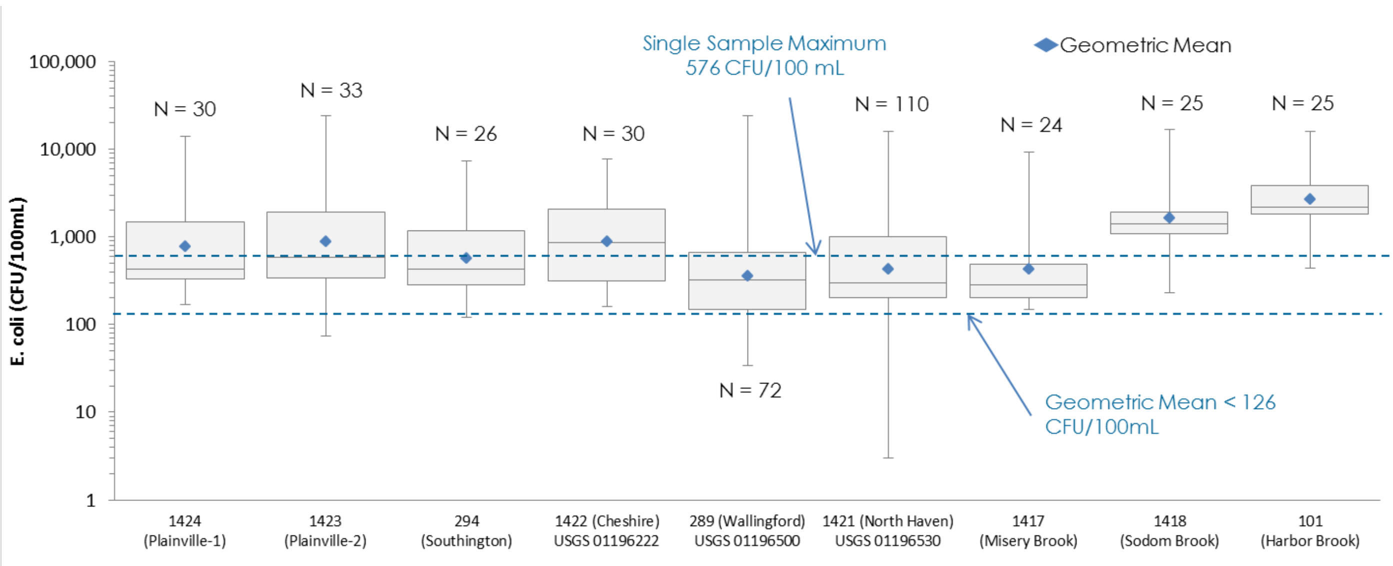


Figure 3-9. Bacteria Boxplots for TMDL Stations

As shown in *Figure 3-10*, there are no clear trends in the indicator bacteria concentrations at the three water quality monitoring stations along the lower main stem Quinnipiac River. As discussed in *Section 5.3*, the Cheshire, Meriden, Southington, and Wallingford WPCFs and Cytec Industries Inc. have indicator bacteria limits in their NPDES Permits. Nonpoint source pollution is a major source of bacteria loads to the river, and significant efforts to reduce nonpoint source pollution are required to reduce bacteria loads.

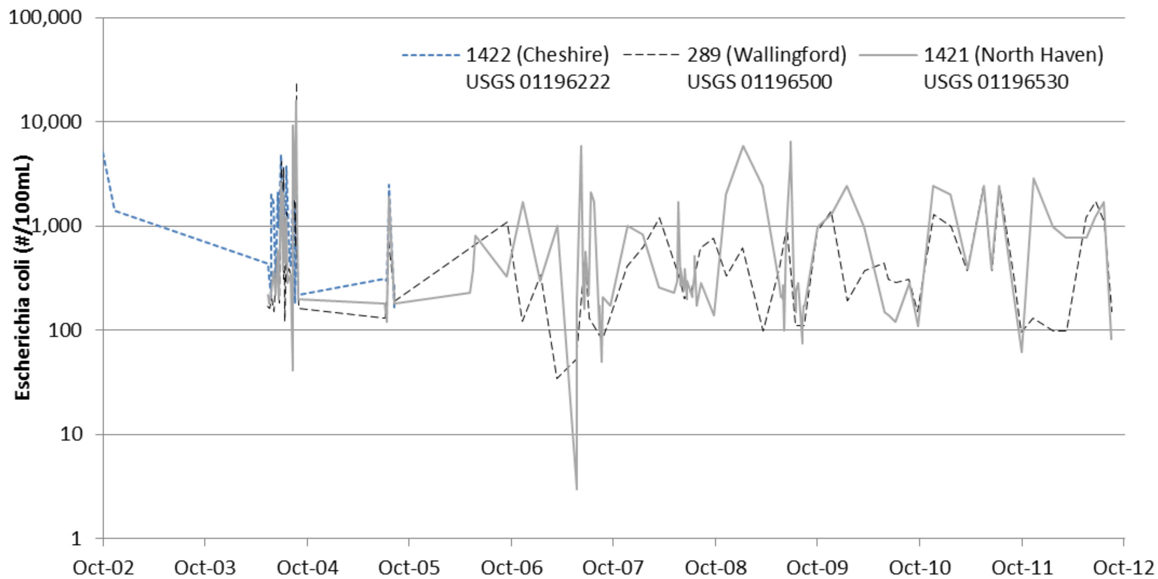


Figure 3-10. Bacteria Trends for the Lower Quinnipiac River

Benthic Macroinvertebrates

Sampling of macroinvertebrates via kick-net collection methods was performed by CTDEEP with the assistance of the QRWA from 1969 to 2011. *Figure 3-11* shows the multi-metric index (MMI) score calculated for the sampling events within each subwatershed where surveys were conducted during the last 10 years. The MMI is an index that combines indicators, or metrics, into a single value. Each metric is tested and calibrated to a scale and transformed into a unitless score prior to being aggregated into a multi-metric index. Both the index and metrics are useful in assessing ecological conditions.

Figure 3-11 shows that for all sampling events in the Quinnipiac River, Misery Brook, Harbor Brook, Wharton Brook and Muddy River subwatersheds, the calculated MMI falls below the target value of 50, which is the basis of the aquatic life impairment designations for some of the stream segments within these subwatersheds. The Quinnipiac River subwatershed has the lowest measured MMI value (12.7), the lowest average (26.4), and the lowest 75th percentile (29.5) in the watershed. All of the measured MMI values in the Eightmile River subwatershed are greater than the target value of 50.

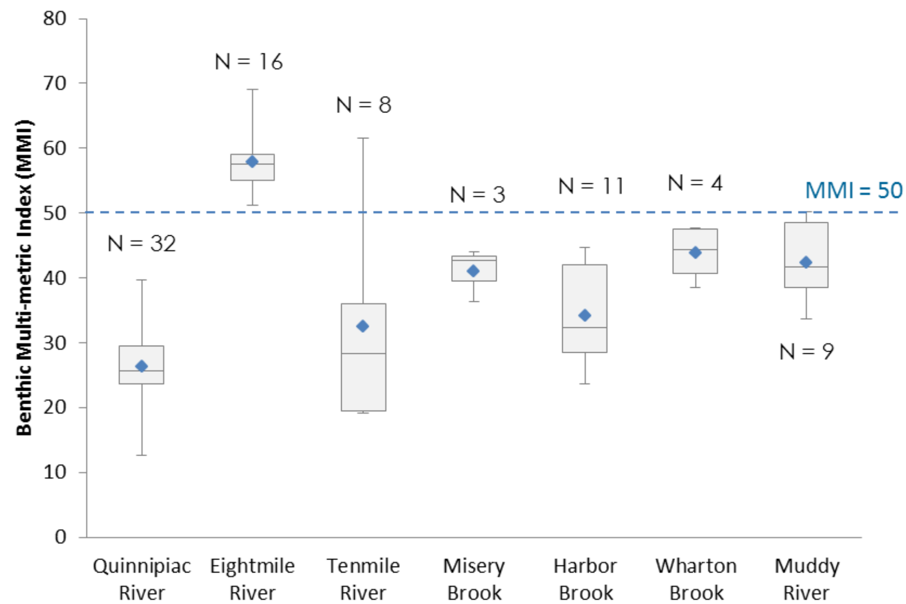


Figure 3-11. Benthic Macroinvertebrates Multi-metric Index (MMI) Boxplots

3.2.2 USGS Surface Water Monitoring Program

Monitoring Program

The U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program was developed to gather long-term information on streams, rivers, groundwater, and aquatic systems in support of national, regional, state, and local information needs and decisions related to water-quality management and policy. There are 14 USGS monitoring sites within the Quinnipiac River watershed; however, many of the sites were used for one-time sampling projects. Three stations along the main stem of the Quinnipiac River are maintained cooperatively with CTDEEP (from downstream to upstream: North Haven (ID#01196530), Wallingford (ID# 01196500), and Cheshire (ID# 01196222)) and have been consistently monitored since the 1950s for metals, nutrients, solids, turbidity, dissolved oxygen, and bacteria. The data collected by the USGS for metals, nutrients, and bacteria were discussed with the CTDEEP data in *Section 3.2.1*. As discussed previously, only data collected within the last 10 years (2002 – 2012) are evaluated and discussed in this section.

Solids, Turbidity, and Dissolved Oxygen

Total solids and turbidity generally increase from upstream to downstream along the main stem Quinnipiac River (*Figure 3-12*). Dissolved oxygen increases slightly between Cheshire and Wallingford, but then decreases between Wallingford and North Haven. Generally, the dissolved oxygen concentrations are above the CWQS of 5 mg/L for Class B streams.

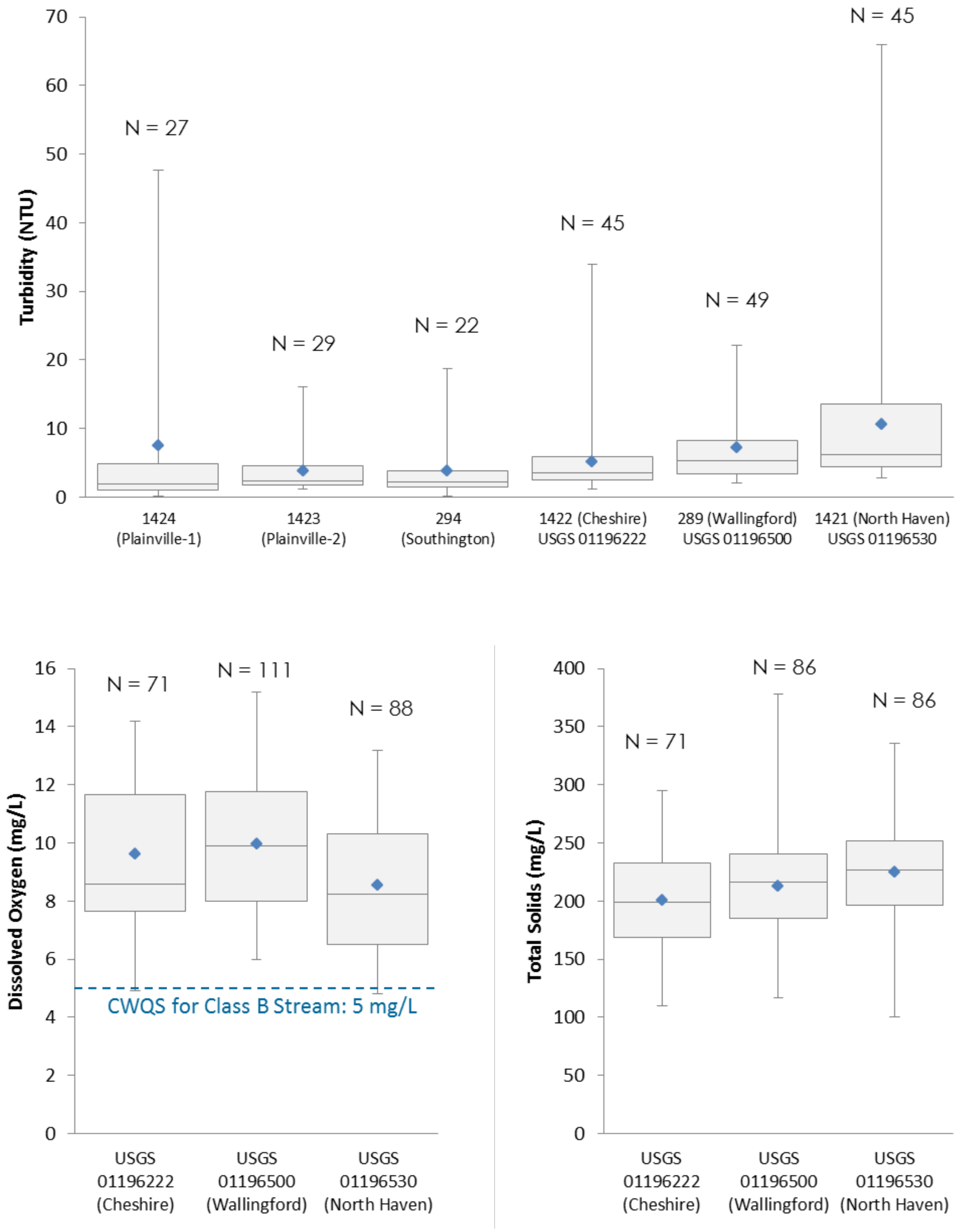


Figure 3-12. Solids, Turbidity, and Dissolved Oxygen Boxplots

3.2.3 QRWA Monitoring Program

The QRWA conducts annual benthic macroinvertabrate surveys as part of the Rapid Bioassessment in Wadeable Streams & Rivers by Volunteer Monitors (RBV) program, which is a citizen-based water quality-monitoring program developed by CTDEEP. The RBV program is a standardized screening method that keeps the equipment, expertise, and time commitment to a minimum while simultaneously identifying sections of streams with pollution-sensitive organisms. Volunteer monitoring data from the CTDEEP-sponsored Rapid Bioassessment for Volunteers was incorporated into Impaired Waters assessments a number of cycles ago. The results of the RBV monitoring by the QRWA are summarized in *Section 3.2.1*.

3.2.4 University Monitoring Programs

The University of New Haven and the Yale School of Forestry and Environmental Studies have conducted testing of water and sediment for organic and metal pollutants in the lower portions of the Quinnipiac River watershed, including the tidal marshes and floodplain areas. These studies have generally focused on addressing specific research questions and involved monitoring at individual locations for short periods of time. The results of these studies are beyond the scope of the broader watershed assessment that is the focus of this report.

3.2.5 Discharge Permit Monitoring

In Connecticut, all point source discharges to surface waters are required to obtain a permit from the CTDEEP, which establishes limits on the discharge quantity and quality. Routine monitoring of the discharges is required to demonstrate compliance with permit effluent limits. Through this process, progressively more stringent discharge requirements have been imposed over the last thirty to forty years, resulting in higher quality and lower volume discharges to the Quinnipiac River and its tributaries.

There are a number of permitted surface water discharges within the Quinnipiac River watershed, including 5 municipal Water Pollution Control Facilities (WPCFs) and several industrial facilities. All treated process water discharges in the watershed are directed to the Quinnipiac River. They include Cytec Industries, Inc., Evonik-Cyro Industries, LLC, Nucor Steel Connecticut, Inc., and Allegheny Ludlum Corporation in Wallingford; Pharmacia & Upjohn Company and United Aluminum Corporation in North Haven; and Tilcon Connecticut, Inc. in Plainville. Indirect discharges to the WPCFs are regulated through individual and general permits, which limit their quality and quantity to levels that are protective of the collection systems and treatment processes to ensure adequate treatment and effluent quality in the WPCF discharges.

4 Natural Resources

The Quinipiac River watershed is characterized by diverse physical settings and natural resources. This section examines the watershed's wetlands and wildlife as natural resources and indicators of environmental health. This section also includes a brief discussion of the geology and topography of the watershed as these and other watershed factors are closely related to watershed ecology.

4.1 Geology

Geologic processes have shaped the physical landforms and soils of the Quinnipiac River watershed. Evidence of these geologic processes can be observed throughout the watershed, from the basalt ridges and traprock formations that define the watershed's boundaries to the glacially-derived soils of the Quinnipiac River valley.

The State of Connecticut is comprised of three distinct geologic units divided longitudinally across the state. These three units are known as the Western Uplands, the Central Valley, and the Eastern Uplands. The Quinnipiac River watershed is within the Central Valley. The Central Valley is a younger unit comprised of sedimentary rocks while the Western and Eastern Uplands are comprised of metamorphic rocks – rocks subjected to intense heat and pressure of the Earth's interior. The Newark Terrane region of the Central Valley is composed of middle-aged material (195 to 215 million years old), and is primarily sandstone and conglomerate (Bell, 1985).

The Natural Resources Conservation Service Soil Survey Geographic (SSURGO) database for the State of Connecticut identifies two predominant surficial materials in the Quinnipiac River watershed. Thin till and sand overlying fines are the predominant surficial materials within the watershed. Watershed areas within New Haven and North Haven and immediately adjacent to the Quinnipiac River along its extents are predominantly sand overlying fine soil types. Upland areas are covered predominantly by thin till. In addition, smaller, non-contiguous areas of surficial material, include various types of sand and gravel and sand and fine soils and alluvial deposits, are found interspersed throughout the watershed.

The surficial geology of the Quinnipiac River watershed reflects the prominent role that glaciers played in shaping the landscape of New England. The soil parent material (native) in the upper portions of the watershed is glacial meltwater till (various types). The native soil parent material in the tidally influenced lower portion of the watershed is composed of organic material. Till and glaciofluvial materials comprise a majority of the watershed. Upland areas are characterized by glacial till and exposed bedrock; lowland area are characterized by sands and gravels deposited by glacial meltwater. The natural soil parent material is composed of arkose, shale and basalt in the lower portions of the watershed and gneiss, schist and granite in the upper portions of the watershed. However, the most abundant soil parent material in the entire watershed, primarily focused in the New Haven, North Haven, Wallingford and Meriden area, is urban influenced material, reflecting significant urbanization within the watershed.

4.2 Topography

The topography of the Quinnipiac River watershed is generally shallow-sloping with wide floodplain areas, although the watershed is also characterized by prominent traprock ridges. The Quinnipiac River originates at the base of basalt ridges in Farmington and Plainville and passes numerous traprock formations between Southington and Meriden, including Meriden Mountain, Short Mountain, Ragged Mountain, and Castle Craig in Hubbard Park in Meriden. Red sandstones and mudstones are especially apparent in the Quinnipiac River Gorge, in South Meriden. Further south in North Haven and New Haven, cliffs of red sandstone, called "arkose" can be observed on the river's east side. Erosion of the arkose, the principal sedimentary rock of the watershed, gives many of the soils their signature red-brown color (QWP, 2004).

In addition to the traprock ridges, sand plains are located in Wallingford and North Haven. Due to development throughout the watershed, only a few remnant sand plains remain. Sand plains are found east of the Quinnipiac River and provide habitat to rare species (QWP, 2004). Sand plains are discussed further under critical habitats in *Section 4.5.4*.

4.3 Wetlands

Generally, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands and buffer zones between watercourses and developed areas help to preserve stream water quality by filtering pollutants, encouraging infiltration of stormwater runoff, and protecting against stream bank erosion.

4.3.1 Inland Wetlands

The State of Connecticut designates wetlands by soil classification since certain soils can cause groundwater to linger near the ground surface and since, conversely, groundwater lingering near the ground surface tends to transform soil characteristics. Wetland soils can also be defined by landscape position. The following classes of wetland soils are defined by the Connecticut Inland Wetlands and Watercourses Act (CTDEP, 2009).

- **Poorly drained soils** – These soils occur in places where the groundwater level is near or at the ground surface during at least part of most years. These soils generally occur in areas that are flat or gently sloping.
- **Very poorly drained soils –** These soils are typically characterized by groundwater levels at or above the ground surface during the majority of most years, especially during the spring and summer months. These areas are generally located on flat land and in depressions.
- **Alluvial and floodplain soils** – These soils form where sediments are deposited by flowing water, and thus typically occur along rivers and streams that are flooded periodically. The drainage characteristics of these soils vary significantly based on the characteristics of the

flowing water, ranging from excessively drained where a stream tends to deposit sands and gravel to very poorly drained where a stream deposits silts or clays.

In contrast, the Federal Clean Water Act definition for wetlands is based on soil characteristics, vegetation, and hydrology. The federal wetland designation defines wetlands as (Cowardin et al., 1979):

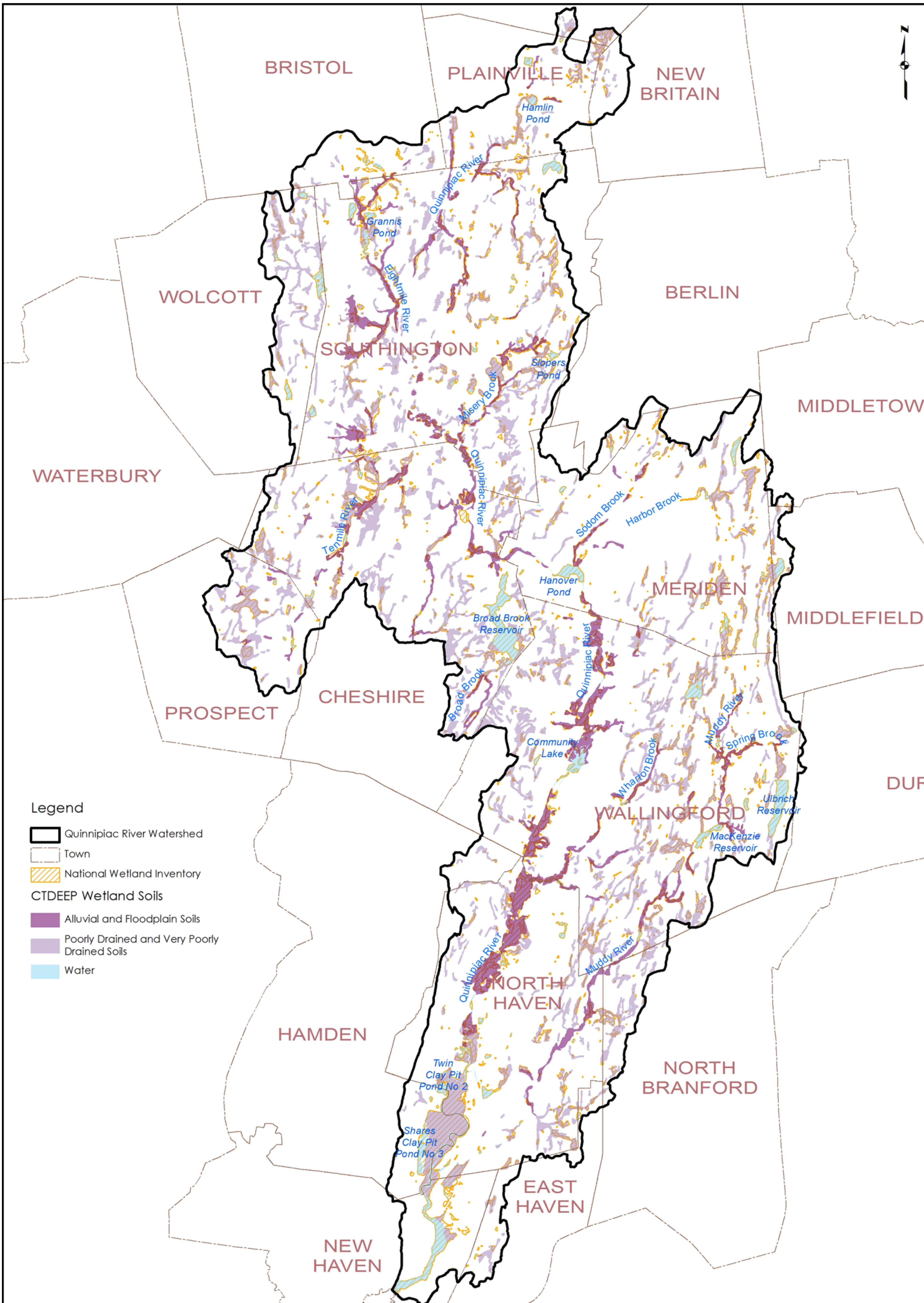
> "Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water as some time during the growing season of each year."

Figure 4-1 depicts the extent and distribution of wetland soils in the Quinnipiac River watershed based on Natural Resources Conservation Service soil classifications, following the State of Connecticut definition. *Figure 4-1* also shows wetland classifications available from the U.S. Fish & Wildlife Service National Wetlands Inventory. State-designated wetlands and surface waters comprise nearly 16% of the overall watershed (approximately 17,022 acres), while approximately 7% of the watershed area (approximately 7,646 acres) is mapped as Federally designated wetlands and surface waters (*Table 4-1*).

Table 4-1. Wetlands in the Quinnipiac River Watershed by Municipality

Subwatershed	Area of Mapped State Wetlands & Surface Waters (acres)	% of Subwatershed	Area of Mapped Federal (NWI) Wetlands & Surface Waters (acres)	% of Subwatershed
Broad Brook	892	29.0%	409	13.3%
Eightmile River	1,479	15.7%	539	5.7%
Harbor Brook	807	10.4%	566	7.3%
Misery Brook	749	18.8%	333	8.3%
Muddy River	2,596	18.6%	1,056	7.6%
Quinnipiac River (Main Stem)	7,178	15.4%	3,502	7.5%
Sodom Brook	213	6.3%	110	3.3%
Tenmile River	2,172	16.7%	808	6.2%
Wharton Brook	937	19.1%	321	6.6%
Watershed (Total)	**17,022**	**16.1%**	**7,646**	**7.2%**

Vernal pools are a unique category of wetlands. A vernal pool is an isolated land depression which lacks a permanent aboveground outlet. Vernal pools may be the size of a small puddle or shallow lake. Vernal pools fill with freshwater in the fall and winter due to the rising water table and/or in the spring due to meltwater from winter snow and runoff from spring rains. Many vernal pools in the Northeast are



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Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), National Wetlands Inventory, U.S Fish & Wildlife Service.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 4-1
WETLAND RESOURCES

covered with ice in the winter months. They contain water for a few months in the spring and early summer but by late summer are generally dry.

As vernal pools usually dry up during a period of most years, species tend to use the area for specific portions but not all of their life cycle. "Obligate" vernal pool species (typically reptiles and amphibians) are those that must use a vernal pool for a portion of their life cycle. Common obligate species in Connecticut include spotted, Jefferson's, and marbled salamanders, wood frogs, eastern spadefoot toads, and fairy shrimp. Several productive clusters of vernal pools are associated with traprock rldges and river floodplains in the Quinnipiac River watershed.

Vernal pools are unique and very fragile, containing significant biodiversity, frequently including endangered plants and animals. They are typically threatened by adjacent land uses and development including changes to the natural topography. Given the importance of these microhabitats, the EPA, CTDEEP, and the U.S. Army Corps of Engineers (USACE) regulate their protection.

Kettle wetlands formed when blocks of ice from the glaciers that once covered New England melted, and left behind depressions in the sandy soil. Kettle wetlands often have deep peat deposits, sphagnum moss, and more northern bog-type vegetation. Such wetlands are common in Southington. Floodplain wetlands are also important as wildlife habitat where they form broad, undeveloped corridors along the main stem Quinnipiac and its major tributaries (QWP, 2004).

In 1972, Connecticut enacted the Inland Wetlands and Watercourses Act, which regulates activities affecting wetlands and watercourses. This act is implemented through municipal inland wetlands and watercourses agencies statewide as well as the CTDEEP. Local commissions have adopted regulations governing activities affecting inland wetlands and watercourses, including land adjacent to inland wetlands and watercourses, which is referred to as upland review area. The upland review area defines the extent of regulated activities in non-wetland or non-watercourse upland areas.

4.3.2 Tidal Marsh

Tidal marshes are a type of tidal wetlands occurring at the interface of the land and ocean. Tidal marshes support a diverse ecosystem of vegetation and wildlife. They serve as nursery grounds for many coastal fishes; and waterfowl and many aquatic animals use them for homes, food, and resting areas. Tidal marshes also play a role in improving water quality and protecting shore areas from flooding.

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. *Table 4-2* shows the percent total coverage for the major vegetation types in the Quinnipiac tidal marsh over a 26-year period between 1974 and 2000 based on historical aerial photographs. The cause of this change is not clear and 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).

Table 4-2. Quinnipiac Tidal Marsh Cover Types

Cover Type	1974	1986	1995	2000
% of Total Marsh Coverage				
Phragmites australis	6.7	20.9	30.4	25.6
Typha latifolia	66.8	41.0	16.7	11.4
Pluchea purpurascens	--	--	--	1.7
Spartina alternaflora	--	--	0.2	0.7
Unknown	4.7	1.8	2.2	2.4
Water & Mudflat	21.8	36.3	50.5	58.2

Note: Mudflats had not yet developed in the 1974 aerial. Therefore, 21.8% is representative of the amount of open water and channels visible.
Source: Baseline Assessment, 2002

4.4 Fish and Wildlife

The Quinnipiac River is characterized by a mosaic of forests, urban/suburban developments and agricultural land, providing a variety of fisheries and wildlife habitats. A biological inventory of the watershed was conducted in the late 1990s by the Yale School of Forestry and Environmental Studies Center for Coastal and Watershed Systems. As part of this effort, several communities within the watershed were inventoried. *Table 4-3* summarizes general observations made of the inventoried communities.

Table 4-3. Quinnipiac River Biologial Inventory Summary (1997 and 1998)

Community	Observations
Polychaetes	• The invertebrate community composition in the lowere Quinnipiac River is strongly affected by salinity • The invertebrate community of the lower river is dominated by pollution-tolerant species typical of impacted systems; the low abundance and small sizes of these species indicate substantial stress on these populations
Diadromous Fish	• 8 species of diadromous fish were identified at multiple sites in the lower Quinnipiac, below Wallace Dam (alewife, American shad, blueback herring, American eel, gizzard shad, striped bass, white perch and brown trout)
Floodplain Vegetation	• The riverbank corridor from Southington to North Haven consists of healthy riparian forest, with relatively low dominance of invasive species • The old Community Lake bottom is composed of a meadow community at an early successional stage (given the elapsed time since the lake was drained)

Table 4-3. Quinnipiac River Biologial Inventory Summary (1997 and 1998)

Community	Observations
Birds	• Surveys conducted in 3 red maple swamps (Dead Wood Swamp, Community Lake Park and Quinnipiac River State Park) found a total of 39 bird species, but all 3 sites were dominated by species commonly found in fragmented landscapes (American robin, gray catbird and common grackle)
Sensitive Species	• The Ground Beetle (*Tetragonoderus fasciatus*), a state-listed species of special concern, was found near the sandbars of the old Community Lake Bottom • Horned pondweed (*Zannichellia palustris*), formerly a state-listed aquatic plant, was found in abundance in the intertidal zone of the river south of Sackett Point Road • Wild lupine (*Lupinus spp.*), an unlisted but rare species, was found in the Community Lake area • Eastern lampmussel (*Lampsilis radiata*), a rare and declining mussel species, was found at 2 locations within the Tenmile River watershed

Source: Quinnipiac River Watershed Data Integration Report: A Study of the Quinnipiac River Watershed's Nine Sub-Basins (Anisfeld & Zajac, 2004).

These resources are discussed further in this section, including updated information since the original 1997 and 1998 inventories.

4.4.1 Fisheries

The Quinnipiac River and its tributaries provide a variety of habitats for cold and warm water fish species. The Quinnipiac River watershed was also once an important habitat for anadromous fish species. Anadromous fish begin life in freshwater, migrate to the sea to reach maturity, and return to freshwater to spawn. CTDEEP has identified the Quinnipiac River as a high priority for anadromous fish restoration, particularly for the Alewife, American Shad, and Blueback Herring. As a result of this designation and the conservation efforts of various watershed stakeholder groups, 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. *Table 4-4* lists fish species that have been identified in the Quinnipiac River watershed based on fish population surveys conducted by the CTDEEP between 1969 and 2011.

The entire length of the Eight Mile 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. Muddy River is reportedly stocked intermittently with trout from below the McKenzie Reservoir in Wallingford to Spring Street in North Haven. Ten Mile River in Cheshire is stocked with trout from Route 70 to Route 322. The Quinnipiac River is stocked in Southington and Cheshire, upstream from Cheshire Street. It is also considered a Class 1 wild trout management area and is catch and release only. The Quinnipiac River in Southington, Cheshire, Meriden and Wallingford reportedly contains wild brown trout and is lightly to moderately stocked by CTDEEP (CTDPH and CTDEEP, 2012). A no fishing zone exists downstream of the Wallace Dam fishway.

Table 4-4. Fish Species within the Quinnipiac River Watershed

Native Fish	
Common Name	**Scientific Name**
American eel	*Anguilla rostrata*
Banded killifish	*Fundulus diaphanous*
Blacknose dace	*Rhinichthys atrarulus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus*
Brown trout	*Salmo trutta*
Common shiner	*Luxilus cornutus*
Fathead minnow	*Pimephales promelas*
Gizzard shad	*Dorosoma cepedianum*
Golden shiner	*Notemigonus crysoleucas*
Longnose dace	*Rhinichthys cataractae*
Minnow	*Cyprinidae spp.*
Pumpkinseed	*Lepomis gibbosus*
Readbreast sunfish	*Lepomis auritus*
Redfin pickerel	*Esox americanus*
Sea lamprey	*Petromyzon marinus*
Spottail shiner	*Notropis hudsonius*
Tessellated darter	*Etheostoma olmstedi*
Tomcod	*Microgadus tomcod*
White sucker	*Catostomus commersonii*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*
Exotic Fish	
Black crappie	*Promoxis nigromaculatus*
Bluegill sunfish	*Lepomis macrochirus*
Carp	*Family: Cyprinidae*
Central mudminnow	*Umbra limi*
Largemouth bass	*Micropterus salmoides*
Rainbow trout	*Oncorhynchus mykiss*
Rock bass	*Ambloplites rupestris or A. constellatus*

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 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).

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 Eight Mile 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 Eight Mile River, and only one meal per month should be consumed of fish caught between the Quinnipiac Gorge/Hanover Pond (CTDPH and CTDEEP, 2012).

4.4.2 Birds

The Quinnipiac River watershed is recognized as an important birding area by the Connecticut Audubon Society (2009). Such a designation indicates the presence of state-listed endangered and threatened species present, and that the river provides a rare, unique or representative habitat, hosts significant concentrations of migratory land birds, and has been monitored over time. In addition to recognition from the Connecticut Audubon Society, the National Audubon Society has identified the marshland along the Quinnipiac River as a significant nesting area, providing wintering grounds for the Northern harrier, and nesting locations for Ospreys, Blue Heron, Bald Eagles, American Black Ducks, Saltmarsh Sharp-tailed Sparrow, Common Moorhen and Least Bittern.

4.4.3 Amphibians & Reptiles

Table 4-5 lists amphibians and reptiles that have been sighted within at least one of the watershed municipalities, based on records from the Bulletin of the Peabody Museum of Natural History published in October 2006 and records published by Klemens in 1993.

Table 4-5. Amphibians and Reptiles within the Quinnipiac River Watershed

Amphibians	
Common Name	**Scientific Name**
Jefferson salamander	*Ambystoma cf. jeffersonianum*
Spotted salamander	*Ambystoma maculatum*
Marbled salamander	*Ambystoma opacum*
American toad	*Bufo americanus*
Northern dusky salamander	*Desmognathus fuscus*
Northern two-lined salamander	*Eurycea bislineata*
Four-toed salamander	*Hemidactylium scutatum*
Gray treefrog	*Hyla versicolor*
Eastern newt	*Notophthalmus viridescens*
Red-backed salamander	*Plethodon cinereus*
Spring peeper	*Pseudacris crucifer*
American bullfrog	*Rana catesbeiana*
Green frog	*Rana clamitans*
Pickerel frog	*Rana palustris*
Wood frog	*Rana sylvatica*

Table 4-5. Amphibians and Reptiles within the Quinnipiac River Watershed

Reptiles	
Common Name	**Scientific Name**
Southern copperhead	*Agkistrodon contortrix*
Eastern wormsnake	*Carphophis amoenus*
Common snapping turtle	*Chelydra serpentine*
Painted turtle	*Chrysernys picta*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Clemmys insculpta*
Ring-necked snake	*Diadophis punctatus*
Eastern hog-nosed snake	*Heterodon platirhinos*
Milk snake	*Lampropeltis triangulum*
Northern water snake	*Nerodia sipedon*
Smooth green snake	*Opheodrys vernalis*
Brown snake	*Storeria dekayi*
Eastern box turtle	*Terrapene carolina*
Common garter snake	*Thamnophis sirtalis*
Red-eared slider	*Trachemys scripta*

Source: Yale Peabody Museum of Natural History, Online Guide to Herpetology, 2006 and Klemens, 1993.

4.4.4 Threatened and Endangered Species and Critical Habitats

The CTDEEP Natural Diversity Data Base (NDDB) maintains information on the location and status of endangered, threatened, and special concern species in Connecticut. The Connecticut Endangered Species Act defines "Endangered" as any native species documented by biological research and inventory to be in danger of extirpation (local extinction) throughout all or a significant portion of its range within Connecticut and to have no more than five occurrences in the state. The Act defines "Threatened Species" as any native species documented by biological research and inventory to be likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range within Connecticut and to have no more than nine occurrences in the state. "Species of Special Concern" means any native plant or any native non-harvested wildlife species documented to have a naturally restricted range or habitat in the state, to be at a low population level, to be in such high economic demand that its unregulated taking would be detrimental to the conservation of its population, or has become locally extinct in Connecticut.

Figure 4-2 depicts the generalized areas of endangered, threatened, and special concern species in the Quinnipiac River watershed. These areas represent a buffered zone around known species or community locations. *Table 4-6* lists species known to exist within the watershed. The locations of species and natural community occurrences depicted on the NDDB mapping are based on data collected over the years by the Environmental and Geographic Information Center's Geologic and Natural History Survey, other units of the CTDEP, conservation groups, and the scientific community. Areas throughout the watershed are identified as Natural Diversity Areas.

Table 4-6. Endangered, Threatened, and Special Concern Species

Common Name	Scientific Name	Status
Northern harrier	*Circus cyaneus*	Endangered
Common moorhen	*Gallinula chloropus*	Endangered
Pied-billed grebe	*Podilymbus podiceps*	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Threatened
Least bittern	*Ixobrychus exilis*	Threatened
Great egret	*Ardea alba*	Threatened
Snowy egret	*Egretta thula*	Threatened
Seaside sparrow	*Ammodramus maritimus*	Threatened
American kestrel	*Falco sparverius*	Special Concern
Saltmarsh sharp-tailed sparrow	*Ammodramus caudacutus*	Special Concern
Jefferson salamanders	*Ambystoma jeffersonianum*	Special Concern
Wood turtle	*Glyptemys insculpta*	Special Concern

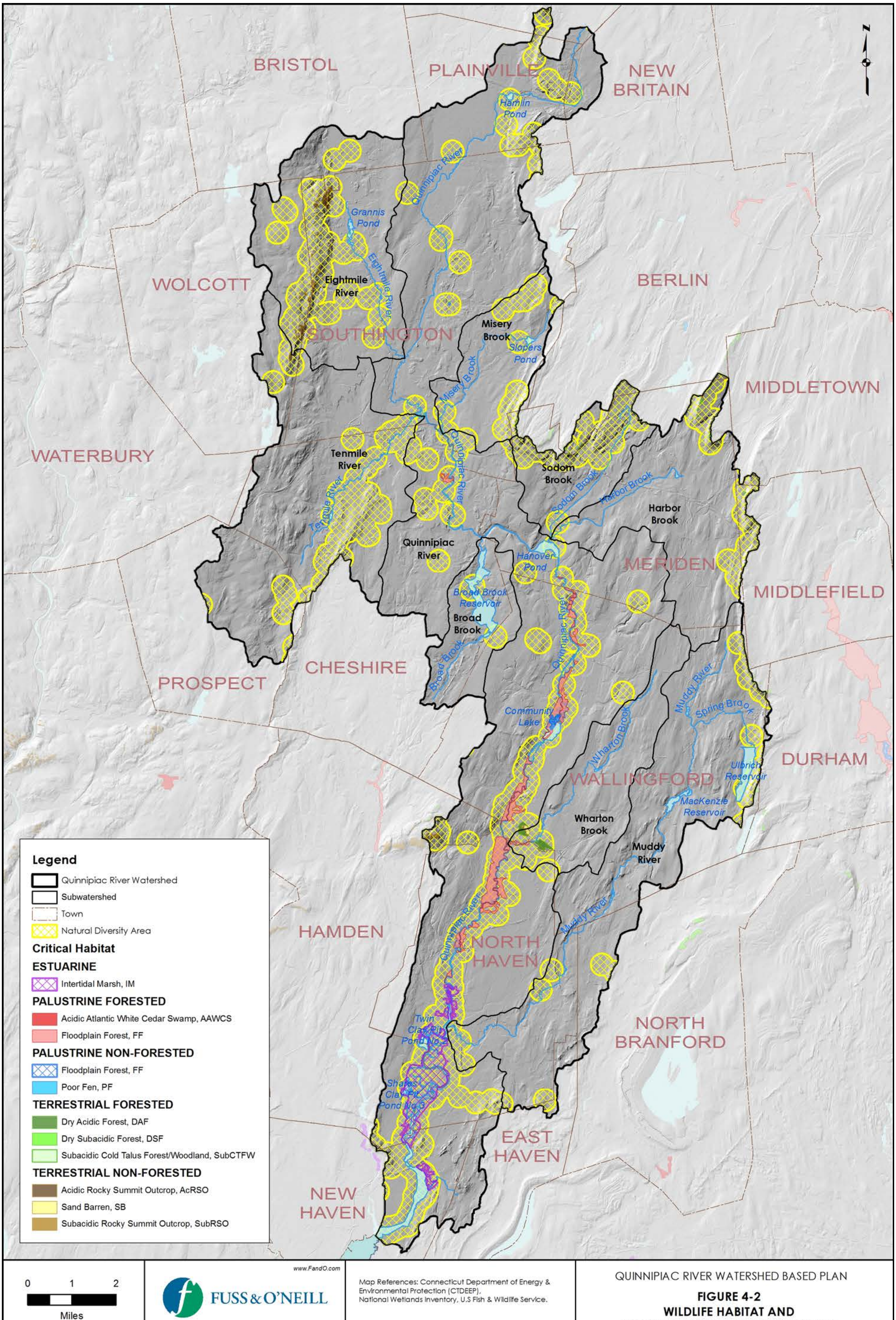
Source: CTDEEP County Report of Connecticut's Endangered, Threatened and Special Concern, New Haven County, 2012.

Because new information is continually being added to the NDDB and existing information updated, the areas are reviewed on an annual basis by the CTDEEP. Areas can be removed or added based upon the results of the review.

Several other unique and critical habitat types exist within the Quinnipiac River watershed – the Quinnipiac River estuary, traprock ridges, sand plains, and kettle wetlands.

The Quinnipiac River estuary, located along the southern reaches of the river from just north of the confluence with Muddy River to just north of New Haven Harbor, is considered a critical habitat area, providing a home for a wide variety of wildlife and plant life.

Portions of the Quinnipiac River watershed are located along the basalt ridges found in Central Connecticut and designated as a critical habitat by CTDEEP. These ridges are rich in uncommon, characteristic plant species (e.g., Dutchman's Beeches and bladdernut, as well as state-listed species like wall rue and narrow-leaved spleenwort found in the Hanging Hills) due to the presence of more fertile and less acidic soils. The ridges also include uncommon microhabitats, such as exposed, dry, south-facing ridge crests, cliff faces, and cool fields of broken rock at the base of the cliffs, all of which support unusual flora and fauna such as copperhead snakes and ravens and healthy populations of disturbance-sensitive, forest interior songbirds (QWP, 2004).



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Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), National Wetlands Inventory, U.S Fish & Wildlife Service.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 4-2
WILDLIFE HABITAT AND NATURAL DIVERSITY DATABASE AREAS

Only a few remnant parcels of sand plains remain in the watershed, located east of the Quinnipiac River in Wallingford and North Haven. Sand plains are characterized by uncommon flora and fauna due to their sandy, well-drained soils, which have been developed or mined in most areas of the state (QWP, 2004).

Kettle wetlands are wetlands that formed in depressions created when pockets of underlying ice melted at the end of the last glacial period. Kettle wetlands provide a unique ecological community for some species of flora and fauna. The black spruce bog on Route 120 in eastern Southington is a kettle wetland (QWP, 2004).

4.5 Vegetation

The Quinnipiac River watershed is home to a wide variety of vegetation communities – floodplain forests, wooded swamps, mixed harwood forests, white pine forests, and other natural vegetation found elsewhere in Connecticut. The most common trees, shrubs and vines located along the banks of the Quinnipiac River are listed in *Table 4-7*, which is based on a botanical inventory of the Quinnipiac River from Mill Street in Southington to Sackett Point Road in North Haven conducted in 1997 by the Yale School of Forestry and Environmental Studies Center for Coastal and Watershed Systems.

Table 4-7. Plants Common to the Banks of the Quinnipiac River

Common Name	Scientific Name
Red maple	*Acer rubrum*
Eastern cottonwood	*Populus deltoids*
Green ash	*Fraxinus pensylvanica*
American elm	*Ulmus americana*
Black willow	*Salix negra*
Silky dogwood	*Cornus amomum*
Wild grape	*Vitis spp.*
Jewelweed	*Impatiens apensis*
False hellebore	*Veratrum viride*
Sensitive fern	*Onoclea sensibilis*
Giant ragweed	*Artemisia trifida*
Garlic mustard (invasive)	*Alliara petiolaris*

Source: Yale School of Forestry and Environmental Studies Center for Coastal and Watershed Systems, 1997.

Invasive plant species, which are mostly non-native plant species that successfully out-compete native plants, are also prevalent throughout the watershed. The invasive species of most concern are listed in *Table 4-8* (QWP, 2004).

Table 4-8. Invasive Plants Common to the Quinnipiac River Watershed

Common Name	Scientific Name
Norway maple	*Acer platanoides*
Garlic mustard	*Alliaria petiolata*
Japanese barberry	*Berberis thunbergii*
Asiatic bittersweet	*Celastrus orbiculatus*
Autumn olive	*Eleagnus umbellifera*
Winged euonymous	*Euonymous alatus*
Japanese honeysuckle	*Lonicera japonica Thunbergii*
Purple loostrife	*Lythrum salicaria*
Japanese stilt-grass	*Microstegium vimineum*
Common reed	*Phragmites australis*
Japanese knotweed	*Polygonum cuspidatum*
Glossy and common buckthorn	*Rhamnus frangula and R. catharticus*
Multiflora rose	*Rosa multiflora*

Source: Quinnipiac Watershed Plan, 2004.

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).

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.

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).

5 Water Infrastructure

This section describes the water infrastructure within the Quinnipiac River watershed – dams, water supply, wastewater collection and treatment, stormwater and flood management – as it relates to water quality and quantity issues.

5.1 Dams

Numerous dams were constructed along the Quinnipiac River and its tributaries during the industrial revolution of the 18th and 19th centuries. Approximately 110 dams have been constructed within the Quinnipiac River watershed. *Table 5-1* lists some of the more notable dams in the Quinnipiac River watershed. Only five dams remain on the main stem of the Quinnipiac River, with several dams having breached since 1938. Eleven dams in the watershed are associated with public water supplies. The majority of the dams are run-of-river, meaning that the dams restrict minimal amounts of water flow (i.e., inflow equals outflow). Most dams in the watershed are privately owned, and many were constructed for recreational or aesthetic purposes (QWP, 2004).

Table 5-1. Notable Dams within the Quinnipiac River Watershed

Dam Name	Waterbody	Location	Town
Wallace Dam/Quinnipiac Street Dam	Quinnipiac River	Downstream of Hall Avenue (Route 150)	Wallingford
Britannia Spoon Dam	Quinnipiac River	Upstream of Main Street (Route 150), Wallingford	Wallingford
Hanover Pond Dam	Quinnipiac River	Downstream of confluence with Harbor Brook	Meriden
Carpenters Dam	Quinnipiac River	Downstream of Cheshire Road, upstream of Quinnipiac Gorge	Meriden
Clarks Brothers Dam	Quinnipiac River	Near Bowling Alley in Southington	Southington
Unnamed Dam	Misery Brook	Upstream of South End Road	Southington
Grannis Pond Dam	Eightmile River	Outlet of Grannis Pond, Upstream of Churchill Road	Southington
Dayton Pond Dam	Muddy River	Southern end of Dayton Pond, upstream of Dayton Hill Road	Wallingford
Mackenzie Reservoir Dam	Muddy River	Western end of Mackenzie Reservoir	Wallingford
Moss Farms Dam	Tenmile River	Upstream of Jarvis Street	Cheshire
Mixville Pond Dam	Tenmile River	Upstream of Notch Road	Cheshire
Pond along Tenmile River	Tenmile River	Upstream of Marion Road	Cheshire
Simpson Pond Dam	Wharton Brook	Near Center Street and Simpson Avenue	Wallingford

Dams and their associated impoundments provide water supplies, recreational opportunities, and aquatic and wildlife habitat. However, dams can also serve as significant barriers to fish migration. Five potential barriers to fish migration exist along the Quinnipiac River. Wallace Dam, located in Wallingford approximately 12 miles north of the mouth of the river, had historically been the the first major impediment to fish migration along the river. 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 fishway also exists at Hanover Pond, which had been the second major impediment to fish passage along the Quinnipiac River (Community Lake Dam is completely breached). The U.S. Fish and Wildlife Service and CTDEEP are considering removal of the remaining dams upstream, including the partially-breached dam behind the Britannia Spoon building in Wallingford, the partially-breached Carpenter's Dam at the upper end of Quinnipiac Gorge in Meriden, and the Clarks Brothers Dam in Southington.

The Eightmile River has also been targeted by CTDEEP for potential fisheries restoration. Providing fish passage at the outlet for Grannis Pond combined with additional fish passage restoration along the upper Quinipiac River could provide spawning habitat for diadromous fish in the Eightmile River.

5.2 Water Supply

Approximately 80 percent of the population in the Quinnipiac River watershed obtains their water from public water supply systems, consisting of roughly 20 surface water reservoirs and 40 community water supply well fields. *Table 5-2* lists the major public water supply systems in the watershed. The South Central Connecticut Regional Water Authority (SCCRWA) and the municipalities of Wallingford, Meriden, and Southington are the major suppliers of drinking water in the watershed (QWP, 2004).

Approximately 55 percent of public water serving the watershed population is derived from groundwater sources via well fields in stratified drift aquifers (*Figure 5-1*), which are typically layered deposits of gravel, sand and silt found in valleys. Storage space exists for water between the gravel particles, allowing water to travel relatively easily towards the wells. Roughly 93 percent of Southington's water supply comes from public wells. Due to the high dependence on public groundwater supplies, aquifer protection is a particular concern for the Quinnipiac River watershed (QWP, 2004).

Connecticut's Aquifer Protection Area Program protects major public water supply wells in sand and gravel aquifers. Aquifer Protection Areas (also referred to as "wellhead protection areas") are designated around active well fields in sand and gravel aquifers that serve more than 1,000 people. Designated Aquifer Protection Areas exist in portions of the upper watershed communities along the Quinnipiac River corridor extending from Plainville to Wallingford (*Figure 5-1*). Responsibility for implementation of the Aquifer Protection Area Program is shared by the CTDEEP, municipalities, and water companies.

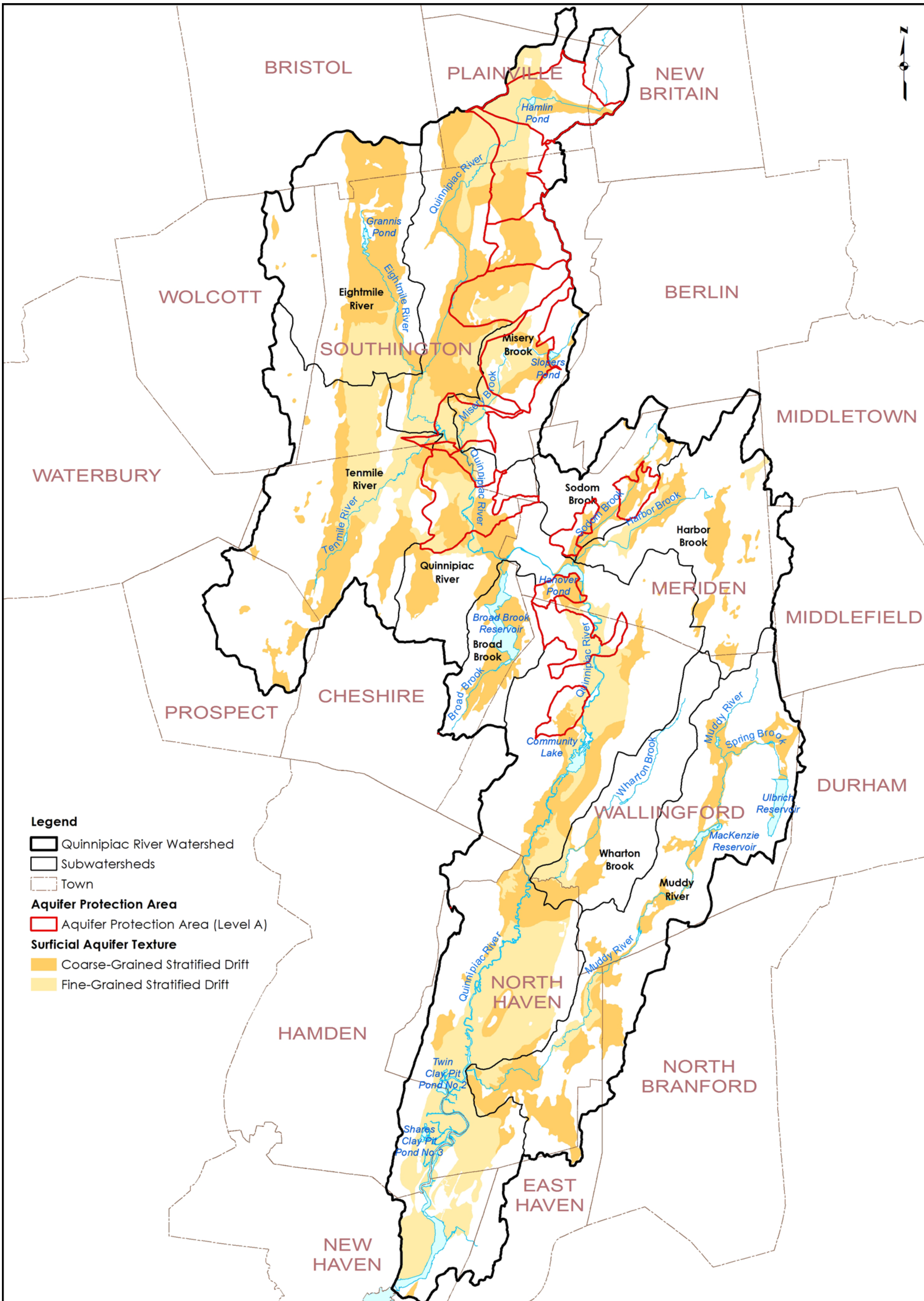
Municipalities are responsible for appointing an aquifer protection agency, inventorying land uses within the aquifer protection area, designating the aquifer protection area boundary, and adopting and implementing local land use regulations. The majority of the Quinnipiac River watershed communities with Aquifer Protection Areas have adopted local aquifer protection area regulations consistent with the state regulations (CTDEEP, 2012).

Table 5-2. Public Water Supply Systems in the Quinnipiac River Watershed

Water Supply	Town
Woodford Avenue Aquifer Protection Area	Plainville
Well 9 Aquifer Protection Area	Plainville/Southington
Patton Aquifer Protection Area	Southington
Well 1A Aquifer Protection Area	Southington
Well 7,8 Aquifer Protection Area	Southington
Well 2 Aquifer Protection Area	Southington/Cheshire
North Cheshire Aquifer Protection Area	Cheshire
Mule Aquifer Protection Area	Meriden
Merimere Reservoir	Meriden
Hallmere Reservoir	Meriden
Kenmere Reservoir	Meriden
Elmere Reservoir	Meriden
Bradley/Hubbard Reservoir	Meriden
Columbus Park Well	Meriden
Platt Well	Meriden
Lincoln Well	Meriden
Broad Brook Reservoir	Meriden
Evansville Aquifer Protection Area	Meriden/Wallingford
Oak Street Aquifer Protection Area	Wallingford
North Turnpike Aquifer Protection Area	Wallingford

Approximately 25 percent of public water serving the watershed population is dervied from surface water reservoirs within the watershed, while another 20 percent is transferred from reservoirs in other nearby watersheds. SCCRWA owns and operates the four largest reservoirs serving the Quinnipiac Watershed, which include Lake Gaillard, Lake Saltonstall, the Hammonasset Reservoir, and the Broad Brook Reservoir. Of the four, only the Broad Brook Reservoir is inside the Quinnipiac Watershed (QWP 2004). Much of the open space in the watershed is comprised of forested or lightly developed land owned by the water utilities. Most of the reservoirs have good water quality and effective source water protection programs due to the considerable open space under the ownership of the water supply utilities and the low intensity land use of the small amount of watershed land in private ownership.

Concerns have existed for over a decade about the ability of the watershed's aquifers to meet the public drinking water demands of the watershed communities. Similarly, tributaries of the Quinnipiac River have experienced seasonal impairments due to insufficient flows to sustain a healthy aquatic community, resulting in part from a loss of groundwater recharge. The 2004 *Quinnipiac Watershed Action Plan* identified the need for careful study and planning for water allocation. The availability and use of water resources to serve future potable water supply demands and which are compatible with environmental objectives remain a primary concerns for the watershed.



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Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Water Quality Standards 1:24,000-scale; Surface Water Quality Standards Effective February 25, 2011, Groundwater Quality Standards Effective April 12, 1996. Aquifer Protection Areas 1:24,000-scale.

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 5-1
AQUIFER PROTECTION AREAS AND STRATIFIED DRIFT

As described in *Section 1.4* of this report, CTDEEP, Save the Sound, and other partners are undertaking a project to protect and replenish drinking water supplies in the Quinnipiac River watershed by using stormwater runoff and green infrastructure techniques to recharge groundwater aquifers. The goal is to capture and infiltrate stormwater runoff from rooftops (in aquifer recharge areas of the watershed) that would otherwise end up in the municipal stormwater system, pick up pollution, and flow into nearby streams. This project would also benefit streamflow conditions for some of the smaller streams in the watershed through an increase in groundwater recharge and baseflow replenishment. Groundwater is the primary contributor to the natural baseflow of a stream and is critical to sustaining flows during dry periods.

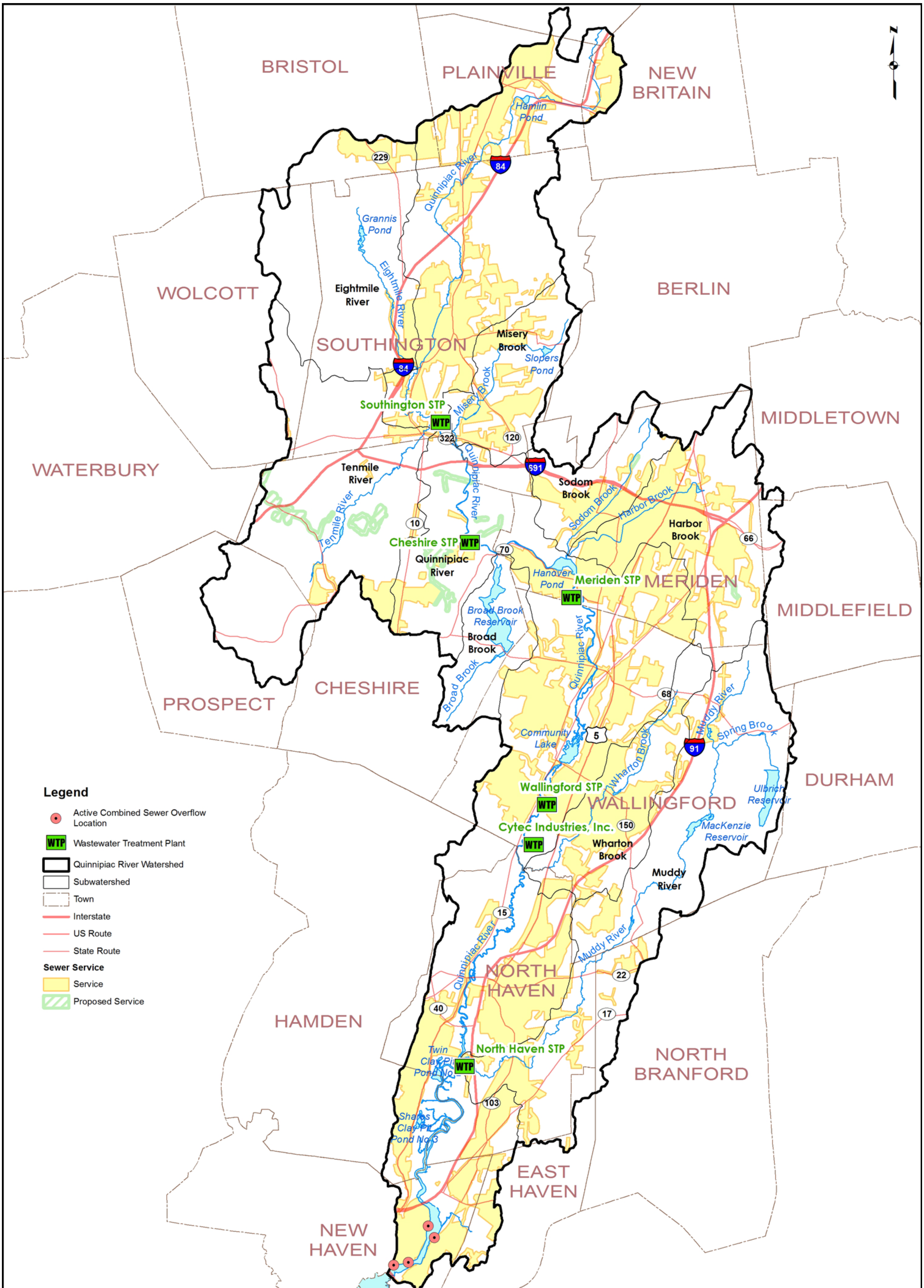
On a state-wide level, CTDEEP adopted streamflow standards and regulations in December 2011 to protect Connecticut's river and streams by balancing human and ecological needs for water. The regulation is primarily applicable to dam owners or operators that impound or divert the waters of a river or stream or that affect the flow of water in such a system, but also imposes restrictions for water users potentially impacting flow in a stream or river system as a result of groundwater withdrawal. The program's regulatory requirements are anticipated to be implemented over the next 10 years or more.

5.3 Wastewater

Approximately 66 percent of the population (100,000 households) within the Quinnipiac River watershed is served by municipal sanitary sewers and wastewater treatment plants (also referred to as Water Pollution Control Facilities or WPCFs). *Figure 5-2* depicts areas served by municipal sanitary sewer systems and the locations of the municipal wastewater treatment plants in the watershed, which serve Southington, Cheshire, Meriden, Wallingford, and North Haven. Populations located outside of the sewer services areas have on-site septic systems.

The watershed's wastewater treatment plants are a potential source of nutrients (nitrogen and phosphorus) and bacteria to the Quinnipiac River and Long Island Sound. Excessive discharge of nitrogen from human activities is the primary cause of very low oxygen levels in the bottom waters in the western half of Long Island Sound. Some of the municipal wastewater treatment plants in the watershed have begun implementing denitrification, a process that converts nitrate into nitrogen gas prior to the release of effluent, or advanced treatment for nitrogen removal.

When present in excessive amounts, phosphorus contributes to a process called "eutrophication" that can impair both aquatic life and recreational use of Connecticut's water resources. Excessive loading of phosphorus to surface waters as a result of discharges from industrial and municipal WPCFs or non point 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).



0 1 2 Miles	www.FandO.com FUSS & O'NEILL 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, Final – May 31, 2011; Combined Sewer Locations from Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria-Impaired Waters, September, 2012.	QUINNIPIAC RIVER WATERSHED BASED PLAN **FIGURE 5-2 SEWER SERVICE AREAS & WASTEWATER TREATMENT PLANTS**

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.[2]) that discharge to the Quinnipiac River. As discussed in *Section 1.4* of this report, CTDEEP is working collaboratively with several of the Quinnipiac River watershed communities including Meriden, Cheshire, Southington and Wallingford to reduce phosphorus and to make recommendations regarding a state-wide strategy to reduce phosphorus to comply with EPA standards.

Excessive levels of indicator bacteria are a leading cause of water quality impairments in the Quinnipiac River and its major tributaries. 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 (*Figure 5-2*) – the James Street siphon, Poplar Street at River Street, Pine Street at North Front Street, and Quinnipiac Avenue at Clifton Street.

The City of New Haven has been working to address CSOs since the early 1980s. Several major CSO abatement projects were completed in New Haven prior to regionalization of the City of New Haven Water Pollution Control Authority in the mid 2000s. These projects focused on sewer separation. More recent projects that have been completed since the City's current Long-Term Control Plan was prepared include tide gate replacement, additional sewer separation, and CSO storage tanks. In the past few years, the City of New Haven has adopted new regulatory requirements to address stormwater runoff contributing to the City's combined sewer system from development projects. New Haven is also in the process of 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 and Low Impact Development approaches.

[2] 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).

5.4 Stormwater

As described in *Section 3* of this report, 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 and downstream coastal waters.

Urbanization within the Quinnipiac River watershed has altered the watershed's natural hydrologic characteristics. Large areas of marshes, wetlands and forests have been replaced by impervious surfaces, which prevent infiltration of stormwater into the ground and accumulate pollutants from the atmosphere, vehicles, industry, lawns, construction sites, humans and animals. These pollutants are quickly conveyed to storm drainage systems during storms, and are in turn directed to the receiving waterbodies without treatment. Impervious surfaces also increase the volume, peak flow rates, and timing of stormwater runoff to receiving waters, contributing to the channel erosion, sedimentation, and reduced stream baseflow during dry periods. *Section 6* of this report addresses the amount of impervious cover in the Quinnipiac River watershed and the implications for water quality and overall stream health.

The CTDEEP regulates stormwater discharges from municipalities in designated urbanized areas under the General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4). All of the municipalities in the Quinnipiac River watershed are regulated under the MS4 General Permit. The MS4 General Permit requires these municipalities to register with CTDEEP, develop and implement a Stormwater Management Plan that addresses six minimum control measures, and annually collect stormwater samples for representative industrial, commercial, and residential land uses. The six minimum control measures include public education and outreach, public participation, illicit discharge detection/elimination, construction stormwater management, post-construction stormwater management, and pollution prevention/good housekeeping.

5.5 Flooding

The Quinnipiac River watershed has a long history of flooding as a result of historical development of the watershed. *Figure 5-3* depicts flood hazard areas within the Quinnipiac River watershed, including the 100-year and 500-year flood zones and the regulatory floodway. Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified size. FEMA also defines a "floodway" as the stream channel and adjacent areas that carry the majority of the flood flow at a significant velocity, whereas "floodplain" also includes the flood fringe or areas that are flooded without a strong current.

The United States Geological Survey (USGS) has estimated peak-flow magnitudes for various recurrence intervals based on historical peak streamflow measurements (Ahearn, 2003). *Table 5-3* summarizes peak flow frequency estimates for given recurrence intervals and the maximum known peak flow for the Quinnipiac River in Wallingford.

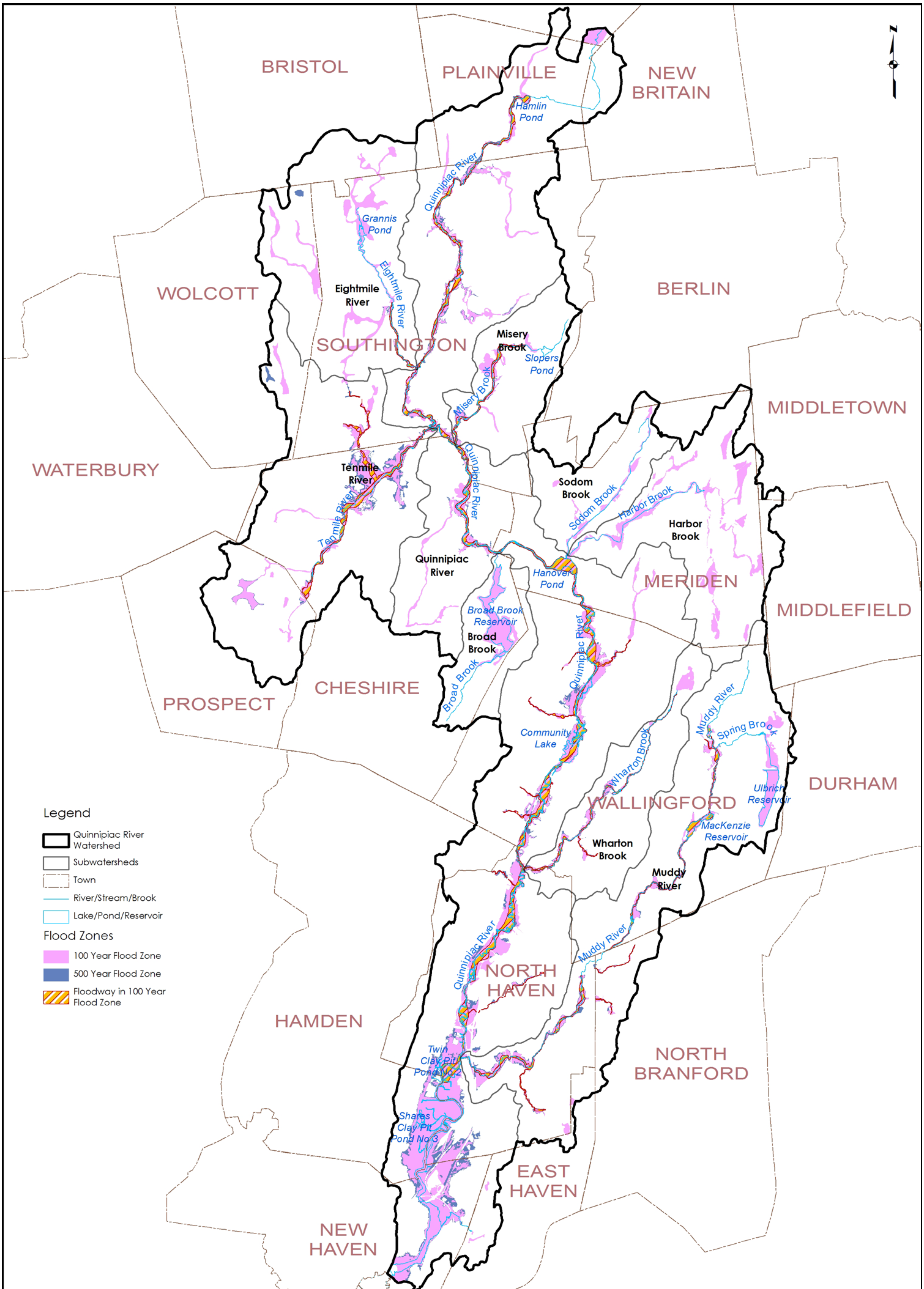
Table 5-3. Peak Flow Frequency Estimates and Maximum Peak Flow of the Quinnipiac River

Parameter	Peak Flow (cubic feet per second)
Peak-flow Frequency Estimates for Specified Recurrence Intervals	
1.5 years	1,690
2 years	2,100
10 years	4,100
25 years	5,260
50 years	6,180
100 years	7,140
500 years	9,610
Maximum Known Peak Flow	
June 6, 1982	8,200[1]

[1] Estimated
Source: Based on stream flow data from USGS Gage Station 01196500, Quinnipiac River at Wallingford, period of record 1931-2001 (Ahearn, 2003).

Based on the New Haven and Hartford County Flood Insurance Studies (FEMA, 2010 and 2011), significant flooding has occurred in 1815, 1893, 1927, March 1936, January and September 1938, January 1949, August and October 1955, January 1978, June 1982, March and April 1987, and June 1992. The most severe coastal flooding occurred during the hurricanes of September 1938 and August 1954. The flooding of the Quinnipiac River has increased significantly since about 1970, when the area surrounding the river was heavily urbanized (QWP, 2004).

Flooding within the watershed is not limited to the Quinnipiac River. Harbor Brook floods with frequency from the area of Baldwin's Pond to Hanover Pond, through the City of Meriden. Ten significant floods have been reported since 1869, which have been a result of heavy rain, rapid snow melt and hurricanes. The first reported damaging flood in 1869 destroyed newly paved roadways, washed out bridges, caused failure of the Baldwin Pond Dam, and inundated homes and businesses. Record flooding occurred during the September 1938 hurricane, when much of the center of the City was underwater for several days (USGS, 1994). Extensive physical damage occurs on a recurring basis along the floodplain of Harbor Brook. In addition to the physical damage, crosstown transportation service is disrupted during flood events and emergency services must be diverted around these areas (GZA, 2011). The City of Meriden is implementing comprehensive flood control measures to address flooding in Harbor Brook.



0 1 2 Miles	www.FandO.com FUSS & O'NEILL 78 Interstate Drive West Springfield, MA 01089	Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Federal Emergency Management Agency Digital Flood Insurance Rate Maps from Middlesex County (8/28/2008), Hartford County (9/26/2008), and New Haven County (12/17/2010).	QUINNIPIAC RIVER WATERSHED BASED PLAN **FIGURE 5-3** **FLOOD ZONES**

6 Watershed Land Use

The type and distribution of land use and land cover within a watershed has a direct impact on nonpoint sources of pollution and water quality. This section describes the current land use and land cover patterns in the watershed, and the implications for water quality and stream health.

6.1 Land Use/Land Cover

6.1.1 Land Use

The Quinnipiac River watershed is characterized by a wide variety of land uses. Areas along the main stem Quinnipiac River and particularly the lower portions of the watershed are characterized by significant commercial, industrial, and residential land use. An approximately four-mile long forested, floodplain corridor remains in North Haven and Wallingford. A substantial portion of the watershed in Cheshire is also relatively undeveloped. Sodom Brook and Harbor Brook flow through a heavily urbanized area in Meriden. Other land uses include suburban residential, suburban commercial, agricultural land, forest, and open space areas. Substantial tracts of open space (including land owned by the public water utilities) are associated with the traprock ridges and Southington Mountain. Several broad floodplain wetlands also form open space corridors including the Quinnipiac Marsh in North Haven (QWP, 2004).

Each of these land uses affects the quality of stormwater and nonpoint source runoff that flows into the Quinnipiac River and its tributaries. Forested land, meadows, and wetlands are generally beneficial to water quality. Residential, commercial, and industrial areas contribute greater amounts of runoff and associated pollutants, which tends to degrade water quality. Farmland and agricultural activities can also affect water quality by contributing elevated pollutant loads. *Table 6-1* identifies the various land cover types, and lists the percent and area of the watershed associated with each of them.

Table 6-1. Watershed Land Use

Land Use Category	Percent of Watershed	Watershed Area (Acres)
Agriculture	3.8	4,070
Commercial/Institutional	6.8	7,157
Forest	21.4	22,689
Industrial	7.5	7,970
Marsh	3.5	3,743
Multi-Family	2.4	2,518
Recreation/ Open Space	4.2	4,448
Roadway	8.4	8,875
Single Family	39.7	42,025
Water	2.3	2,457
Watershed (Total)	**100**	**105,952**

Figure 6-1 depicts generalized land use in the Quinnipiac River watershed. The data in *Figure 6-1* reflect land use categories for the watershed communities 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 were derived from the National Hydrography Dataset (NHD), while recreation/open space parcels and roadways were derived from CTDEEP GIS data. The data was verified using 2010 aerial photographs, and updates to the data set were made to reflect current conditions. The land use categories were consolidated into 10 generalized land use categories (*Table 6-1*).

Approximately 65% of the watershed consists of developed land uses, with residential uses comprising the largest percentage. Single family residential accounts for approximately 39.7% and multi-family residential for 2.4%. Highways and roads comprise approximately 8.4% of the watershed area. Industrial land use accounts for approximately 7.5% of the watershed area, and commercial and institutional comprise 6.8%. Approximately 27% of the watershed is classified as undeveloped (water, wetland/marsh, or forest), while the remaining 8% is classified as open space land use, including agriculture, parkland, conservation land, and other protected and unprotected open space.

6.1.2 Land Cover

Land cover, as its name implies, refes to what is present on the land surface, which differs from land use, which is what is permitted, practiced or intended for a given area (UConn Center for Land Use Education and Research, 2012). *Figure 6-2* depicts land cover in the Quinnipiac River watershed, which was derived from 2010 Landsat satellite imagery with a ground resolution of 30 meters. The land cover data in the watershed are classified into eleven categories (*Table 6-2*), which are used in the Connecticut Land Cover Map Series and described following the table (University of Connecticut Center for Land Use Education and Research, 2012).

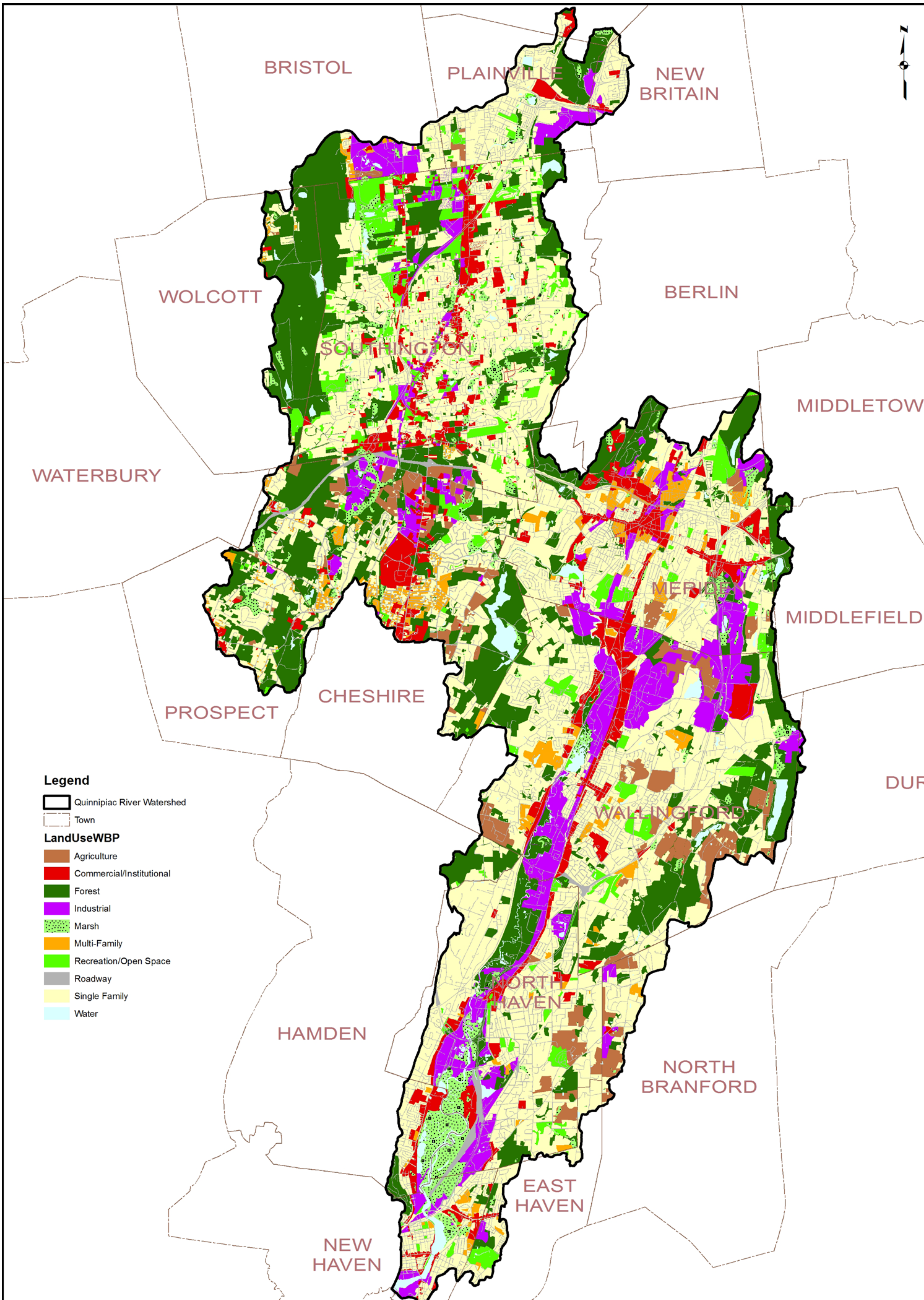
Table 6-2. Watershed Land Cover

	1985		2010		Relative Change in Percent of Watershed (%)[1]	Relative Change in Acreage (%)[2]
Land Cover Type	Acres	Percent of Watershed	Acres	Percent of Watershed		
Developed	31,025	29.3%	36,975	34.9%	5.6%	19.2%
Turf & Grass	13,138	12.4%	15,325	14.5%	2.1%	16.6%
Other Grasses	2,879	2.7%	2,950	2.8%	0.1%	2.5%
Agriculture	8,694	8.2%	5,888	5.6%	-2.6%	-32.3%
Deciduous Forest	38,691	36.5%	34,087	32.2%	-4.3%	-11.9%
Coniferous Forest	2,816	2.7%	2,588	2.4%	-0.2%	-8.1%
Water	2,462	2.3%	2,272	2.1%	-0.2%	-7.7%
Non-forested Wetland	239	0.2%	234	0.2%	0.0%	-1.8%
Forested Wetland	2,895	2.7%	2,568	2.4%	-0.3%	-11.3%
Tidal Wetland	1,059	1.0%	982	0.9%	-0.1%	-7.3%
Barren Land	1,506	1.4%	1,565	1.5%	0.1%	3.9%
Utility Rights-of-Way	548	0.5%	518	0.5%	0.0%	-5.5%

[1]Calculation = % land cover 2010 - % land cover 1985
[2]Calculation = (acres land cover 2010 – acres land cover 1985) / acres land cover 1985
Source: University of Connecticut Center for Land Use Education and Research (CLEAR)

The land cover types in *Table 6-2* have the following characteristics:

- Developed – High density built-up areas typically associated with commercial, industrial and residential activities and transportation routes. These areas contain a significant amount of impervious surfaces, roofs, roads, and other concrete and asphalt surfaces.
- Turf & Grass – A compound category of undifferentiated maintained grasses associated mostly with developed areas. This class contains cultivated lawns typical of residential neighborhoods, parks, cemeteries, golf courses, turf farms, and other maintained grassy areas. Also includes some agricultural fields due to similar spectral reflectance properties.
- Other Grasses – Includes non-maintained grassy areas commonly found along transportation routes and other developed areas, and within and surrounding airport properties. Also likely to include forested clear-cut areas, and some abandoned agricultural areas that appear to be undergoing conversion to woody scrub and shrub cover.
- Agriculture - Includes areas that are under agricultural uses such as crop production and/or active pasture. Also likely to include some abandoned agricultural areas that have not undergone conversion to woody vegetation.
- Deciduous Forest – Includes Southern New England mixed hardwood forests. Also includes scrub areas characterized by patches of dense woody vegetation. May include isolated low density residential areas.
- Coniferous Forest – Includes Southern New England mixed softwood forests. May include isolated low density residential areas.
- Water – Open water bodies and watercourses with relatively deep water.
- Non-forested Wetland – Includes areas that predominantly are wet throughout most of the year and that have a detectable vegetative cover (therefore not open water). Also includes some small watercourses due to spectral characteristics of mixed pixels that include both water and vegetation.
- Forested Wetland – Includes areas depicted as wetland, but with forested cover. Also includes some small watercourses due to spectral characteristics of mixed pixels that include both water and vegetation.
- Tidal Wetland - Emergent wetlands, wet throughout most of the year, with distinctive marsh vegetation and located in areas influenced by tidal change.
- Barren Land – Mostly non-agricultural areas free from vegetation, such as sand, sand and gravel operations, bare exposed rock, mines, and quarries. Also includes some urban areas where the composition of construction materials spectrally resembles more natural materials. Also includes some bare soil agricultural fields.
- Utility ROWs – Includes utility rights-of-way. This category was manually digitized on-screen from rights-of-way visible in the Landsat satellite imagery. The class was digitized within the deciduous and coniferous categories only.



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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 6-1
LAND USE

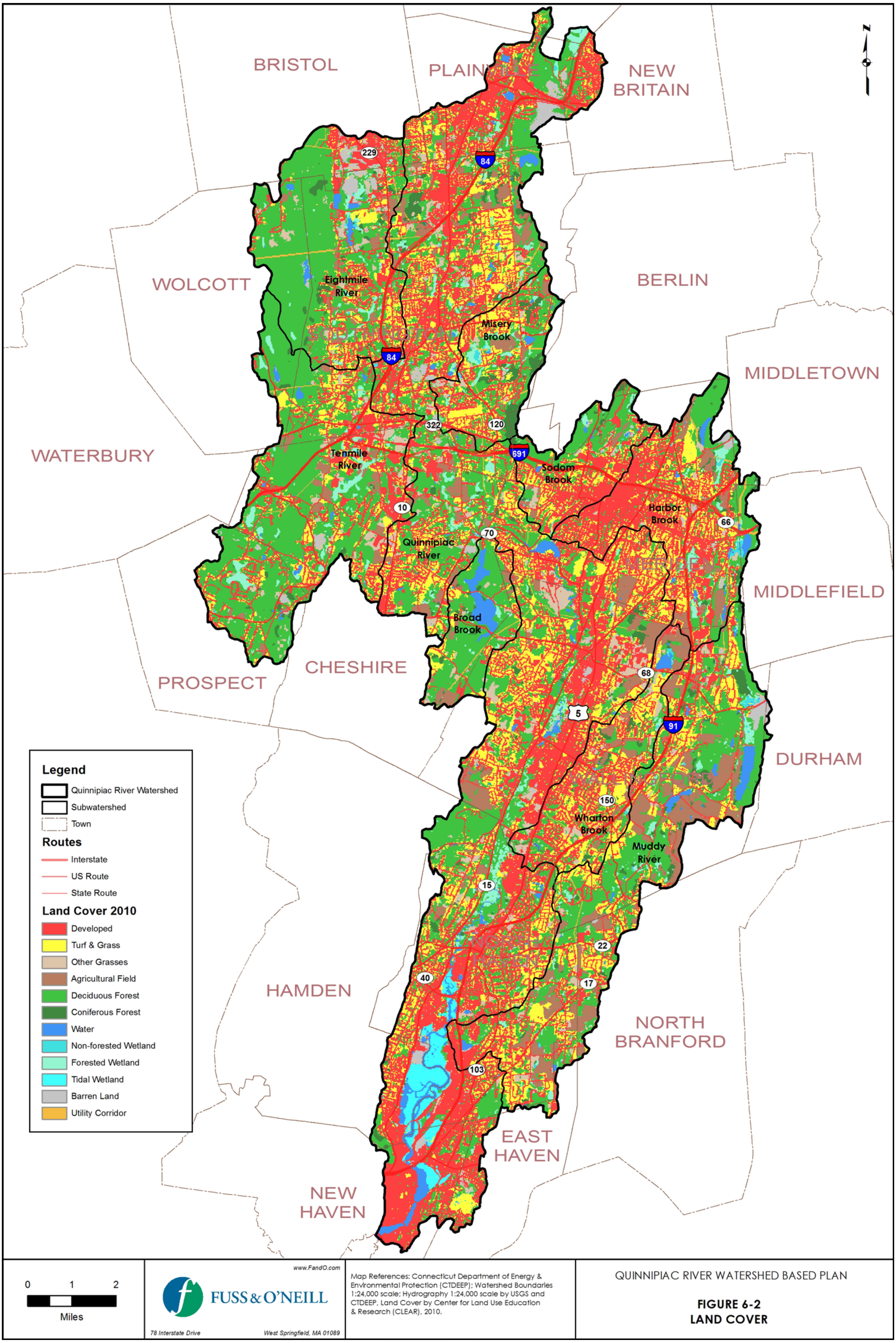


FIGURE 6-2
LAND COVER

A comparison of watershed land cover between 1985 and 2010 (*Table 6-2*) shows a moderate increase in watershed development during this period (5.6% increase in developed and 2.1% increase in turf/grass cover types) and a corresponding loss of forest (4.5% decrease), agriculture (2.6% decrease) and forested wetland (0.3% decrease). There was a significant relative percentage loss of agricultural lands (32.3% loss). The Quinnipiac River watershed is characterized by roughly equal amounts of developed and forested land cover.

Developed land cover, characterized by significant amounts of impervious surfaces such as roofs, roads, and other concrete and asphalt surfaces, accounted for approximately 35% of the watershed in 2010. When considered together with the turf/grass land cover category (primarily cultivated lawns typical of residential neighborhoods, parks, cemeteries, golf courses, turf farms, and other maintained grassy areas), approximately 49% of the watershed land area consists of developed land cover types. The percentage of developed land cover (not including turf/grass) in each subwatershed (*Table 6-3*) ranges from approximately 11% in the Broad Brook subwatershed to approximately 47% in the Harbor Brook subwatershed.

Table 6-3. Developed Land Cover by Subwatershed

Subwatershed Name	Developed Land Cover in Subwatershed (acres)	Percent Developed Land Cover in Subwatershed (%)
Broad Brook	345	11%
Eightmile River	2,082	22%
Muddy River	3,114	22%
Tenmile River	3,056	24%
Misery Brook	1,184	30%
Wharton Brook	1,917	39%
Sodom Brook	1,359	40%
Quinnipiac River (Main Stem)	20,256	44%
Harbor Brook	3,663	47%
Watershed (Total)	**36,974**	**35%**

Source: University of Connecticut's Center for Land Use Education and Research (CLEAR).

6.2 Impervious Cover

Impervious surfaces prevent precipitation from naturally soaking into the ground, resulting in a variety of hydrologic changes. Impervious cover is a measure of the amount of impervious surfaces covering the landscape. Impervious cover is a measurable, integrating concept used to assess the overall condition of a watershed. Numerous studies have documented the cumulative effects of urbanization on stream and watershed ecology (Center for Watershed Protection, 2003; Schueler et al., 1992; Schueler, 1994; Schueler, 1995; Booth and Reinelt, 1993, Arnold and Gibbons, 1996; Brant, 1999; Shaver and Maxted, 1996). Research has also demonstrated similar effects of urbanization and watershed impervious cover on downstream receiving waters such as lakes, reservoirs, estuaries, and coastal areas.

The correlation between watershed impervious cover and stream indicators is due to the relationship between impervious cover and stormwater runoff, since streams and receiving water bodies are directly influenced by stormwater quantity and quality. Although well-defined imperviousness thresholds are difficult to recommend, research has generally shown that when impervious cover in a watershed reaches between 10 and 25 percent, ecological stress becomes clearly apparent. Between 25 and 60 percent, stream stability is reduced, habitat is lost, water quality becomes degraded, and biological diversity decreases (NRDC, 1999). Watershed imperviousness in excess of 60 percent is generally indicative of watersheds with significant urban drainage. *Figure 6-3* illustrates this effect. These research findings have been integrated into a general watershed planning model known as the Impervious Cover Model (CWP, 2003).

Figure 6-3 also demonstrates the wide variability in stream response found in less-urban watersheds at lower levels of impervious cover (generally less than 10 percent). Stream quality at lower ranges of impervious cover is generally influenced more by other watershed metrics, such as forest cover, road density, extent of riparian vegetative cover, and cropping practices. Less variability exists in the stream quality at higher levels of impervious cover because most streams in highly impervious, urban watersheds exhibit fair or poor stream health conditions, regardless of other conditions (CWP, 2008).

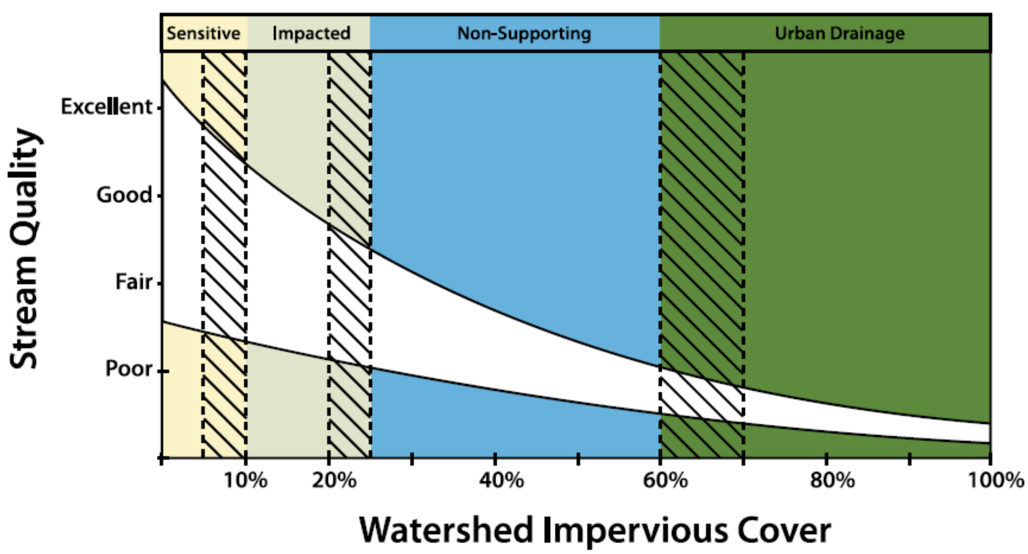


Figure 6-3. Conceptual Model Illustrating Relationship Between Watershed Impervious Cover and Stream Quality

A GIS-based impervious cover analysis was performed for the Quinnipiac River watershed. The impervious cover acreage was calculated using the Impervious Surface Analysis Tool (ISAT) and land cover-dependent impervious surface coefficients for each category of land cover described in *Section 6.1.2*. The ISAT coefficients in *Table 6-4* were derived by the University of Connecticut's Center for Land Use Education and Research (CLEAR) based on planimetric data from nine Connecticut towns (Prisloe, et. al, 2003).

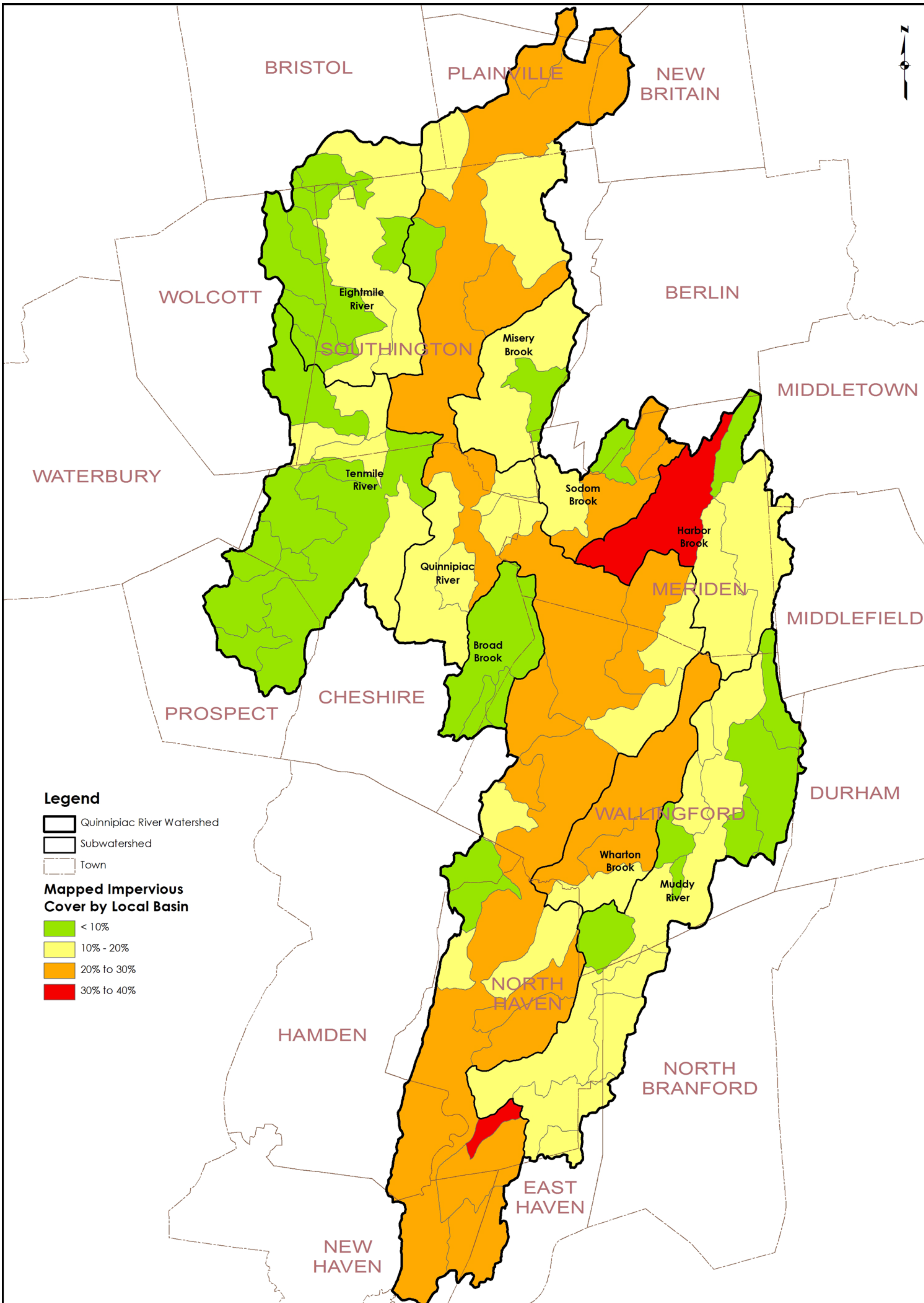
Table 6-4. Impervious Surface Coefficients

Land Cover	ISAT Coefficient		
	Low Density (< 500 people/mi²)	Medium Density (500-1800 people/mi²)	High Density (> 1800 people/mi²)
Agricultural Field	2.97	6.25	11.56
Barren Land	8.18	12.29	19.92
Coniferous forest	1.00	3.17	14.98
Deciduous forest	1.37	2.91	5.08
Developed	22.67	26.07	42.26
Forested wetland	0.46	1.03	1.20
Non-forested wetland	0.48	2.29	5.98
Other Grasses	2.97	6.25	11.56
Tidal wetland	3.11	1.63	1.02
Turf & Grass	8.58	12.09	12.87
Utility Corridor	1.20	0.80	5.52
Water	0.46	0.77	4.25

Source: University of Connecticut's Center for Land Use Education and Research (CLEAR).
Prisloe, Michael, Emily Hoffhine Wilson, & Chester Arnold (2003), "Final Report Refinement of Population-Calibrated Land-Cover-Specific Impervious Surface Coefficients for Connecticut." Accessed at http://nemo.uconn.edu/tools/impervious_surfaces/pdfs/Prisloe_etal_2003.pdf

Impervious cover percentages were calculated for each subwatershed. "Mapped or total impervious cover" includes all mapped impervious surfaces and is based on land cover data, while "effective impervious cover" is impervious cover that is hydraulically connected to the drainage system. Effective impervious cover is estimated for each subwatershed based on an empirical relationship between drainage system connectivity, land use, and development intensity (Sutherland, 1995). Effective impervious cover is a more representative measure of potential water resource impacts than mapped impervious cover.

Figure 6-4 shows estimated mapped impervious cover for the local basins in the Quinnipiac River watershed. Mapped impervious cover for the overall Quinnipiac River watershed is estimated at 17.3%, while the effective impervious cover for the overall watershed is estimated at approximately 11% (*Table 6-5*), which exceeds the 10% threshold in the ICM where ecological stress and stream impacts become apparent. The Harbor Brook, Quinnipiac River main stem, and Sodom Brook subwatershed have between 10 and 20% effective impervious cover and are considered in the "Impacted" ICM category, which is consistent with the higher-density development in this portion of the watershed. The other subwatersheds are generally characterized by moderate levels of effective impervious cover, ranging from 1.6 to 5.6% effective impervious cover, and are in the "Sensitive" ICM category.



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Miles

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www.FandO.com
78 Interstate Drive
West Springfield, MA 01089

Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP); University of Connecticut's Center for Land Use Education and Research (CLEAR) 2010 Land Cover Data; Prisloe, Michael, Emily Hoffhine Wilson, & Chester Arnold (2003), "Final Report Refinement of Population-Calibrated Land-Cover-Specific Impervious Surface Coefficients for Connecticut."

QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 6-4
MAPPED IMPERVIOUS COVER

Table 6-5. Existing Subwatershed Impervious Cover

Subwatershed	Mapped Impervious Cover	Effective Impervious Cover#	ICM Category*
Harbor Brook	24.6%	18.7%	Impacted
Quinnipiac River (Main Stem)	23.2%	17.4%	Impacted
Sodom Brook	21.8%	16.1%	Impacted
Wharton Brook	14.6%	5.6%	Sensitive
Misery Brook	11.6%	4.0%	Sensitive
Muddy River	10.2%	3.3%	Sensitive
Tenmile River	9.4%	2.9%	Sensitive
Eightmile River	9.2%	2.8%	Sensitive
Broad Brook	6.4%	1.6%	Sensitive
Watershed (total)	**17.3%**	**11.0%**	**Impacted**

* ICM = Center for Watershed Protection Impervious Cover Model Category shown in *Figure 6-3*.
\# Effective Impervious Cover estimated from mapped impervious cover (Sutherland, 1995).
Sources: National Land Cover Database (NLCD 2001) and University of Connecticut's Center for Land Use Education and Research (CLEAR) 2010 Land Cover Data, Sutherland, 1995.

The results of this analysis provide an initial diagnosis of potential stream and receiving water quality within the watershed study area. The analysis method and Impervious Cover Model are based on several assumptions and caveats, which limits its application to screening-level evaluations. Some of the assumptions of the Impervious Cover Model include:

- Requires accurate estimates of percent impervious cover.
- Predicts potential rather than actual stream quality.
- Does not predict the precise score of an individual stream quality indicator but rather predicts the average behavior of a group of indicators over a range of impervious cover.
- The impact thresholds are approximate transitions rather than sharp breakpoints.
- Does not currently predict the impact of watershed best management practices (treatment or non-structural controls).
- Does not consider the geographic distribution of the impervious cover relative to the streams and receiving waters. (Some of the geographic distribution is captured by using effective impervious cover in place of mapped impervious cover.)
- Impervious cover is a more robust and reliable indicator of overall stream quality beyond the 10 percent threshold. The influence of impervious cover on stream quality is relatively weak compared to other potential watershed factors such as percent forest cover, riparian community, historical land use, soils, agriculture, etc. for impervious cover less than 10 percent.
- Use should be restricted to 1st to 3rd order alluvial streams with no major point sources of pollutant discharge and no major impoundments or dams.
- Stream slope, as measured across the subwatershed, should be in the same range for all subwatersheds.
- Management practices in the contributing watershed must be good (e.g., no deforestation, acid mine drainage, major point sources, intensive row crops, etc.).

6.3 Open Space

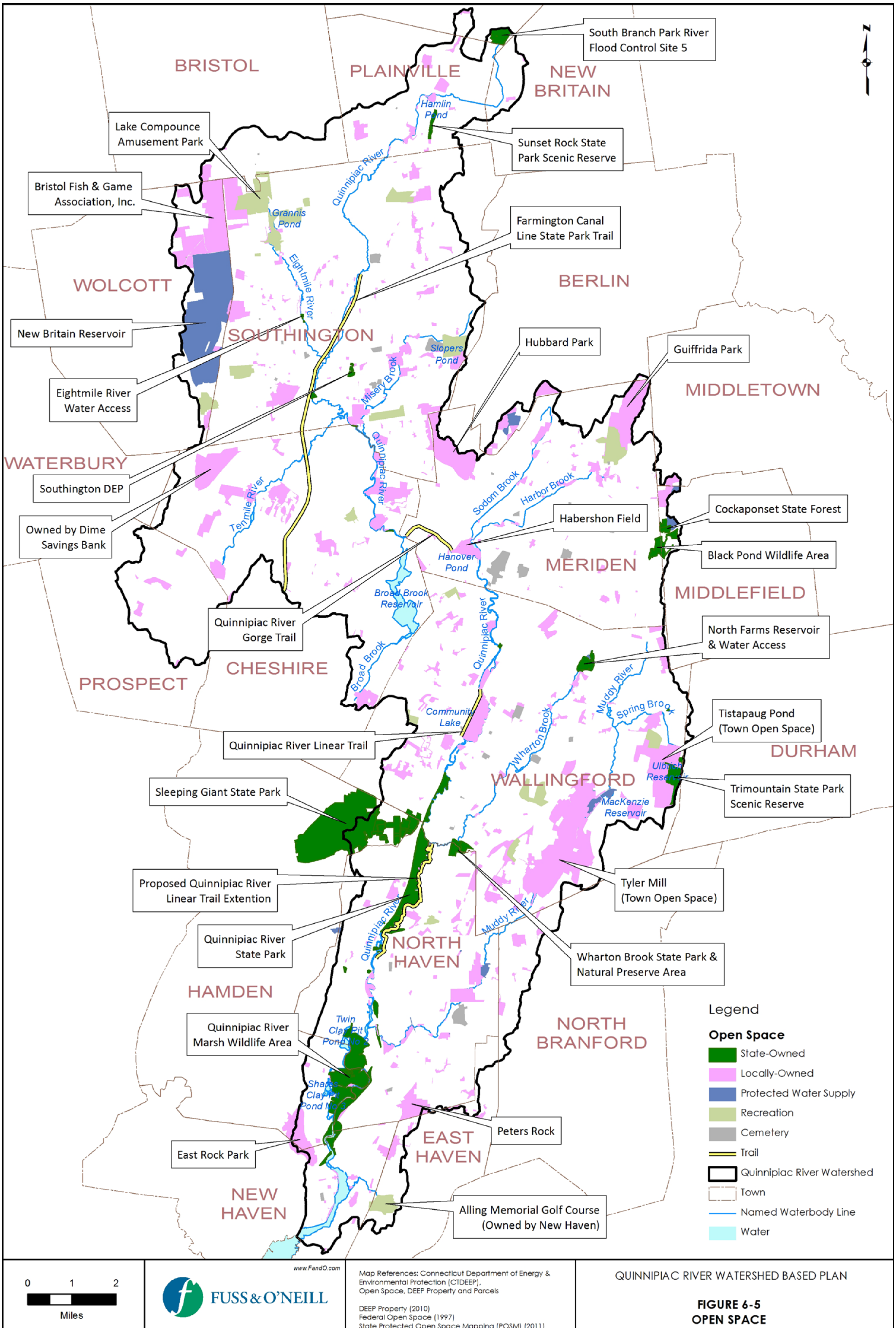
Open space can provide opportunities for active or passive outdoor recreation, enhance the aesthetic appeal and character of an area, or support natural resources, including plant and animal habitat (QWP, 2004). Open space plays a critical role in protecting and preserving the health of a watershed by 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.

Active and passive open space areas in the Quinnipiac River watershed were identified based on information presented in the 2004 action plan in addition to more recent data compiled and published by CTDEEP, including federal land, state-owned property, and other municipal and privately-owned open space. Regional land use data, Tele Atlas data, and other online mapping sources were also used. *Figure 6-5* shows open space land in the Quinnipiac River watershed.

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 uncomitted public and private open space (QWP, 2004). Some of the notable or sizable open space areas within the watershed listed by acreage include:

- Black Pond Wildlife Area (68 acres)
- Cockaponset State Forest (35 acres)
- Eightmile River Water Access (2.4 acres)
- Farmington Canal Line State Park Trail (61 acres)
- North Farms Reservoir (60 acres)
- North Farms Reservoir Water Access (3.2 acres)
- Quinnipiac River Marsh Wildlife Area (563 acres)
- Quinnipiac River State Park (323 acres)
- Quinnipiac River Water Access (25 acres)
- Sleeping Giant State Park (445 acres)
- South Branch Park River Flood Control Site 5 (82 acres)
- Southington DEP (12 acres)
- Sunset Rock State Park Scenic Reserve (20 acres)
- Three Ponds Area (2.4 acres)
- Trimountain State Park Scenic Reserve (116 acres)
- Wharton Brook Natural Area Preserve (23 acres)
- Wharton Brook State Park (44 acres)

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. The watershed communities have identified open space protection goals and priorities within the watershed primarily through their Plans of Conservation and Development.



BRISTOL
PLAINVILLE
NEW BRITAIN
WOLCOTT
SOUTHINGTON
BERLIN
MIDDLETOWN
WATERBURY
MERIDEN
MIDDLEFIELD
PROSPECT
CHESHIRE
DURHAM
WALLINGFORD
NORTH HAVEN
HAMDEN
NORTH BRANFORD
EAST HAVEN
NEW HAVEN
South Branch Park River Flood Control Site 5
Sunset Rock State Park Scenic Reserve
Lake Compounce Amusement Park
Bristol Fish & Game Association, Inc.
Farmington Canal Line State Park Trail
New Britain Reservoir
Eightmile River Water Access
Hubbard Park
Guiffrida Park
Southington DEP
Owned by Dime Savings Bank
Cockaponset State Forest
Habershon Field
Black Pond Wildlife Area
Quinnipiac River Gorge Trail
North Farms Reservoir & Water Access
Tistapaug Pond (Town Open Space)
Quinnipiac River Linear Trail
Trimountain State Park Scenic Reserve
Sleeping Giant State Park
Proposed Quinnipiac River Linear Trail Extention
Tyler Mill (Town Open Space)
Quinnipiac River State Park
Wharton Brook State Park & Natural Preserve Area
Quinnipiac River Marsh Wildlife Area
Peters Rock
East Rock Park
Alling Memorial Golf Course (Owned by New Haven)
Hamlin Pond
Grannis Pond
Quinnipiac River
Eightmile River
Slopers Pond
Misery Brook
Ten mile River
Sodom Brook
Harbor Brook
Hanover Pond
Broad Brook Reservoir
Broad Brook
Community Lake
Muddy River
Spring Brook
Wharton Brook
MacKenzie Reservoir
Ulbrich Reservoir
Twin Clay Pit Pond
Legend
Open Space
State-Owned
Locally-Owned
Protected Water Supply
Recreation
Cemetery
Trail
Quinnipiac River Watershed
Town
Named Waterbody Line
Water
0 1 2
Miles
www.FandO.com
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78 Interstate Drive
West Springfield, MA 01089
Map References: Connecticut Department of Energy & Environmental Protection (CTDEEP), Open Space, DEEP Property and Parcels
DEEP Property (2010)
Federal Open Space (1997)
State Protected Open Space Mapping (POSM) (2011)
QUINNIPIAC RIVER WATERSHED BASED PLAN
FIGURE 6-5
OPEN SPACE

7 Pollutant Loading

A pollutant loading analysis was performed for the Quinnipiac River watershed to guide the development of the watershed based plan recommendations and to quantify the anticipated load reductions associated with the recommendations. The pollutant loading model will be used to identify and rank pollutant sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollutant control strategies. This section summarizes the methods and results of the existing conditions pollutant loading analysis, which are presented in greater detail in *Appendix B*.

7.1 Model Description

A pollutant loading model was developed for the Quinnipiac River watershed using the land use/land cover data described in *Section 6*. It is important to note that the results of this screening-level analysis are intended for the purposes of identify and ranking pollutant sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollutant control strategies and not to predict future water quality. The Watershed Treatment Model (WTM), Version October 17, 2011, developed by the Center for Watershed Protection, was used for this analysis. This model calculates watershed pollutant loads primarily based on nonpoint source (NPS) runoff from various land uses. The model was also used to estimate pollutant loads from other sources, including:

- Wastewater Treatment Plant Discharges
- Combined Sewer Overflows
- Illicit Discharges
- Septic Systems
- Managed Turf
- Road Sanding

The pollutants modeled in this analysis are total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS), and total fecal coliform (FC) bacteria. These pollutants are the major NPS pollutants of concern in environmental systems.

7.2 Model Inputs

7.2.1 Nonpoint Source Runoff

Land use/land cover data described in *Section 6* were adapted for use in WTM. The model uses the Simple Method to calculate nutrient, sediment, and bacteria loads from various land uses. The user specifies several model parameters for each land use in the watershed that are used to estimate runoff quantity and pollutant levels. These parameters include Event Mean Concentrations (EMCs), which are literature values for the mean concentration of a pollutant in stormwater runoff for each land use, and an average impervious cover percentage for each land use. A literature review was conducted to determine EMC values and impervious percentage values for use in the evaluation. Literature-based TP EMC values were adjusted based on the calculated TP load at the USGS Wallingford station using water quality and flow data and calculated point source TP loads from the upstream WPCFs. The adjusted TP EMC values calculated for the area of the watershed upstream of the Wallingford gage were used for the entire watershed. The total annual TN load estimated using EMC literature values was consistent with the total annual TN load calculated using water quality and flow data. Therefore, the literature-based TN EMC values were not adjusted. Impervious cover coefficients for each land use category were selected from WTM default impervious cover coefficients and literature values. The default impervious cover coefficients in the model were adjusted to reflect local conditions in the Quinnipiac River watershed.

7.2.2 Other Pollutant Sources

In addition to nonpoint source runoff pollutant loads, WTM also provides the capability to model other pollutant sources including point sources and subsurface contributions. The following sections describe the model inputs and parameter values for other pollutant sources within the Quinnipiac River watershed.

Wastewater Treatment Plant Discharges
Annual loading rates for TN, TP, TSS, and FC were estimated for the wastewater treatment plants (Cytec Industries Inc., Cheshire WPCF, Meriden WPCF, North Haven WPCF, Southington WPCF, and Wallingford WPCF) that discharge to the Quinnipiac River. The annual loading rates were calculated based upon discharge monitoring report (DMR) data obtained from CTDEEP. The DMR data included reported concentrations or loadings in pounds per day of these pollutants and the average flow rates of the effluent discharge for the first 9 or 10 months of 2012. The data were used to estimate the average annual point discharges loadings for TN, TSS, and FC. TP data was estimated from nutrient analysis reports (NARs) to CTDEEP from 2001-2007. Data was not available for the average annual TP loading from the North Haven WPCF, and was therefore estimated using a typical TN to TP ratio.

Combined Sewer Overflows
WTM uses a modification of the Simple Method to calculate annual loads from Combined Sewer Overflows (CSOs). The primary assumption is that CSO discharges occur when the combined volume of stormwater and wastewater exceeds the total system capacity. There are currently 4 active CSO locations in the Quinnipiac River watershed (*Figure 5-2*) located in the Fair Haven area of New Haven. The CSO drainage area is approximately 480 acres. The system is assumed to experience approximately 50 CSO discharge events annually in the Quinnipiac River. Statistical analysis of 11 years of daily precipitation data at a nearby weather station in New Haven reveals that the median storm in the area is approximately 0.15 inches and the critical depth of rain that causes a CSO discharge event is assumed to be 0.1 inches. The volume of a typical CSO is based on the median storm event. In the model, any rainfall beyond the system capacity contributes to the CSO volume. Thus, this volume is calculated as the runoff caused by the difference between the median storm event depth and the rainfall depth that causes CSOs (assumed to be 0.1 inch). The runoff volume from this storm event is determined using the Simple Method. The resulting CSO pollutant load is the product of the CSO volume, the number of CSO events, and typical CSO pollutant concentrations.

Illicit Discharges

The WTM default assumptions for illicit discharges were used (i.e., a fraction of the total sewage flow contributes to illicit connections). The model makes separate assumptions for residential and business illicit connections. For residential connections, the WTM default assumption is that one in every 1,000 sewered individuals is connected to the sewer system via an illicit connection. This value is then multiplied by the number of individuals connected to the system, and then by typical per capita flow and pollutant concentrations for raw sewage. The number of sewered dwelling units was estimated as the number of households in the sewered 2010 U.S. Census blocks within the watershed. For businesses, it is assumed that 10% of businesses have illicit connections, and approximately 10% of those have direct sewage discharges. The number of businesses was estimated as the number of parcels with commercial land use.

Septic Systems

The number of unsewered dwelling units in each subwatershed was estimated using GIS data including the mapped sewer service areas, number of households in the unsewered 2010 U.S. Census blocks, and aerial photographs. The WTM default values were used for septic system failure rate (30%) and effluent concentrations from both working and failing septic systems.

Managed Turf

In urban watersheds, subsurface flow constitutes a relatively small fraction of total annual flow, and most constituents have a relatively low concentration in groundwater. One possible exception is nitrogen, which can leach from urban lawns and other managed turf grass. The annual nitrogen load from managed turf areas is calculated as the product of its concentration and the annual infiltration volume. The area of managed turf in each subwatershed is based on typical lawn areas of residential land uses.

Road Sanding

Sediment loads from road sanding are calculated based on the quantity of sand applied to roads in a typical year. A sanding application rate for typical roads was based on the average rate of 5 tons/lane-mile per year (Transportation Research Board, 1991). Two-lane roads are assumed throughout the watershed. The local roads GIS layer was used to calculate the total length of roads in each subwatershed and the total amount of sand applied to the roads in an average year. Default delivery ratios were used for various road types since not all road sand that is applied will reach the receiving water body.

7.3 Existing Pollutant Loads

Table 7-1 presents the existing modeled pollutant loads for the Quinnipiac River watershed. 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. *Table 7-2* presents a breakdown of estimated annual loadings of TN, TP, TSS, and FC by subwatershed.

Table 7-1. Modeled Existing Pollutant Loads by Source Type

	TN (1,000 lb/yr)	TP (1,000 lb/yr)	TSS (1,000 lb/yr)	FC (trillion/yr)	Runoff Volume (1,000 acre-feet/year)
Primary Sources - Land Use	1,025	41	38,220	7,189	138
Secondary Sources	509	169	23,896	3,282	0
CSOs	1.1	0	2.9	428	0
Channel Erosion	38	8.8	12,740	0	0
Road Sanding	0	0	10,330	0	0
Illicit Discharges	6.6	0.6	54	2,672	0
WPCF Point Sources	405	157	428	3.4	0
Septic Systems	58	2.2	388	178	0
Total	**1,534**	**210**	**62,163**	**10,471**	**138**

Table 7-2. Modeled Existing Pollutant Loads by Subwatershed

	Point and Nonpoint Source Loads				Nonpoint Source Loading Rates			
Subwatershed	**TN (10^3 lb/yr)**	**TP (10^3 lb/yr)**	**TSS (10^3 lb/yr)**	**FC (10^9/yr)**	**TN lb/ac-yr**	**TP lb/ac-yr**	**TSS lb/ac-yr**	**FC 10^9/ac-yr**
Broad Brook (3,080 ac)	20	1.1	957	173	6.4	0.34	311	56
Eightmile River (9,441 ac)	78	3.8	3,932	584	8.3	0.40	416	62
Harbor Brook (7,751 ac)	94	4.2	5,518	619	12.1	0.54	712	80
Misery Brook (3,993 ac)	35	1.9	1,942	407	8.7	0.47	486	102
Muddy River (13,947 ac)	145	6.5	7,395	1,057	10.4	0.47	530	76
Quinnipiac River (46,500 ac)	538	25	30,216	5,796	11.6	0.53	650	125
WPCF Point Sources	405	157	428	3	--	--	--	--
Sodom Brook (3,377 ac)	36	1.7	2,101	370	10.7	0.51	622	109
Tenmile River (12,967 ac)	126	5.8	6,361	837	9.7	0.45	491	65
Wharton Brook (4,895 ac)	58	2.7	3,312	625	11.9	0.56	677	128
Watershed Total (18,639 ac)	**1,534**	**210**	**62,163**	**10,470**	**14.5**	**1.98**	**587**	**99**

Because the study subwatersheds vary in size, nonpoint source pollutant loads were also evaluated in terms of loading rates (i.e., pollutant loads per acre of land area, as shown in *Table 7-2*). Point source discharges associated with WPCFs are not considered in these loading rates. A higher loading rate indicates relatively greater pollutant sources per unit area, which suggests that implementation of nonpoint source best management practices (BMPs) in these areas may be more effective in reducing pollutant loads. The highest loading rates for TN, TP, and TSS and the highest total runoff volumes are associated with the Wharton Brook, Harbor Brook, and Quinnipiac River subwatersheds. Wharton Brook, Quinnipiac River, and Sodom Brook subwatersheds have the highest loading rates of fecal coliform.

- **Wharton Brook Subwatershed** – The Wharton Brook subwatershed is the sixth largest subwatershed and has the highest annual loading rate per acre for FC and TP and the second highest annual loading rates for TSS and TN. The high loading rates are due to the proportionally large amount of single family, roadway, and agricultural land uses in this subwatershed. The estimated nonpoint source TN loading rate is 10.9 lb/ac-year, the TP loading rate is estimated at 1.9 lb/ac-year, the TSS loading rate is estimated at 361 lb/ac-year, and the estimated fecal coliform loading due to point and nonpoint source runoff is approximately 68 billion/ac-year.

- **Harbor Brook Subwatershed** – The Harbor Brook subwatershed is the fifth largest subwatershed in the Quinnipiac River watershed, and it has the highest estimated annual nonpoint source loading rates for TN, TSS and total runoff volume. The subwatershed has the highest percentage of industrial land use and roadways in the watershed and the second highest percentage of commercial and multi-family land use, which contribute to the high pollutant loading rates. In addition, the high intensity of land uses corresponds to a larger impervious cover percentage in the subwatershed, therefore increasing the runoff volume from land areas contributing to nonpoint source pollutant loads in the Quinnipiac River and its tributaries. Since this subwatershed is smaller in total land area than others, it does not have the highest absolute pollutant loading. The estimated nonpoint source TN loading rate is 11.1 lb/ac-year, the TP loading rate is estimated at 1.8 lb/ac-year, the TSS loading rate is 421 lb/ac-year, and the estimated FC loading due to point and nonpoint source runoff is approximately 72 billion/ac-year. The estimated pollutant loading rates in this subwatershed are generally 1.5 to 2 times larger than the subwatershed with the lowest pollutant loading rates.

- **Quinnipiac River Subwatershed** – The Quinnipiac River subwatershed is the largest in the watershed in terms of land area (between approximately 3 and 15 times the size of the other subwatersheds) and therefore has the highest absolute pollutant loading rates. It is also among the highest in terms of pollutant loading rates from nonpoint sources due to the high percentages of industrial, commercial/institutional, and single family land uses. The estimated nonpoint source TN loading rate is 10.4 lb/ac-year, the TP loading rate is estimated at 1.8 lb/ac-year, the TSS loading rate is 398 lb/ac-year, and the estimated FC loading due to point and nonpoint source runoff is approximately 75 billion/ac-year. The CSO discharges account for approximately 7% of the total FC loads in the subwatershed. The WPCFs within the watershed all discharge to the mainstem Quinnipiac River; therefore, the point sources from the WPCFs account for approximately 26% of the TN load, 51% of the TP load, and <1% of the TSS and FC loads for the entire watershed.

Table 7-3 summarizes the contribution of modeled nonpoint source pollutant loads for the entire watershed. The majority of the TN, TP, and TSS loads in the watershed are from single family residential, industrial, and roadway land uses. Single-family residential land use accounts for approximately 75.2% of the nonpoint source bacterial load. Other modeled pollutant sources contribute significantly to the watershed pollutant loads, particularly illicit discharges, which are a major source of fecal coliform loads in the watershed.

Table 7-3. Modeled Existing Nonpoint Source Pollutant Loads by Land Use

Land Use	N (10^3 lb/yr)	P (10^3 lb/yr)	TSS (10^3 lb/yr)	Fecal Coliform (10^9/yr)	N (%)	P (%)	TSS (%)	Fecal Coliform (%)
Agriculture	81	2	1,919	30	7.9%	4.0%	5.0%	0.4%
Commercial/ Institutional	139	4	3,585	297	13.6%	9.5%	9.4%	4.1%
Forest	90	5	2,214	99	8.8%	11.2%	5.8%	1.4%
Industrial	166	4	6,145	432	16.2%	8.9%	16.1%	6.0%
Wetland/Marsh	12	1	44	17	1.2%	1.7%	0.1%	0.2%
Multi-Family	27	1	1,202	477	2.7%	3.2%	3.1%	6.6%
Recreation/ Open Space	19	1	495	22	1.9%	2.2%	1.3%	0.3%
Roadway	170	7	8,974	406	16.6%	16.1%	23.5%	5.6%
Single Family	319	18	13,636	5,407	31.1%	43.2%	35.7%	75.2%
Water	1	0	5	2	0.1%	0.0%	0.0%	0.0%
Watershed (Total)	**1,025**	**41**	**38,220**	**7,189**				

7.4 Quinnipiac River Bacteria TMDL Pollutant Loads

A Total Maximum Daily Load (TMDL) analysis was performed by CTDEEP in 2008 for indicator bacteria in the Quinnipiac River Regional Basin (Watershed). The waterbodies included in the TMDL analysis are Harbor Brook, Misery Brook, Quinnipiac River, and Sodom Brook. These waterbodies are included on the List of Connecticut Waterbodies Not Meeting Water Quality Standards due to exceedances of the indicator bacteria criteria contained within the State Water Quality Standards (WQS). In general, a TMDL represents the maximum loading that a waterbody can receive without exceeding the water quality criteria, which have been adopted into the WQS for that parameter. In the Quinnipiac River Watershed TMDL, loadings are expressed as the average percent reduction from current loadings that must be achieved to meet water quality standards.

Connecticut's WQS establish criteria for bacterial indicators of sanitary water quality that are based on protecting recreational uses such as swimming (both designated and non-designated swimming areas), kayaking, wading, water skiing, fishing, boating, aesthetic enjoyment and others. The applicable water quality criteria for indicator bacteria to the Quinnipiac River Regional Basin are Geometric Mean less than 126/100ml and Single Sample Maximum 576/100ml. *Table 7-4* presents the TMDL average percent reductions in indicator bacteria required to meet the WQS.

Table 7-4. Average TMDL Percent Reductions to Meet Water Quality Standards

<table>
<tr><th rowspan="2">Waterbody</th><th rowspan="2">Waterbody Segment Description</th><th rowspan="2">Segment ID</th><th rowspan="2">Monitoring Site[1]</th><th colspan="3">Average Percent Reduction to Meet Water Quality Standards</th></tr>
<tr><th>TMDL</th><th>WLA[2]</th><th>LA[3]</th></tr>
<tr><td rowspan="2">Harbor Brook</td><td rowspan="2">From mouth at confluence with Quinnipiac River upstream to exit of box culvert, Meriden.</td><td>CT5206-00_01</td><td rowspan="2">101</td><td rowspan="2">95</td><td rowspan="2">95</td><td rowspan="2">95</td></tr>
<tr><td>CT5206-00_02</td></tr>
<tr><td>Misery Brook</td><td>From mouth at Quinnipiac River upstream to Slopers Pond outlet dam, Southington.</td><td>CT5203-00_01</td><td>1417</td><td>65</td><td>74</td><td>59</td></tr>
<tr><td rowspan="7">Quinnipiac River</td><td rowspan="7">From Rt. 5, North Haven upstream to headwaters at Dead Wood Swamp, Farmington.</td><td>CT5200-00_01</td><td>1421</td><td>68</td><td>73</td><td>64</td></tr>
<tr><td>CT5200-00_02</td><td>289</td><td>64</td><td>73</td><td>58</td></tr>
<tr><td>CT5200-00_02</td><td rowspan="2">1422</td><td rowspan="2">84</td><td rowspan="2">88</td><td rowspan="2">80</td></tr>
<tr><td>CT5200-00_02</td></tr>
<tr><td>CT5200-00_05</td><td>294</td><td>75</td><td>80</td><td>71</td></tr>
<tr><td>CT5200-00_06</td><td>1423</td><td>82</td><td>85</td><td>80</td></tr>
<tr><td>CT5200-00_07</td><td>1424</td><td>78</td><td>83</td><td>75</td></tr>
<tr><td>Sodom Brook</td><td>From mouth at confluence with Quinnipiac River upstream to headwaters, Meriden.</td><td>CT5205-00_01</td><td>1418</td><td>92</td><td>92</td><td>91</td></tr>
</table>

Notes:
(1) Monitoring Site locations are shown on *Figure 3-4*.
(2) WLA - Wasteload Allocation is the portion of the total loading which is allocated to point source discharges
(3) LA - Load Allocation is the portion of the total loading attributed to nonpoint sources

Estimated pollutant load reductions for the watershed plan recommendations will be presented in the Watershed Based Plan. The predicted pollutant load reductions will be evaluated relative to the required reductions specified in the TMDL.

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Appendix A

Water Quality Classifications and Impaired River Segments

Table A-1. Water Quality Classifications in the Quinnipiac River Watershed

Waterbody Name	Segment ID	Length/Area (Miles/Square Miles)	Water Quality Classification
Rivers			
Quinnipiac River-01	CT5200-00_01	5.05	B
Quinnipiac River-02	CT5200-00_02	8.50	B
Quinnipiac River-03	CT5200-00_03	1.29	B
Quinnipiac River-04	CT5200-00_04	4.78	B
Quinnipiac River-05	CT5200-00_05	8.32	B
Quinnipiac River-06	CT5200-00_06	3.00	B
Quinnipiac River-07	CT5200-00_07	3.50	B
Patton Brook-01	CT5200-02_01	2.84	A
Honeypot Brook-01	CT5200-07_01	4.95	A
Hemingway Creek-01	CT5200-23_01	0.74	A
Eightmile River (Southington)-01	CT5201-00_01	3.39	B
Eightmile River (Southington)-02	CT5201-00_02	2.37	A
Dayton Brook-01	CT5201-04_01	2.03	A
Roaring Brook (Southington)-01	CT5201-08_01	2.25	A
Tenmile River (Southington/Cheshire)-01	CT5202-00_01	4.10	B
Tenmile River (Cheshire)-02	CT5202-00_02	1.42	B
Misery Brook-01	CT5203-00_01	4.23	A
Misery Brook-02	CT5203-00_02	0.79	A
Sodom Brook-01	CT5205-00_01	4.16	A
Harbor Brook (Meriden)-01	CT5206-00_01	2.02	B
Harbor Brook (Meriden)-02	CT5206-00_02	0.40	B
Harbor Brook (Meriden)-03	CT5206-00_03	1.48	B
Wharton Brook-01	CT5207-00_01	3.97	A
Wharton Brook-02	CT5207-00_02	2.94	A
Allen Brook-01	CT5207-02_01	0.05	A
Allen Brook-02	CT5207-02_02	1.80	A
Muddy River (North Haven)-01	CT5208-00_01	0.68	B
Muddy River (North Haven)-02a	CT5208-00_02a	8.10	AA
Muddy River (Wallingford)-02b	CT5208-00_02b	1.81	A
Muddy River (Wallingford)-03	CT5208-00_03	1.98	AA
Muddy River (Wallingford)-04	CT5208-00_04	0.86	AA
Lakes			
Hanover Pond (Meriden)	CT5200-00-4-L2_01	70.5	B
North Farms Reservoir (Wallingford)	CT5207-00-1-L1_01	66.1	A
Allen Brook Pond (North Haven/Wallingford)	CT5207-02-1-L1_01	4.8	A
Black Pond (Meriden/Middlefield)	CT5206-01-1-L2_01	69.9	A
Mixville Pond (Cheshire)	CT5202-00-1-L3_01	10.7	A
Estuaries			
LIS CB Inner - New Haven Harbor, New Haven	CT-C1_013-SB	2.343	SB
LIS CB Inner - Quinnipiac River (mouth), New Haven	CT-C1_014-SB	0.626	SB

Table A-2. Impaired River Segments in the Quinnipiac Watershed

Waterbody Name	TMDL Category/ Priority Year	Impaired Designated Use	Cause	Potential Sources/ Comments
Quinnipiac River-01	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Potential Sources for the Habitat for Fish, Other Aquatic Life and Wildlife Impairment include Industrial point source discharges, municipal discharges, landfills, illicit discharge, remediation sites, and groundwater contamination The Quinnipiac River Regional Basin E.coli TMDL was Approved by EPA in 2008.
	4a	Recreation	Escherichia coli	
Quinnipiac River-02	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
	4a	Recreation	Escherichia coli	
Quinnipiac River-03	5/None	Fish Consumption	Polychlorinated biphenyls	
		Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
	4a	Recreation	Escherichia coli	
Quinnipiac River-04	5/None	Fish Consumption	Polychlorinated biphenyls	
		Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
	4a	Recreation	Escherichia coli	
Quinnipiac River-05	5/None	Fish Consumption	Polychlorinated biphenyls	
		Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
	4a	Recreation	Escherichia coli	
Quinnipiac River-06	5/ None	Fish Consumption	Polychlorinated biphenyls	
		Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
Quinnipiac River-07	5/ None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	
	4a	Recreation	Escherichia coli	
Hanover Pond (Meriden)	5/ 2013 for Recreation	Fish Consumption	Polychlorinated biphenyls	Unknown
		Habitat for Fish, Other Aquatic Life and Wildlife	Nutrient/ Eutrophication Biological Indicators	Industrial point source discharges, municipal discharges, landfills, illicit discharge, remediation sites, groundwater contamination
			Sedimentation/ Siltation	
		Recreation	Enterococcus	Unknown
Patton Brook-01	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Unknown

Waterbody Name	TMDL Category/ Priority Year	Impaired Designated Use	Cause	Potential Sources/ Comments
Hemingway Creek-01	5/2013 for Habitat for Fish, Other Aquatic Life and Wildlife	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Combined sewer overflow
Eightmile River (Southington)-01	4b	Fish Consumption	PCBs	Release of PCBs from nearby storage tanks resulted in elevated levels of PCBs in fish tissue. The impacted area has been remediated and follow-up fish tissue analysis indicates that PCBs in fish have decreased to acceptable levels
Tenmile River (Southington/ Cheshire)-01	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Industrial point sources discharge, illicit discharge, remediation sites, groundwater contamination
Mixville Pond (Cheshire)	5/2012 for Recreation	Recreation	Escherichia coli	Permitted and non-permitted stormwater, illicit discharges, agricultural activity, insufficient septic systems, nuisance wildlife/pets
Misery Brook-01	5/ 2013 for Impervious Cover	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Industrial point source discharges, insufficient septic systems
	4a	Recreation	Escherichia coli	The Quinnipiac River Regional Basin E.coli TMDL was Approved by EPA in 2008.
Sodom Brook-01	5/ 2013 for Impervious Cover	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Industrial point source discharges, illicit discharges, remediation sites, groundwater contamination
	4a	Recreation	Escherichia coli	The Quinnipiac River Regional Basin E.coli TMDL was Approved by EPA in 2008.
Harbor Brook (Meriden)-01	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Groundwater contamination
	4a	Recreation	Escherichia coli	The Quinnipiac River Regional Basin E.coli TMDL was Approved by EPA in 2008.
Harbor Brook (Meriden)-02	4c	Habitat for Fish, Other Aquatic Life and Wildlife	Physical substrate habitat alterations	Channelization
		Recreation		
	4a	Recreation	Escherichia coli	The Quinnipiac River Regional Basin E.coli TMDL was Approved by EPA in 2008.

Waterbody Name	TMDL Category/ Priority Year	Impaired Designated Use	Cause	Potential Sources/ Comments
Harbor Brook (Meriden)-03	5/None	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Industrial point source discharges, remediation sites, groundwater contamination
Wharton Brook-01	5/2013 for Impervious Cover	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Industrial point source discharges, landfills, illicit discharge
Wharton Brook-02	5/2013 for Impervious Cover	Habitat for Fish, Other Aquatic Life and Wildlife	Cause Unknown	Residential areas
Allen Brook-01	4a	Recreation	Escherichia coli	EPA Approved "Allen Brook, Allen Brook Pond, Gay City Pond and Schreeder Pond E. coli TMDL" in 2007
Allen Brook-02	4a	Recreation	Escherichia coli	
Allen Brook Pond (North Haven/Wallingford)	4a	Recreation	Escherichia coli	
Muddy River (North Haven)-02a	5/2013 for Recreation	Recreation	Escherichia coli	Unknown
Muddy River (North Haven)-02b	4c	Habitat for Fish, Other Aquatic Life and Wildlife	Other flow regime alterations	Agricultural Activities, Upstream Impoundments
			Temperature, water	Agricultural Activities, Upstream Impoundments, Flow Alterations from Water Diversions
LIS CB Inner - New Haven Harbor, New Haven	5/2013 for Bacteria	Commercial Shellfish Harvesting Where Authorized	Fecal Coliform	Potential sources include permitted and non-permitted stormwater, illicit discharge, CSOs/SSOs, marinas, insufficient septic systems, nuisance wildlife/pets
		Habitat for Marine Fish, Other Aquatic Life and Wildlife	Dissolved oxygen saturation	Potential sources include industrial point source discharge, municipal discharges, landfills, illicit discharge, remediation sites, groundwater contamination, combined sewer overflow
			Nutrient/ Eutrophication Biological Indicators	
			Oil & Grease	
			Dissolved Oxygen	
			Polychlorinated biphenyls	Potential sources include industrial point source discharge, landfills, illicit discharge, remediation sites, groundwater contamination
		Recreation	Enterococcus	Potential sources include permitted and non-permitted stormwater, illicit discharge, CSOs/SSOs, marinas, insufficient septic systems, nuisance wildlife/pets

Waterbody Name	TMDL Category/ Priority Year	Impaired Designated Use	Cause	Potential Sources/ Comments
LIS CB Inner - Quinnipiac River (mouth), New Haven	5/None	Commercial Shellfish Harvesting Where Authorized	Fecal Coliform	Unknown
		Habitat for Marine Fish, Other Aquatic Life and Wildlife	Dissolved oxygen saturation	Potential sources include industrial point source discharge, municipal discharges, landfills, illicit discharge, remediation sites, groundwater contamination, combined sewer overflow
			Nutrient/ Eutrophication Biological Indicators	
			Oil & Grease	
			Dissolved Oxygen	
			Polychlorinated biphenyls	Potential sources include industrial point source discharge, landfills, illicit discharge, remediation sites, groundwater contamination
		Recreation	Enterococcus	Unknown

Source: State of Connecticut Integrated Water Quality Report Draft – September 19, 2012
TMDL Priority Definitions (i.e., Potential for TMDL Development within 3 Years):

H – high priority for which there is assessment information that suggests that a TMDL may be needed to restore the water quality impairment; TMDLs may be developed within 3 years.
M – medium priority indicates that there may be insufficient information to assess the impairment or that other programs are likely to remedy the water quality impairment; TMDLs may be developed within 3-7 years.
L – low priority; may be reassigned to another EPA category or TMDLs may be developed in 7-11 years.
N – not applicable; the impact to the stream is not being caused by a pollutant.

TMDL Category Definitions for Waterbodies Not Meeting State Water Quality Standards:

4A – A TMDL to address a specific pollutant combination has been approved or established by EPA.
4B – A use impairment caused by a pollutant is being addressed by the State through pollution control requirements other than TMDL.
4C – A use is impaired, but the impairment is not caused by a pollutant.
5 – Available data and/or information indicate that at least one designated use is not being supported and a TMDL is needed.

Appendix B

Pollutant Loading Analysis

Table B-1. Impervious Cover Coefficients

	Impervious Cover Coefficient				
Land Use	**Cappiella and Brown (2001)**	**Sleavin et al. (2000)**	**Prisloe et al. (2003)**	**WTM (2010)**	**Selected**
Agriculture	0.019	0.356	0 - 0.23	-	0.2
Commercial/Institutional	0.722/0.344	0.54	0.260 - 0.557	0.72	0.7
Forest	-	0.01 - 0.068	0.003 - 0.197	-	0.01
Industrial	-	0.53	0.325 - 0.557	0.53	0.5
Wetland/Marsh	-	0.016	0.0251 - 0.0552		0.02
Multi-Family	0.44	0.205	-	0.44	0.44
Recreation/Open Space	0.086 - 0.125	0.050 - 0.094	0.036 - 0.056		0.05
Roadway	-	0.433	0.325 - 0.557	0.8	0.8
Single Family	0.106 - 0.409	0.08 - 0.39	0.065 - 0.12	0.12 - 0.33	0.21
Water	-	-	-	-	0

Sources:

Center for Watershed Protection (CWP), 2011. *Watershed Treatment Model (WTM) 2010 User's Guide.* Prepared by Deb Caraco, P.E. and the Center for Watershed Protection. Updated April, 2011.

Cappiella, K. and K. Brown, 2001. *Impervious Cover and Land Use in the Chesapeake Bay Watershed.* Center for Watershed Protection. Ellicott City, MD.

Prisloe, Michael, Emily Hoffhine Wilson, & Chester Arnold (2003), *Final Report Refinement of Population-Calibrated Land-Cover-Specific Impervious Surface Coefficients for Connecticut.* Accessed at http://nemo.uconn.edu/tools/impervious_surfaces/pdfs/Prisloe_etal_2003.pdf

Sleavin, William J., Daniel L. Civco, Sandy Prisloe, & Laurie Giannotti, 2000. *Measuring Impervious Surfaces for Non-Point Source Pollution Modeling.*

Table B-2. Runoff Event Mean Concentrations (EMCs)

Source	NH Stormwater Manual			PLOAD	Selected			
Pollutant	TN	TP	TSS	FC	**TN**	**TP***	**TSS**	**FC**
Units	mg/L	mg/L	mg/L	#/100mL	**mg/L**	**lbs/ac-yr**	**mg/L**	**#/100mL**
Agriculture	5.98	0.37	145	-	**5.98**	**0.40**	**145**	**500**
Commercial/Institutional	2.97	0.33	77	1,400	**2.97**	**0.54**	**77**	**1,400**
Forest	1.78	0.11	51	500	**1.78**	**0.20**	**51**	**500**
Industrial	3.97	0.32	149	2,300	**3.97**	**0.46**	**149**	**2,300**
Wetland/Marsh	1.38	0.08	6	500	**1.38**	**0.19**	**6**	**500**
Multi-Family	2.2	0.4	100	8,700	**2.2**	**0.53**	**100**	**8,700**
Recreation/Open Space	1.74	0.11	51	500	**1.74**	**0.20**	**51**	**500**
Roadway	2.65	0.43	141	1,400	**2.65**	**0.74**	**141**	**1,400**
Single Family	2.2	0.4	100	8,700	**2.2**	**0.42**	**100**	**8,700**
Water	1.38	0.08	6	500	**1.38**	**0.01**	**6**	**500**

Notes:
*TP loading was calculated based on Export Coefficients rather than EMCs. The values are based on estimated nonpoint source loading from water quality and flow data from a USGS station, minus the known point sources from WPCFs.

Sources:
McCarthy, Jillian, 2008. *New Hampshire Stormwater Manual Volume 1: Stormwater and Antidegradation,* December 2008. http://des.nh.gov/organization/divisions/water/stormwater/documents/wd-08-20a_apxd.pdf.

Edwards C, Miller M. 2001. PLOAD Version 3.0: An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects. User's Manual. USEPA: Washington, DC, USA.

Notes:
TP - Total Phosphorus
TN - Total Nitrogen
TSS - total suspended solids
FC - fecal coliform bacteria

Table B-3. Existing Land Use Composition by Subwatershed

Subwatershed	Agriculture	Commercial/ Institutional	Forest	Industrial	Wetland/ Marsh	Multi-Family	Recreation/ Open Space	Roadway	Single Family	Water	TOTAL
Broad Brook (3,080 ac)	80	0	1,496	0	28	28	21	111	998	318	3,080
Eightmile River (9,441 ac)	52	408	3,884	575	295	98	901	412	2,620	196	9,441
Harbor Brook (7,751 ac)	148	765	1,132	948	349	421	303	844	2,704	137	7,751
Misery Brook (3,993 ac)	0	184	637	0	244	0	323	249	2,328	28	3,993
Muddy River (13,947 ac)	1,712	305	3,315	807	256	121	308	821	5,979	323	13,947
Quinnipiac River (46,500 ac)	1,085	3,887	6,148	4,700	1,903	986	1,898	4,516	20,165	1,213	46,500
Sodom Brook (3,377 ac)	2	447	1,066	110	69	235	0	338	1,089	22	3,377
Tenmile River (12,967 ac)	517	932	4,835	583	569	395	352	1,059	3,598	127	12,967
Wharton Brook (4,895 ac)	474	229	175	246	31	232	343	526	2,543	94	4,895
Total (Watershed)	**4,070**	**7,157**	**22,689**	**7,970**	**3,743**	**2,518**	**4,448**	**8,875**	**42,025**	**2,457**	**105,952**

Table B-4. Existing Land Use Composition Percentages

Subwatershed	Agriculture	Commercial/ Institutional	Forest	Industrial	Wetland/ Marsh	Multi-Family	Recreation/ Open Space	Roadway	Single Family	Water	TOTAL
Broad Brook (3,080 ac)	3%	0%	49%	0%	1%	1%	1%	4%	32%	10%	100%
Eightmile River (9,441 ac)	1%	4%	41%	6%	3%	1%	10%	4%	28%	2%	100%
Harbor Brook (7,751 ac)	2%	10%	15%	12%	5%	5%	4%	11%	35%	2%	100%
Misery Brook (3,993 ac)	0%	5%	16%	0%	6%	0%	8%	6%	58%	1%	100%
Muddy River (13,947 ac)	12%	2%	24%	6%	2%	1%	2%	6%	43%	2%	100%
Quinnipiac River (46,500 ac)	2%	8%	13%	10%	4%	2%	4%	10%	43%	3%	100%
Sodom Brook (3,377 ac)	0%	13%	32%	3%	2%	7%	0%	10%	32%	1%	100%
Tenmile River (12,967 ac)	4%	7%	37%	4%	4%	3%	3%	8%	28%	1%	100%
Wharton Brook (4,895 ac)	10%	5%	4%	5%	1%	5%	7%	11%	52%	2%	100%

Figure B-1. Existing Land Use Composition

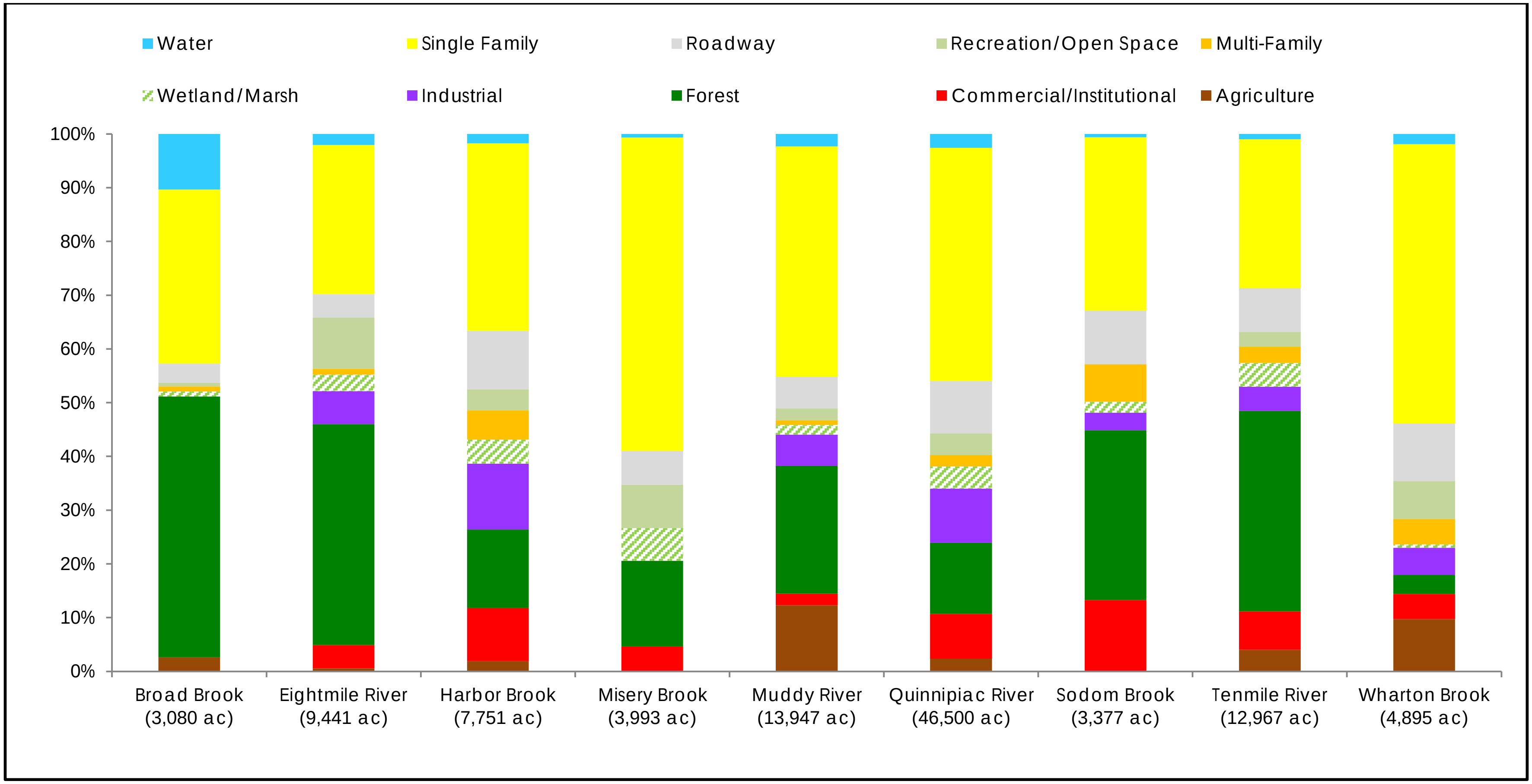

Table B-5 Model Input Data – Septic Systems, Illicit Connections, and Road Sanding

Subwatershed	Estimated Number of Dwelling Units	Estimated Number of Unsewered Dwelling Units	Estimated Unsewered Dwelling Units (% of Total)	Septic Systems <100 ft from a waterway (% of Total)	Estimated Number of Businesses	Length of Roads (miles)	Road Sand Application (lbs/yr)
Broad Brook (3,080 ac)	931	682	73%	0.00%	0	13.2	131,792
Eightmile River (9,441 ac)	4,115	3,090	75%	1.84%	54	79.0	790,226
Harbor Brook (7,751 ac)	14,518	2,254	16%	0.22%	767	148.7	1,486,819
Misery Brook (3,993 ac)	2,964	1,440	49%	0.00%	33	42.5	424,709
Muddy River (13,947 ac)	4,762	3,401	71%	0.41%	46	130.1	1,301,482
Quinnipiac River (46,500 ac)	57,260	16,445	29%	0.99%	4652	697.5	6,975,440
Sodom Brook (3,377 ac)	4,531	1,122	25%	0.80%	235	59.9	598,852
Tenmile River (12,967 ac)	4,713	3,597	76%	0.53%	181	110.8	1,108,245
Wharton Brook (4,895 ac)	5,790	1,288	22%	0.08%	677	73.0	730,327

Sources and Notes:
Number of Households from 2010 census data, by subwatershed block groups - FTP directory is at http://www2.census.gov/census_2010/; 2010 Census Summary File 1 and 2010 Census Summary File 2.

Road sand application rate based on the Massachusetts average of 5 tons/lane-mile (annual); assumed 2 lane roads and a 50/50 sand mix. From *Highway Deicing Comparing Salt and Calcium Magnesium Acetate*. Transportation Research Board National Research Council Washington, D.C. 1991 Special Report 235.

Sewered Areas from CTDEEP GIS Data: http://www.ct.gov/dep/cwp/view.asp?a=2698&q=322898.

Estimated number of businesses - 1 business per parcel within commercial and industrial land use areas

Table B-6. Modeled Existing Pollutant Loads by Source Type

	TN (1,000 lb/yr)	TP (1,000 lb/yr)	TSS (1,000 lb/yr)	FC (trillion/yr)	Runoff Volume (1,000 acre-feet/year)
Primary Sources - Land Use	1,025	**41**	38,220	7,189	138
Secondary Sources	509	**169**	23,943	3,282	0
CSOs	1.1	**0**	2.9	428	0
Channel Erosion	38	**8.8**	12,740	0	0
Road Sanding	0	**0**	10,330	0	0
Illicit Discharges	6.6	**0.6**	54	2,672	0
WPCF Point Sources	405	**157**	428	3.4	0
Septic Systems	58	**2.2**	388	178	0
Total	1,534	**210**	62,163	10,471	138
Primary and Secondary Sources~~-~~ ~~Sources~~ Other than WPCFs~~(Nonpoint)~~ (%)	***74%***	***25%***	***99%***	***100%***	***100%***
WPCFs ~~Point Sources~~ (%)	***26%***	***75%***	***1%***	***0%***	***0%***

Table B-7. Modeled Existing Nonpoint Source Pollutant Loads by Source Type

Land Use	TN (1,000 lb/yr)	TP (1,000 lb/yr)	TSS (1,000 lb/yr)	FC (trillion/ yr)	Runoff Volume (1,000 ac-ft/yr)	TN (%)	TP (%)	TSS (%)	FC (%)	Runoff Volume (%)
Agriculture	81	2	1,919	30	5	7.9%	4.0%	5.0%	0.4%	3.5%
Commercial/ Institutional	139	4	3,585	297	17	13.6%	9.5%	9.4%	4.1%	12.4%
Forest	90	5	2,214	99	16	8.8%	11.2%	5.8%	1.4%	11.6%
Industrial	166	4	6,145	432	15	16.2%	8.9%	16.1%	6.0%	11.0%
Wetland/ Marsh	12	1	44	17	3	1.2%	1.7%	0.1%	0.2%	2.0%
Multi-Family	27	1	1,202	477	4	2.7%	3.2%	3.1%	6.6%	3.2%
Recreation/ Open Space	19	1	495	22	4	1.9%	2.2%	1.3%	0.3%	2.6%
Roadway	170	7	8,974	406	23	16.6%	16.1%	23.5%	5.6%	17.0%
Single Family	319	18	13,636	5,407	50	31.1%	43.2%	35.7%	75.2%	36.4%
Water	1	0	5	2	0	0.1%	0.0%	0.0%	0.0%	0.2%
Total	**1,025**	**41**	**38,220**	**7,189**	**138**	--	--	--	--	--

Table B-8. Modeled Existing Pollutant Loads by Subwatershed

Subwatershed	Point and Nonpoint Source Loads				Nonpoint Source Loading Rates			
	TN (10^3 lb/yr)	TP (10^3 lb/yr)	TSS (10^3 lb/yr)	FC (10^9/yr)	TN lb/ac-yr	TP lb/ac-yr	TSS lb/ac-yr	FC 10^9/ac-yr
Broad Brook (3,080 ac)	20	1.1	957	173	6.4	0.34	311	56
Eightmile River (9,441 ac)	78	3.8	3,932	584	8.3	0.40	416	62
Harbor Brook (7,751 ac)	94	4.2	5,518	619	12.1	0.54	712	80
Misery Brook (3,993 ac)	35	1.9	1,942	407	8.7	0.47	486	102
Muddy River (13,947 ac)	145	6.5	7,395	1,057	10.4	0.47	530	76
Quinnipiac River (46,500 ac)	538	25	30,216	5,796	11.6	0.53	650	125
WPCF Point Sources	405	157	428	3	--	--	--	--
Sodom Brook (3,377 ac)	36	1.7	2,101	370	10.7	0.51	622	109
Tenmile River (12,967 ac)	126	5.8	6,361	837	9.7	0.45	491	65
Wharton Brook (4,895 ac)	58	2.7	3,312	625	11.9	0.56	677	128
Watershed Total (18,639 ac)	**1,534**	**210**	**62,163**	**10,471**	**14.5**	**1.98**	**587**	**99**

Technical Memorandum #2:
Low Impact Development &
Green Infrastructure Assessment

Quinnipiac River Watershed Based Plan

September 2013

Prepared For:

Quinnipiac River Watershed Association

In Cooperation With:

**Connecticut Department of
Energy & Environmental Protection
U.S Environmental Protection Agency**

FUSS & O'NEILL

Project No. 20111176.A10

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Technical Memorandum #2:
Low Impact Development & Green Infrastructure Assessment

Appendices **End of Report**

1 Introduction

1.1 What is LID and Green Infrastructure?

Low Impact Development (LID) and green infrastructure are the preferred approaches for stormwater management by the Connecticut Department of Energy and Environmental Protection (CTDEEP) and the U.S Environmental Protection Agency (EPA), but are also relatively new and sometimes not well-understood by designers, municipalities, and the public.


Coventry Town Hall Annex, Coventry CT; Source: CTDEEP

LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID principles include preserving and restoring natural landscape features, minimizing effective impervious cover (i.e., the impervious cover that is directly connected to the storm drainage system and/or receiving waters), and creating functional and appealing site drainage that treats stormwater as a resource. The goal of LID is to mimic a site's pre-development hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID addresses stormwater through small, cost-effective landscape features located throughout a site. LID is a versatile approach that can be applied equally well to new development, urban retrofits, and redevelopment projects.


Evergreen Walk Mall Parking Lot, South Windsor, CT Source: CT NEMO

Green infrastructure is similar to LID and refers to systems and practices that use or mimic natural processes to infiltrate, evapotranspire, or reuse stormwater. Green infrastructure and LID include stormwater management practices such as rain gardens, permeable pavement, green and blue roofs, green streets, infiltration planters, trees and tree boxes, and rainwater harvesting. These practices capture, manage, and/or reuse rainfall close to where it falls, thereby reducing stormwater runoff and keeping it out of receiving waters.

In addition to reducing polluted runoff and improving water quality, green infrastructure has been shown to provide other social and economic benefits relative to reduced energy consumption, improved air quality, carbon reduction and sequestration, improved property values, recreational opportunities, overall economic vitality, and adaptation to climate change. For these reasons, many communities are exploring the use of and are adopting green infrastructure within their municipal infrastructure programs.

1.2 Objectives

As documented in *Technical Memorandum #1, State of the Quinnipiac River Watershed* (June 2013), nonpoint sources such as stormwater runoff from developed areas and impervious surfaces are major contributors of bacteria, sediment, and nutrients in the Quinnipiac River watershed. Much of the watershed was developed prior to the adoption of stormwater quality regulatory requirements. Therefore, most of the existing drainage infrastructure consists of traditional storm drains/catch basin and drainage pipes that discharge directly to surface waters without treatment, other than detention to maintain peak rates of discharge. Uncontrolled stormwater runoff from impervious surfaces is a significant source of impacts to surface waters and water quality within the watershed. An important objective of this watershed plan is to reduce runoff volumes and pollutant loads through the use of LID and green infrastructure.

Portions of the watershed in Southington, Meriden, Wallingford and Cheshire are in Aquifer Protection Areas (APAs), which are recharge areas to groundwater public drinking water supplies. Historical development and increases in impervious surfaces within these areas has increased stormwater runoff but reduced infiltration and groundwater recharge. Therefore, a second objective is to increase groundwater recharge to the drinking water aquifers through the use of LID and green infrastructure within the APAs. To protect the quality of the groundwater drinking water supplies, such practices should generally be located within the APA but no closer than 200 feet from a public drinking water well.

A watershed assessment was performed to identify opportunities and develop concepts for site-specific LID and green infrastructure retrofits that could also be applied to other similar land uses and locations in the watershed. To meet water quality and groundwater recharge objectives. This technical memorandum documents the methods and findings of this assessment.

1.3 Examples of Existing and Proposed Green Infrastructure in the Watershed

Due to efforts by the Quinnipiac River Watershed Association (QRWA), CTDEEP, Save the Sound, various municipalities, and other organizations, several LID retrofits are planned or have already been constructed in the watershed:

- Quinnipiac River Watershed Groundwater Restoration Project[1] - Save the Sound, a program of Connecticut Fund for the Environment, is working to expand drinking water supplies in the Quinnipiac River watershed through the use of green infrastructure techniques. Funding is provided by the CTDEEP through the Quinnipiac River Groundwater Natural Resources Damages Fund.

[1] http://reducerunoff.org/quinnipiac.htm

Save the Sound and its partners, which include the University of Connecticut NEMO Program, the United States Geological Survey (USGS), and the towns of Southington and Meriden, are constructing bioretention rain gardens at sites throughout the Quinnipiac River watershed. These green infrastructure projects would absorb stormwater run-off and thereby “recharge” the groundwater aquifers, providing some replenishment of the drinking water resource. The goal is to capture and infiltrate stormwater runoff from rooftops that would otherwise end up in the municipal stormwater system, pick up pollution, and flow into nearby streams. Projects are located and proposed in the towns of Southington, Meriden, Wallingford or Cheshire where groundwater is a major source of public water supply.

Save the Sound is currently working with the Town of Southington to plan and design two large bioretention projects. The first is located at the Southington Community Center and has the potential to include above-ground bioretention areas, the installation of permeable pavement in the parking area, and underground infiltration. The second project is located at Southington High School. Current plans are targeting a median strip in the school’s main parking lot for its potential to capture runoff that would normally flow into existing storm drains. A green infrastructure retrofit concept for meeting these objectives for Southington High School is provided in *Section 2.2*.

- Save the Sound’s Rain Garden Program – As part of the Quinnipiac River Watershed Groundwater Restoration Project, the Rain Garden Program has funded the construction of nine residential rain gardens in Southington, which were completed during the summer of 2013. The rain gardens capture over 6,600 square feet of roof runoff. Over 60 volunteers contributed their time to construct the rain gardens.

- Lowe’s and Target, Southington - Bioretention areas were installed in 2009 at Lowe’s and Target parking lots off of Route 229 in Southington as shown in the photo to the right.


Source: National LID Atlas

- Municipal Building, Southington - Gravel filter strips and a stormwater basin were constructed to treat runoff from the parking lot as a part of the recent renovations at the Southington Municipal Building as shown in the photo below.


Source: Fuss & O’Neill, 2013

2 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 APAs. 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 2.1)*.

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 A*.

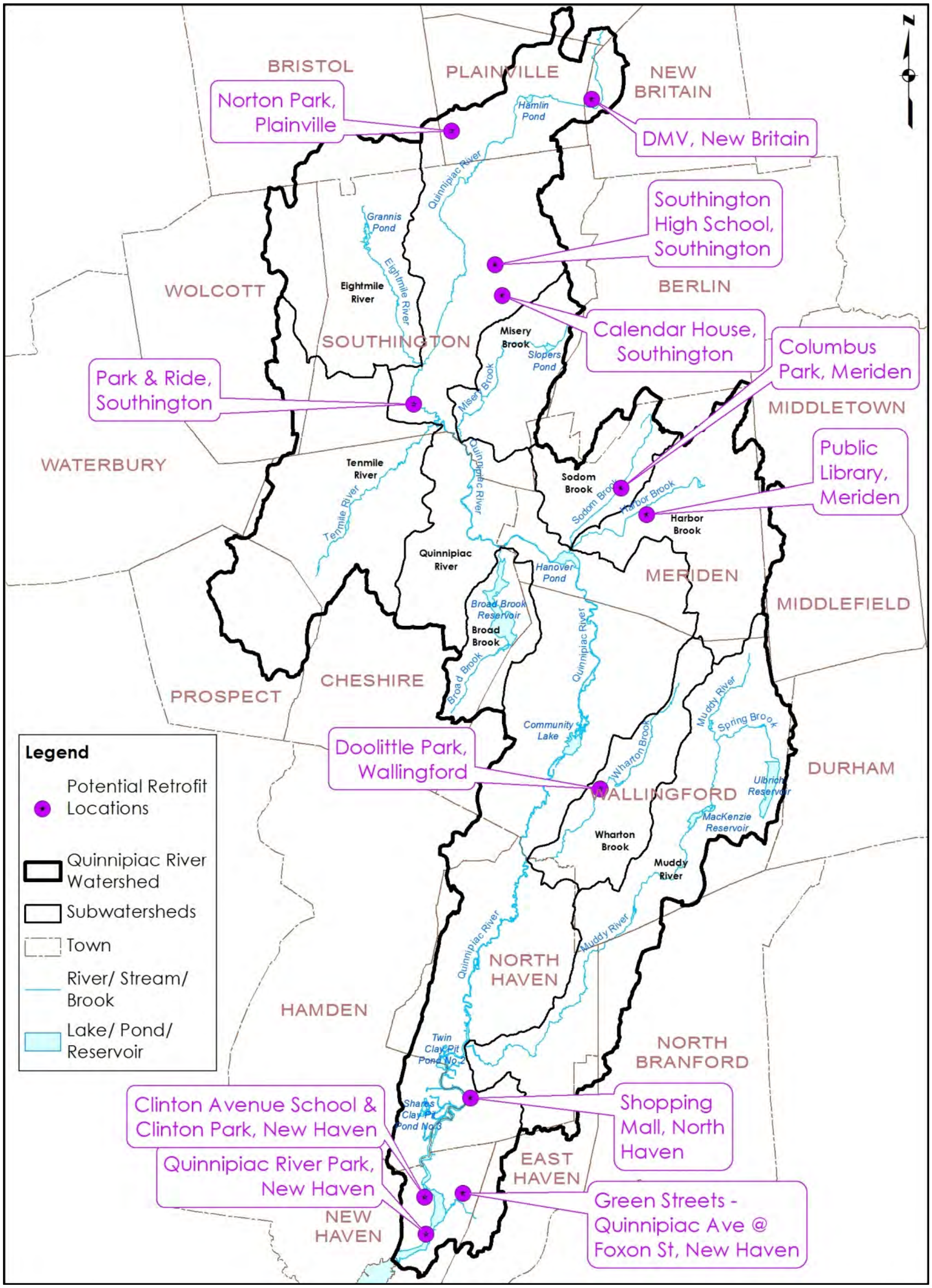


Figure 2.1 Site-Specific Project Locations

2.1 Quinnipiac River Park, New Haven

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 2.1.1,* and is likely caused by wave action from Hurricane Sandy and is being exacerbated by stormwater runoff from Front Street and upland areas.

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

Figure 2.1.1. Shoreline Erosions and Erosion on Walkways at Quinnipiac River Park

The proposed concept for this site, shown in *Figures 2.1.2 and 2.1.3,* 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:

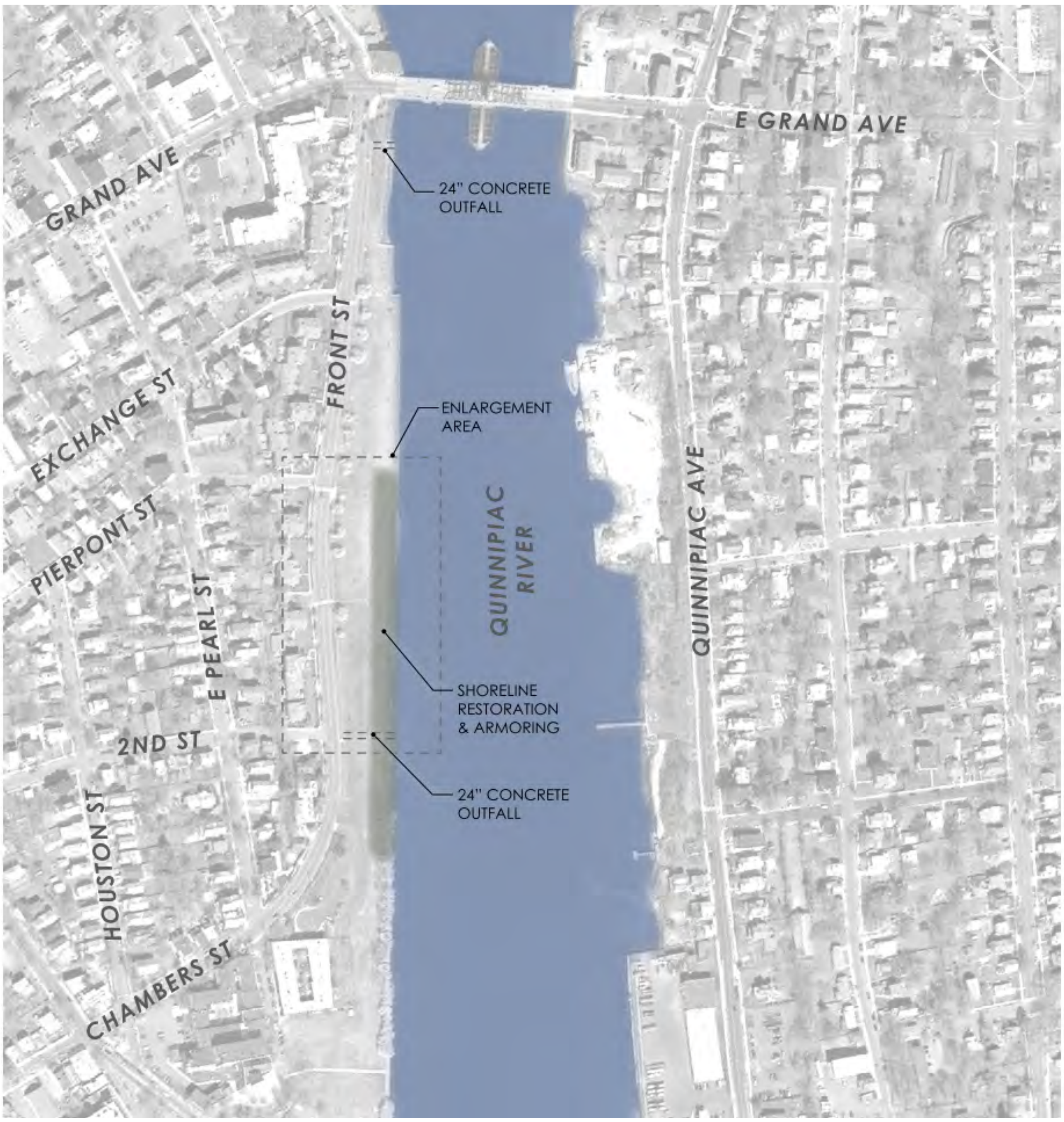


Figure 2.1.2. Quinnipiac River Park Green Infrastructure Retrofit Concept

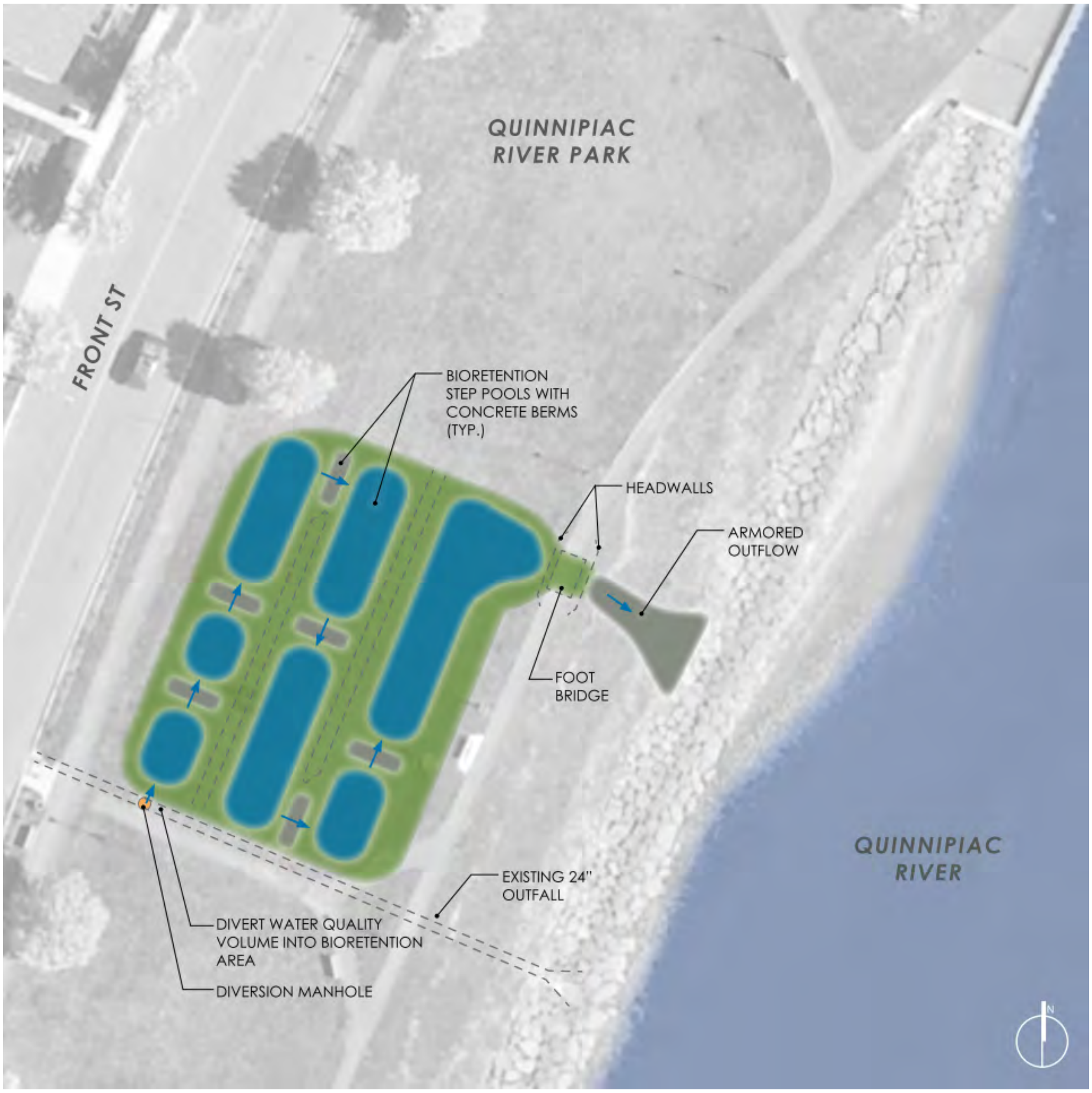
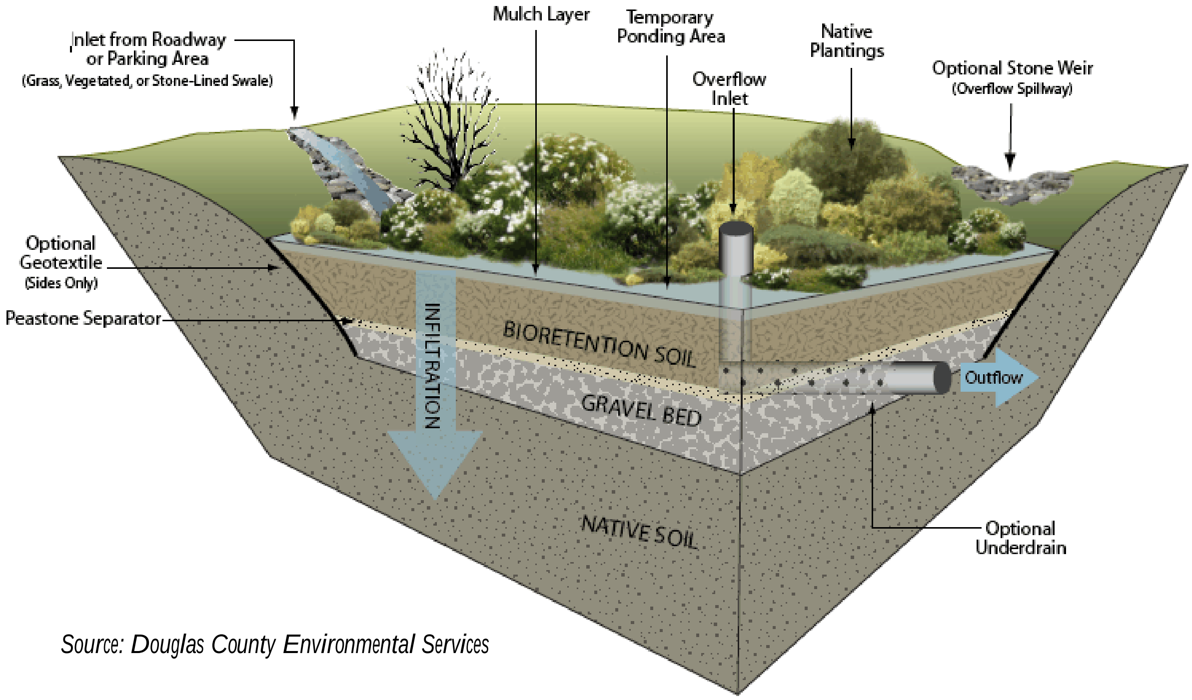


Figure 2.1.3. Enlargement Area for Quinnipiac River Park Green Infrastructure Retrofit Concept

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 2.1.4*. A visualization of several step pools of the proposed system is shown in *Figure 2.1.5.*



Source: Douglas County Environmental Services

Figure 2.1.4. Typical Bioretention Design

Figure 2.1.5. 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 2.1.1*, 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.

2.2 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 *Figure 2.2.1* 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 2.1.* 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 2.2.2*.

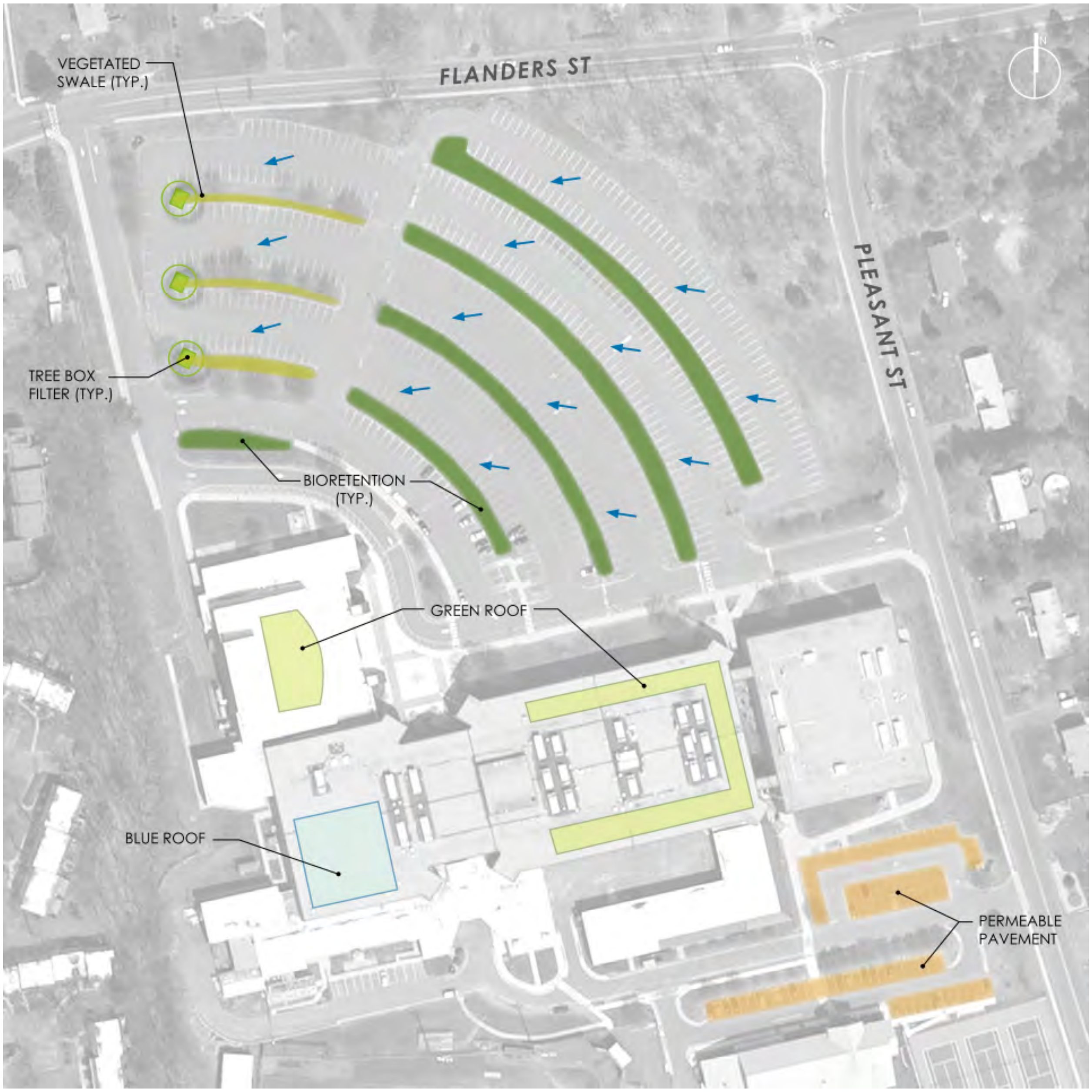


Figure 2.2.1. Southington High School Green Infrastructure Retrofit Concept

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, as shown in *Figures 2.2.3 and 2.2.4*.

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 2.3*. Porous asphalt could be used at this site to minimize costs.

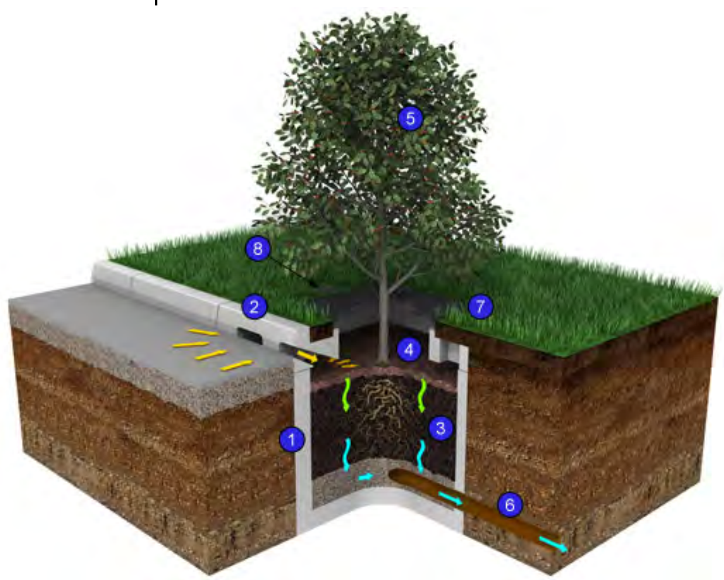


Figure 2.2.2. Typical Tree Box Filter (Source: Hydro International, Inc.)

Figure 2.2.3. Modular Green Roof System Installation

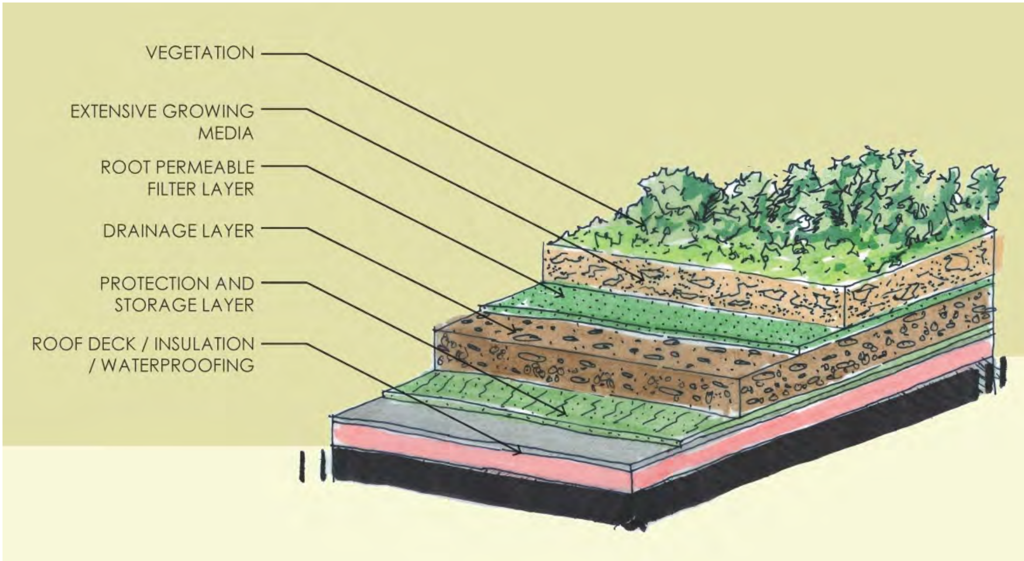


Figure 2.2.4. Typical Green Roof Design

Figure 2.2.5. Existing and Proposed Visualization for the Parking Island Bioretention Areas

2.3 Clinton Avenue School and Clinton Fields, New Haven

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.

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

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/yeard 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 2.3.2).* Permeable pavement material should be selected based on the characteristics of the site and the application, as well as cost and maintenance considerations.

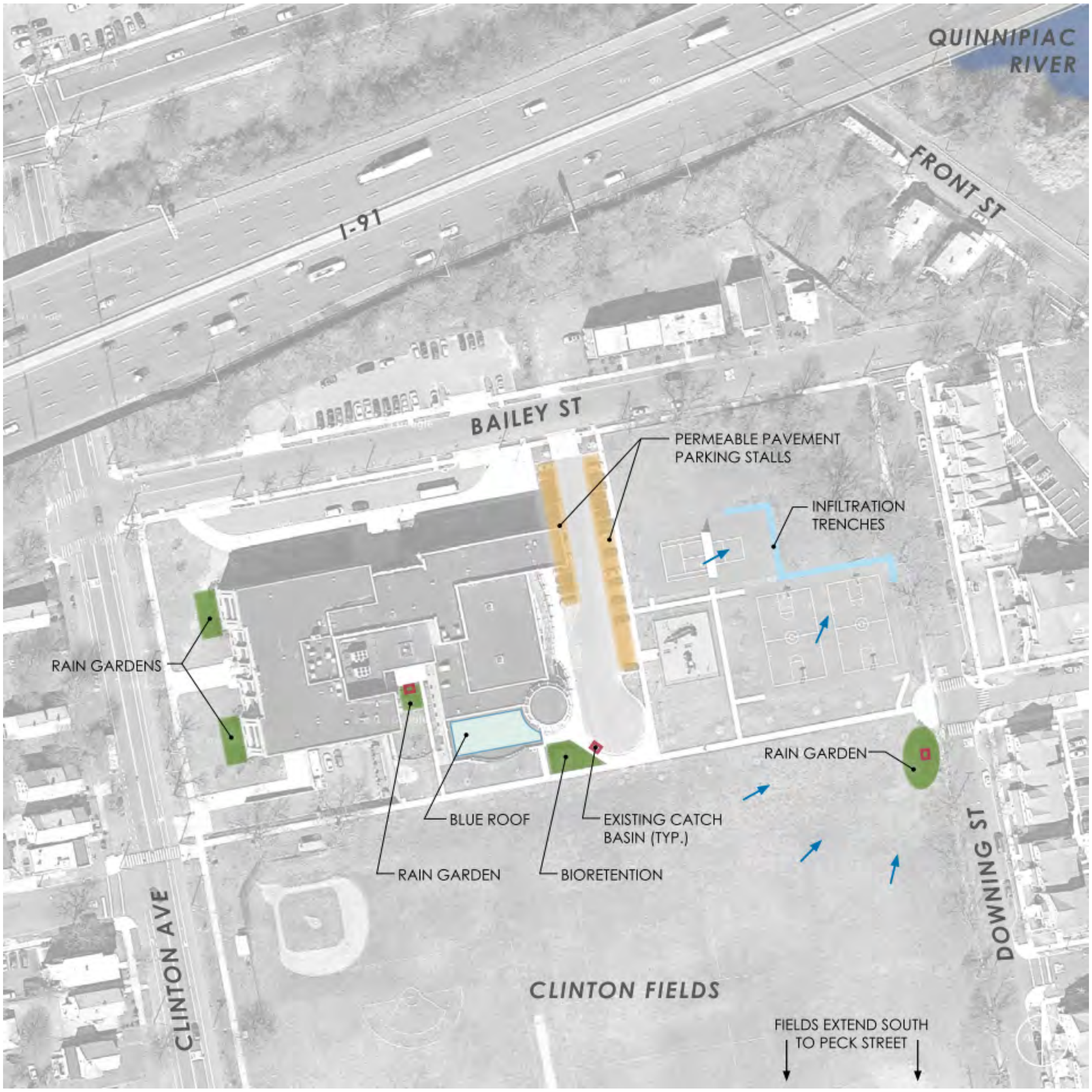


Figure 2.3.1. Clinton Avenue School and Clinton Fields Green Infrastructure Retrofit Concept

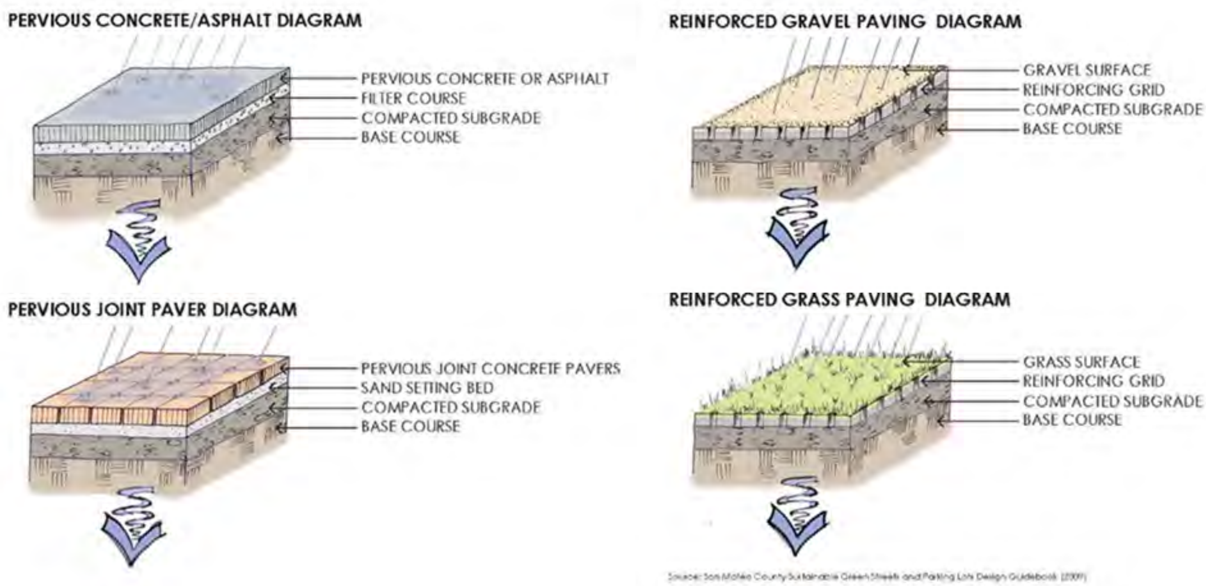


Figure 2.3.2. Diagrams of Selected Permeable Pavement Systems

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.

2.4 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 2.4.1)* 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 2.4.1. 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 2.4.2* shows a typical detail of a green street parking bay.

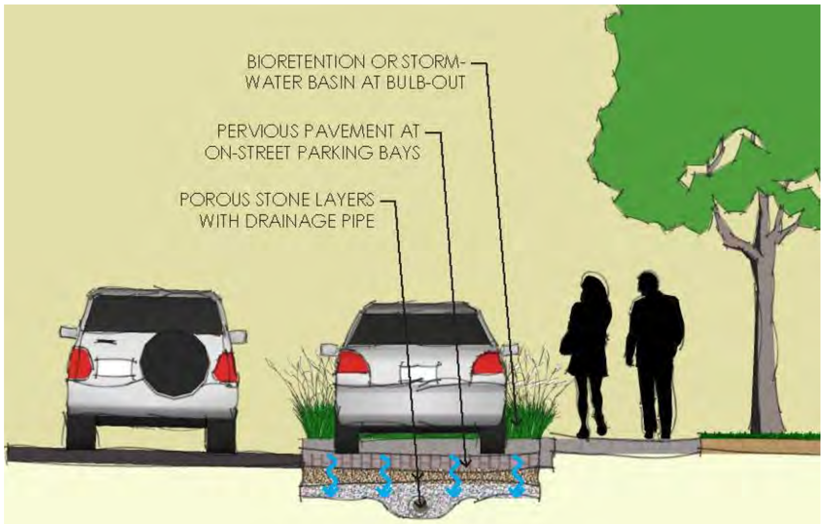


Figure 2.4.2. Typical Green Street Parking Bay

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 2.4.3*. 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.

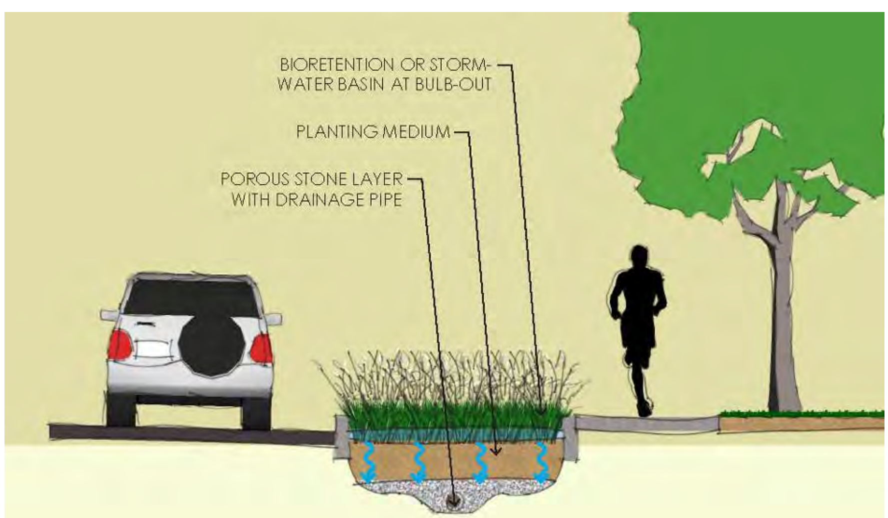


Figure 2.4.3. Typical Green Street Bioretention Bulb-out

2.5 Calendar House, Southington

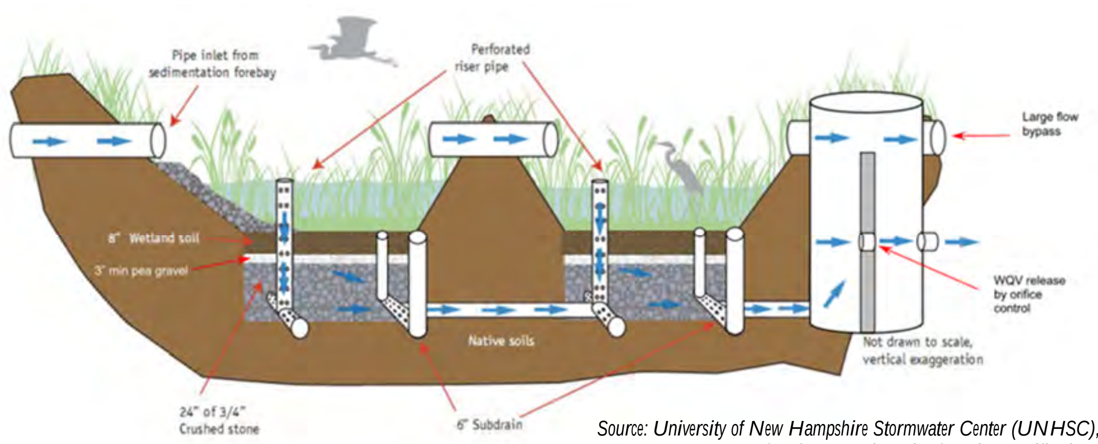
The Calendar House is home to the Southington Senior Center located at the corner of Pleasant Street and Hobart Street in Southington. The parking lot was recently reconstructed and consists of traditional drainage structures including catch basins and piped drainage that are believed to drain to a dry 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 2.5.2)*. 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 2.5.1)*. 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 2.5.1. Typical Subsurface Gravel Wetland Design

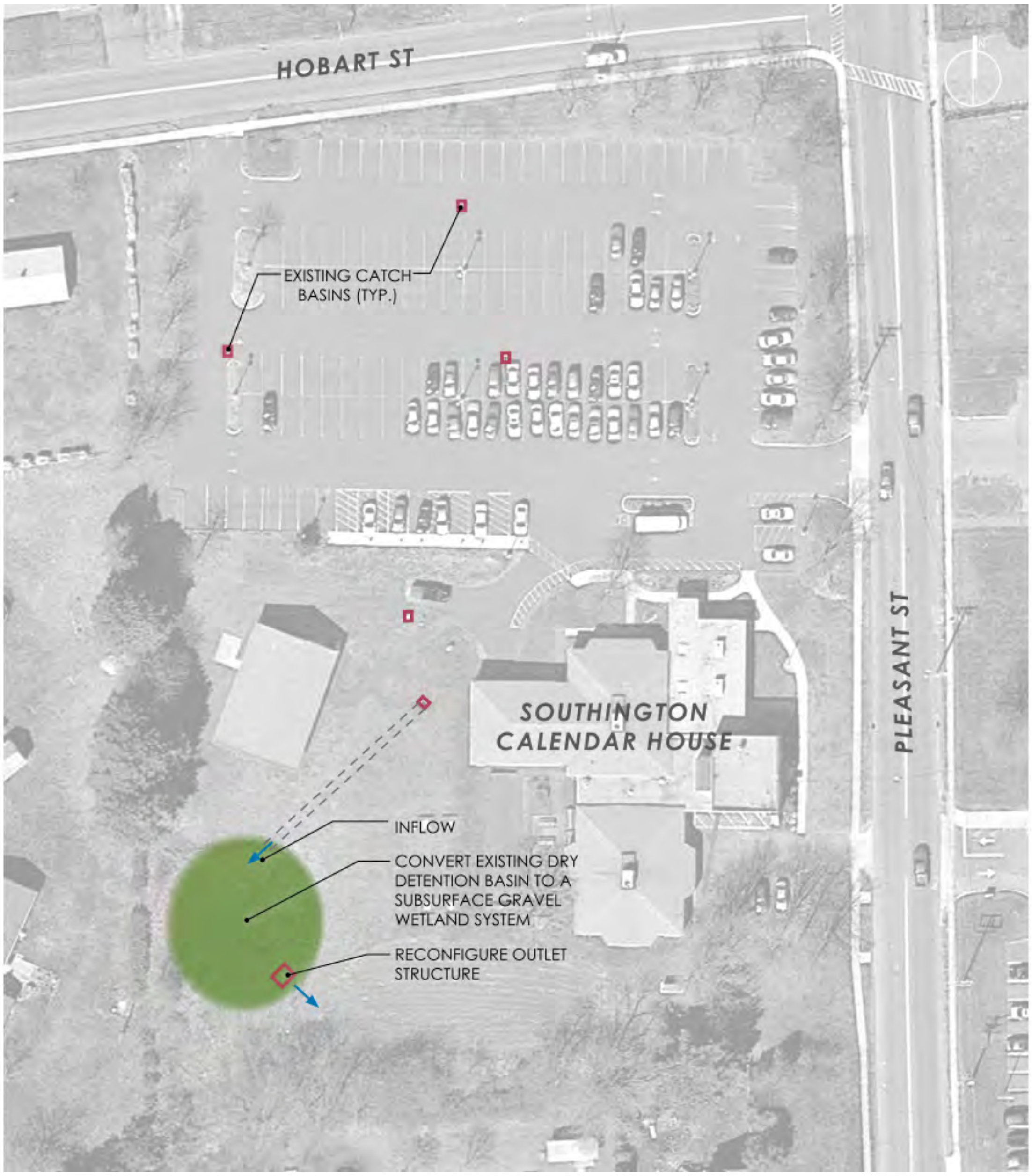


Figure 2.5.2. Calendar House Green Infrastructure Retrofit Concept

2.6 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 2.6.1*, 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 2.6.1. 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 2.6.2)*. Japanese knotweed is considered shade intolerant and is therefore unlikely to grow under closed tree canopy, mititgating the growth of future knotweed vegetation.

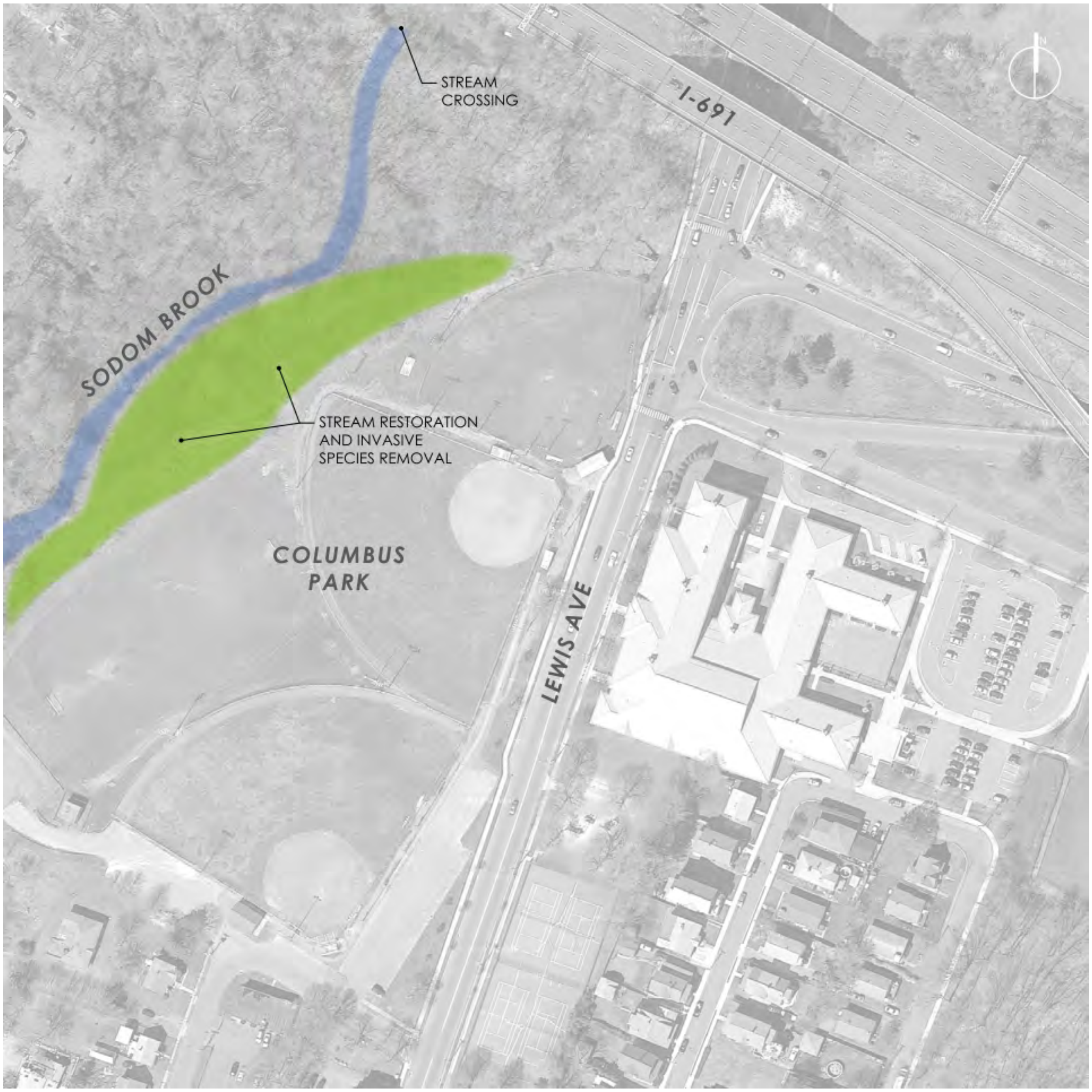


Figure 2.6.2. Columbus Park Stream Restoration Concept

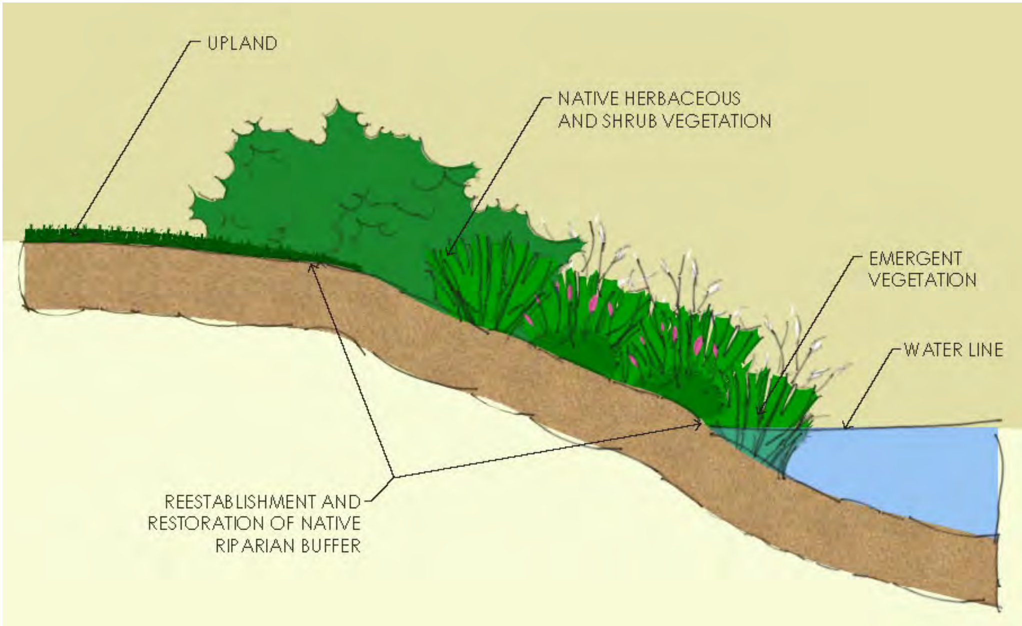


Figure 2.6.3. Typical Bank Restoration Planting for Small Streams

A typical bank restoration planting for small streams is shown in *Figure 2.6.3*. 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.

2.7 Department of Motor Vehicles Office, New Britain

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:

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

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.

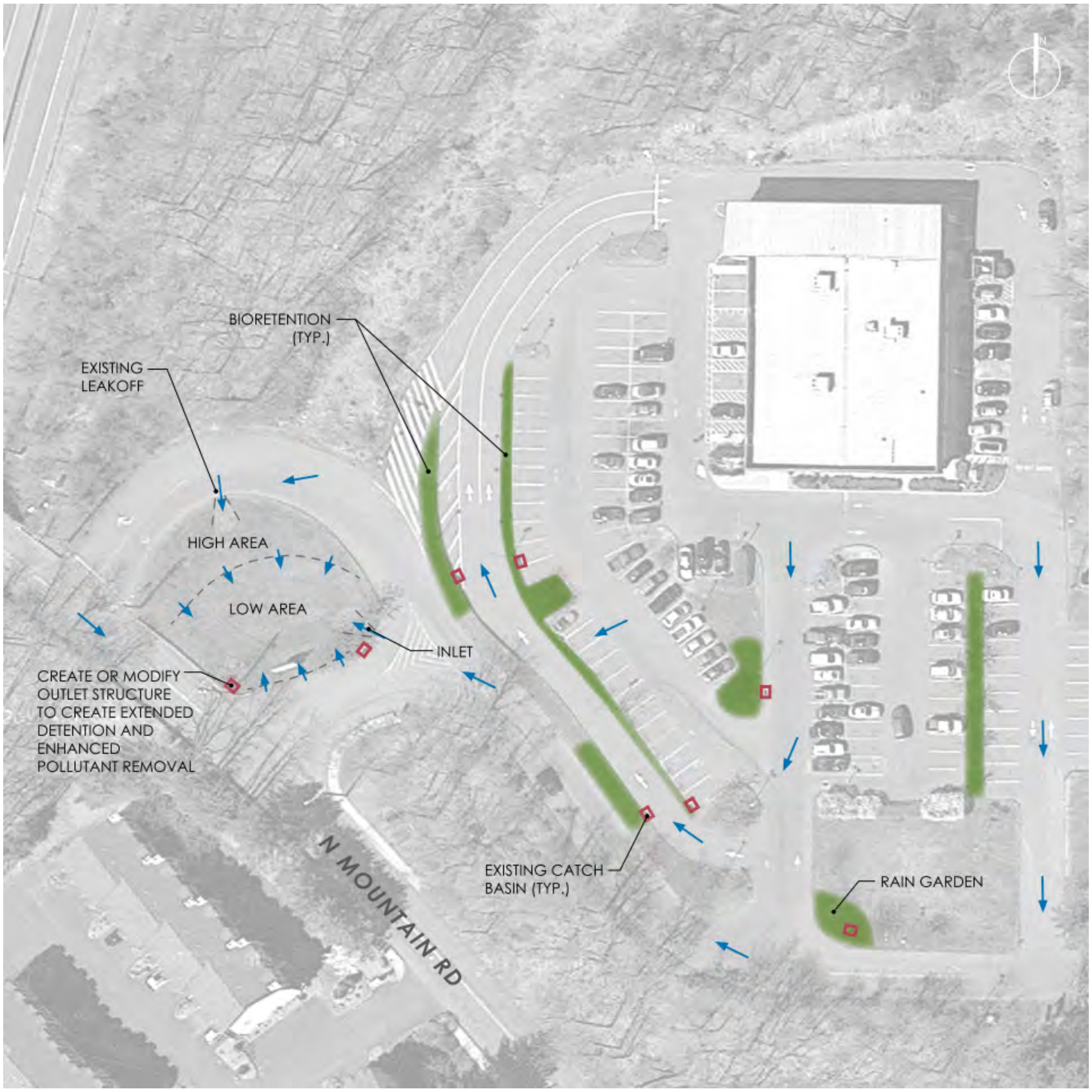
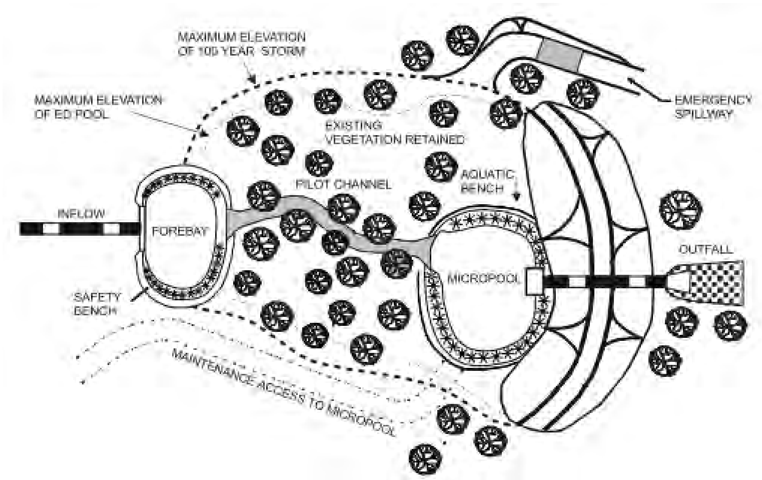


Figure 2.7.1. New Britain DMV Green Infrastructure Retrofit Concept

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 2.7.2)*.



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

Figure 2.7.2. Micropool Detention Pond Typical Design

2.8 Doolittle Park, Wallingford

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 2.8.1)*:

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

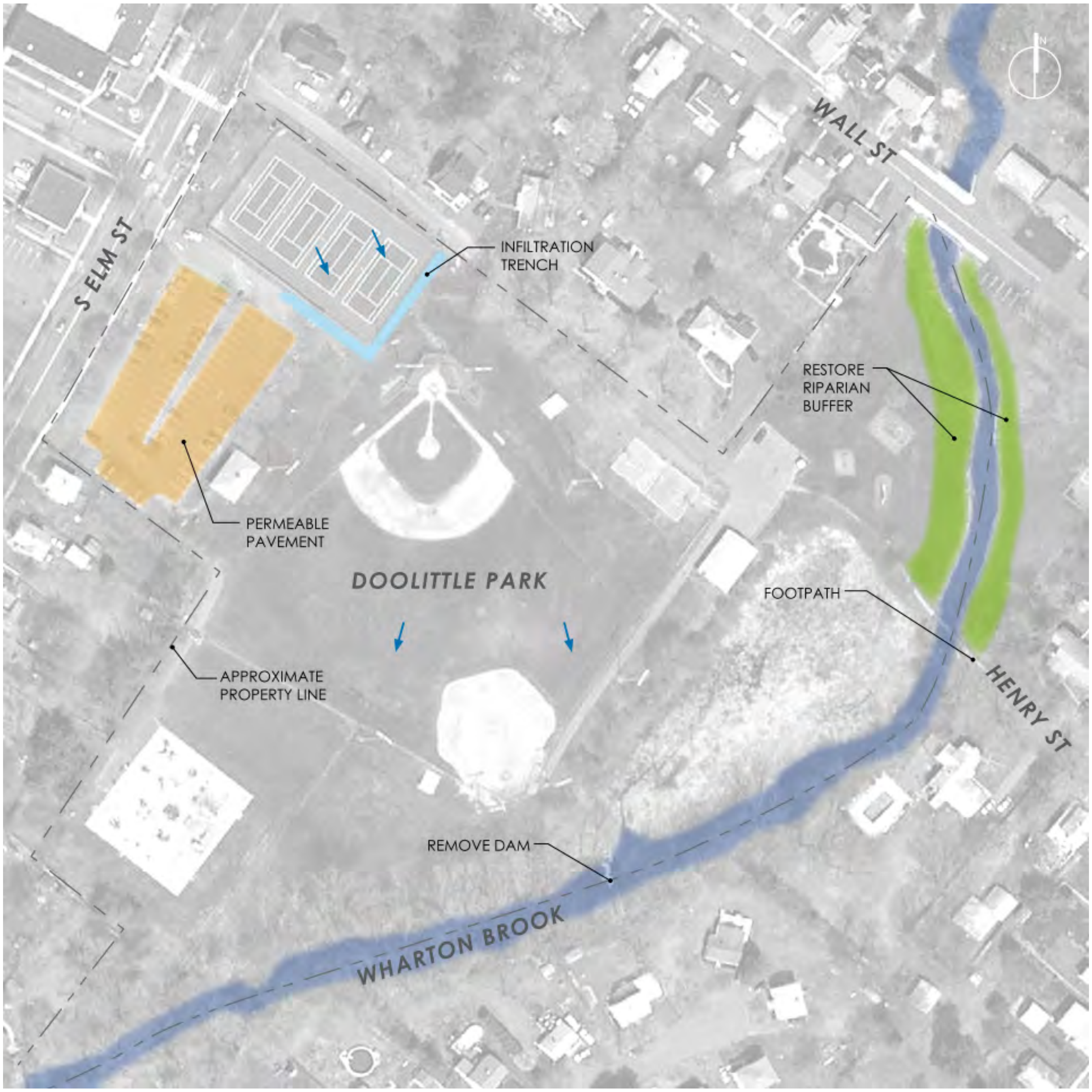


Figure 2.8.1. Doolittle Park Green Infrastructure Retrofit Concept

Reinforced Gravel Parking: Reinforced gravel parking (a type of permeable pavement, see *Section 2.3)* 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 2.8.2* shows a conceptual visualization of the proposed buffer restoration along the stream. The addition of trees would help shade the stream and decrease water temperatures.

Figure 2.8.2. 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 2.8.3)*. 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 2.8.3. Small Dam on Wharton Brook

2.9 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 2.9.1*). 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 2.9.2*.

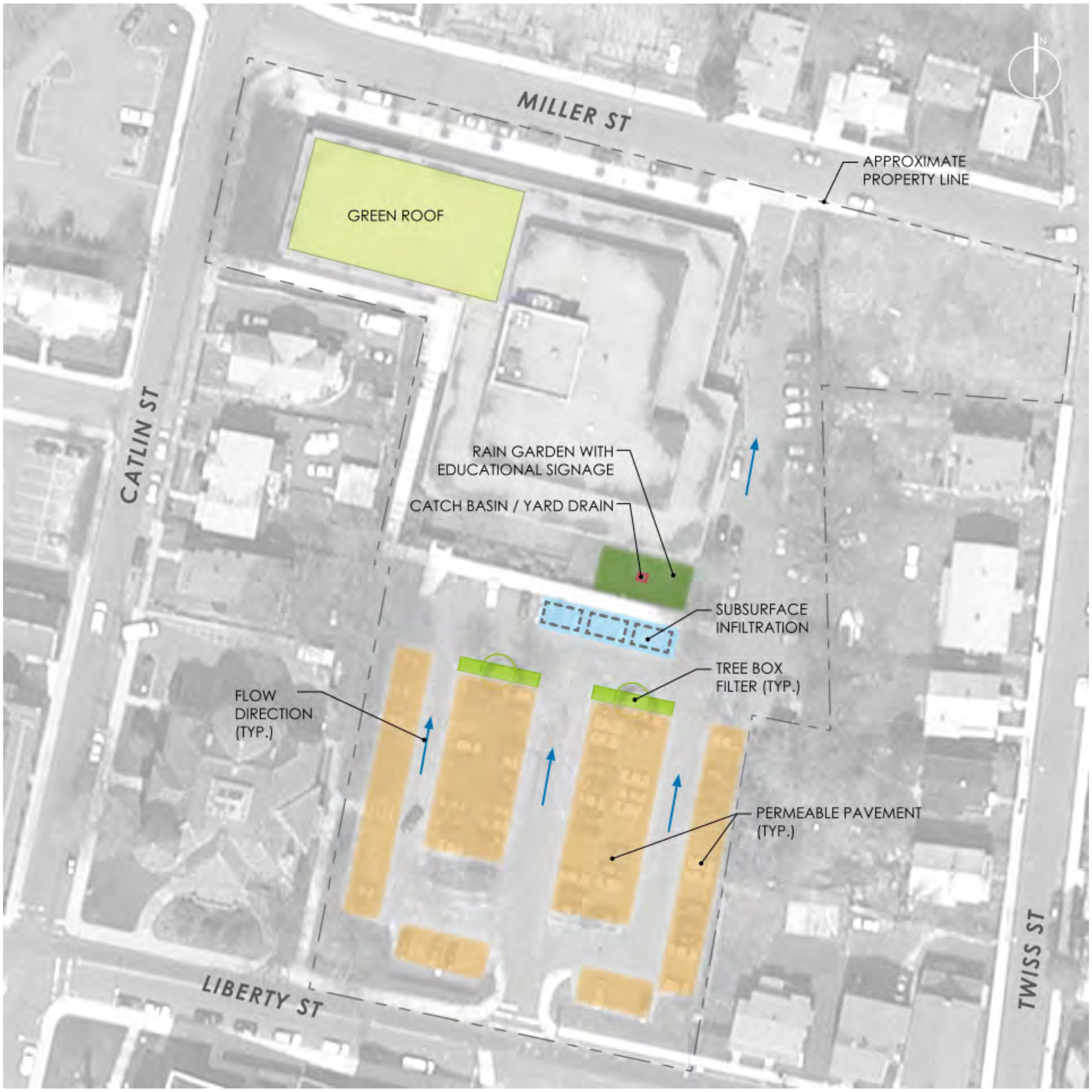
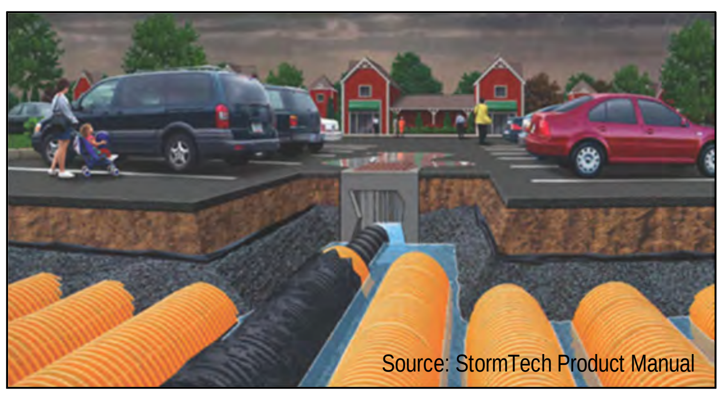


Figure 2.9.1. Meriden Public Library Green Infrastructure Retrofit Concept

Figure 2.9.2. Existing and Proposed Visualization for the Meriden Public Library Rain Garden


Source: StormTech Product Manual

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.

2.10 Norton Park, Plainville

Norton Park is located at 72 Norton Trail in Plainville just off South Washington Street, across from Prior Avenue. The park is approximately 63 acres and includes baseball, tennis and soccer fields, a water park, playscapes, picnic areas, and open space. The former New Haven and Northampton Canal flows along the western boundary of the site, which is accessible to the public from the park. A pavilion is located along the former canal, which is an ideal location to place educational signage. The former canal parallels a small tributary to the Quinnipiac River and discharges to the main stem approximately 1.5 miles downstream of Norton Park.

Norton Park Retrofit

Location:
72 Norton Trail, Plainville

Objectives:
Restore stream habitat and improve water quality from parking areas

Essential Elements:
Stream buffer restoration and invasive species removal, parking lot improvements including filter strips and bioretention/biofiltration

Estimated Cost: $27,000–$56,000

Stream Buffer Restoration. Although this site is relatively far from the main stem Quinnipiac River, it provides an ideal opportunity to educate the public at a popular public park in Plainville. There is little riparian buffer along the banks of the former canal *(Figure 2.10.2)*.

Figure 2.10.1. Riparian Buffer Encroachment at Norton Park

Parking Lot Improvements. The existing parking lot could be retrofitted with a filter strip and bioretention/biofiltration to capture, treat, and infiltrate stormwater prior to reaching the stream. These improvements could significantly reduce the stormwater contribution of this parking lot to the stream during most storms.

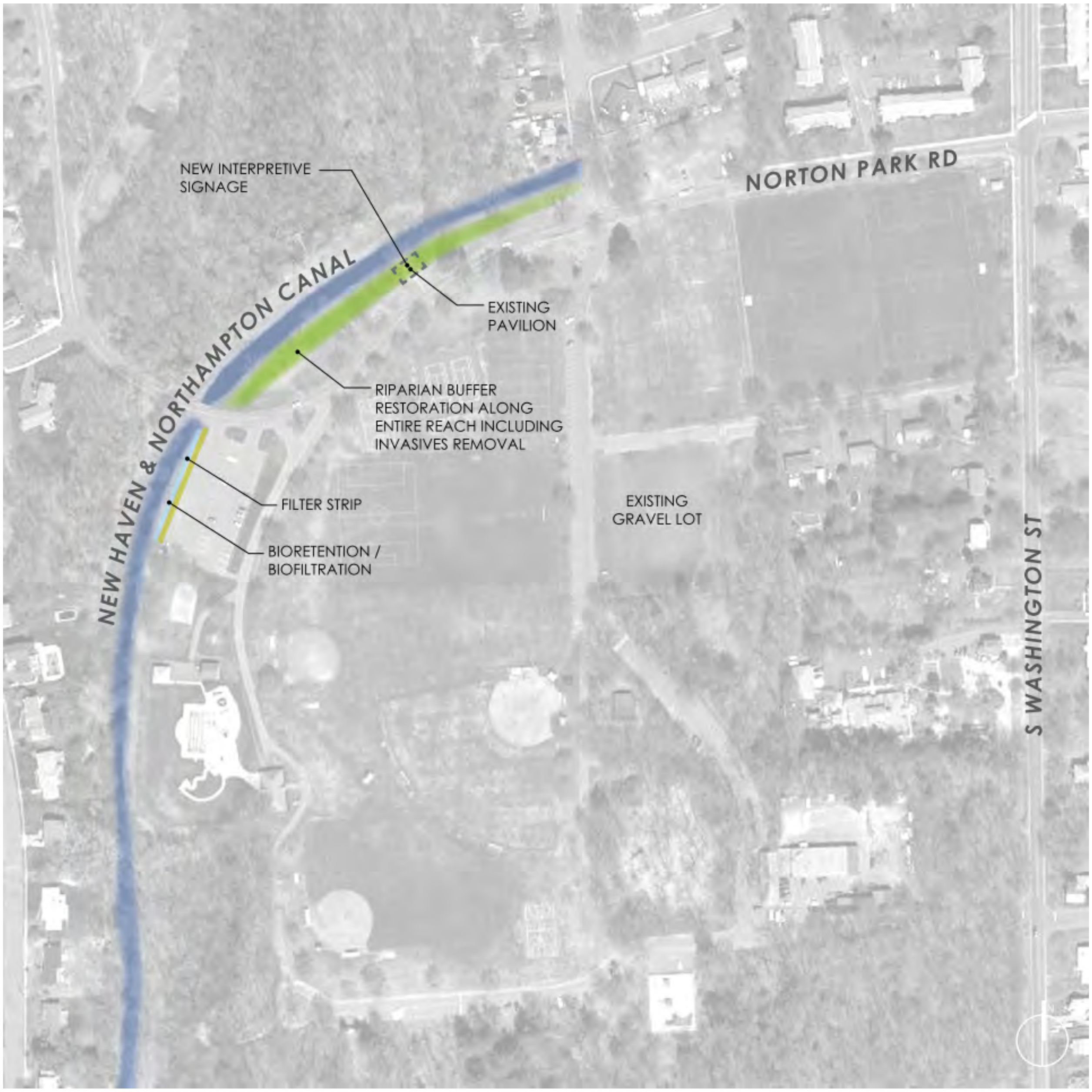


Figure 2.10.2. Norton Park Green Infrastructure Retrofit Concept

2.11 Park & Ride, Southington

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

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 west toward a degraded swale with some wetland vegetation *(Figure 2.11.2)*. 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 2.11.1 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 2.11.2. Existing Conveyance Channel at the Park & Ride

2.12 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 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 2.12.1*:

Figure 2.12.1. 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 avoidregrading 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.

3 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 1* summarizes potential green infrastructure retrofit sites, in addition to the concepts presented in *Section 2,* that were identified during the desktop screening-level review, field inventories, and during the community workshops.

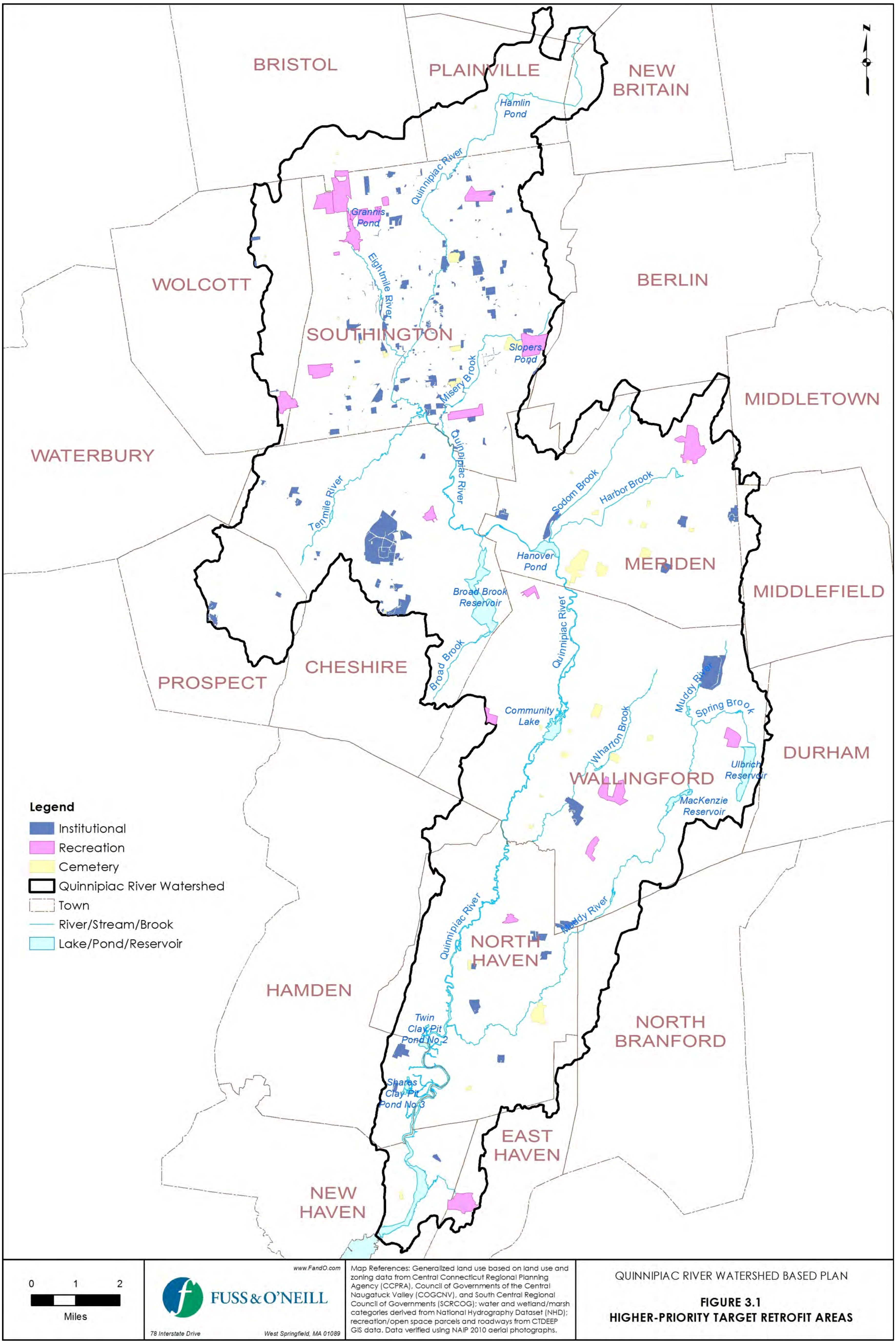
Table 3.1. Other Potential Green Infrastructure Retrofits

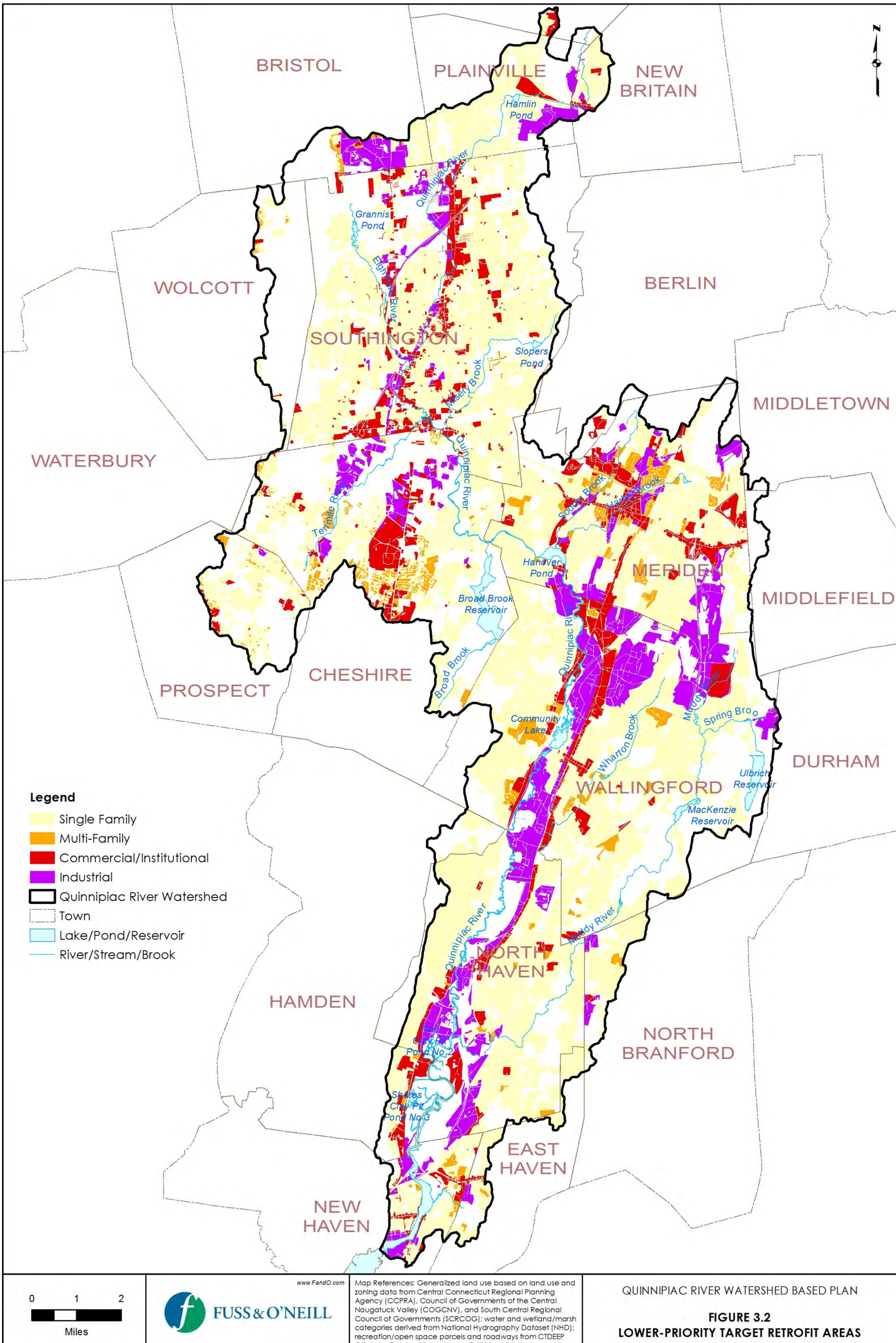
Site	Land Use	Town	Description/Potential Retrofits
Gulf Gas Station, Route 322	Commercial	Cheshire	Gas station adjacent to Quinnipiac River; non-infiltration LID practices could be implemented to treat stormwater runoff from parking lot.
Castle Heights	Residential	Cheshire	Construction was underway during 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.

Site	Land Use	Town	Description/Potential Retrofits
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.
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.
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.

Site	Land Use	Town	Description/Potential Retrofits
Wharton Brook State Park	Recreation	North Haven	Remove invasive species, stream cleanup (trash in stream), restore riparian buffer; restore eroded banks.
Connecticut Commons Shopping Center (Kings Plaza)	Commercial	Plainville	Retrofit existing stormwater pond for additional detention and enhanced sediment removal. Site is almost entirely impervious and LID (bioretention, permeable pavement) could be implemented in parking areas.
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.
Southington Shopping Center & Southington 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.

Site	Land Use	Town	Description/Potential Retrofits
Jennings Trailer Park, Aircraft Road	Residential	Southington	Stream restoration and riparian buffer improvements to replace existing lawn/turf along stream corridor.
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.
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 runoff 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
WOLCOTT
BERLIN
SOUTHINGTON
MIDDLETOWN
WATERBURY
MERIDEN
MIDDLEFIELD
CHESHIRE
PROSPECT
DURHAM
WALLINGFORD
NORTH HAVEN
HAMDEN
NORTH BRANFORD
EAST HAVEN
NEW HAVEN
Hamlin Pond
Quinnipiac River
Grannis Pond
Eightmile River
Slopers Pond
Misery Brook
Tenmile River
Sodom Brook
Harbor Brook
Hanover Pond
Broad Brook Reservoir
Broad Brook
Community Lake
Muddy River
Spring Brook
Wharton Brook
Ulbrich Reservoir
MacKenzie Reservoir
Twin Clay Pit Pond No.2
Shares Clay Pit Pond No 3
Legend
Institutional
Recreation
Cemetery
Quinnipiac River Watershed
Town
River/Stream/Brook
Lake/Pond/Reservoir
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 (CCRPA), 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 3.1
HIGHER-PRIORITY TARGET RETROFIT AREAS



QUINNIPIAC RIVER WATERSHED BASED PLAN

FIGURE 3.2
LOWER-PRIORITY TARGET RETROFIT AREAS

Appendix A

Site-Specific Project Cost Estimates

Order of Magniude Cost Range

Location and Element	Construction				Design and Planning		Cost Range			Life Cycle				
	Unit Cost	Unit	Quantity	Cost (2013$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Quinnipiac River Park, New Haven														
1 Bioretention Area - Step Pools	$12.19	cf of runoff treated	7,800	$95,110	30%	$28,530	$124,000	$87,000	$186,000	15	$11,150	4%	$450	$11,600
2 Diversion Manhole	$2,500	ea	1	$2,500	30%	$750	$4,000	$3,000	$6,000	15	$360	4%	$10	$370
3 Armored Outflow Channel	$45.72	CY	24	$1,118	30%	$340	$2,000	$1,000	$3,000	30	$120	4%	$0	$120
4 Bank Restoration and Armoring	$45.72	CY	593	$27,093	30%	$8,130	$36,000	$25,000	$54,000	30	$2,080	2%	$40	$2,120
						Total	**$166,000**	**$116,000**	**$249,000**					
Southington High School, Southington														
1 Bioretention Islands	$33.02	sf	4,035	$133,246	30%	$39,970	$174,000	$122,000	$261,000	15	$15,650	4%	$630	$16,280
2 Vegetated Swales	$10.16	sf	1,470	$14,935	30%	$4,480	$20,000	$14,000	$30,000	15	$1,800	4%	$70	$1,870
3 Green Roof	$23.37	sf	19,500	$455,676	30%	$136,700	$593,000	$415,000	$890,000	20	$43,630	4%	$1,750	$45,380
4 Blue Roof	$5.08	sf	7,600	$38,608	30%	$11,580	$51,000	$36,000	$77,000	20	$3,750	4%	$150	$3,900
5 Tree Box	$6,096	ea	3	$18,288	30%	$5,490	$24,000	$17,000	$36,000	20	$1,770	4%	$70	$1,840
6 Porous Asphalt	$2.84	sf	16,300	$46,370	30%	$13,910	$61,000	$43,000	$92,000	20	$4,490	4%	$180	$4,670
						Total	**$923,000**	**$647,000**	**$1,386,000**					
Clinton Avenue School and Clinton Park, New Haven														
1 Bioretention Area	$33.02	sf	366	$12,077	30%	$3,620	$16,000	$11,000	$24,000	15	$1,440	4%	$60	$1,500
2 Rain Gardens	$7.40	sf	1,128	$8,340	30%	$2,500	$11,000	$8,000	$17,000	15	$990	4%	$40	$1,030
3 Infiltration Trenches	$18.58	lf	300	$5,574	30%	$1,670	$8,000	$6,000	$12,000	20	$590	2%	$10	$600
4 Blue Roof	$5.08	sf	1,800	$9,144	30%	$2,740	$12,000	$8,000	$18,000	20	$880	2%	$20	$900
5 Permeable Pavers	$10.16	sf	17,760	$180,442	30%	$54,130	$235,000	$165,000	$353,000	20	$17,290	4%	$690	$17,980
						Total	**$282,000**	**$198,000**	**$424,000**					
Green Streets – Quinnipiac Avenue @ Foxon Street, New Haven														
1 Pervious Pavers (20 spaces)	$10.16	sf	2,240	$22,758	30%	$6,830	$30,000	$21,000	$45,000	20	$2,210	4%	$90	$2,300
2 Bioretention Areas	$33.02	sf	1,120	$36,982	30%	$11,090	$49,000	$34,000	$74,000	15	$4,410	4%	$180	$4,590
3 Tree Box	$6,096	ea	10	$60,960	30%	$18,290	$80,000	$56,000	$120,000	20	$5,890	4%	$240	$6,130
						Total	**$159,000**	**$111,000**	**$239,000**					
Calendar House, Southington														
1 Subsurface Gravel Wetland	$22.18	cf of runoff treated	5,366	$119,010	30%	$35,700	$155,000	$109,000	$233,000	30	$8,960	4%	$360	$9,320
2 Outlet Structure	$4,500	ea	1	$4,500	30%	$1,350	$6,000	$4,000	$9,000	30	$350	2%	$10	$360
						Total	**$161,000**	**$113,000**	**$242,000**					
Columbus Park, Meriden														
1 Invasive Species Control	$3,401	acre	4.0	$13,603	30%	$4,080	$18,000	$13,000	$27,000	2	$9,540	4%	$380	$9,920
2 Stream Restoration	$13,106	ac	4.0	$52,425	30%	$15,730	$69,000	$48,000	$104,000	15	$6,210	4%	$250	$6,460
						Total	**$87,000**	**$61,000**	**$131,000**					

Order of Magniude Cost Range														
	Construction				Design and Planning		Cost Range			Life Cycle				
Location and Element	Unit Cost	Unit	Quantity	Cost (2013$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Department of Motor Vehicles Office, New Britain														
1 Bioretention Areas and Rain Garden	$33.02	sf	1,147	$37,877	30%	$11,360	$50,000	$35,000	$75,000	15	$4,500	4%	$180	$4,680
2 Detention Basin Restoration	$12,890.43	impervious acre of runoff treated	2.4	$30,937	30%	$9,280	$41,000	$29,000	$62,000	30	$2,370	4%	$90	$2,460
3 Outlet Structure	$4,500	ea	1	$4,500	30%	$1,350	$6,000	$4,000	$9,000	30	$350	2%	$10	$360
						Total	**$97,000**	**$68,000**	**$146,000**					
Doolittle Park, Wallingford														
1 Reinforced Gravel Parking	$5.07	sf	14,840	$75,235	30%	$22,570	$98,000	$69,000	$147,000	20	$7,210	2%	$140	$7,350
2 Infiltration Trenches	$18.58	lf	200	$3,716	30%	$1,110	$5,000	$4,000	$8,000	20	$370	2%	$10	$380
3 Riparian Buffer Restoration	$11,204	ac	0.85	$9,523	30%	$2,860	$13,000	$9,000	$20,000	15	$1,170	4%	$50	$1,220
4 Dam Removal	$18,278	ea	1	$18,278	60%	$10,970	$30,000	$21,000	$45,000	100	$1,220	0%	$0	$1,220
						Total	**$146,000**	**$103,000**	**$220,000**					
Public Library, Meriden														
1 Rain Garden	$7.40	sf	2,000	$14,793	30%	$4,440	$20,000	$14,000	$30,000	15	$1,800	4%	$70	$1,870
2 Educational Signage	$1,200	ea	1	$1,200	30%	$360	$2,000	$1,000	$3,000	10	$250	2%	$10	$260
3 Subsurface Infiltration System	$37	cf of runoff treated	2,711	$99,580	30%	$29,870	$130,000	$91,000	$195,000	20	$9,570	4%	$380	$9,950
4 Porous Asphalt	$2.84	sf	20,000	$56,896	30%	$17,070	$74,000	$52,000	$111,000	20	$5,450	4%	$220	$5,670
5 Tree Box	$6,096	ea	2	$12,192	30%	$3,660	$16,000	$11,000	$24,000	20	$1,180	2%	$20	$1,200
6 Green Roof	$23.37	sf	2,000	$46,736	30%	$14,020	$61,000	$43,000	$92,000	20	$4,490	4%	$180	$4,670
						Total	**$303,000**	**$212,000**	**$455,000**					
Norton Park, Plainville														
1 Riparian Buffer Restoration	$11,204	ac	1.6	$17,926	30%	$5,380	$24,000	$17,000	$36,000	15	$2,160	4%	$90	$2,250
3 Filter Strip	$10.16	sf	600	$6,096	30%	$1,830	$8,000	$6,000	$12,000	20	$590	4%	$20	$610
4 Infiltration Trench	$18.58	lf	200	$3,716	30%	$1,110	$5,000	$4,000	$8,000	20	$370	4%	$10	$380
						Total	**$37,000**	**$27,000**	**$56,000**					
Park & Ride, Southington														
1 Water Quality Swale	$10.16	sf	1,230	$12,497	30%	$3,750	$17,000	$12,000	$26,000	15	$1,530	4%	$60	$1,590
2 Constructed Wetland	$4.38	sf	2,000	$8,756	30%	$2,630	$12,000	$8,000	$18,000	15	$1,080	4%	$40	$1,120
						Total	**$29,000**	**$20,000**	**$44,000**					
2.12 Commercial Development, North Haven														
1 Bioretention Parking Islands	$33.02	sf	12,640	$417,373	30%	$125,210	$543,000	$380,000	$815,000	15	$48,840	4%	$1,950	$50,790
						Total	**$543,000**	**$380,000**	**$815,000**					

Notes:
Rate of Inflation used = $0.02
Interest (discount) rate used = $0.06
*Projects are proposed for these locations already. Costs estimated in this table are for adding ecological and water quality elements to the assumed original purpose of the proposed projects.
Costs should be used for planning purposes only based on screening-level evaluations of site characteristics. Construction costs could vary significantly.

Unit Costs Table

Element	2013 Adjusted Cost	Unit	Cost	$YEAR	Source
Green Infrastructure Elements					
Large Bioretention Retrofit	$ 12.19	cf of runoff treated	$ 10.50	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-3
Small Bioretention Retrofit (<0.5 acre)	$ 33.02	sf	$ 32.50	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Rain Garden	$ 7.40	sf	$ 7.28	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Water Quality Swale	$ 10.16	sf	$ 10.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Porous Asphalt	$ 2.84	sf	$ 2.80	2012	UNH Stormwater Center 2012 Biennial Report. Page 12
Permeable Pavers	$ 10.16	sf	$ 10.00	2012	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-5
Reinforced Gravel Parking	$ 5.07	sf	$ 5.07	2013	http://www.boddingtonsonline.com/products/grass-ground-reinforcement/grass-reinforcement-protection/bodpave-85-permeable-gravel-pavers.php; Added $2/sf for installation
Subsurface Infiltration Chambers	$ 36.73	cf of runoff treated	$ 36.15	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Green Roof	$ 23.37	sf	$ 23.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Blue Roof	$ 5.08	sf	$ 5.00	2012	NYC Department of Environmental Protection (2012), Rooftop Detention: A Low-Cost Alternative for Complying with New York City's Stormwater Detention Requirements and Reducing Urban Runoff.
Subsurface Gravel Wetland	$ 22.18	cf of runoff treated	$ 21.83	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Pond Retrofit	$ 12,890.43	impervious acre of runoff treated	$ 11,100.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-2
French Drain/Infiltration Trench	$ 18.58	lf	$ 16.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Tree Box	$ 6,096.00	ea	$ 6,000.00	2012	UNH Stormwater Center 2012 Biennial Report
Constructed Wetland	$ 4.38	sf	$ 3.77	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Restoration Elements					
Riparian Buffer Restoration	$ 11,204.05	ac	$ 10,543	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Stream Channel Restoration	$ 13,106.28	ac	$ 12,333	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Remove Invasive Species	$ 3,400.64	acre	$ 3,200	2010	Professional Engineering Experience
Construction Elements					
6" to 12" Rip Rap	$ 45.72	CY	$ 45.00	2012	Professional Engineering Experience
Outlet Structure	$ 4,500	ea	$ 4,500	2013	Professional Engineering Experience
Manhole	$ 2,500	ea	$ 2,500	2013	Professional Engineering Experience
Dam Removal	$ 18,278.44	ea	$ 17,200	2010	Selle, Andy (2010). Dam Removal – A Primer, Presentation; $17,200 is median for dams 1-3 feet high.
Educational Signage	$ 1,200	ea	$ 1,200	2013	Professional Engineering Experience

Inflation Rates Table

Inflation from	Inflation to	Percent
2006	2013	16.13%
2010	2013	6.27%
2011	2013	4.57%
2012	2013	1.6%

Appendix B

Stakeholder Questionnaire Responses

Quinnipiac River Watershed Association

Summary of QWBP Stakeholder Questionnaires
November 29, 2012 Stakeholder Meeting

Question #1 - What are your top priorities/concerns/issues?

- water quality
- Inland/Wetland quality
- stream conditions
- recreation restoration – upgrading for swimming & fishing
- ground water quality and recharge
- WTP Compliance with N&P mandates/discharge permits
- Industry compliance with discharge permits requirements
- establish feasible interventions
- change attitudes towards riparian buffers
- develop upland watershed solutions
- targeting and change attitudes about sewage treatment plants
- define land use types that target opportunities for change
- storm water management
- industrial discharges & discharge enforcements
- lawn pesticides
- Q River Greenway and Trail
- canoe trails
- river clean up of tributaries in Meriden
- sewer relocation in Hanover Pond
- strengthen buffer regulations in new construction
- coalition building in watershed
- increase work groups to monitor and encourage goals of Clean Water Act
- crisp, clear and realistic deliverables
- support and funding from DEEP/EPA/Con Dot
- Hanover Pond improvements
- Phosphorous
- Water Treatment Plant Upgrades

Question #2 - What would you most like to see as outcomes of the QWBP?

- start of plan, with quality impacts realized
- before and after photos of completed projects
- regional push for LID techniques in municipal zoning regulations
- realistic objectives and time tables to reach goals in plan
- implemental projects that can be categorized and scaled down to create feasible solutions

- less pollution and contamination
- improved flood control
- greater public access and use
- a plan to acquire undeveloped land
- broad based funding priorities

Question # 3 - If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?
If yes, Provide examples

- Yes -Input from boards and commissions (Dan Reardon, Chairman, Meriden Inland/Wetlands)
- Yes -Flood control and run off water quality improvements (Meriden's flood control plan being implemented) and some special studies of Hanover Pond contamination with Borings (Phil Ashton, Chairman, Flood Control, Meriden)

Question #4 - What can you or your organization provide to the QWBP (expertise, advice, in-kind services, etc.)

- Expert opinions and input from Inland/Wetland Commission Members (Dan Reardon, Inland/Wetlands Chair, Wallingford)
- 36 year career in public health for local and state; studied water pollution and sampling (Bob Cosgrove, past public health)
- Land use planning and ecological design (Alex Folsom, Yale)
- Expertise advise on lawn pesticides (Jerry Silbert, Watershed Partnership)
- Keep community focused on river health and act as local grass roots arm for governmental initiatives (David James QRWA Board Member)
- Flood control plan and progress on Harbor Brook (Phil Ashton)
- Involve other city managers; i.e. Southington and Plainville (Larry Kendzior)

Question #6 - What other organizations, businesses, or individuals might be interested in providing input to the QWBP?

- Reach out to business owners and civic organizations & clubs for their input
- Local and regional health districts
- Town Councils and Town Managers
- Inland/Wetland commissions
- NRCS, DEEP, USGS

Question #7 - Do you have any other ideas, advice, or words of wisdom that might be helpful?

- Increase public use to advocate for the river and the watershed
- Emphasis on science, and encourage citizen science and administrative support
- Mechanism to coordinate ALL studies in Q River including Universities

P.O. Box 2825 • Meriden, CT 06450 • (203) 237-2237 • qrwainfo@att.net

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: Daniel M. ReaRDon Organization: City wetlANDs BoarD

Position: CHairman INLAND wetlANDs E-mail: AutoWoRlDct @ YAhoo.com

Phone: 203 440-4332 Cell Phone: 203 535 5802

Street Address (for mailings): 152 DeBBie Dr. MeriDen Ct 06451

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

    1. WAter Quality
    2. Wet lAND Quality
    3. StReAm ConDitions
    4. Recreation Restoration
    5. GROUND water QuAlity anD Recharge

2. What would you most like to see as outcomes of the QWBP?

Start OF PlAN, with QuAlity Impacts Realized. BeFORE Pics, anD AFter work completeD.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

yes I Do! INLAND wet lANDS Commission

Can you provide specific examples? BOARDS and Commissions with input.

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

Expert oppinions with Commission members input from Inland wetland Commission.

5. Are you interested in volunteering in watershed activities? ___ Yes ___ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

Reach out to Bussiness owners and civic organizations + clubs for their in put into Plans.

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes _✓_ No

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: Mark S. DeVoe
Organization: Town of Plainville

Position: Director of Planning and Economic Development
E-mail: devoe@plainville-ct.gov

Phone: 860-874-8588
Cell Phone: ______

Street Address (for mailings): One Central Square
Plainville, Connecticut 06062

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

   1. Not familiar with the plan
   2. ______
   3. ______
   4. ______
   5. ______

2. What would you most like to see as outcomes of the QWBP?

Regional push for LID techniques in municipal zoning regulations.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Unsure at this time.

Can you provide specific examples? ___

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

Unsure at this point. My department resources are limited and workload has increased.

5. Are you interested in volunteering in watershed activities? ___ Yes X No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

LID

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes X No

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: ROBERT COSGROVE Organization: (RETIRED)

Position: — E-mail: bc0515@cox.net

Phone: 860-621-5790 Cell Phone: —

Street Address (for mailings): 1227 Pleasant St
Southington, CT 06489

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. WTP compliance with N + P mandates/dischg. permits
2. industry compliance with dischg. permit reg.
3. upgrading QR for fishing/swimming
4. —
5. —

2. What would you most like to see as outcomes of the QWBP?

realistic objectives + timetables to reach the goals in #1 above

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

NA

Can you provide specific examples? ___

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

36 years career in public health at state and local level, part of which involved water pollution issues (investigations, sampling)

5. Are you interested in volunteering in watershed activities? X Yes ___ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

- Local/Regional Health Districts
- Local Inland Wetland/Conservation Commissions
- Town Council/Town Manager representatives

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

not at this time

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes X No

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: ALEX FELSON Organization: YALE

Position: ASSISTANT Professor E-mail: alex.felson@yale.edu

Phone: 203 415-8794 Cell Phone:

Street Address (for mailings): 195 Prospect ST, New Haven CT 06511

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Establishing feasible interventions
2. changing Attitudes about riparian buffers
3. Developing upland watershed Solutions
4. Targeting changing attitudes about sewage treatment
5. more detailed landuse types that target potential opportunities for change

2. What would you most like to see as outcomes of the QWBP?

Implementable projects ~~#~~ across the watershed
Categorizing project types + scaling them ~~to~~
to create feasible solutions.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

NA

Can you provide specific examples?

NA

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

· land use planning ecological design

5. Are you interested in volunteering in watershed activities? ___ Yes   _/_ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? _✓_ Yes   ___ No

www.ued lab.yale.edu

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: Jerry Silbert Organization: Watershed Partnership
Position: Executive Director E-mail: WaterPartnership@SBCglobal.net
Phone: (203) 453-8537 Cell Phone:
Street Address (for mailings): 155 White Birch Dr, Guilford, CT 06437

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Stormwater Management
2. Industrial Discharges
3. Lawn Pesticides
4. Q.River Greenway + Trail
5. Canoe Trail

2. What would you most like to see as outcomes of the QWBP?

- Less pollution + contamination.
- Better Flood control.
- Greater public access + use

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples? ___

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

Expertise on lawn pesticides

5. Are you interested in volunteering in watershed activities? ___ Yes _X_ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

NRCS, DEEP, USGS
Sigrun Gadwa 203-271-1949 (Environmental Consultant) Roman Zajach, U of New Haven.

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

Increased public use will create a constituency to advocate for the River + its watershed.

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes ___ No

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: David James Organization: QRWA

Position: Board member E-mail: Jamesgang7@cox.net

Phone: 203 2372845 Cell Phone: ____________

Street Address (for mailings): 11 Carl St. Meriden 06451

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP
   1. Discharge enforcement in Watershed
   2. Cleanup of tributaries in Meriden
   3. Sewer relocation in Hanover Pond
   4. Strengthening buffer regulation in new Construction.
   5. Coalition building in Watershed area.

2. What would you most like to see as outcomes of the QWBP?

a wider working group to monitor and encourage adherence to goals of Clean Water Act

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

We can keep a community focus on River health, and act as a local grassroots arm for governmental initiatives

5. Are you interested in volunteering in watershed activities? ✓ Yes ___ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

Emphasize the science, and need to win citizen and administrative support.

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes ___ No

already there.

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: LARRY KENDZIOR　　Organization: CITY OF MERIDEN

Position: CITY MANAGER　　E-mail: lkendzior@meridenct.gov

Phone: 203 630 4123　　Cell Phone: ____________

Street Address (for mailings): 142 E. Main Street
Meriden CT 06450

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

   1. ____________
   2. ____________
   3. ____________
   4. ____________
   5. ____________

2. What would you most like to see as outcomes of the QWBP?

____

____

____

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

____

____

Can you provide specific examples? ____

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

5. Are you interested in volunteering in watershed activities? ___ Yes ___ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ___ Yes ___ No

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association
Quinnipiac Watershed Based Plan (QWBP) Questionnaire

Name: PHILIP T. ASHTON Organization: MERIDEN FLOOD CONTROL COUNCIL

Position: CHAIRMAN E-mail: ptashton@aol.com

Phone: 203-237-7385 Cell Phone: ______

Street Address (for mailings): 39 DAFFODIL LANE
MERIDEN CT 06450

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. CRISP, CLEAR, REALISTIC DELIVERABLES
2. BACKING BY DEEP WITH FUNDING AGREEMENT
3. EPA CONCURRANCE AND SUPPORT
4. CON DOT " " "
5. ______

2. What would you most like to see as outcomes of the QWBP?

(1) A PLAN TO ACQUIRE UNDEVELOPED LAND ABUTTING RIVER AND TRIBUTARIES

(2) BROAD BASED FUNDING PRIORITIES

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

YES - IN FLOOD CONTROL AND RUNOFF WATER QUALITY IMPROVEMENTS

Can you provide specific examples?

– MERIDEN'S ADOPTED FLOOD CONTROL PLAN BEING IMPLEMENTED

– SOME SPECIAL STUDIES (e.g., HANOVER POND CONTAMINATION WITH BORINGS)

4. What can you or your organization provide to the Quinnipiac Watershed Based Plan? (expertise, advice, in-kind services, etc.)

FLOOD CONTROL PLAN + PROGRESS ON HARBOR BROOK

5. Are you interested in volunteering in watershed activities? ___ Yes AM ALREADY ___ No

6. What other organizations, businesses, or individuals might be interested in providing input to the Quinnipiac Watershed Based Plan? (Please provide contact info if you have it – Thanks!)

7. Do you have any other ideas, advice, or words of wisdom that might be helpful?

NEED A MECHANISM TO COORDINATE ALL STUDIES IN QR BASIN (INCLUDING BY UNIVERSITIES)

8. Can you provide us with web links or pictures with brief narratives of projects related to the QWBP, so that we can post to our www.qrwa.website? ✓ Yes ___ No

(NOT WEB SITE)

Thank you for time and commitment to serve on the QWBP Stakeholder Committee - Together We Can Make a Difference!

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Dan Pelletier Organization: QRWA

Position: River Runner Lol!! E-mail: ucanoe2001@yahoo.com

Phone: 860-754-8702 Cell Phone: 860-347-6576

Street Address (for mailings): 20 Knox Blvd

Middletown, CT 06457

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Storm Water Run-off
2. TMDL Bacteria Control
3. Water Quantity
4. minimum Stream flows
5. towns to report overflows to the Q-River

2. What would you most like to see as outcomes of the QWBP?

A ten year Plan

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: David James　Organization: QRWA

Position: Board member　E-mail: Jamesgang7@cox.net

Phone: 2032372845　Cell Phone: —

Street Address (for mailings): 11 Carl St. Meriden 06451

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Buffer maintenance
2. Establishing standards regarding run off that are
3. scientifically sound and politicaly enforceable.
4. Keeping a communication among stakeholders - citizens,
5. governments, and business'

2. What would you most like to see as outcomes of the QWBP? feasible and solid scientific proposals for River restoration.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Dwight Needels
Organization: Flood Control / Meriden Land Trust

Position: Chairman / President
E-mail: needels @cox.net

Phone:
Cell Phone: 203-530-3445

Street Address (for mailings): 40 Monroe St.
Meriden, CT 06451

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Identify specific reasons Sodom Brook is so impaired relative to Harbor Brook
2. Public education - lawn watering, sump pumps discharge, rain gardens
3. Increase tributary monitoring - bring data into people's neighborhood.
4. Evaluate flood control plan to maximize bang-for-the-buck on water quality
5. Increase visibility of sedimentation deposition issues in the plan

2. What would you most like to see as outcomes of the QWBP?

I want to see our communities to pull together for a common good.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: E. Kielbasinski Organization: Conservation Commission

Position: member E-mail: —

Phone: 203-634-1121 Cell Phone: —

Street Address (for mailings): 1480 N Broad St

Meriden, Ct. 06450

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Upkeep & cleanliness
2. Cities pay little attention to the future of the Quinnipiac
3. Are any laws mandated for streams & tributaries.
4. City water & sewer workers need Workshops
5.

2. What would you most like to see as outcomes of the QWBP? Education on the necessity of preserving our Streams & Tributaries.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Projects (& volunteers needed.) COMMISSIONS assignments -

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: ED Albrecht Organization: Trout Unlimited

Position: TIC Coordinator E-mail: albrecht_ed@yahoo.com

Phone: 203 271 1103 Cell Phone: ______

Street Address (for mailings): 236 Eastgate Dr.

Cheshire, Ct. 06410

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Water Quality
2. Dam Removal
3. Impaired River - more invertebrates
4. Access To River for quality fishing
5. Recreation Use

2. What would you most like to see as outcomes of the QWBP?

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

______

______

Can you provide specific examples? ______

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Elizabeth Fossett Organization: ____________

Position: ____________ E-mail: emfossett@gmail.com

Phone: ____________ Cell Phone: 610-996-5853

Street Address (for mailings): 534 S. Colony ST
Meriden, CT 06451

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Combined Sewer overflows
2. high level of N and P
3. lack of recreation
4. lack of strong habitat + biodiversity
5. high value for impervious cover

2. What would you most like to see as outcomes of the QWBP?

Community involvement and recreation

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

____

____

Can you provide specific examples? ____________

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Evan Welch Organization: CFE

Position: Green Projects Associate E-mail: ewelch@savethesound.org

Phone: 203-787-0646 Cell Phone: 518-522-1560

Street Address (for mailings): 142 Temple St Suite 305
New Haven CT 06510

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Identifying most prominent PS polluters
2. Expand areas suitable for recreation
3. Restore estuarine ecosystem
4. emphasize simplicity of small scale GI to homes + small businesses
5. More open space protection
6) proliferation of pervious pavement

2. What would you most like to see as outcomes of the QWBP?
Implement positive changes to land use + stormwater handling, efficient + effective outreach, increased land preservation

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

n/a

Can you provide specific examples? n/a

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Jan Johnson Organization: Pathways Regional School

Position: High School Science Teacher E-mail: janjohnson1@me.com

Phone: 203 271-0737 Cell Phone: 203-592-4868

Street Address (for mailings): 825 Cornwall Ave, Cheshire CT 06410

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. fish restoration
2. Water treatment plan upgrades
3. - recreation - increasing public access - raise profile of river
4. protection of riparian buffers
5.

2. What would you most like to see as outcomes of the QWBP?

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Jerry Silbert Organization: Watershed Partnership

Position: Exec Dir. E-mail: WaterPartership@SBCglobal.net

Phone: (203) 453-8537 Cell Phone: ____________

Street Address (for mailings): 155 White Birch Dr., Guilford, CT 06437

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Storm water mitigation (flash floods)
2. Non-point source pollution
3. Lawn pesticides + fertilizer
4. Public Access
5. Erosion of banks

2. What would you most like to see as outcomes of the QWBP?

Cleaner + navigable for recreation; Fishways

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

____

____

Can you provide specific examples? ____________

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Joseph Gregory Organization: QWSA

Position: Stock Holder E-mail: joejgreg@gmail.com

Phone: 860-539-4868 Cell Phone:

Street Address (for mailings): 2 View St. Plainville CT 06062

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Progress Drive / Wonx Spring Road, Plantsville CT development is currently attempting to develop 32.5 acres, 6 acres sit on wetlands, they are looking to drain that water in the river. How does the base plan handle developments like this? Info found at Southington Town
2. Hall
3. Southington seems to have very relaxed laws on developing over wetlands,
4.
5.

2. What would you most like to see as outcomes of the QWBP?

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Mary Mushinsky

Organization: CT General Assembly; QR Linear Trail Advisory Cmte.

Position: State Rep. 85th

E-mail: marymushinsky@att.net

Phone: 203-269-8378

Cell Phone: 203-430-0921

Street Address (for mailings): 188 South Cherry St.
Wallingford, CT 06492

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

(Please see attachment for 5 priorities)

1. Increase public access, especially trails + launches.
2. Decrease pollutants thru MWF permits + land use regulations.
3. Protect baseflow including protecting natural wetlands.
4. Protect + restore vegetation. Reverse losses.
5. Reverse trend toward impervious surfaces.

2. What would you most like to see as outcomes of the QWBP?

Include best practices to reduce damage at municipal land use regulation level.

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Yes

Can you provide specific examples? will submit

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Michelle C. Hosse-Allen Organization: QRWS

Position: ______

E-mail: mlallen@ct.metrocast.net

Phone: ______

Cell Phone: 8608237667

Street Address (for mailings): 24 Pine St

Waterford, CT 06385

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Water quality for both potable and habitat
2. Rain Storm run offs especially from hvy agriculture use.
3. Bacteria monitoring of water supply, especially during the xtrme heat waves.
4. Recycle water that can be used @ the municipal level for watering ~~[illegible]~~ vegetation @ community buildings
5. Water levels in the reservoirs during droughts.
6. Water pollution from both agriculture and human littering.

2. What would you most like to see as outcomes of the QWBP?

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

N/A

Can you provide specific examples? ______

Quinnipiac River Watershed Association Watershed Based Plan (QWBP) Questionnaire

Name: Ronald Graziani Organization: TU

Position: Youth Coordinator E-mail: rongraz70@sbcglobal.net

Phone: 203 265-6035 Cell Phone: —

Street Address (for mailings): 95 Lincy Hall Lane
Wallingford, CT 06492

1. What are your top five (or more) concerns/issues/priorities regarding the QWBP

1. Water quality in the Q to improve Fishing
2. Removal of dams above Hanover Pond
3. improve outflow quality of ~~[illegible]~~ Cytech Ind.
4. improve outflow " of Sanitary Sewage plants
5. Maintain adequate stream flows

2. What would you most like to see as outcomes of the QWBP?

3. If you represent a municipality, do you see opportunities for the QWBP to complement your efforts for your project requirements?

Can you provide specific examples?

Comments on Quinnipiac River Watershed Action Plan (revision 2013) 7/23/13
By Rep. Mary Mushinsky, Wallingford
Thanks to Fuss & O'Neill for a thorough report, especially the pollutant loading analysis.

Main concerns:

1. Increase public access
2. Decrease excess nutrients (phosphorus, nitrogen) and bacteria which hinder recreational uses
3. Baseflow depletion hinders cold water fisheries and summer recreation (paddling, fishing)
4. Unhealthy land use trend: loss of vegetation over time
5. Unhealthy land use trend: increased impervious surfaces over time
6. Progress will require shift away from impervious surfaces, re-vegetation of previously developed sites, local requirement & enforcement to retain runoff and sediment on site

Priorities in my area:

1. Increase public access:
    a. connect segments of linear trails between Meriden, Wallingford, North Haven
    b. provide water based recreational access at old Community Lake basin in reshaped water body east of the river
    c. resurrect USDA canoe launch project
    d. complete additional launch at North Haven town owned parcel, add launch at Tolles Rd
2. Decrease pollutants:
    a. Continue reduction in municipal wastewater treatment facilities phosphorus through permits; provide funding
    b. Reduce nutrient loads in Hanover Pond, main stem QR
    c. Reduce North Farms Reservoir eutrophication-discharges to Wharton Bk
    d. Municipalities to avoid waste oil discharge in vicinity of aquifer protection areas
    e. Municipal enforcement action against sediment loss and runoff
3. Protect baseflow:
    a. Municipal water utilities need to follow lead of state regulated utilities and change rate structure to promote water conservation in low flow seasons (2013 legislation)
    b. Restore natural wetlands, which serve same function as rain gardens
    c. Perform culvert survey on behalf of cold water fisheries (TU)
4. Protect and Restore Vegetation:
    a. Municipal requirement for vegetative buffers
    b. Municipal action to prevent clearcutting of Mixville Pond buffer
5. Reverse trend toward impervious surfaces:
    a. Re-vegetate Harbor Brook, Misery Brook segments
    b. Re-vegetate former industrial sites
    c. Municipal action to reduce impervious surfaces in new developments

Project Ideas With Downstream Impacts in Mind

Projects completed since 2004 Plan:

a. Groundwater recharge with STS/CFE in Southington (9 rain gardens installed; 2 institutional gardens pending)
b. Grant for DPW meetings (recent oil spill incident indicates further outreach needed)
c. Grant-funded lower Quinnipiac water trail with 15 markers, guide (done); needs additional log removal and launch at Valley Service Rd
d. Increased funding for phosphorus reduction--legislature increased grant to 50% for first 3 municipalities to achieve more significant reduction (2013)
e. Extensions of linear trails in Meriden (Ph II in construction) and Wallingford (Ph III ready to construct, Ph IV preliminary design completed)
f. Initiation of North Haven Trails Association; 2 proposed segments
g. Fishway installed at Wallace Dam
h. Sign for Phase III QRLT (in design; to be installed as part of Ph III construction)
i. Urban River Stewardship signs--have been installed at North Haven (2), Wallingford (1), New Haven (1)
j. Marsh bird signs in design for New Haven Land Trust (TBA)

Projects needed after 2013 Plan:

a. Re-shape water body in Community Lake basin adjacent to Wallingford Senior Center to provide more water recreation without negative impact of dam
b. Finish canoe launches; investigate new launch at Tolles Rd
c. Connect inter-town linear trail system along Q River
d. Municipalities improve phosphorus reduction at WTF
e. Extend disinfection at WTF through October (to end of paddle season)
f. Remove Clarks Brothers, other low dams
g. Complete culvert survey for cold water fisheries (TU)
h. Capture and treat Allen Bk bacteria (to protect Wharton Bk public swimming area)
i. Reduce neighborhood nitrogen loads at Wharton Bk, Muddy R, Harbor Bk
j. Reduce neighborhood fecal coliform bacteria at Wharton Bk, QR, Sodom Bk, Misery Bk
k. Uncover Harbor Brook and restore vegetation (2013-funding has been approved) to reduce NPS loads
l. Conduct MS4 public education and outreach in target subwatersheds
m. Improve municipal enforcement at construction sites to reduce runoff, sediment
n. Land use: Reverse the trend by identifying and converting former industrial sites to forest or vegetated open space
o. Land use: Reverse the trend by reducing below 49% developed land cover in Harbor Bk, Sodom Bk and QR mainstem
p. Land use: head off potential negative effects of imminent major development at Eight Mile R (conversion of Pine Valley Golf Course near Grannis Pond to housing) and Ten Mile R (resurrection of Mixville Pond area mall-new design has reduced green space)
q. Load reduction: target education to reduce NPS pollution loads in subwatersheds dominated by single family and multi-family residential dwellings

Edits to Watershed Plan Technical Memorandum #1:
p. 18 Fig. 3-2 assessment results map-orange/brown colors unclear

p. 21 fish surveys-add data is also available from fishway cameras (2012, 2013)
p. 34 4-2 topography-replace "Castle Craig" with "West Peak"
p. 39 4.4.1 fisheries-add stocking at Wharton Brook State Park
p. 69 Fig. 6-5 Pistapaug Pond (sp.); add proposed extension (PH III) of QRLT to Yalesville center (head of the island); proposed extension (PH IV) to North Haven line; proposed Pfizer nature trail at former Upjohn site in North Haven marsh
p. 43 Dutchman's breeches (sp.)
p. 51 5.2 water supply-add: 2013 legislation changed water rate structure to add water conservation to rate base as an incentive to protect flows. Law only applies to state regulated utilities; municipal utilities should follow.
p. 72 7.2 sanding of roads—is 5 tons/lane mile/year (1991) still accurate? Many jurisdictions have switched to salt solution.
Suggest add graphic to show historic growth of sedimentation by using aerial photos to show extension of sand spit at Hanover Pond over time.

Hi Ginny,

I'm wondering if it's possible to get contact information for the Fuss and O'Neill consultant who gave the workshop presentations last night? I am looking into doing a stormwater/impervious cover analysis just within the town of Southington and I'm curious to see what's in the Technical Memo #2 and would like to request a draft from them.

Also I have a couple thoughts to add to yesterday's workshop discussion:

- It may be good to include the impacts of roads/cars in the plan because regional planning organizations within the watershed could provide funding to implement projects if they are linked to transportation. Things like green infrastructure projects that collect stormwater runoff from roads and identifying locations where the transportation infrastructure is overbuilt and should be reduced or removed. This might be particularly beneficial to water quality if focused within riparian buffer zones.

- Perhaps within the outreach element, educate homeowners about ecologically sensitive lawn care/mowing practices, especially those whose parcels which are adjacent to the river… I noticed several properties on Google maps that mow all the way to the river's edge.

Thank you and good luck with the plan!

Amanda Ryan
Assistant Planner
Central Connecticut Regional Planning Agency
225 North Main Street, Suite 304
Bristol, CT 06010
860-589-7820 ext 170
www.ccrpa.org

Quinnipiac River Watershed Community Workshop

Quinnipiac River Watershed Association Headquarters

540 Oregon Rd., Meriden, CT 06451

July 23, 2013, 3:30-5:00pm & 6:30-8:00pm

Presenter: Erik Moss

1st Session

Comment: "A very high, even temporary, maximum value will affect aquatic life."

Question: "Is there any study that shows the comparison or bacteria in the 2004 report to what the river is like today?

Answer: "Bacteria is everywhere; it's a matter of keeping it low."

Question: "Why is there a gap in water quality in the watersheds?"

Answer: "Some data might be about the aquatic life use support. Stream quality is not the same as water quality."

Question: "I'm from the Wallingford Commission. I was struck by your talk about runoff. What would be important to you in terms of a local application?"

Answer: "LIT regulations. Use those because they are in line with the state's greener practices. With new development and redevelopment it's easier to make new practices versus trying to retrofit. Grant money is extremely small and competitive."

Comment: "I bought a house on Glen Hills Rd. and started cleaning up around it and noticed oil and scummy stuff in the river. People throw all kinds of things in there."

Answer: "Water quality has been a huge focus for Meriden. It's tough to change attitudes. It takes years to change the mindset to not throw trash on the ground."

Comment: "I heard that there's going to be an underground reservoir in Meriden?"

Answer from David James (DJ): "The city is going to move the brook. It's public information."

Question from David James: "You mentioned Sodom Brook, Harbor Brook and the Quinnipiac River as being highly polluted. What is people's motivation to not get discouraged?"

Answer: "Part of the plan is to show what could happen. DEEP has set targets for reductions."

DJ: "Prioritization. You suggested realistic goals."

Eric: "Initial set of achievable goals. Problem with watershed management is that you're tackling many parts at one time."

Mary Mushinsky: "You need to add best practices to your report. We're making a new wetland which is difficult. We need to have best practices for new developments. The improvements made with our rain gardens won't be able to keep up with the new developments.

Comment from Wallingford rep: "You need to have developers have the best practices written into their plans so that we have some powerful tools for enforcement."

Joe Gregory: "What does the base plan propose to do? Go after the developers?"

Answer: "First priority is to look at LIT, reduce pollutants."

Comment: "There should be requirements for developers."

Answer: "Towns have different thresholds."

Question: "What is the role of the agricultural community? There needs to be best practices on the part of the agricultural group."

Answer: "I imagine most of it is small-scale but we will look at it."

Comment: "You need to look at the golf courses."

Answer: "Yes, they use pesticides and tend to be along the water."

Question: "We have ....How do we get city officials to preserve fresh water? I've gone to city officials many times and nothing gets done. Do you have any suggestions on how to get city hall interested? Are there grants available to protect fresh water? Do we need to make laws to protect the streams?"

Mary Mushinsky: "There are laws on the books. You have to catch people throwing things into the water."

2nd Session

Joe Zajak: "What is the best dishwashing liquid to use?"

Answer: "Not sure."

Dwight Needels: "Are there specific things that the flood control program can do to affect water quality?"

Answer: "It incorporates some water quality benefits."

Dan Pelletier: "When the hub is done, will there be better bacterial rates?"

Answer: "It incorporates some water quality benefits."

David James: "On thing is that is important for both one-year and 20-year results is that buffers count."

Question: "Has the quality of the river changed?"

David James: "It has been rated as a Class IV River and not repairable."

Chris (DEEP): "It's rated as a Class B. We haven't given up on it. Problems with sediments will take a while to control but we are working on it."

Ron Graziani: "Did the number of fish improve?"

Mary Mushinsky: "Five thousand fish passed."

Question: "They spray chemicals on the roads before storms. Does this affect the river?"

Answer: "Yes, but the chemicals they're using are supposed to be preferable to salt and sand."

Chris: "At the main stem of the Q River, it's not that affected. They are using less salt and no sand."

Dan Pelletier: "Does this study include recreational information like public access?"

Answer: "Yes, there will be access points as part of the plan."

Comment: "Since the trail has been made, access to the River has improved 100%."

Question: "Any plans to have companies like Cytec improve their outflow? When I go down the River, there's a noticeable change in the color and smell of it by Cytec."

Question: "Discharge permits- are the limits in the permits effective?"

Answer:

Dwight: "What's the time of discharge permits?"

Answer: "Five years."

Question: "Do towns have to notify DEEP about overflow?"

Answer: "Yes."

Question: "Who do they report to?"

Answer: "DEEP."

Dwight: "What about sump pump discharge?"

Answer: "Sometimes sump pumps are tied into storm drains, so they cause a bigger problem."

Randy Snow: "In Georgia, towns have a place to put runoff. Then it gets treated."

Chris: "There's very little here. Golf course irrigation is a problem."

Mary Mushinsky: "I'm doing a permit review for Mill River Watershed. It has to be done by March."

Dan Pelletier: "How often do towns reach capacity at sewer plants?"

Chris: "Not often."

Chris: "We have open requests for nonpoint sources to treat storm water. The closing date is Sep. 30. The grant amount is $20,000-$100,000."

Appendix C

Site-Specific Project Cost Estimates

Order of Magniude Cost Range															
		Construction				Design and Planning		Cost Range			Life Cycle				
Location and Element		Unit Cost	Unit	Quantity	Cost (2013$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Quinnipiac River Park, New Haven															
1	Bioretention Area - Step Pools	$12.19	cf of runoff treated	7,800	$95,110	30%	$28,530	$124,000	$87,000	$186,000	15	$11,150	4%	$450	$11,600
2	Diversion Manhole	$2,500	ea	1	$2,500	30%	$750	$4,000	$3,000	$6,000	15	$360	4%	$10	$370
3	Armored Outflow Channel	$45.72	CY	24	$1,118	30%	$340	$2,000	$1,000	$3,000	30	$120	4%	$0	$120
4	Bank Restoration and Armoring	$45.72	CY	593	$27,093	30%	$8,130	$36,000	$25,000	$54,000	30	$2,080	2%	$40	$2,120
							Total	**$166,000**	**$116,000**	**$249,000**					
Southington High School, Southington															
1	Bioretention Islands	$33.02	sf	4,035	$133,246	30%	$39,970	$174,000	$122,000	$261,000	15	$15,650	4%	$630	$16,280
2	Vegetated Swales	$10.16	sf	1,470	$14,935	30%	$4,480	$20,000	$14,000	$30,000	15	$1,800	4%	$70	$1,870
3	Green Roof	$23.37	sf	19,500	$455,676	30%	$136,700	$593,000	$415,000	$890,000	20	$43,630	4%	$1,750	$45,380
4	Blue Roof	$5.08	sf	7,600	$38,608	30%	$11,580	$51,000	$36,000	$77,000	20	$3,750	4%	$150	$3,900
5	Tree Box	$6,096	ea	3	$18,288	30%	$5,490	$24,000	$17,000	$36,000	20	$1,770	4%	$70	$1,840
6	Porous Asphalt	$2.84	sf	16,300	$46,370	30%	$13,910	$61,000	$43,000	$92,000	20	$4,490	4%	$180	$4,670
							Total	**$923,000**	**$647,000**	**$1,386,000**					
Clinton Avenue School and Clinton Park, New Haven															
1	Bioretention Area	$33.02	sf	366	$12,077	30%	$3,620	$16,000	$11,000	$24,000	15	$1,440	4%	$60	$1,500
2	Rain Gardens	$7.40	sf	1,128	$8,340	30%	$2,500	$11,000	$8,000	$17,000	15	$990	4%	$40	$1,030
3	Infiltration Trenches	$18.58	lf	300	$5,574	30%	$1,670	$8,000	$6,000	$12,000	20	$590	2%	$10	$600
4	Blue Roof	$5.08	sf	1,800	$9,144	30%	$2,740	$12,000	$8,000	$18,000	20	$880	2%	$20	$900
5	Permeable Pavers	$10.16	sf	17,760	$180,442	30%	$54,130	$235,000	$165,000	$353,000	20	$17,290	4%	$690	$17,980
							Total	**$282,000**	**$198,000**	**$424,000**					
Green Streets – Quinnipiac Avenue @ Foxon Street, New Haven															
1	Pervious Pavers (20 spaces)	$10.16	sf	2,240	$22,758	30%	$6,830	$30,000	$21,000	$45,000	20	$2,210	4%	$90	$2,300
2	Bioretention Areas	$33.02	sf	1,120	$36,982	30%	$11,090	$49,000	$34,000	$74,000	15	$4,410	4%	$180	$4,590
3	Tree Box	$6,096	ea	10	$60,960	30%	$18,290	$80,000	$56,000	$120,000	20	$5,890	4%	$240	$6,130
							Total	**$159,000**	**$111,000**	**$239,000**					
Calendar House, Southington															
1	Subsurface Gravel Wetland	$22.18	cf of runoff treated	5,366	$119,010	30%	$35,700	$155,000	$109,000	$233,000	30	$8,960	4%	$360	$9,320
2	Outlet Structure	$4,500	ea	1	$4,500	30%	$1,350	$6,000	$4,000	$9,000	30	$350	2%	$10	$360
							Total	**$161,000**	**$113,000**	**$242,000**					
Columbus Park, Meriden															
1	Invasive Species Control	$3,401	acre	4.0	$13,603	30%	$4,080	$18,000	$13,000	$27,000	2	$9,540	4%	$380	$9,920
2	Stream Restoration	$13,106	ac	4.0	$52,425	30%	$15,730	$69,000	$48,000	$104,000	15	$6,210	4%	$250	$6,460
							Total	**$87,000**	**$61,000**	**$131,000**					

	Order of Magniude Cost Range													
	Construction				Design and Planning		Cost Range			Life Cycle				
Location and Element	Unit Cost	Unit	Quantity	Cost (2013$)	Allowance	Cost	Total Cost	-30%	50%	Lifespan (yrs)	Annual Cost over Lifespan	O&M (% Cost)	O&M ($/yr)	Total Capitalized Cost/yr over lifespan
Department of Motor Vehicles Office, New Britain														
1 Bioretention Areas and Rain Garden	$33.02	sf	1,147	$37,877	30%	$11,360	$50,000	$35,000	$75,000	15	$4,500	4%	$180	$4,680
2 Detention Basin Restoration	$12,890.43	impervious acre of runoff treated	2.4	$30,937	30%	$9,280	$41,000	$29,000	$62,000	30	$2,370	4%	$90	$2,460
3 Outlet Structure	$4,500	ea	1	$4,500	30%	$1,350	$6,000	$4,000	$9,000	30	$350	2%	$10	$360
						Total	$97,000	$68,000	$146,000					
Doolittle Park, Wallingford														
1 Reinforced Gravel Parking	$5.07	sf	14,840	$75,235	30%	$22,570	$98,000	$69,000	$147,000	20	$7,210	2%	$140	$7,350
2 Infiltration Trenches	$18.58	lf	200	$3,716	30%	$1,110	$5,000	$4,000	$8,000	20	$370	2%	$10	$380
3 Riparian Buffer Restoration	$11,204	ac	0.85	$9,523	30%	$2,860	$13,000	$9,000	$20,000	15	$1,170	4%	$50	$1,220
4 Dam Removal	$18,278	ea	1	$18,278	60%	$10,970	$30,000	$21,000	$45,000	100	$1,220	0%	$0	$1,220
						Total	$146,000	$103,000	$220,000					
Public Library, Meriden														
1 Rain Garden	$7.40	sf	2,000	$14,793	30%	$4,440	$20,000	$14,000	$30,000	15	$1,800	4%	$70	$1,870
2 Educational Signage	$1,200	ea	1	$1,200	30%	$360	$2,000	$1,000	$3,000	10	$250	2%	$10	$260
3 Subsurface Infiltration System	$37	cf of runoff treated	2,711	$99,580	30%	$29,870	$130,000	$91,000	$195,000	20	$9,570	4%	$380	$9,950
4 Porous Asphalt	$2.84	sf	20,000	$56,896	30%	$17,070	$74,000	$52,000	$111,000	20	$5,450	4%	$220	$5,670
5 Tree Box	$6,096	ea	2	$12,192	30%	$3,660	$16,000	$11,000	$24,000	20	$1,180	2%	$20	$1,200
6 Green Roof	$23.37	sf	2,000	$46,736	30%	$14,020	$61,000	$43,000	$92,000	20	$4,490	4%	$180	$4,670
						Total	$303,000	$212,000	$455,000					
Norton Park, Plainville														
1 Riparian Buffer Restoration	$11,204	ac	1.6	$17,926	30%	$5,380	$24,000	$17,000	$36,000	15	$2,160	4%	$90	$2,250
3 Filter Strip	$10.16	sf	600	$6,096	30%	$1,830	$8,000	$6,000	$12,000	20	$590	4%	$20	$610
4 Infiltration Trench	$18.58	lf	200	$3,716	30%	$1,110	$5,000	$4,000	$8,000	20	$370	4%	$10	$380
						Total	$37,000	$27,000	$56,000					
Park & Ride, Southington														
1 Water Quality Swale	$10.16	sf	1,230	$12,497	30%	$3,750	$17,000	$12,000	$26,000	15	$1,530	4%	$60	$1,590
2 Constructed Wetland	$4.38	sf	2,000	$8,756	30%	$2,630	$12,000	$8,000	$18,000	15	$1,080	4%	$40	$1,120
						Total	$29,000	$20,000	$44,000					
2.12 Commercial Development, North Haven														
1 Bioretention Parking Islands	$33.02	sf	12,640	$417,373	30%	$125,210	$543,000	$380,000	$815,000	15	$48,840	4%	$1,950	$50,790
						Total	$543,000	$380,000	$815,000					

Notes:

Rate of Inflation used = $0.02

Interest (discount) rate used = $0.06

*Projects are proposed for these locations already. Costs estimated in this table are for adding ecological and water quality elements to the assumed original purpose of the proposed projects.

Costs should be used for planning purposes only based on screening-level evaluations of site characteristics. Construction costs could vary significantly.

Unit Costs Table

Element	2013 Adjusted Cost	Unit	Cost	$YEAR	Source
Green Infrastructure Elements					
Large Bioretention Retrofit	$ 12.19	cf of runoff treated	$ 10.50	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-3
Small Bioretention Retrofit (<0.5 acre)	$ 33.02	sf	$ 32.50	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Rain Garden	$ 7.40	sf	$ 7.28	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Water Quality Swale	$ 10.16	sf	$ 10.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Porous Asphalt	$ 2.84	sf	$ 2.80	2012	UNH Stormwater Center 2012 Biennial Report. Page 12
Permeable Pavers	$ 10.16	sf	$ 10.00	2012	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, Page E-5
Reinforced Gravel Parking	$ 5.07	sf	$ 5.07	2013	http://www.boddingtonsonline.com/products/grass-ground-reinforcement/grass-reinforcement-protection/bodpave-85-permeable-gravel-pavers.php; Added $2/sf for installation
Subsurface Infiltration Chambers	$ 36.73	cf of runoff treated	$ 36.15	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Green Roof	$ 23.37	sf	$ 23.00	2012	District of Columbia Water and Sewer Authority, George S. Hawkins, General Manager, Green Infrastructure Summit 2012, February 29, 2012.
Blue Roof	$ 5.08	sf	$ 5.00	2012	NYC Department of Environmental Protection (2012), Rooftop Detention: A Low-Cost Alternative for Complying with New York City's Stormwater Detention Requirements and Reducing Urban Runoff.
Subsurface Gravel Wetland	$ 22.18	cf of runoff treated	$ 21.83	2012	Woodard & Curran - Route 1 Falmouth Commercial District Stormwater Management, 2012
Pond Retrofit	$ 12,890.43	impervious acre of runoff treated	$ 11,100.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-2
French Drain/Infiltration Trench	$ 18.58	lf	$ 16.00	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Tree Box	$ 6,096.00	ea	$ 6,000.00	2012	UNH Stormwater Center 2012 Biennial Report
Constructed Wetland	$ 4.38	sf	$ 3.77	2006	Center for Watershed Protection Urban Subwatershed Retrofit Manual 3 (2007), cost adjusted, page E-11
Restoration Elements					
Riparian Buffer Restoration	$ 11,204.05	ac	$ 10,543	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Stream Channel Restoration	$ 13,106.28	ac	$ 12,333	2010	Oregon Department of Environmental Quality, 2010, Cost Estimate to Restore Riparian Forest Buffers and Improve Stream Habitat in the Willamette Basin, Oregon. Page 20
Remove Invasive Species	$ 3,400.64	acre	$ 3,200	2010	Professional Engineering Experience
Construction Elements					
6" to 12" Rip Rap	$ 45.72	CY	$ 45.00	2012	Professional Engineering Experience
Outlet Structure	$ 4,500	ea	$ 4,500	2013	Professional Engineering Experience
Manhole	$ 2,500	ea	$ 2,500	2013	Professional Engineering Experience
Dam Removal	$ 18,278.44	ea	$ 17,200	2010	Selle, Andy (2010). Dam Removal – A Primer, Presentation; $17,200 is median for dams 1-3 feet high.
Educational Signage	$ 1,200	ea	$ 1,200	2013	Professional Engineering Experience

Inflation Rates Table

Inflation from	Inflation to	Percent
2006	2013	16.13%
2010	2013	6.27%
2011	2013	4.57%
2012	2013	1.6%

Appendix D

Pollutant Load Reduction Model Results

Nitrogen Load Reductions with Watershed Management Recommendations

Watershed Management Recommendation	Existing Conditions (lb/yr)	Future Conditions with Contols (1,000 lb/yr)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	19.7	19.7	19.7	18.9	19.5	19.7	19.5	19.7	19.3	19.5
Eightmile River (9,441 ac)	78.2	78.2	78.2	73.8	77.4	78.2	77.4	78.2	76.6	77.1
Harbor Brook (7,751 ac)	93.5	93.5	93.5	86.1	91.2	83.9	91.2	93.5	90.9	92.7
Misery Brook (3,993 ac)	34.6	34.6	34.6	32.4	34.0	34.6	34.0	34.6	33.7	34.1
Muddy River (13,947 ac)	145.4	145.4	145.4	136.7	144.3	144.2	144.3	145.4	142.3	144.3
Quinnipiac River (46,500 ac)	537.6	536.5	537.6	496.7	527.6	493.0	527.6	536.9	523.3	531.8
WPCF Point Sources	404.8	404.8	370.9	404.8	404.8	404.8	404.8	404.8	404.8	404.8
Sodom Brook (3,377 ac)	36.2	36.2	36.2	33.6	35.5	36.2	35.5	36.2	35.2	35.8
Tenmile River (12,967 ac)	125.6	125.6	125.6	117.8	124.6	125.6	124.6	125.5	122.6	124.3
Wharton Brook (4,895 ac)	58.0	58.0	58.0	54.0	57.0	51.2	57.0	57.9	56.5	57.6
Watershed Total (105,952 ac)	1,533.7	1,532.5	1,499.7	1,454.8	1,515.7	1,471.5	1,515.7	1,532.7	1,505.3	1,522.0

Watershed Management Recommendation	Existing Conditions (lb/yr)	Load Reduction due to Contols (%)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	19.7	0.0%	0.0%	4.2%	1.1%	0.0%	1.1%	0.0%	1.8%	1.2%
Eightmile River (9,441 ac)	78.2	0.0%	0.0%	5.6%	1.0%	0.0%	1.0%	0.0%	2.1%	1.4%
Harbor Brook (7,751 ac)	93.5	0.0%	0.0%	7.9%	2.5%	10.2%	2.5%	0.1%	2.8%	0.9%
Misery Brook (3,993 ac)	34.6	0.0%	0.0%	6.3%	1.8%	0.0%	1.8%	0.1%	2.5%	1.4%
Muddy River (13,947 ac)	145.4	0.0%	0.0%	6.0%	0.8%	0.9%	0.8%	0.0%	2.1%	0.8%
Quinnipiac River (46,500 ac)	537.6	0.2%	0.0%	7.6%	1.9%	8.3%	1.9%	0.1%	2.7%	1.1%
WPCF Point Sources	404.8	0.0%	8.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sodom Brook (3,377 ac)	36.2	0.0%	0.0%	7.3%	2.1%	0.0%	2.1%	0.1%	2.8%	1.1%
Tenmile River (12,967 ac)	125.6	0.0%	0.0%	6.2%	0.8%	0.0%	0.8%	0.0%	2.4%	1.0%
Wharton Brook (4,895 ac)	58.0	0.0%	0.0%	7.0%	1.8%	11.7%	1.8%	0.1%	2.6%	0.8%
Watershed Total (105,952 ac)	1,533.7	0.1%	2.2%	5.1%	1.2%	4.1%	1.2%	0.1%	1.9%	0.8%

Phosphorus Load Reductions with Watershed Management Recommendations

Watershed Management Recommendation	Existing Conditions (lb/yr)	Future Conditions with Contols (1,000 lb/yr)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	1.1	1.1	1.1	1.0	1.1	1.1	1.0	1.1	1.0	1.0
Eightmile River (9,441 ac)	3.8	3.8	3.8	3.6	3.8	3.8	3.7	3.8	3.6	3.7
Harbor Brook (7,751 ac)	4.2	4.2	4.2	3.9	3.8	3.8	4.1	4.2	3.9	4.2
Misery Brook (3,993 ac)	1.9	1.9	1.9	1.8	1.9	1.9	1.8	1.9	1.8	1.9
Muddy River (13,947 ac)	6.5	6.5	6.5	6.2	6.5	6.5	6.4	6.5	6.2	6.5
Quinnipiac River (46,500 ac)	24.8	24.8	24.8	23.3	23.0	23.0	24.5	24.8	23.3	24.6
WPCF Point Sources	157.2	157.2	86.1	157.2	157.2	157.2	157.2	157.2	157.2	157.2
Sodom Brook (3,377 ac)	1.7	1.7	1.7	1.6	1.7	1.7	1.7	1.7	1.6	1.7
Tenmile River (12,967 ac)	5.8	5.8	5.8	5.5	5.8	5.8	5.8	5.8	5.5	5.8
Wharton Brook (4,895 ac)	2.7	2.7	2.7	2.6	2.4	2.4	2.7	2.7	2.6	2.7
Watershed Total (105,952 ac)	209.8	209.7	138.6	206.7	207.2	207.2	209.0	209.7	206.6	209.3

Watershed Management Recommendation	Existing Conditions (lb/yr)	Load Reduction due to Contols (%)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	1.1	0.0%	0.0%	3.8%	0.0%	0.0%	1.3%	0.0%	3.7%	0.9%
Eightmile River (9,441 ac)	3.8	0.0%	0.0%	4.9%	0.0%	0.0%	1.1%	0.0%	4.8%	1.1%
Harbor Brook (7,751 ac)	4.2	0.0%	0.0%	6.5%	8.9%	8.9%	1.6%	0.2%	6.9%	0.7%
Misery Brook (3,993 ac)	1.9	0.0%	0.0%	5.7%	0.0%	0.0%	1.8%	0.1%	5.2%	1.0%
Muddy River (13,947 ac)	6.5	0.0%	0.0%	5.1%	0.7%	0.7%	1.3%	0.0%	5.3%	0.7%
Quinnipiac River (46,500 ac)	24.8	0.2%	0.0%	6.4%	7.3%	7.3%	1.5%	0.3%	6.4%	0.9%
WPCF Point Sources	157.2	0.0%	45.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sodom Brook (3,377 ac)	1.7	0.0%	0.0%	6.2%	0.0%	0.0%	1.4%	0.2%	6.5%	0.9%
Tenmile River (12,967 ac)	5.8	0.0%	0.0%	5.3%	0.0%	0.0%	1.0%	0.1%	5.7%	0.8%
Wharton Brook (4,895 ac)	2.7	0.0%	0.0%	5.9%	10.5%	10.5%	1.6%	0.3%	6.3%	0.6%
Watershed Total (105,952 ac)	209.8	0.0%	33.9%	1.5%	1.2%	1.2%	0.3%	0.0%	1.5%	0.2%

Sediment (TSS) Load Reductions with Watershed Management Recommendations

Watershed Management Recommendation	Existing Conditions (lb/yr)	Future Conditions with Contols (1,000 lb/yr)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	957.4	957.4	957.4	926.3	957.4	957.4	957.4	957.4	934.1	955.8
Eightmile River (9,441 ac)	3,932.1	3,932.1	3,932.1	3,754.2	3,932.1	3,932.1	3,932.1	3,931.9	3,813.1	3,924.9
Harbor Brook (7,751 ac)	5,517.5	5,517.5	5,517.5	5,185.7	5,517.5	4,962.0	5,517.5	5,516.9	5,313.5	5,512.2
Misery Brook (3,993 ac)	1,942.4	1,942.4	1,942.4	1,848.7	1,942.4	1,942.4	1,942.4	1,942.2	1,878.3	1,939.0
Muddy River (13,947 ac)	7,395.1	7,395.1	7,395.1	7,047.8	7,395.1	7,326.1	7,395.1	7,394.9	7,181.6	7,387.3
Quinnipiac River (46,500 ac)	30,216.4	30,213.5	30,216.4	28,397.4	30,216.4	27,575.9	30,216.4	30,210.8	29,168.7	30,177.9
WPCF Point Sources	428.5	428.5	428.5	428.5	428.5	428.5	428.5	428.5	428.5	428.5
Sodom Brook (3,377 ac)	2,100.5	2,100.5	2,100.5	1,985.8	2,100.5	2,100.5	2,100.5	2,100.2	2,019.6	2,097.9
Tenmile River (12,967 ac)	6,361.0	6,361.0	6,361.0	6,040.0	6,361.0	6,361.0	6,361.0	6,360.7	6,164.4	6,352.7
Wharton Brook (4,895 ac)	3,312.4	3,312.4	3,312.4	3,136.3	3,312.4	2,908.6	3,312.4	3,311.6	3,200.9	3,309.4
Watershed Total (105,952 ac)	62,163.2	62,160.3	62,163.2	58,750.6	62,163.2	58,494.5	62,163.2	62,155.2	60,102.6	62,085.6

Watershed Management Recommendation	Existing Conditions (lb/yr)	Load Reduction due to Contols (%)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	957.4	0.0%	0.0%	3.3%	0.0%	0.0%	0.0%	0.0%	2.4%	0.2%
Eightmile River (9,441 ac)	3,932.1	0.0%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%	3.0%	0.2%
Harbor Brook (7,751 ac)	5,517.5	0.0%	0.0%	6.0%	0.0%	10.1%	0.0%	0.0%	3.7%	0.1%
Misery Brook (3,993 ac)	1,942.4	0.0%	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	3.3%	0.2%
Muddy River (13,947 ac)	7,395.1	0.0%	0.0%	4.7%	0.0%	0.9%	0.0%	0.0%	2.9%	0.1%
Quinnipiac River (46,500 ac)	30,216.4	0.0%	0.0%	6.0%	0.0%	8.7%	0.0%	0.0%	3.5%	0.1%
WPCF Point Sources	428.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sodom Brook (3,377 ac)	2,100.5	0.0%	0.0%	5.5%	0.0%	0.0%	0.0%	0.0%	3.9%	0.1%
Tenmile River (12,967 ac)	6,361.0	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	3.1%	0.1%
Wharton Brook (4,895 ac)	3,312.4	0.0%	0.0%	5.3%	0.0%	12.2%	0.0%	0.0%	3.4%	0.1%
Watershed Total (105,952 ac)	62,163.2	0.0%	0.0%	5.5%	0.0%	5.9%	0.0%	0.0%	3.3%	0.1%

Fecal Coliform Load Reductions with Watershed Management Recommendations

Watershed Management Recommendation	Existing Conditions (lb/yr)	Future Conditions with Contols (trillion/yr)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	172.5	172.5	172.5	166.1	165.1	172.5	165.1	168.9	172.5	172.2
Eightmile River (9,441 ac)	584.2	584.2	584.2	557.2	551.3	584.2	551.3	567.5	584.2	578.7
Harbor Brook (7,751 ac)	618.7	618.7	618.7	571.9	502.8	531.6	502.8	610.9	618.7	617.2
Misery Brook (3,993 ac)	407.4	407.4	407.4	385.3	383.7	407.4	383.7	395.5	407.4	406.7
Muddy River (13,947 ac)	1,057.0	1,057.0	1,057.0	999.8	1,019.0	1,044.0	1,019.0	1,037.9	1,057.0	1,054.3
Quinnipiac River (46,500 ac)	5,795.7	5,367.3	5,795.7	5,512.3	5,338.2	5,333.9	5,338.2	5,524.1	5,795.7	5,776.0
WPCF Point Sources	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Sodom Brook (3,377 ac)	369.8	369.8	369.8	351.8	333.6	369.8	333.6	349.6	369.8	368.6
Tenmile River (12,967 ac)	836.8	836.8	836.8	792.1	799.2	836.8	799.2	816.5	836.8	833.7
Wharton Brook (4,895 ac)	625.2	625.2	625.2	594.0	578.9	547.7	578.9	595.6	625.2	624.5
Watershed Total (105,952 ac)	10,470.7	10,042.3	10,470.7	9,934.0	9,675.2	9,831.3	9,675.2	10,069.9	10,470.7	10,435.1

Watershed Management Recommendation	Existing Conditions (lb/yr)	Load Reduction due to Contols (%)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	172.5	0.0%	0.0%	3.7%	4.3%	0.0%	4.3%	2.1%	0.0%	0.2%
Eightmile River (9,441 ac)	584.2	0.0%	0.0%	4.6%	5.6%	0.0%	5.6%	2.9%	0.0%	0.9%
Harbor Brook (7,751 ac)	618.7	0.0%	0.0%	7.6%	18.7%	14.1%	18.7%	1.3%	0.0%	0.3%
Misery Brook (3,993 ac)	407.4	0.0%	0.0%	5.4%	5.8%	0.0%	5.8%	2.9%	0.0%	0.2%
Muddy River (13,947 ac)	1,057.0	0.0%	0.0%	5.4%	3.6%	1.2%	3.6%	1.8%	0.0%	0.3%
Quinnipiac River (46,500 ac)	5,795.7	7.4%	0.0%	4.9%	7.9%	8.0%	7.9%	4.7%	0.0%	0.3%
WPCF Point Sources	3.4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sodom Brook (3,377 ac)	369.8	0.0%	0.0%	4.8%	9.8%	0.0%	9.8%	5.4%	0.0%	0.3%
Tenmile River (12,967 ac)	836.8	0.0%	0.0%	5.3%	4.5%	0.0%	4.5%	2.4%	0.0%	0.4%
Wharton Brook (4,895 ac)	625.2	0.0%	0.0%	5.0%	7.4%	12.4%	7.4%	4.7%	0.0%	0.1%
Watershed Total (105,952 ac)	10,470.7	4.1%	0.0%	5.1%	7.6%	6.1%	7.6%	3.8%	0.0%	0.3%

Runoff Volume Reductions with Watershed Management Recommendations

Watershed Management Recommendation	Existing Conditions (acre-ft/yr)	Future Conditions with Contols (1,000 acre-ft/yr)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	2.8	2.8	2.8	2.7	2.8	2.8	2.8	2.8	2.8	2.8
Eightmile River (9,441 ac)	10.2	10.2	10.2	9.8	10.2	10.2	10.2	10.2	10.2	10.2
Harbor Brook (7,751 ac)	11.3	11.3	11.3	10.6	11.3	10.4	11.3	11.3	11.3	11.3
Misery Brook (3,993 ac)	4.8	4.8	4.8	4.5	4.8	4.8	4.8	4.8	4.8	4.8
Muddy River (13,947 ac)	16.7	16.7	16.7	15.8	16.7	16.6	16.7	16.7	16.7	16.7
Quinnipiac River (46,500 ac)	64.8	64.8	64.8	60.7	64.8	60.3	64.8	64.8	64.8	64.8
WPCF Point Sources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sodom Brook (3,377 ac)	4.7	4.7	4.7	4.4	4.7	4.7	4.7	4.7	4.7	4.7
Tenmile River (12,967 ac)	15.9	15.9	15.9	15.1	15.9	15.9	15.9	15.9	15.9	15.9
Wharton Brook (4,895 ac)	6.9	6.9	6.9	6.5	6.9	6.2	6.9	6.9	6.9	6.9
Watershed Total (105,952 ac)	138.1	138.1	138.1	130.0	138.1	131.8	138.1	138.1	138.1	138.1

Watershed Management Recommendation	Existing Conditions (lb/yr)	Load Reduction due to Contols (%)								
		CSO Abatement	WPCF Point Source Reductions	Green Infrastructure/ LID Retrofits (Retrofit 10% of residential, industrial, commercial, and transportation land uses)	Riparian Buffer Restoration	Reforestation	Public Education	Illicit Discharge Detection and Elimination (IDDE)	Street Sweeping and Catch Basin Cleaning	Septic Repair
Broad Brook (3,080 ac)	2.8	0.0%	0.0%	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eightmile River (9,441 ac)	10.2	0.0%	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Harbor Brook (7,751 ac)	11.3	0.0%	0.0%	6.4%	0.0%	8.6%	0.0%	0.0%	0.0%	0.0%
Misery Brook (3,993 ac)	4.8	0.0%	0.0%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Muddy River (13,947 ac)	16.7	0.0%	0.0%	5.1%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%
Quinnipiac River (46,500 ac)	64.8	0.0%	0.0%	6.4%	0.0%	7.0%	0.0%	0.0%	0.0%	0.0%
WPCF Point Sources	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sodom Brook (3,377 ac)	4.7	0.0%	0.0%	6.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tenmile River (12,967 ac)	15.9	0.0%	0.0%	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wharton Brook (4,895 ac)	6.9	0.0%	0.0%	6.0%	0.0%	9.6%	0.0%	0.0%	0.0%	0.0%
Watershed Total (105,952 ac)	138.1	0.0%	0.0%	5.9%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%

Appendix E

Implementation Schedule, Milestones, and Evaluation Criteria

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Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Objective 1-1. Promote Inter-municipal Coordination				
Adoption of the updated watershed based plan by the watershed municipalities	QRWA	6 mos	Memorandum of Agreement (MOA), inter-municipal agreement, or compact	Signing of MOA by watershed municipalities
Re-establish a formal watershed coalition or initiative	QRWA	6 mos	Watershed Coalition members identified	
Establish subcommittees for implementation of the watershed plan	QRWA	6 mos	Subcommittee members identified	
Hire a long-term Watershed Coordinator	QRWA	1 yr	Watershed Coordinator position funded and filled	Develop and track annual work plan; leading outreach activities
Objective 1-2. Identify and Secure Funding				
Review and identify priority funding sources	QRWA, Municipalities	Ongoing	Target funding sources	Sources identified
Submit grant applications for projects identified in the Watershed Management Plan	QRWA, Municipalities	Ongoing	Grant applications	Amount of funding secured and grant applications submitted
Actively advocate for state and federal funding	QRWA and other interested organizations in Connecticut	Ongoing	Grant applications	Amount of funding secured and grant applications submitted
Pursue EPA Urban Waters designation for the Q River watershed	QRWA, CTDEEP, and EPA	2 yrs	Coordination with CTDEEP and EPA	Federal Partnership designation
Objective 1-3. Promote Regional Collaboration				
Engage local, state, and regional organizations	QRWA	Ongoing	Relationships with organizations	
Initiate contact with other municipalities, agencies, organizations and communities	QRWA	Ongoing	Support from private and public economic and business sectors	
Review and implement, as appropriate, new approaches from revised CTDEEP NPS Management Plan	QRWA	1 yr	New NPS management approaches and tools	
Objective 1-4. Conduct Stream Walks				
Review the previous stream walk findings (from 2006)	QRWA	1 yr	Review findings	
Conduct stream walks, including planning and training, in priority subwatersheds	QRWA, NRCS, volunteers	1-5 yrs	Streamwalk findings report	Number of reaches and areas assessed
Conduct visual trackdown surveys	QRWA, NRCS, SWCD, volunteers	1-5 yrs	Trackdown survey reports	Number of reaches and areas assessed and number of potential restoration and retrofit projects

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Objective 1-5. Prepare and Implement Subwatershed Action Plans				
Prepare and implement subwatershed action plans for priority subwatersheds	QRWA and Municipalities	2-5 yrs	Subwatershed Action Plans	Number of recommendations from Subwatershed Action Plans implemented
Objective 2-1. Continue Water Quality Monitoring				
Perform an analysis of critical data gaps at high-priority monitoring sites	QRWA	1 yr	Data gaps report	
Continue ongoing water quality (chemical and biological) monitoring program	CTDEEP, USGS, Municipalities (MS4s)	Ongoing	Monitoring data, reporting	Monitoring results, findings
Continue the QRWA volunteer participation in benthic macroinvertebrate monitoring using Rapid Bioassessment in Wadeable Streams & Rivers by Volunteer Monitors (RBV) program	QRWA, NRCS, CTDEEP	Ongoing	Monitoring data, reporting	Monitoring results, findings
Pursue dedicated funding to finance annual or biennial water quality monitoring summary reports	Watershed Coalition, NRCS, CTDEEP	1-2 yrs	Monitoring data, reporting	Monitoring results, findings
Objective 2-2. Reduce or Eliminate Point Source Discharges				
Eliminate the four active Combined Sewer Overflows (CSO) discharge locations within the Quinnipiac River watershed	New Haven	10 yrs	CSOs Eliminated	
Continue reduction in phosphorus loads from municipal Water Pollution Control Facilities (WPCFs) in the watershed	Southington, Cheshire, Meriden, and Wallingford	5-10 yrs	Provide funding to help implement the necessary WPCF upgrades	Meets existing NPDES permit limits and/or the outcome of the CTDEEP's ongoing state-wide phosphorus reduction strategy
Extend disinfection at WPCFs through October (to end of paddle season)	Southington, Cheshire, Meriden, Wallingford, and North Haven	1-5 yrs	Disinfection extended	
Objective 2-3. Reduce Impacts of the Subsurface Sewage Disposal Systems				
Strengthen municipal regulations to require upgrades to on-site sewage disposal systems	Municipalities	2-10 yrs	Revised regulations	Implementation of revised regulations and number of systems upgraded
Objective 2-4. Promote LID and Green Infrastructure				
Continue LID and green infrastructure demonstration projects. Implement stormwater retrofits identified in watershed plan.	Municipalities, QRWA	2-10 yrs	Completed projects	Number of projects, photos, monitoring
Incorporate LID and green infrastructure requirements into local land use regulations. Implement LID/GI recommendations of ongoing regional regulatory review.	Municipalities	1-5 yrs	Revised land use regulations and policies	

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Provide education and outreach for designers, land use commissioners, municipal staff, and the public	QRWA, Municipalities	1-5 yrs	Educational events and materials	Number of events and participants
Pursue sustainable, long-term funding sources to create a comprehensive green infrastructure program	Municipalities	5-10 yrs	Alternative funding sources for green infrastructure projects	Funding programs implemented
Objective 2-5. Implement Municipal Stormwater Management Programs				
Revise and update municipal stormwater management programs	Municipalities (MS4s)	2-5 yrs	Municipal stormwater management plans	Compliance with the re-issued MS4 General Permit
Work cooperatively to implement MS4 programs. Consider forming a regional coalition of regulated MS4s.	Municipalities (MS4s)	1-5 yrs	Cost savings for public education and outreach, monitoring, mapping, and IDDE requirements	Compliance with the re-issued MS4 General Permit
Objective 2-5. Protect Existing and Restore Degraded Riparian Buffers				
Implement priority buffer restoration projects	QRWA, Municipalities	2-10 yrs	Completed projects	Number of projects, photos, monitoring
Adopt/strengthen local riparian buffer protection regulations	Municipalities	2-5 yrs	Revised regulations	
Riparian buffer education for developers, designers, municipal staff, and the public	QRWA	2-5 yrs	Educational events and materials	Number of participants and audience reached
Preserve and enhance riparian buffers for projects that provide public access. Engage volunteers in buffer restoration projects.	QRWA	Ongoing	Completed projects	Number of projects, photos, monitoring, and number of volunteers
Objective 2-7. Reduce Nuisance Waterfowl				
Continue/enhance waterfowl deterrent efforts, focusing on vegetative buffers/barriers.	QRWA, Municipalities	2-5 yrs	Education/outreach materials	
Augmented existing regulatory controls prohibiting the feeding of waterfowl	Municipalities	1-2 yrs	Revised regulations	
Adopt and implement pet waste regulations/programs	Municipalities, State Parks	2-5 yrs	New or enhanced programs	
Objective 2-8. Identify and Eliminate Illicit Discharges				
Implement IDDE programs as required by the existing and re-issued MS4 Permit	Municipalities (MS4s)	2-5 yrs	Updated IDDE program	Meets requirements of MS4 Permit
Educate municipal staff and the public on the topic of illicit discharges	Municipalities (MS4s)	Ongoing	Education events and materials	Number of participants and audience reached
Implement priority stream cleanup projects	QRWA	Ongoing	Completed cleanups	Number of cleanups, photos, amount of waste cleaned up

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Conduct follow-up illicit discharge investigations at priority outfall locations identified during stream walks	QRWA, Municipalities (MS4s)	1-5 yrs	Completed follow-up and action taken to rectify illicit discharges	Number of potential identified illicit discharges investigated; number of illicit discharges rectified
Objective 2-9. Promote Good Lawn Care Practices				
Promote good lawn care practices and organic lawn care techniques through education and outreach	QRWA, Watershed Partnership, Inc., Municipalities	Ongoing	Workshops, educational material	
Develop incentive-based programs	QRWA, Municipalities	2-5 yrs	Certificate program or other implemented	Amount of funding
Promote organic lawn/land care and non-lawn alternatives to the landscaping industry. Decrease and eliminate the use of toxic lawn pesticides.	QRWA, Watershed Partnership, Inc.	Ongoing	Educational materials and programs	
Transition to pesticide-free athletic fields and other municipal properties	Municipalities	5 yrs	Educational materials and programs	
Pass resolutions asking their citizens to voluntarily stop using toxic lawn pesticides and synthetic fertilizers.	QRWA, Municipalities	5 yrs	Resolutions passed	Decreased usage of pesticides and synthetic fertilizers by residents
Implement a public awareness campaign modeled after the City of Middletown's Project Green Lawn to encourage residents and businesses to eliminate lawn chemicals	QRWA, Municipalities	5 yrs	Educational materials and programs	
Objective 2-10. Reduce Impacts from Hotspot Land Uses				
Improve housekeeping programs and stormwater compliance at DPW facilities and parks	Municipalities	1-2 yrs	Compliance reviews and follow-up correctvie actions	Compliance with respect to NPDES and MS4 Permits
Develop outreach program to dovetail with CTDEEP industrial stormwater permitting requirements for facility operators	Municipalities	1-2 yrs	Outreach with industrial facilities	Number of facilities visited
Ensure that reissued NPDES industrial water discharge permits contain provisions for TMDL implementation, LID, runoff volume reduction, and water quality protection	QRWA, CTDEEP	Ongoing	Reviewed/revised NPDES permits	Number of NPDES permits reviewed
Incorporate source controls, green infrastructure, and LID practices into brownfield redevelopment projects to reduce pollutant loads and runoff volumes	Municipalities, Developers	1-2 yrs	Improved stormwater controls at redevelopment sites	Number of redevelopment projects
Cleanup and promote sustainable re-use of contaminated sites	Municipalities	2-5 yrs	Cleanup of brownfields	Number of cleanup projects

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Objective 3-1. Protect and Restore In-Stream and Riparian Habitat				
Implement recommendations of ongoing Trout Unlimited stream continuity surveys. Implement fish passage projects at identified barriers or impediments.	QRWA, TU, TNC, Municipalities, NRCS, CTDEEP	5-10 yrs	Feasibility assessment and fish passage projects	Number of projects completed, percent of barriers removed
Revise local storm drainage design standards and regulations to comply with Connecticut Stream Crossing Guidelines	Municipalities	2-5 yrs	Revised local storm drainage design standards	
Evaluate feasibility and cost of removing remaining Q River dams	USFWS, CTDEEP, QRWA	2 yrs	Feasibility assessment	
Implement priority stream restoration projects	QRWA, Municipalities, NRCS, CTDEEP	2-10 yrs	Completed projects	Number of projects, photos, monitoring
Implement stream daylighting projects for priority culvertized segments in the watershed	Watershed Coalition, Municipalities, NRCS, CTDEEP	5-10 yrs	Completed projects	Number of projects, photos, monitoring
Change rate structure of municipal water utilities to promote water conservation in low-flow seasons	Municipalities	2-10 yrs	Utility rate structure revised	Increased stream flows in low-flow season
Objective 3-2. Protect and Restore Forested Areas and Watershed Tree Canopy				
Protect existing forests through land acquisition and conservation easements	Municipalities	Ongoing	Completed projects	Area of forest land preserved
Strengthen local tree removal regulations and enforcement. Consider developing a tree ordinance.	Municipalities	1-5 yrs	Adopted/amended regulations and ordinance	
Reforest public lands. Encourage reforestation of private land with native species. Identify and convert former industrial sites to forest or vegetated open space.	Municipalities, QRWA, private landowners	Ongoing	Completed projects	Area of reforested land
Establish tree canopy goals for Harbor Brook, Sodom Brook, and Quinnipiac River mainstem	QRWA, Municipalities	2-5 yrs	Completed Tree Canopy evaluation	
Engage the tree wardens in the watershed municipalities	QRWA, Municipalities	1-5 yrs	Meetings and discussions with tree wardens	Participation be tree wardens in urban forestry efforts
Implement local tree planting demonstration projects	Municipalities	2-10 yrs	Completed projects	Number of projects, photos
Objective 3-3. Manage Invasive Plant Species				
Implement priority invasive species management projects identified during streamwalks and trackdown surveys	QRWA, Municipalities, Universities and Schools	2-10 yrs	Completed projects	Number of projects, photos, monitoring
Develop an invasive species management plan for targeted areas	QRWA, Municipalities, CT DEEP, The Nature Conservancy,	5 yrs	Management plan	
Educate residents, facility maintenance personnel, landscapers and local nurseries, and land use commissions about non-native invasive species	QRWA	2 yrs	Education events and materials	number of participants and audience reached

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Involve volunteers and neighborhood groups in invasive species removal	QRWA	Ongoing	Invasive species removal	Number of sites or areas restored
Objective 3-4. Investigate, Protect, and Restore the Quinnipiac River Tidal Marsh and Estuary				
Develop an Ecological Master Plan for the Quinnipiac River tidal marsh	QRWA	2-5 yrs	Ecological Master Plan	
Continue investigations into the causes and implications of marsh drowning	Yale University, Quinnipiac University	Ongoing	Study reports	
Monitor development and redevelopment projects adjacent to the tidal marsh to prevent adverse impacts to wildlife habitat	QRWA, Hampden, New Haven, and North Haven land use boards and commissions	Ongoing	Coordination with town/city land use boards/commissions	Number of projects evaluated
Continue to improve public access to the marsh	QRWA, North Haven Trail Association	Ongoing	Easements and/or acquisition for access or trail locations	number of access points, acres of land acquired or gained easements
Objective 3-5. Restore Hanover Pond				
Conduct an evaluation of Hanover Pond, including possible restoration strategies and costs	QRWA, Meriden Linear Trails Advisory Committee and "Hanover Pond Initiative" sub-committee	1-2 yrs	Evaluation report	Identify and begin implementing action items
Objective 4-1. Strengthen Land Use Regulations				
Implement recommendations of updated regional land use regulatory review by Mill River Watershed Association	Municipalities	2-5 yrs	Amended/new land use regulations and policies	Number of towns with amended/new regulations and policy
Reference the Quinnipiac River Watershed Based Plan in municipal Plans of Conservation and Development	Watershed Coalition	1-2 yrs	POCD revised	
Objective 4-2. Address Flooding Through a Watershed Approach				
Continue implementing Meriden's flood control plan	Meriden	Ongoing	Flood control projects complete	Reduction in flooding
Adopt a policy of no-net-loss of flood storage capacity or flood conveyance	Municipalities	2-5 yrs	Revised floodplain management codes	
Updating the design storm rainfall amounts and assessing the vulnerability of public and private infrastructure (e.g., utilities, transportation, structures)	Municipalities	2-10 yrs	Design storm amount changes in regulations; climate change vulnerability assessments	Number of municipalities to adopt revised design storm amounts and complete vulnerability assessments
Address current flood problems using federal and state agency assistance and resources	QRWA, Municipalities	2-5 yrs	Pursue federal grants and technical assistance	
Objective 4-3. Preserve and Protect Open Space				
Acquire unprotected open space	QRWA, Land Trusts, Municipalities	Ongoing	Protected land	Number of sites and acres protected

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Provide for public access to open space areas	Municipalities	Ongoing	Completed projects	Number of sites
Update open space planning documents at least every five years	Municipalities	1-5 yrs	Open space planning documents updates	
Perform an evaluation of undeveloped and underdeveloped parcels in the watershed	QRWA	2-5 yrs	Evaluation report	
Objective 4-4. Increase Public Access to the River				
Continue the Quinnipiac River Greenway and connect inter-municipal segments of linear trails along the Quinnipiac River throughout the watershed.	QRWA, New Haven, North Haven, Hamden, Wallingford, Cheshire, Meriden, Southington and Plainville	10 yrs	Completed Greenway, connectivity achieved	
Develop a public access area inventory for the Quinnipiac River and its tributaries	QRWA	2-5 yrs	Map and listing of the areas summarizing location, size, current and potential uses, and ownership.	
Complete USDA canoe launch project. Aomplete additional launch at North Haven municipal-owned parking lot and add a launch at Tolles Road.	QRWA, Municipalities	2-5 yrs	Canoe launches	
Investigate log jam issue on Lower Quinnipiac Canoeable Trail at Tolles Road and Banton Street and long-term maintenance and funding needed.	QRWA	1-2 yrs	Evaluation recommendations and suggested funding approach	
Re-shape water body in Community Lake basin adjacent to Wallingford Senior Center and provide water-based recreational access.	QRWA, Wallingford	2-5 yrs	Reconstructed basin	
Enhance or provide river access at existing public open spaces	QRWA, Municipalities	Ongoing	Public access location	Number of access locations
Introduce educational signage, interpretive stations, maps and online resources to public access areas	QRWA, Municipalities	Ongoing	Public access locations with signage	Number/percentage of access locations with signage
Objective 5-1. Enhance the QRWA Website				
Create webpage on QRWA website for the watershed plan. Expand website to include downloadable educational materials. Create working library of technical and outreach materials. Include prominent links to other major sources of information on the Q River.	QRWA	1-2 yrs	Website updated	
Objective 5-2. Advance Local Government and Business Community Awareness				
Provide Annual Municipal Pollution Prevention Training	Municipalities, NEMO	Annually	Training materials	Number of training sessions provided, number of participants

Quinnipiac River Watershed Based Plan - Implementation Schedule, Milestones, and Evaluation Criteria

Action Items	Lead Entity	Timeline	Products	Evaluation Criteria
Provide Training for Municipal Reviewers, and Designers	Municipalities, NEMO, CTDEEP	2-5 yrs	Training materials	Number of sessions or participants
Provide Training for Municipal Building Inspectors	Municipalities, NEMO	2-5 yrs	Training materials	Number of sessions or participants
Conduct targeted outreach for municipal parks and recreation employees on riparian buffers, invasive plant management, and organic lawn care practices	QRWA, Southwest Conservation District, CT Sea Grant, NEMO, NRCS	2-5 yrs	Outreach materials	Number of materials and programs
Conduct targeted outreach to residential builders on Low Impact Development	NEMO, CTDEEP, Southwest Conservation District	2-5 yrs	Outreach materials	Number of materials and programs
Conduct workshops on best practices for institutional land owners	NEMO, CTDEEP, Southwest Conservation District	2-5 yrs	Outreach materials	Number of sessions or participants
Objective 5-3. Conduct Homeowner Outreach and Education				
Promote Sustainable Lawn and Landscape Maintenance and Backyard Habitat	QRWA	Ongoing	Education materials	Number of workshops and number of attendees
Promote Rooftop Disconnection	QRWA	Ongoing	Education materials on the use of rain barrels/cisterns and rain gardens for rooftop disconnection	Number of roof leaders disconnected
Increase Watershed Stewardship Signage	QRWA	Ongoing	New signage	Number of signs and participants
Objective 5-4. Enhance School Education and Stewardship Programs				
Identify Target Schools for Educational Programs	QRWA, Municipalities	1-2 yrs	Schools identified	Number of schools identified, number of students
Implement a Watershed-Based Curriculum	QRWA, Municipalities	2-5 yrs	Complete curriculum	Number of school districts implementing new curriculum
Establish a Stewardship Work Program	QRWA, Municipalities, Businesses	5 yrs	Establish work program	Number of participating schools, teachers, and students

Appendix F

Potential Funding Sources

Quinnipiac River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
EPA Urban Waters Small Grants Program	Funds research, investigations, experiments, training, surveys, studies, and demonstrations that will advance the restoration of urban waters by improving water quality through activities that also support community revitalization and other local priorities. Projects proposed for funding must take place entirely within and focus on specific Eligible Geographic Areas.	http://www2.epa.gov/urbanwaters/urban-waters-small-grants
EPA Healthy Communities Grant Program	EPA New England's main competitive grant program to work directly with communities to reduce environmental risks to protect and improve human health and the quality of life.	http://www.epa.gov/region1/eco/uep/hcgp.html
EPA Targeted Watersheds	EPA initiated the Targeted Watersheds Grant Program in 2002 to encourage successful community-based approaches to protect and restore the nation's watersheds. Watershed health is important to providing clean, safe water where Americans live, work and play. Since 2003, more than $50 million has been provided to 61 organizations through EPA Targeted Watersheds Grants.	http://water.epa.gov/grants_funding/twg/initiative_index.cfm
EPA Environmental Education Grants	The Grants Program sponsored by EPA's Office of Environmental Education (OEE), Office of External Affairs and Environmental Education, supports environmental education projects that enhance the public's awareness, knowledge, and skills to help people make informed decisions that affect environmental quality.	http://www.epa.gov/enviroed/grants.html
EPA Five Star Restoration Grant Program	The Five Star Restoration Program brings together students, conservation corps, other youth groups, citizen groups, corporations, landowners and government agencies to provide environmental education and training through projects that restore wetlands and streams. The program provides challenge grants, technical support and opportunities for information exchange to enable community-based restoration projects.	http://www.epa.gov/owow/wetlands/restore/5star/
United States Fish and Wildlife Service (USFWS)	The USFWS administers a variety of natural resource assistance grants to governmental, public and private organizations, groups and individuals.	http://www.fws.gov/grants/

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Funding Source	Description	Reference
USFWS North American Wetlands Conservation Act (NAWCA)	NAWCA provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.	http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm
USFWS Partners for Fish and Wildlife Program	The Partners Program provides technical and financial assistance to private landowners and Tribes who are willing to work with USFWS and other partners on a voluntary basis to help meet the habitat needs of Federal Trust Species. The Partners Program can assist with projects in all habitat types which conserve or restore native vegetation, hydrology, and soils associated with imperiled ecosystems such as longleaf pine, bottomland hardwoods, tropical forests, native prairies, marshes, rivers and streams, or otherwise provide an important habitat requisite for a rare, declining or protected species.	http://www.fws.gov/partners/
USFWS National Coastal Wetlands Conservation Grant Program	The NCWCGP provides States with financial assistance to protect and restore these valuable resources. Projects can include (1) acquisition of a real property interest (e.g., conservation easement or fee title) in coastal lands or waters (coastal wetlands ecosystems) from willing sellers or partners for long-term conservation or (2) restoration, enhancement, or management of coastal wetlands ecosystems. All projects must ensure long-term conservation.	http://www.fws.gov/coastal/coastalgrants/
USFS Watershed and Clean Water Action and Forestry Innovation Grants	This effort between USDA FS-Northeastern Area and State Foresters is to implement a challenge grant program to promote watershed health through support of state and local restoration and protection efforts.	http://www.na.fs.fed.us/watershed/gp_innovation.shtm
NRCS Conservation Stewardship Program	This program is available to producers to address resource concerns in a comprehensive manner by improving existing conservation activities and undertaking new conservation activities.	http://www.nrcs.usda.gov/programs/csp/

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Funding Source	Description	Reference
NRCS Conservation Reserve Program	This program is to provide technical and financial assistance to eligible farmers to address soil, water, and related natural resource concerns on their lands in an environmentally-beneficial and cost-effective manner.	http://www.nrcs.usda.gov/programs/crp/
NRCS Emergency Watershed Protection (EWP) Program	The Emergency Watershed Protection (EWP) Program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, wind-storms, and other natural occurrences. EWP is an emergency recovery program.which responds to emergencies created by natural disasters. It is not necessary for a national emergency to be declared for an area to be eligible for assistance. EWP is designed for installation of recovery measures. Activities include providing financial and technical assistance to remove debris from stream channels, road culverts, and bridges, reshape and protect eroded banks, correct damaged drainage facilities, establish cover on critically eroding lands, repair levees and structures, and repair conservation practices.	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/
NRCS Floodplain Easement Program	NRCS is providing up to $124.8 million in Emergency Watershed Protection Program-Floodplain Easement funding to help prevent damages from future storm events in Connecticut and other states affected by Hurricane Sandy. NRCS purchases the permanent easements on eligible lands and restores the area to natural conditions. The program complements traditional disaster recovery funding and allows NRCS to purchase a permanent easement on lands within floodplains that sustained damage from Sandy.	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/home/?cid=stelprdb1143958
NRCS Wildlife Habitat Incentives Program (WHIP)	For creation, enhancement, maintenance of wildlife habitat; for privately owned lands.	http://www.nrcs.usda.gov/programs/whip/
NRCS Environmental Quality Incentives Program (EQIP)	For implementation of conservation measures on agricultural lands.	http://www.ct.nrcs.usda.gov/programs/eqip/eqip.html

Quinnipiac River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
NRCS Healthy Forests Reserve Program	For restoring and enhancing forest ecosystems	http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html
NRCS Wetlands Reserve Program	For protection, restoration and enhancement of wetlands	http://www.nrcs.usda.gov/programs/wrp/
CTDEEP Section 319 Grant Program	Clean Water Act Section 319 funds to effectively and efficiently address nonpoint source pollution are available to municipalities, nonprofit environmental organizations, regional water authorities/planning agencies, and watershed associations.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325594&deepNav_GID=1654
CTDEEP Section 604(b) Grant Program	Under the federal Clean Water Act, Section 604(b) funds are awarded to CTDEEP to carry out water quality management planning including revising water quality standards; performing waste load allocation/total maximum daily loads, point and non-point source planning activities, water quality assessments and watershed restoration plans.	http://www.ct.gov/deep/cwp/view.asp?a=2688&Q=458026&depNav_GID=1511
CTDEEP Connecticut Clean Water Fund	The Connecticut Clean Water Fund (CWF) is the state's environmental infrastructure assistance program. The fund was established in 1986 to provide financial assistance to municipalities for planning, design and construction of wastewater collection and treatment projects. This program was developed to replace state and federal grant programs that had existed since the 1950s. The 1987 amendments to the Federal Clean Water Act required that states establish a revolving loan program by 1989. The fund was modified in 1996 to include the Drinking Water State Revolving Fund (DWSRF) to assist water companies in complying with the Safe Drinking Water Act by providing low cost financing.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325578&depnav_gid=1654

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Quinnipiac River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
Connecticut Lakes Grant Program	Provides matching grants for lake restoration projects to municipalities, lake authorities, and lake taxing districts at lakes that are available to the general public for recreation. Funds for the Lakes Grant Program are made available through authorizations of the State Legislature and allocated by the State Bond Commission. The Lakes Grant Program requires a 25% match for studies and a 50% match for implementation of control measures. When funding is available for the Lakes Grant Program, notification is provided to every municipality in Connecticut and to groups who have previously inquired about funding for lake management projects.	http://www.ct.gov/deep/cwp/view.asp?a=2719&q=332726&depnav_gid=1654
Long Island Sound Study - Long Island Sound Research Grant Program	To support research that will enhance scientific understanding of Long Island Sound, and provide information needed by managers to protect and effectively manage the Sound and its valuable resources. Available to Connecticut academic institutions.	http://longislandsoundstudy.net/research-monitoring/lis-research-grant-program/
CTDEEP Hazard Mitigation Grant Program	Provides financial assistance to state and local governments for projects that reduce or eliminate the long-term risk to human life and property from the effects from natural hazards.	http://www.ct.gov/dep/cwp/view.asp?a=2720&q=325654&depNav_GID=1654
CTDEEP Landowner Incentive Program	The Wildlife Division's Landowner Incentive Program (LIP) provides technical advice and cost assistance to private landowners for habitat management that will result in the protection, restoration, reclamation, enhancement, and maintenance of habitats that support fish, wildlife, and plant species considered at-risk. This program has been made possible through grants from the U.S. Fish and Wildlife Service.	http://www.ct.gov/dep/cwp/view.asp?a=2723&q=325734&depNav_GID=1655
CTDEEP Long Island Sound License Plate Program	Section 14-21e of the Connecticut General Statutes (CGS) authorizes the issuance of the Long Island Sound license plate by the Department of Motor Vehicles, while CGS Section 22a-27k establishes the Long Island Sound Fund to be administered by the Department of Energy and Environmental Protection into which proceeds from the sale of the plates are deposited.	http://www.ct.gov/dep/cwp/view.asp?a=2705&q=323782&depNav_GID=1635

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Quinnipiac River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
CTDEEP Open Space and Watershed Land Acquisition	The Open Space and Watershed Land Acquisition (OSWA) Grant Program provides financial assistance to municipalities and nonprofit land conservation organizations to acquire land for open space and to water companies to acquire land to be classified as Class I or Class II water supply property.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323834&depNav_GID=1641
CTDEEP Recreation and Natural Heritage Trust Program	The Recreation and Natural Heritage Trust program was created by the Legislature in 1986 in order to help preserve Connecticut's natural heritage. It is the CTDEEP's primary program for acquiring land to expand the state's system of parks, forests, wildlife, and other natural open spaces.	http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1641
CTDEEP Urban Forestry Grant Programs	America the Beautiful Urban Forestry Grants: Grants of up to $12,000 are available to assist municipalities and non-profits in local urban forestry efforts. Urban Forestry Outreach Grant: Grants for non-profit organizations in urbanized areas to foster outreach in these areas.	http://www.ct.gov/dep/cwp/view.asp?a=2697&q=322872&depNav_GID=1631&depNav=|
CT OPM Small Town Economic Assistance Program (STEAP)	Funds economic development, community conservation and quality of life projects for localities that are ineligible to receive Urban Action (CGS Section 4-66c) bonds. This program is administered by the Office of Policy and Management. STEAP funds are issued by the State Bond Commission and can only be used for capital projects. Eligible projects include projects involving environmental protection. STEAP fnds were recently award to the Town of Bolton for preparation of a management plan for Bolton Lakes.	http://www.ct.gov/opm/cwp/view.asp?Q=382970
American Rivers – NOAA Community-Based Restoration Program Partnership	These grants are designed to provide support for local communities that are utilizing dam removal or fish passage to restore and protect the ecological integrity of their rivers and improve freshwater habitats important to migratory fish.	http://www.americanrivers.org/initiative/grants/projects/american-rivers-and-noaa-community-based-restoration-program-river-grants-2/

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Funding Source	Description	Reference
FishAmerica Foundation Conservation Grants	FishAmerica, in partnership with the NOAA Restoration Center, awards grants to local communities and government agencies to restore habitat for marine and anadromous fish species. Successful proposals have community-based restoration efforts with outreach to the local communities.	http://www.fishamerica.org/grants.html
NFWF Five Star and Urban Waters Restoration Grant Program	The Five Star and Urban Waters Restoration Program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country.	http://www.nfwf.org/fivestar/Pages/home.aspx
NFWF Long Island Sound Futures Fund	The Long Island Sound Futures Fund supports projects in local communities that aim to protect and restore the Long Island Sound. It unites federal and state agencies, foundations and corporations to achieve high-priority conservation objectives. Funded activities demonstrate a real, on-the-ground commitment to securing a healthy future for the Long Island Sound.	http://longislandsoundstudy.net/about/grants/lis-futures-fund/
NFWF Hurricane Sandy Coastal Resiliency Competitive Grant Program	Funding will support projects that reduce communities' vulnerability to the growing risks from coastal storms, sea level rise, flooding, erosion and associated threats through strengthening natural ecosystems that also benefit fish and wildlife. Eligible projects include project planning and design, coastal resiliency assessments, restoration and resiliency projects, green infrastructure, and community coastal resiliency planning. Eligible applicants include non-profit 501(c) organizations, local governments and agencies, recognized tribes, state government agencies and academic institutions.	http://www.nfwf.org/hurricanesandy/Pages/home.aspx

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Funding Source	Description	Reference
Corporate Wetlands Restoration Partnership (CWRP)	Coastal America is an action-oriented, results-driven process aimed at restoring and preserving vital coastal ecosystems and addressing our most critical environmental issues. The Coastal America Partnership was launched in 1991 and formalized in 1992 with a Memorandum of Understanding signed by nine sub-cabinet level agency representatives. These representatives committed their agencies to work together and integrate their efforts with state, local and nongovernmental activities. The Coastal America Partnership utilizes a number of tools and programs to facilitate its mission. These include the Corporate Wetlands Restoration Partnership (CWRP) and the network of Coastal Ecosystem Learning Centers (CELCs), and the Coastal America Partnership Awards program.	http://www.ctcwrp.org/9/
Trout Unlimited Embrace A Stream	Embrace-A-Stream (EAS) is a matching grant program administered by TU that awards funds to TU chapters and councils for coldwater fisheries conservation.	http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream
Quinnipiac River Fund	The Quinnipiac River Fund was created to improve the environmental quality of the Quinnipiac River, New Haven Harbor and its surrounding watersheds, and otherwise to benefit the environment of these resources. Each year the Fund distributes more than $100,000 to projects that conserve and protect the River and surrounding watersheds. The Fund supports projects focused on research, public access, land use planning, land acquisition, habitat restoration, advocacy, and education.	http://thequinnipiacriver.com/the-fund
Community Foundation for Greater New Haven	A variety of competitive funding opportunities for non-profit groups are offered by The Community Foundation for Greater New Haven.	http://www.cfgnh.org/Grant/AboutourGrantmaking/tabid/189/Default.aspx

Quinnipiac River Watershed Based Plan - Potential Funding Sources

Funding Source	Description	Reference
Cuno Foundation	The Cuno Foundation provides grants for public, charitable or educational purposes. Grants are usually made for specific, tangible items or capital expense requests that directly benefit the recipient. The Cuno Foundation does not grant funds for salaries. Applications are reviewed three times a year. Preference is given to proposals submitted by tax-exempt, not for profit organizations located in the Meriden area.	cunofoundation@cox.net
Meriden Foundation	The Meriden Foundation provides grants to non-profit organizations in the Meriden area primarily for education, health organizations and hospitals, children and youth services, including children's hospitals, social services, YMCAs, and Protestant and Roman Catholic churches.	http://firegrants.info/GrantDetails.aspx?gid=34597

Grant Search Resources

Please also see the following grant search resources for assistance in finding additional state, federal, local, and private sources of funding related to nonpoint source pollution management:

Grants.gov
http://grants.gov/

Catalog of Federal Domestic Assistance
https://www.cfda.gov/

CTDEEP Watershed and Stormwater Funding Website
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=335494&depNav_GID=1654&pp=12&n=1

EPA Catalog of Federal Funding Sources for Watershed Protection
https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1

EPA Watershed Funding
http://water.epa.gov/aboutow/owow/funding.cfm

EPA Green Infrastructure Funding Website
http://cfpub.epa.gov/npdes/greeninfrastructure/fundingopportunities.cfm

Quinnipiac River Watershed Based Plan - Potential Funding Sources

Foundation Center: Philanthropy News Digest
http://foundationcenter.org/pnd/rfp/cat_environment.jhtml

USDA National Agriculture Library: Water Quality Information Center
http://wqic.nal.usda.gov/nal_display/index.php?info_center=7&tax_level=2&tax_subject=589&level3_id=0&level4_id=0&level5_id=0&topic_id=2342&&placement_default=0

Other Nonpoint Source Funding Opportunities

Congressional Appropriation - Direct Federal Funding
State Appropriations - Direct State Funding
Membership Drives Membership drives can provide a stable source of income to support watershed management programs.
Donations Donations can be a major source of revenue for supporting watershed activities, and can be received in a variety of ways.
User Fees, Taxes, and Assessments Taxes are used to fund activities that do not provide a specific benefit, but provide a more general benefit to the community.
Rates and Charges State law authorizes some public utilities to collect rates and charges for the services they provide.
Stormwater Utility Districts A stormwater utility district is a legal construction that allows municipalities to designated management districts where storm sewers are maintained in order to the quality of local waters. Once the district is established, the municipality may assess a fee to all property owners.

Quinnipiac River Watershed Based Plan - Potential Funding Sources

Other Nonpoint Source Funding Opportunities

Impact Fees Impact fees are also known as capital contribution, facilities fees, or system development charges, among other names.
Special Assessments Special assessments are created for the specific purpose of financing capital improvements, such as provisions, to serve a specific area.
Property Tax These taxes generally support a significant portion of a county's or municipality's non-public enterprise activities.
Excise Taxes These taxes require special legislation, and the funds generated through the tax are limited to specific uses: lodging, food, etc.
Bonds and Loans Bonds and loans can be used to finance capital improvements. These programs are appropriate for local governments and utilities to support capital projects.
Investment Income Some organizations have elected to establish their own foundations or endowment funds to provide long-term funding stability. Endowment funds can be established and managed by a single organization-specific foundation or an organization may elect to have a community foundation to hold and administer its endowment. With an endowment fund, the principal or actual cash raised is invested. The organization may elect to tap into the principal under certain established circumstances.
Emerging Opportunities for Program Support for Water Quality Trading Allows regulated entities to purchase credits for pollutant reductions in the watershed or a specified part of the watershed to meet or exceed regulatory or voluntary goals. There are a number of variations for water quality credit trading frameworks. Credits can be traded, or bought and sold, between point sources only, between NPSs only, or between point sources and NPSs.

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Quinnipiac River Watershed Based Plan - Potential Funding Sources

Other Nonpoint Source Funding Opportunities

Mitigation and Conservation Banks Created by property owners who restore and/or preserve their land in its natural condition. Such banks have been developed by public, nonprofit, and private entities. In exchange for preserving the land, the "bankers" get permission from appropriate state and federal agencies to sell mitigation banking credits to developers wanting to mitigate the impacts of proposed development. By purchasing the mitigation bank credits, the developer avoids having to mitigate the impacts of their development on site. Public and nonprofit mitigation banks may use the funds generated from the sale of the credits to fund the purchase of additional land for preservation and/or for the restoration of the lands to a natural state.
Public Private Partnerships (P3s) 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.