Baseline Watershed Assessment
Pequonnock River Watershed

City of Bridgeport

September 2010

FUSS & O'NEILL
Disciplines to Deliver

In Cooperation With:

Pequonnock River Initiative

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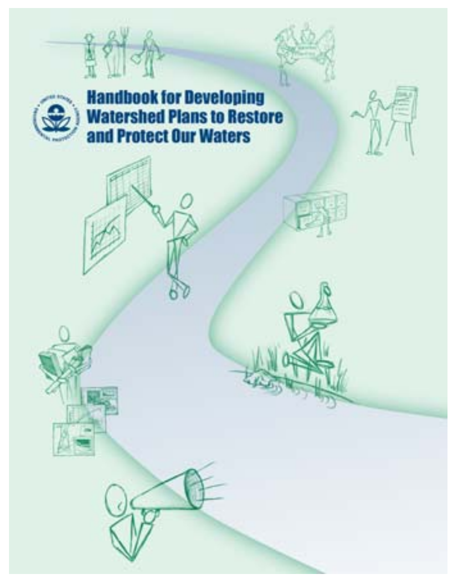
1 Introduction

During the summer of 2010 the Pequonnock River Initiative (PRI) was formed as a partnership between the City of Bridgeport and the towns of Monroe and Trumbull to develop a watershed plan for the Pequonnock River watershed. The City of Bridgeport, through a Section 319 grant from the Connecticut Department of Environmental Protection (CTDEP), retained Fuss & O'Neill, Inc. to perform the technical components of the watershed plan development. The CTDEP also awarded a Section 604(b) grant of the American Recovery and Reinvestment Act to Save the Sound, a program of Connecticut Fund for the Environment, Inc. and the Southwest Conservation District. Save the Sound is responsible for the formation of a watershed coalition, organizing workshop meetings, assisting in the development of the watershed plan recommendations, and performing public education and outreach. Additionally, Harbor Watch/River Watch, a program of Earthplace, The Nature Discovery Center at Westport, received 319 funding provided by the U.S. Environmental Protection Agency (EPA) under the Clean Water Act to perform water quality monitoring of the Pequonnock River for the years 2009 and 2010. The monitoring data will be used to assess current water quality conditions in the Pequonnock River and ultimately guide the watershed plan recommendations.

The watershed planning process includes the preparation of four primary documents, including: (1) a baseline watershed assessment report, (2) a detailed subwatershed field assessment report, (3) a land use regulatory review, and (4) a watershed management plan.



The management plan will be developed to satisfy EPA and CTDEP criteria for watershed-based plans.

The baseline watershed assessment report, which is the subject of this document, summarizes existing environmental and land use conditions in the watershed, while identifying priority areas in the watershed for subwatershed field inventories. The results of the subwatershed field inventories will be documented in a subsequent field assessment report, which will include targeted and site-specific opportunities for watershed restoration projects. A parallel land use regulatory review is also being performed to identify potential land use regulatory and planning mechanisms that can be implemented by municipalities and other governmental entities to better protect water quality and other valuable natural resources within the watershed. Finally, the watershed management plan will identify prioritized action items to protect and improve water resource conditions of the Pequonnock River and its watershed based on the priorities and issues identified in previous phases of the plan development, with input from the Pequonnock River Initiative steering committee, the CTDEP, and other stakeholders.

The watershed management plan is being developed consistent with the U.S. Environmental Protection Agency (EPA) and CTDEP guidance for the development of watershed-based plans. The guidance outline nine key elements that establish the structure of the plan, including specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act.

The watershed plan will be a comprehensive, scientifically-sound, and practical planning document for the protection and restoration of water resources in the Pequonnock River watershed. The watershed plan will detail the existing conditions of the watershed and identify its current problems and sources of pollution. Also, it will address emerging issues facing the watershed, and will outline detailed action steps for implementation. The plan will have the potential to affect on-the-ground change within the watershed.

1.1 Development of the Baseline Assessment Report

The following tasks were completed in developing this *Baseline Watershed Assessment* report for the Pequonnock River watershed:

- Reviewed existing data, studies, and reports on the watershed.
- Compiled and analyzed available Geographic Information System (GIS) data.
- Consulted with the PRI steering committee, the watershed municipalities, the regional planning agency, and other governmental entities regarding available land use information, mapping, and land use planning regulations.
- Identified and delineated subwatersheds within the overall Pequonnock River watershed.
- Conducted a comparative subwatershed analysis to prioritize watershed field inventories and management plan recommendations.

This report documents current watershed conditions for the following topics:

- Study area, including a basic description of the watershed (Section 2).
- Historical and social perspective (Section 3).
- Natural resources including geology and soils, topography, hydrology, wetlands and watercourses, and fish and wildlife resources (Section 4).
- Watershed modifications including dams, water supply, wastewater, stormwater, and regulated sites (Section 5).
- Water quality including classifications and trends based on available monitoring data (Section 6).
- Land use and land cover, including an analysis of existing and potential future impervious cover in the watershed (Section 7).
- Pollutant loading (Section 8).
- Comparative subwatershed analysis (Section 9).

1.2 Background

The Pequonnock River watershed[1] is an approximately 29 square-mile sub-regional basin within the Southwest Coast major basin in the southwestern portion of Connecticut (*Figure 1-1*). The watershed is located within portions of five communities, with the majority of the watershed (approximately 96%) located within the towns of Trumbull and Monroe and the City of Bridgeport.

The Pequonnock River begins at its headwaters in Monroe and flows in a south-southeasterly direction through the center of Trumbull and the northern neighborhoods of the City of Bridgeport on its way to inner Bridgeport Harbor. The river becomes tidal just upstream of its confluence with Island Brook and continues flowing along the East Side and Downtown Bridgeport neighborhoods until converging with Yellow Mill Channel within Bridgeport Harbor and ultimately Long Island Sound.

Land use within the watershed trends from undeveloped or lightly developed areas near the headwaters in Monroe, portions of which serve as a backup drinking water supply; to low- and medium-density residential and commercial uses along with protected open space through Trumbull and the northern portions of Bridgeport; and finally to the City center and former industrial and manufacturing uses near the mouth of the river at Bridgeport Harbor (*Figure 1-2*).

The water quality of the Pequonnock River generally reflects the land use and development patterns within the watershed. The lower two-thirds of the river through most of Trumbull and Bridgeport is classified as impaired by the CTDEP as it does not meet state standards for supporting a healthy macroinvertebrate community. Similarly, Bridgeport Harbor including the tidal portion of the Pequonnock River, is also considered impaired by the CTDEP due to elevated levels of indicator bacteria resulting from discharges of combined sewer overflows (CSO), urban stormwater runoff, historical sediment contamination of former industrial uses in the lower watershed, and other nonpoint sources. Due to existing water quality conditions in Bridgeport Harbor, harvesting of shellfish for uses other than depuration in other waters or aquaculture purposes is currently prohibited.

Flooding is also common along the Pequonnock River and many of its tributaries. In the City of Bridgeport, most areas adjacent to the river are subject to recurring flooding problems due to dense urban development. Flooding along the river corridor in Trumbull is exacerbated by the steep topography and limited floodplain storage in this portion of the river valley, while the lowlands adjacent to the upper reaches of the Pequonnock River in Monroe are also subject to frequent flooding during major storms.

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

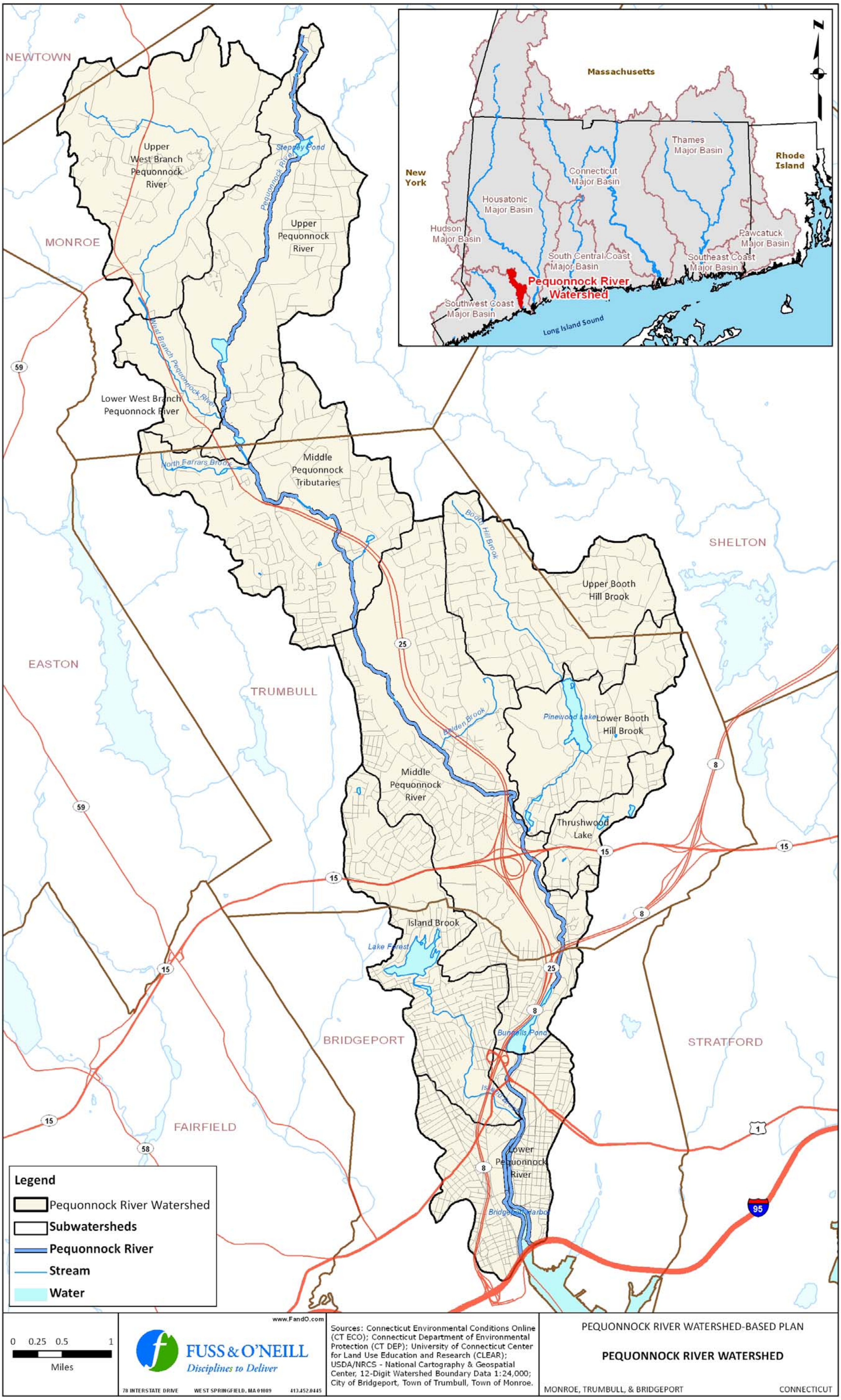


Figure 1-1. Pequonnock River Watershed

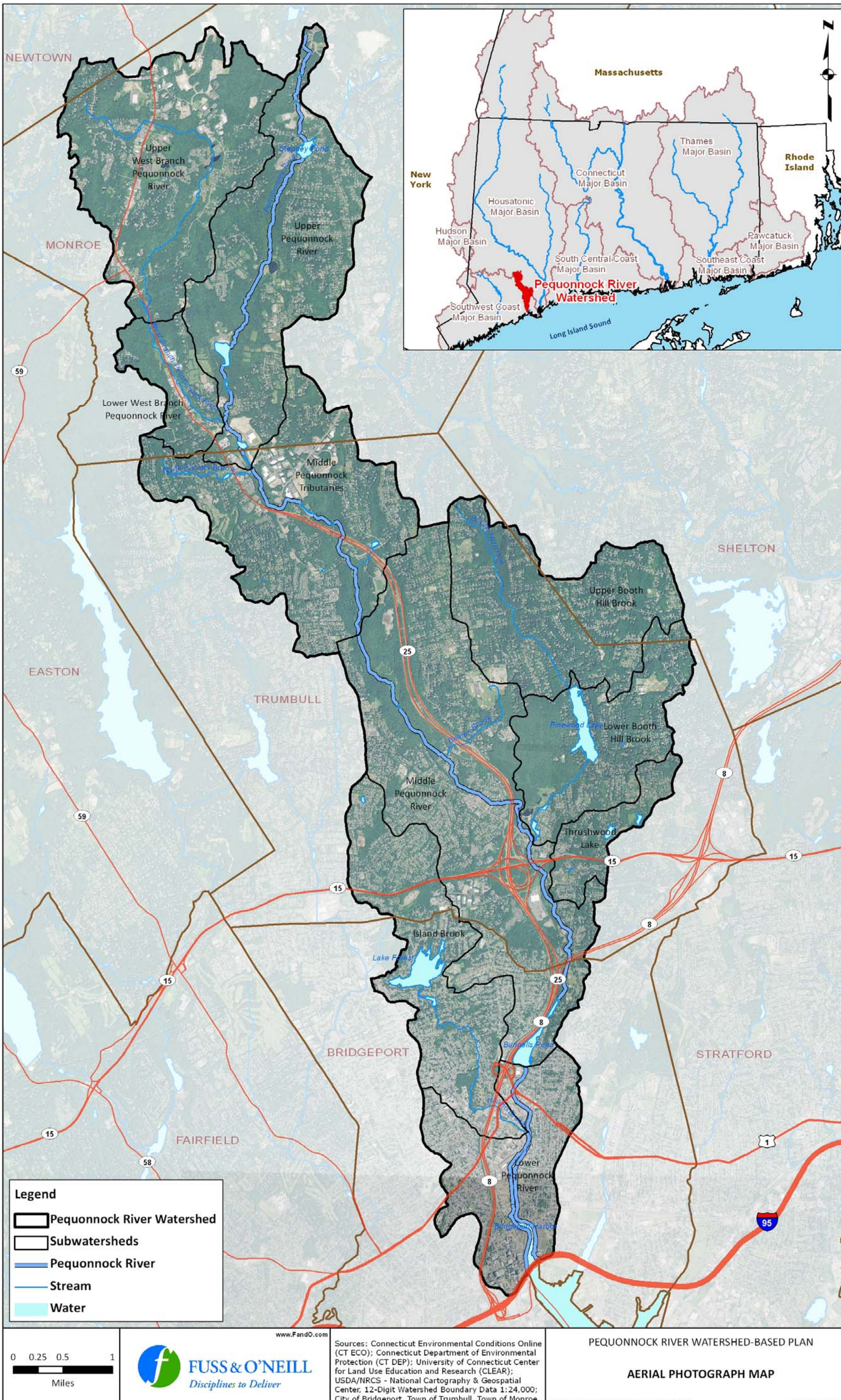


Figure 1-2. Watershed Aerial Photograph

1.3 Watershed Stewardship Efforts

The City of Bridgeport, the Towns of Trumbull and Monroe, the CTDEP, and other groups, through the Pequonnock River Initiative, have begun to address the water resource issues facing the Pequonnock River and its watershed. Notable ongoing and planned water resource-related stewardship efforts, including conservation and restoration projects, within the Pequonnock River watershed are summarized below.

- An Alaskan steep-pass fishway was constructed by the City of Bridgeport at the Bunnell's Pond dam in 2002 to allow fish passage along the lower Pequonnock River upstream of Bunnell's Pond dam. The dam is currently owned by the State of Connecticut and operated by the CTDEP and is reported to be the tallest steep-pass fishway on the east coast. Thousands of blueback and river herring are estimated to use the fishway each year. Pending the availability of future funding, the CTDEP plans to install a camera at the fishway to count and identify fish and educate the general public. Bunnel's Pond dam also has an eel pass. Eels are captured in a holding tank and are then transported upstream by CTDEP staff to the pond. CTDEP is working to modify the eel pass configuration to improve eel passage at this location.

- Save the Sound in conjunction with the CTDEP and U.S. Fish and Wildlife Service received funding to address a significant obstruction to fish passage in the lower portion of the Pequonnock River in Bridgeport, just downstream of Bunnell's Pond. When the highway was constructed, approximately 12 feet of the river was turned into a smooth concrete channel below the Route 8 bridge. The flow in the river is so shallow that river herring and blueback herring cannot pass safely below the bridge at times. The objective of this project is to create a fish ladder in the existing concrete apron to restore safe passage of river herring and other resident fish species to the Bunnell's Pond fishway and upstream reaches within the watershed. Construction of the project, referred to as the Pequonnock River Apron Fishway, is anticipated to occur in 2011.

- The City of Bridgeport is implementing an ambitious city-wide sustainability initiative through its BGreen 2020 sustainability master plan. The plan includes a number of water resource-related programs including the use of green infrastructure to address combined sewer overflows and stormwater management through stormwater retrofits at vacant or underutilized parcels, water conservation as well as stormwater harvesting and reuse, and integration of stormwater management and public infrastructure improvements through the City's "complete streets" policy.

- The City of Bridgeport is undertaking a "complete streets" program as part of its city-wide sustainability initiatives. Complete streets or "green streets" integrate bicycle and pedestrian opportunities, along with automobile lanes, as well as incorporate landscaping and green infrastructure stormwater management elements into public infrastructure projects. Complete streets projects are planned along Park Avenue and the Park Avenue/Railroad Avenue areas of the City. The plan also promotes related programs that will benefit the Pequonnock River watershed including a street tree and urban forestry initiative, programs to increase and enhance open spaces and recreation, and enhanced public access to the river through waterfront redevelopment.

- Connecticut Fund for the Environment, in partnership with the Natural Resources Defense Council, has received funding through a CTDEP Supplemental Environmental Project to assess the feasibility of green infrastructure implementation in two Connecticut cities, including Bridgeport. The project seeks to identify real-world green infrastructure opportunities, determine the cost of implementing those improvements, and align the potential stormwater flow control solutions with needed CSO flow reduction to determine the overall benefit green infrastructure could provide. The study would include a cost-benefit analysis and identify financing options, incentives, and disincentives that could be specifically employed. The goal is to assess the actual financial savings and environmental enhancement green infrastructure could support.

- The City of Bridgeport is embarking on developing a new parks or "green spaces" master plan to provide for linkages between green spaces, and at the same time protect the integrity of Bridgeport's natural resources and natural systems.

- A key component of the City of Bridgeport's revitalization efforts is increasing waterfront access opportunities along its coastline including the Pequonnock River. The City is pursuing several opportunities along the lower Pequonnock River to provide public access to the river by redeveloping vacant or underutilized former industrial sites for passive recreation and other mixed-uses.

- The City of Bridgeport is exploring opportunities to integrate green infrastructure approaches into its combined sewer overflow (CSO) control plan. The Bridgeport Water Pollution Control Authority has developed plans for capital improvements to separate combined sanitary/stormwater system in certain areas to limit CSO discharges into the city's waterways. Implementation of green infrastructure approaches within the public realm (i.e., expansion of the urban tree canopy, incorporation of rain gardens and swales into street design, and the use of permeable pavement) is also being considered to reduce the frequency and volume of overflows and mitigate some of the need for high-cost sewer separation.

- The Regional Bicycle Plan for the Greater Bridgeport Planning Region includes a concept to develop a continuous and interconnected multi-use trail for bicyclists and pedestrians from the Water Street Dock in Bridgeport to the Newtown town line. The approximate 15-mile trail includes a section along the Pequonnock River Valley through Monroe and Trumbull as well as Glenwood Park, Beardsley Park, and Waterfront Park in Bridgeport. Portions of the trail system have been completed, while others are in deign or construction.

- Researchers at Yale University School of Architecture, School of Forestry & Environmental Studies are working on a green infrastructure demonstration project in the Seaside Village section of Bridgeport. The project is exploring ways to integrate Low Impact Development stormwater management practices such as water quality swales and bioretention into the existing streetscape and yards of this planned community. Concepts that are developed as part of this project could potentially be applied elsewhere in the City and in the Pequonnock River watershed.

2 Study Area Description

2.1 Municipal Jurisdictions

The Pequonnock River watershed is an approximately 29 square-mile sub-regional basin located within portions of five communities. The majority of the watershed (approximately 96%) is located within the towns of Trumbull and Monroe and the City of Bridgeport, with the balance of the watershed land area consisting of small portions of Shelton and Newtown. *Table 2-1* summarizes the distribution of land area within the watershed by municipality.

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

Municipality	Total Acreage of Municipality	Acreage in Watershed	% of Municipality in Watershed	% of Watershed
Trumbull	15,040	9,128	60.7%	49.0%
Monroe	16,832	5,702	33.9%	30.6%
Bridgeport	12,416	3,080	24.8%	16.5%
Shelton	20,416	657	3.2%	3.5%
Newtown	37,824	71	0.2%	0.4%
Total	**102,528**	**18,639**		**100%**

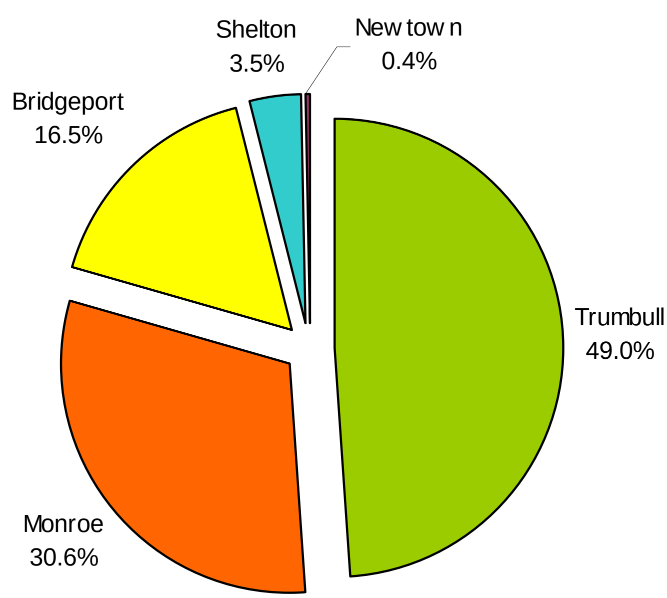


Figure 2-1. Watershed Land Area by Municipality

2.2 Pequonnock River Watershed

The Pequonnock River begins in Monroe in a mostly forested area with fresh water marshes and little development. The river flows through William E. Wolfe Park and then Great Hollow Lake before flowing through several industrial parks near the Monroe/Trumbull town line. The river then crosses Monroe Turnpike and skirts the western edge of Old Mine Park. Much of the river in Trumbull flows through wooded areas and limited residential development. Once the brook reaches Daniel's Farm Road, the river enters a congested corridor between White Plains Road to the west and Route 25 to the east. Ultimately, the river skirts the western edge of Twin Brooks Park where it makes a confluence with Booth Hill Brook and heads south under the Merritt Parkway to enter the western edge of Unity Park.

The Pequonnock River crosses under Route 8 and enters the City of Bridgeport and Bunnell's Pond. The pond is approximately a mile long with Route 25 and a concrete bank on the west side and Beardsley Park on the east bank. Once the river flows over a large concrete dam and leaves the park it enters a long tunnel and emerges in the old industrial area of Bridgeport on its way to Bridgeport Harbor. This section of the river flows through a heavily industrialized and deteriorating portion of the City and is lined with former industrial uses. The river is tidal for its final mile as it flows into Bridgeport Harbor and Long Island Sound. The Pequonnock River and its major tributaries are further described in Section 4.3 *Hydrology*.

The Pequonnock River watershed is an approximately 29 square-mile sub-regional basin within the Southwest Coast major basin in the southwestern portion of Connecticut. The watershed includes all of the land area that drains to the non-tidal and tidal portions of the Pequonnock River upstream of the Interstate 95 bridge crossing over the river/harbor.

The northern portion of the watershed in Monroe is sparsely developed, with increasing intensity of residential and commercial land use in the central portions of the watershed within the Town of Trumbull. South of Route 15, the watershed transitions to higher density residential and commercial development as the river flows from Trumbull into Bridgeport. The urban development in the watershed intensifies downstream of Bunnell's Pond, eventually transitioning to highly industrialized uses along the tidal portion of the river and portions of downtown Bridgeport west of the river. Section 7 *Land Use and Land Cover* further describes land uses within the Pequonnock River watershed.

Transportation corridors within the watershed include several heavily-travelled state routes (State Routes 8, 25, and 15) as well as Interstate 95 and U.S. Route 1. These transportation corridors are generally located in the lower third of the watershed, although Route 25 follows the Pequonnock River for much of its length, with several river crossings.

A basic profile of the watershed is provided in *Table 2-2*. Later sections of this document provide more detailed information on these watershed characteristics.

Table 2-2. Profile of the Pequonnock River Watershed

Area	29.1 square mile (18,639 acres)
Municipal Jurisdictions	Trumbull, Monroe, Bridgeport, Shelton, and Newtown
Stream Length	Approximately 60 miles (main stem and major tributaries)
Subwatersheds	10 defined for study and watershed planning: Upper Pequonnock River Upper West Branch Pequonnock River Lower West Branch Pequonnock River Middle Pequonnock Tributaries Middle Pequonnock River Upper Booth Hill Brook Lower Booth Hill Brook Thrushwood Lake Island Brook Lower Pequonnock River
Major Tributaries and Water Bodies	West Branch Pequonnock River North Farrars Brook Booth Hill Brook Belden Brook Island Brook Stepney Pond Pinewood Lake Thrushwood Lake Bunnell's Pond Lake Forest Bridgeport Harbor
Water Quality	2008 DEP Impaired Waters List: Lower Pequonnock River – impaired for habitat for fish, other aquatic life and wildlife due to unknown causes and sources Bridgeport Harbor – impaired for habitat for marine fish, other aquatic life and wildlife, recreation, and commercial shellfish harvesting due to unspecified urban stormwater, marina/boating sanitary discharges, combined sewer overflows, waterfowl, residential districts, contaminated sediments, and other nonpoint sources are suspected contributors to the impairments.
Current Watershed Impervious Cover	25% mapped impervious cover 15% effective (directly connected) impervious cover
Current Watershed Forest Cover	36%
Major Transportation Routes	Interstate 95 U.S. Route 1 State Route 15 (Merritt Parkway) State Route 25 State Route 8 State Route 111 State Route 127
Significant Natural, Historic, and Land Use Features	Barnum Museum, Beardsley Zoo and Botanical Gardens, Thomas Hawley House, Kaatz Ice House, sunken barges located in the Pequonnock River (Elmer S. Dailey, Priscilla Dailey, and Berkshire No. 7), six historic districts located completely or partially within the watershed, Pequonnock Valley Wildlife Area (Trumbull), William E. Wolfe Park (Monroe), Twin Brooks Park (Trumbull) Centennial Watershed State Forest (Monroe, Trumbull, Shelton), Robert G. Beach Memorial Park (Trumbull), and Beardsley Park (Trumbull, Bridgeport)

2.3 Subwatersheds

For the purpose of this watershed planning study, the Pequonnock River watershed is divided into 10 subwatersheds, from which surface runoff potentially enters the river or its tributaries. The subwatershed delineations are based on basin delineations by the CTDEP and the U.S. Geological Survey, with modifications based on updated land use mapping, topographic mapping, and field observations. Subwatersheds were also delineated to facilitate assessment and development of watershed management plan recommendations.

Four of the subwatersheds are located along the main stem of the Pequonnock River and contain areas that drain directly to the river or indirectly via primarily small, unnamed tributary streams. The other six subwatersheds correspond to the land area that drains the major tributaries of the Pequonnock River, namely the West Branch Pequonnock River, Booth Hill Brook, Thrushwood Lake, and Island Brook.

General characteristics of these subwatersheds are presented in *Table 2-3*, and their locations and boundaries are shown in *Figure 1-1*.

Table 2-3. Pequonnock River Subwatersheds

Subwatershed	Acronym	Area (acres)	Area (square miles)
Upper Pequonnock River	UPR	2,456	3.8
Upper West Branch Pequonnock River	UWB	2,522	3.9
Lower West Branch Pequonnock River	LWB	553	0.9
Middle Pequonnock Tributaries	MPT	2,434	3.8
Middle Pequonnock River	MPR	3,835	6.0
Upper Booth Hill Brook	UBH	1,895	3.0
Lower Booth Hill Brook	LBH	1,363	2.1
Thrushwood Lake	THR	442	0.7
Island Brook	ISL	1,741	2.7
Lower Pequonnock River	LPR	1,398	2.2

3 Historical and Social Perspective

3.1 History of the Watershed

The Pequonnock River watershed has been a place of human activity for thousands of years, and throughout that time the river and its tributaries have played an important role. For Native Americans, whose presence in the area can be documented at least back to the Late Archaic period (6,000 to 2,700 years ago) and probably earlier, the river was a rich food source, providing freshwater fish, edible plants, and waterfowl in its upper reaches and a variety of estuarine plants, shellfish, and ocean fish in its tidewater portions. The river also served a transportation function; its valley created a passageway through an otherwise hilly terrain, providing access to extensive upland hunting grounds. In the later Woodland period, agriculture played an important role in Native American culture, with beans, squash and corn adding to the diversity of their diet. Water may also have played an important part in their belief system; many of the known Native American burial grounds were on sandy knolls overlooking a river or bay. Golden Hill in Bridgeport, the traditional seat of the Paugussett people, is said to have included such a burial ground. John Warner Barber reported in 1836 that "[Indian] skeletons are frequently dug up on the banks of the Pequonnoc River."

Archaeological investigation of the watershed area can be called fragmentary at best, but the work that has been done provides clear evidence of the presence and lifeways of Native peoples for thousands of years – a large deposit of oyster and clam shells adjacent to the tidal portion of the river in Bridgeport, stone projectile points discovered in Beardsley Park, and multiple rock shelters in Trumbull where early hunters sought refuge from the elements.

The word "Pequonnock" refers to land that has been cleared and broken up for planting and, reflecting the extent of Native American agriculture at the time of contact with Europeans, became a commonplace name in Connecticut. The particular planting grounds in this area were just outside the watershed in other parts of what today is Bridgeport, but at an early date the name "Pequonnock" was applied to both the general area and the river.

The Native Americans in the area at the time of contact with Europeans were known as the Paugusett people. In the first few decades of English settlement, there was a great deal of acrimony over the fact that the English claimed the land as a result of the Pequot War of 1637 (in which the local Indians were thought to have aided fleeing Pequots), whereas the Indians felt they should be compensated for the loss of their land to the English. A settlement was reached wherein the Paugusetts received some monetary compensation and a small reservation at Golden Hill. A guardian was appointed by the General Court in Hartford, and over the years land was sold to pay for their support. By 1800, there were only 20 acres left, on which about a dozen people lived in wigwams and pursued their traditional way of life. Although the Paugusetts eventually lost Golden Hill entirely, they remain a state-recognized tribe today, with land in both Trumbull and Colchester.

With the exception of the small corner in Newtown, the entire watershed was originally within the town of Stratford. The English had come to the area during the Pequot War, and after the war some of the combatants, including Roger Ludlow of Windsor, were granted land for what was then called a "plantation." Ludlow claimed his land a little further west, the settlers there being recognized as the town of Fairfield. The first English to settle in Stratford were about a dozen and a half people from Wethersfield led by their minister, Rev. Adam Blakeman. At first the place was called by its Indian names, Pequonnock and Cupheag, but in 1643 the General Court at Hartford renamed the town Stratford.

Although the earliest settlers took up lands near the coast, perhaps envisioning themselves becoming rich through trade, what most English families wanted was upland farmland. Although today we think of river-bottom land as prime agricultural land, in the opinion of 17th and 18th-century farmers, the flatness and fertility of river land was far outweighed by its frequent flooding. Colonial farmers practiced a generalized, near-subsistence form of farming that consumed most of the produce within the family or surrounding community. Only a small portion of their acreage was devoted to plow land; the rest was used for hay meadows, grazing pastures, and wood lots.

The result was a continual dispersal of settlement as farming families took up lands ever further away from the coast. When enough families had settled in a given area, they would petition the General Court for the right to form an ecclesiastical society separate from the Congregational Church in the older part of town. Instead of traveling some distance to attend services, the settlers could build a meetinghouse and hire their own minister. The first of these separate parishes was Stratfield, formed from parts of both Stratford and Fairfield in 1691. The congregation built a meetinghouse just south of North Avenue in present-day Bridgeport, along the boundary between the two towns. The first church in Shelton Center was further divided in 1717 when the Ripton parish was established in the northeastern part of town and again in 1725, when the North Stratford Society, later called Unity Society, was set off for the area in the northwestern part of the town. In 1762, portions of the North Stratford and Ripton parishes were combined to form a new ecclesiastical society called the New Stratford Society. Although the population continued to be widely dispersed throughout the 18th century, the meetinghouses that were erected by these ecclesiastical societies, along with the associated burying grounds and the public schools each society was obliged to maintain by law, became the nuclei for later town centers. The ecclesiastical societies also became the basis for dividing up the territory from which "train bands"--militia companies--were drawn, and highway-repair funds were usually allocated on a parish-by-parish basis.

The Pequonnock River Watershed as shown on an 1811 map. Trumbull's boundaries are the same as today, but Bridgeport is shown as part of Stratford, and Monroe is the New Stratford section of Huntington (Shelton). The symbols along the river indicate the locations of water-powered gristmills and sawmills. The two southernmost gristmills are probably tide-powered.

The Pequonnock River played a vital role in the agricultural economy that dominated the area. Waterpowered gristmills produced cornmeal and other flours for human consumption and a variety of ground grains for animal feed. Sawmills made boards for flooring and fencing that could be made only with great difficulty by hand. Other common waterpowered mills in the colonial period were fulling mills, in which hand-woven cloth was finished by waterpowered beaters, and oil mills, in which linseed oil was extracted from flax seeds. As a medium-sized fast-flowing stream, the Pequonnock River was the site of numerous small-scale waterpowered mills through the Colonial Period and the early 19th century. Even the tidewater portion of the river was harnessed to the task. Bridgeport had a number of tide-powered gristmills, in which water at high tide was impounded, then allowed to run out with the receding tide so as to power a mill wheel.

Trumbull was the first town to become politically independent from Stratford. Named for Connecticut's Revolutionary War governor Jonathan Trumbull, it had early been known as Old Farm and as Nichols Farm, after Caleb Nichols, who had been one of the first settlers there in 1674. As incorporated in 1797, the town's boundaries closely followed those of the North Stratford ecclesiastical society. Similarly, the New Stratford parish in the north part of Stratford became the town of Monroe in 1823, named after James Monroe, who was president at the time.

The political history of Bridgeport is more complicated. Even while most residents of the area earned their living from farming or farm-related occupations like blacksmithing and milling, the residents along the coast, where the Pequonnock River and other streams empty into a fine harbor, were pursuing trade, shipbuilding, fishing, and other maritime activities. As Rev. Philo Shelton reported in his description of Stratfield parish in 1800, the growth of the harbor area was especially pronounced in the years following the American Revolution:

> "In the year 1783 this village contained only eleven dwelling houses, two stores, two wharves and four small vessels. From that period until the year 1793 the growth was rapid, and a large trade to the West Indies and other states carried on from this port. . . . There are now [October 1800] fifty-five dwelling houses, seventeen stores for dry-goods, nine wharves each with a large granary, and fifteen sail of vessels."

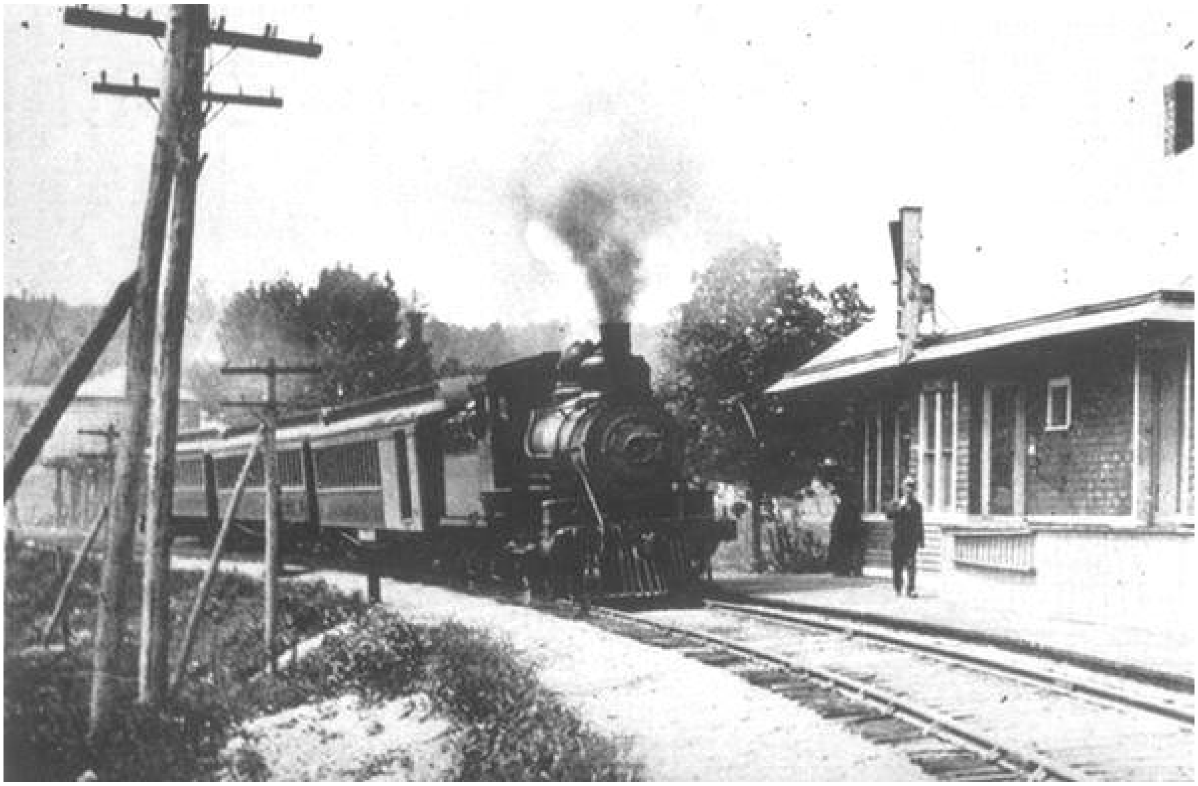
A bustling port required more in the way of government than an agricultural town, and in 1800 the General Court incorporated Bridgeport as a borough within the town of Fairfield. A borough was not a separate town but rather a sub-government, consisting of a board of burgesses that could provide a particular area with services such as market regulation and fire protection and also act in some matters as a local court. The name "Bridgeport" reflected the borough's character as a port and also the fact that it had a major bridge across the harbor portion of the Pequonnock River. The bridge was built in 1791 with funding from a special lottery and was operated as a toll bridge by a private company. Set on piles, it was a quarter-mile long and included a swing span so as to maintain navigation further up the river. Bridgeport remained a borough until 1821, when it was incorporated as a separate town that included parts of Stratford and Fairfield.


View of Bridgeport in 1837 by John Warner Barber; the Pequonnock River bridge is on the right.

In the early 19th century, the valley of the Pequonnock River continued to be exploited for transportation purposes. In 1801, the Bridgeport and Newtown Turnpike Company was chartered by the state legislature and given the right to collect tolls in exchange for widening and leveling the road between those two towns. The turnpike paralleled the river and approximates the course of present-day Route 25. The improved road had the effect of allowing farmers in Trumbull and Monroe to market their produce more widely. Grain and livestock could be moved along the turnpike to Bridgeport and carried from there to markets in coastal cities. The turnpike especially benefited the larger farmers in the area, who had more land that could be used for commercially-oriented activities such as raising livestock.

Three decades later, the river valley accommodated the construction of an even greater transportation improvement. Chartered in 1836, the Housatonic Railroad built its line parallel to the Pequonnock River, with station stops in Trumbull center and Long Hill in Trumbull, and Stepney and Pepper Crossing in Monroe. Construction was completed to New Milford in 1840, the Massachusetts state line in 1842, and West Stockbridge, Massachusetts, in 1843. The idea behind the railroad, which received considerable public financing from Bridgeport, was to tap into the quarrying and iron industries of northwestern Connecticut and also to connect with the Western Railroad between Boston and Albany.

In addition to benefiting Bridgeport merchants, the railroad provided a major boost to the fortunes of the watershed's farm families, allowing them to market vegetables, dairy products, and ice in New York City. By the late 1860s, the Housatonic Railroad was shipping 100,000 gallons of milk a day to New York from the agricultural countryside through which it ran. The rail line through the project area was eclipsed somewhat in 1887, when the Housatonic Railroad built a connecting line between Hawleyville in Newtown and Derby that became its main line. Shortly thereafter, the Housatonic Railroad was merged into the New York, New Haven and Hartford Railroad system, which favored the Housatonic River route. The frequency of both passenger and freight service was cut back, and in the 1940s, the route paralleling the Pequonnock River was discontinued.



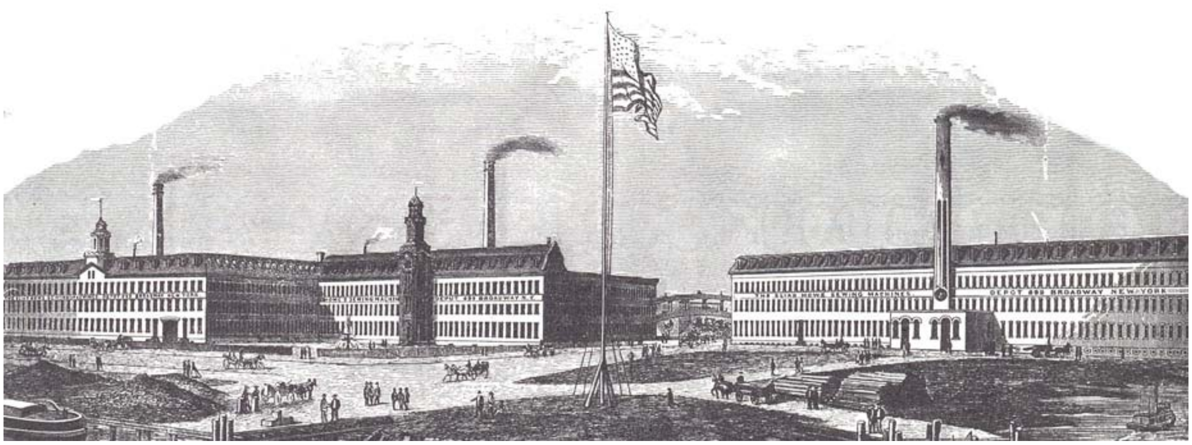
A passenger train at the Stepney station in Monroe, ca. 1900 (Dodd Research Center, University of Connecticut).

Monroe and Trumbull remained largely agricultural towns throughout the 19th century well into the 20th century, until suburban residential development began to change the towns' characters. The population of Monroe dropped from 1,442 in 1850 to 1,043 in 1900, while Trumbull grew only slowly, with 1,309 residents in 1850 and 1,587 in 1900. The mineral deposits of Trumbull and Monroe, including tungsten, lead, and bismuth, were exploited for a short time. There were also a few small-scale industrial enterprises in the two towns. Carriage shops, a small woolen mill, and a shirt factory were clustered in the Beers Mills section of Trumbull, a number of small paper mills were spaced along the Pequonnock River in the central and southern parts of that town, and there were also at one time cigarmaking shops and a witch-hazel factory.

Monroe's 19th-century industries included a small-scale cotton mill, a carriage works, a hat factory, and a brick yard. Most of the population of the two towns continued to pursue farming as their livelihood, but with a greater concentration on market production, such as vegetables, orchard products, and dairying. After World War II, both Trumbull and, to a lesser extent, Monroe shared in the national trend toward suburban-style single family housing. In the 1950s, Trumbull's population more than doubled, exceeding 20,000 in 1960, as did Monroe's, going from 2,892 to 6,402 in that decade.

Bridgeport, meanwhile, was transformed from a small but thriving commercial port city to an industrial powerhouse. By the 1850s, coal-fired steam engines had replaced waterwheels as the chief form of industrial power, and as a consequence, factories tended to locate in coastal areas with good railroad connections. At the same time, the marketing and distribution of goods had become concentrated in New York and other large cities. Bridgeport, with its good harbor, multiple railroad connections, and proximity to New York City, was an unusually attractive place to industrialists looking to expand. In 1854, Marcellus Hartley relocated his ammunition company to Bridgeport, eventually becoming the Union Metallic Cartridge Company and then Remington Arms.

The R.C. Toucey shirt factory in Trumbull in 1893. The shop was later incorporated into the United Witch Hazel Company's factory (Trumbull Historical Society).



The factories of the Howe Sewing Machine Company in 1876. A work force of 1,500 employees produced 800 sewing machines a day.

Two years later, the Wheeler and Wilson Sewing Machine Company set up shop in East Bridgeport. By the time Elias Howe started his sewing-machine factory in 1865, Bridgeport was one of the largest producers of sewing machines in the world. In addition to major manufacturers of end products, Bridgeport developed a large machine-shop and foundry sector, as well as several major producers of basic metals such as brass and steel. The industrialization process fed on itself; once a few major industries were established, the city's vast reservoir of skilled and semi-skilled industrial labor attracted other industries. Corsets, valves, typewriters, electrical products, organs, toys, and phonograph records were all produced in Bridgeport at one time or another, in many cases in factories that were among the largest of their kind in the nation. The period around World War I was an especially prosperous time for Bridgeport. The European economies collapsed during the early years of the war, and America's industrial cities, with Bridgeport at the forefront, became essential sources for war material.

Along with industrial growth came population growth. Between its founding and 1920, Bridgeport's population doubled or more than doubled every 20 years, exceeding 29,000 in 1880, 70,000 in 1900, and 143,000 in 1920. Bridgeport attracted working people both from this country's rural areas and from Europe, beginning with the Irish and Germans around 1850 and eventually including Italians, Poles, East European Jews, Slovaks, and dozens of other nationalities. Like other medium-sized cities, Bridgeport developed immigrant neighborhoods centered around ethnic businesses and places of worship, while other parts of the city saw huge housing projects built for workers during the industrial expansion of the World War I period. The downtown had large commercial blocks, impressive churches, and elaborate movie palaces, serving as the commercial, financial, institutional, and entertainment center for much of the region. In the early 20th century, streetcar lines radiated out from Bridgeport to the surrounding communities, strengthening the connections between the city and the surrounding small towns.

By the end of World War II, economic changes that had begun in the late 19th Century – mainly a shift from traditional industrial goods to capital goods needed in a modern industrial economy – had reduced the role of small- and mid-sized cities. The shift led to consolidation of firms and the establishment of their headquarters in large cities near the sources of capital. The growth of trucking also gave manufacturing firms more choice of locations near the big cities. Faced with these trends, Bridgeport lost population and jobs to its suburbs through most of the 20th Century (BFJ Planning, 2008).

3.2 Population and Demographics

The Pequonnock River Watershed is located within portions of five communities, but the majority of the watershed area is within Monroe, Trumbull, and Bridgeport. This section provides a summary of overall population trends in these three communities, as well as estimated population and demographic information for the Pequonnock River Watershed.

Population in the greater Bridgeport area roughly tripled from 1900 to its peak in 1970. Since 1970 population declined slightly and has remained relatively stable. Bridgeport and Trumbull have followed this trend, but Monroe has shown steady growth from 1970 through 2000 which appears to have stabilized at approximately 19,000 over the past decade. *Figure 3-1* illustrates the population by municipality from 1990-2000 in the greater Bridgeport area, including Monroe, Trumbull and Bridgeport (GBRPA, 2003). The population trend also shows the shift from growth in the City of Bridgeport from the turn of the century to the 1960s, to decline in the city population and growth of the suburban communities in the latter half of the 20th century. This growth pattern is also reflected in the number of housing units built prior to 1950 (CERC, 2010). In 2009, 45.8% of the housing units in Bridgeport were built pre-1950. In contrast, in 2009 only 17.5% of the housing units in Trumbull and 10.6% of the housing units in Monroe were built prior to 1950. These growth patterns are also reflected in changes in land use as discussed in Section 7.

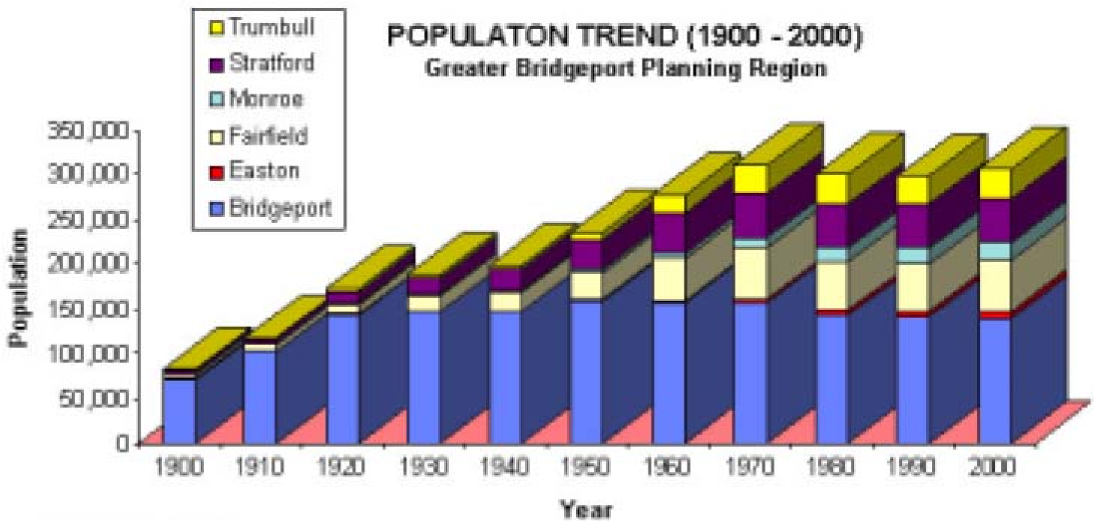


Figure 3-1. Population Trends (GBRPA, 2003)

Population estimates from the Connecticut State Data Center indicate increased growth in the next 20 years (*Figure 3-2*). The projected changes in population density over that time reflect the current level of development in each of the three communities. Bridgeport, with the greatest population and highest population density in Connecticut, is expected to experience a 5% increase in population density but will continue to have a population density approximately 14 times that of the state as a whole. Population density is expected to increase by approximately 30% in Monroe and 14% in Trumbull from 2009 to 2030 (Connecticut State Data Center, 2010).

Population and demographic information for the Pequonnock River watershed was analyzed using data from the Connecticut Economic Resource Center (CERC, 2010). Population within the watershed is estimated at 72,000. This estimate is based on the population densities within the five communities that make up the watershed land area. Of the total population in the watershed, it is estimated that 59% live in Bridgeport, 30% in Trumbull, 9% in Monroe, 2% in Shelton, and less than 1% in Newtown.

Since Bridgeport, Trumbull, and Monroe dominate the watershed population due to their areal extent in the watershed and population density, demographics in those communities reflect the demographic makeup of the watershed. Data on race and ethnicity from the Connecticut Economic Research Center indicate that over 90% of the population in these communities identifies their race as while. In contrast, in Bridgeport 47% of the population identifies their race as while. Nearly 42% of the population is Hispanic (of any race) and nearly 30% of the population identified their race as Black. *Figure 3-3* illustrates race and ethnicity information for these three communities. Using the percentages of different races/ethnicities reported in the communities and the estimated watershed population contributed by each community, an estimate of race and ethnicity demographics for the watershed was obtained. It is estimated that approximately 65% of the watershed population is White, 18% Black, 4% Asian Pacific, 0.2% Native American, and 12% another race or multiracial. In addition, it is estimated that nearly 27% is Hispanic of any race.

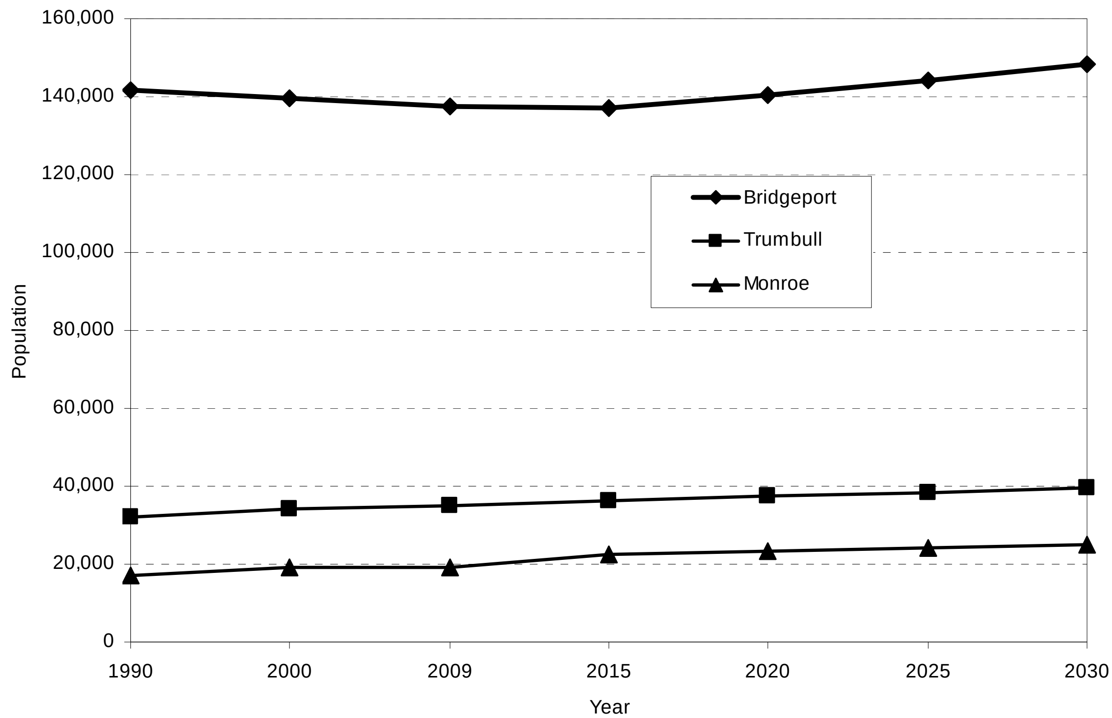


Figure 3-2. Population Growth

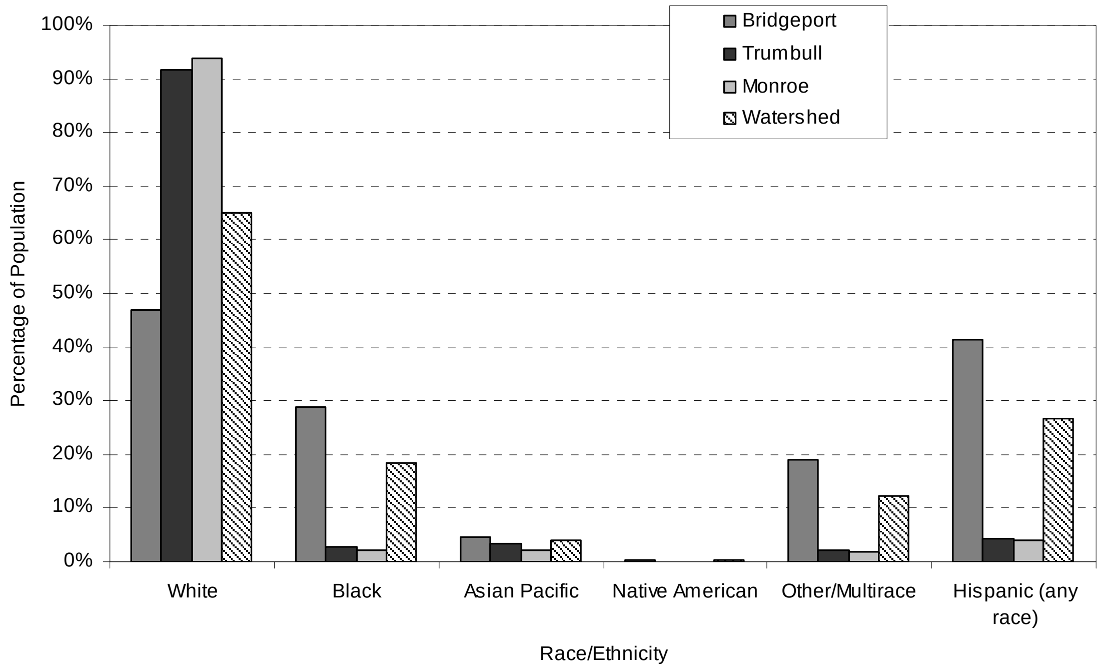
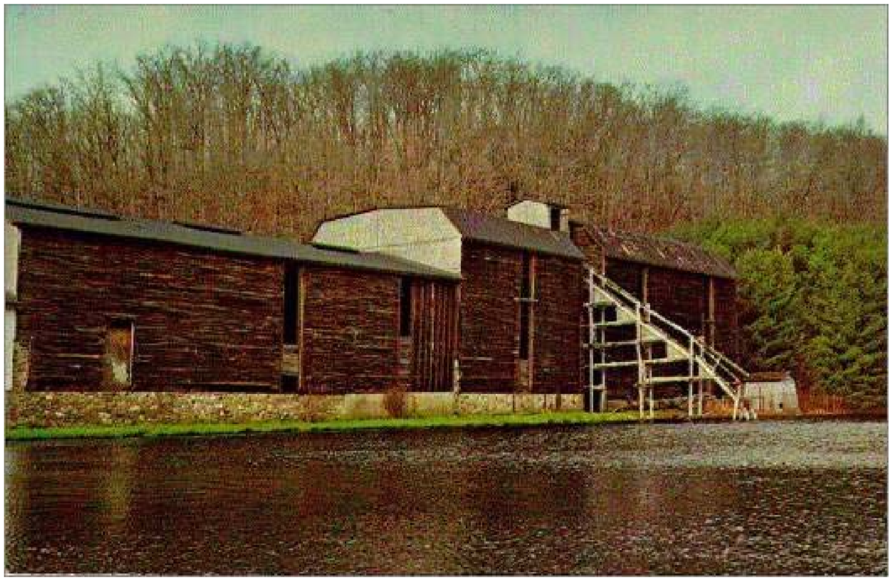


Figure 3-3. Race and Ethnicity Data

3.3 Historical Resources

The Pequonnock River watershed is home to numerous sites and buildings that are on the State or National Register of Historic Places as well as local historic districts. Existing State or National-registered historic places in the watershed are listed in *Table 3-1*. Several of the notable cultural resources in the watershed include:

- Barnum Museum, the former home of Phineas Taylor "P.T." Barnum, Bridgeport's most famous resident and mayor. Barnum was most famous as the founder of the circus that became the Ringling Bros. and Barnum & Bailey Circus.
- Beardsley Park, located between Route 8/25 and Noble Street/East Main Street (Route 127). The Beardsley Zoo (52 acres), the only zoo in the State, is in the southeast section of the Park. The Pequonnock River flows through Bunnell's Pond within Beardsley Park.
- Thomas Hawley House, located on Purdy Hill Road, is a historic Colonial American wooden post-and-beam saltbox farm house built in 1755.
- Kaatz Ice House, a storage house for ice blocks removed from the pond located on Whitney Avenue. The house was acquired by E. Kaatz in 1904, operated until 1955, and was demolished in 1978. At the time of demolition, the Kaatz Ice House was the last standing ice house in New England.



Kaatz Icehouse (Trumbull). Source: Trumbull, CT Historical Society.

- Three sunken barges are located in the Pequonnock River at the downstream boundary of the watershed in an area that is part of Bridgeport Harbor. The *Elmer S. Dailey*, *Priscilla Dailey*, and *Berkshire No. 7* sank in 1974. when the Berkshire No. 7 took on water. All three are registered in the National Register, but the *Elmer S. Dailey*, which dates from 1915, is thought to be the last remaining Erie Canal boat in the country, and is likely to be the most historically significant of the three. One of the barges is occasionally visible at low tide.
- Six historic districts are located completely or partially within the watershed (listed in *Table 3-1*), including
  - Bridgeport Downtown North Historic District, roughly bounded by Congress and Water Streets and Fairfield Avenue, contains 200 acres and 38 buildings.
  - Bridgeport Downtown South Historic District, roughly bounded by Elm, Cannon, Main, Gilbert and Broad Streets, contains 270 acres and 50 buildings.
  - East Bridgeport Historic District, roughly bounded by railroad tracks and Beach, Arctic and Knowlton Streets, contains 938 acres and 250 buildings.
  - Golden Hill Historic District in Bridgeport, roughly bounded by Congress Street, Lyon Terrace and Elm and Harrison Streets, contains 100 acres and 13 buildings.
  - Sterling Hill Historic District in Bridgeport, bordered by Washington Ave, Pequonnock St., Harral Ave., and James St. This area district contains 43 urban residential structures, the majority of which date from the later 19th century, although the oldest is from 1821.
  - Nichols Farms Historic District in Trumbull consists of 104 acres and 81 contributing buildings, one contributing site, and one contributing object.

Table 3-1. National and State Register of Historic Places and Local Historic Districts

Town/City	Date Listed	Resource Name	Address
Bridgeport	11/7/1972	Barnum Museum	805 Main St.
Bridgeport	3/18/1999	Beardsley Park	1875 Noble Ave.
Bridgeport	12/21/1978	BERKSHIRE NO. 7	Bridgeport Harbor
Bridgeport	9/19/1977	Bridgeport City Hall	202 State St.
Bridgeport	11/2/1987	Bridgeport Downtown North Historic District	Roughly bounded by Congress, Water, Fairfield Ave., Elm, Golden Hill
Bridgeport	9/3/1987	Bridgeport Downtown South Historic District	Roughly bounded by Elm, Cannon, Main, Gilbert, and Broad Sts.
Bridgeport	12/3/1987	Connecticut Railway and Lighting Company Car Barn	55 Congress St.
Bridgeport	4/25/1979	East Bridgeport Historic District	Roughly bounded by RR tracks, Beach, Arctic, and Knowlton Sts.
Bridgeport	12/21/1978	ELMER S. DAILEY	Bridgeport Harbor
Bridgeport	1/21/1982	Fairfield County Courthouse	172 Golden Hill St.
Bridgeport	4/18/1985	Fairfield County Jail	1106 North Ave.
Bridgeport	9/3/1987	Golden Hill Historic District	Roughly bounded by Congress St., Lyon Terr., Elm, and Harrison Sts.
Bridgeport	12/14/1978	Hotel Beach	140 Fairfield Ave.
Bridgeport	2/21/1985	United Illuminating Company Building	1115-1119 Broad St.
Bridgeport	3/17/1986	US Post Office-Bridgeport Main	120 Middle St.
Bridgeport	12/14/1979	Palace and Majestic Theaters	1315-1357 Main St.
Bridgeport	6/12/1987	Pequonnock River Railroad Bridge	AMTRAK Right-of-way at Pequonnock River
Bridgeport	12/21/1978	PRISCILLA DAILEY	Bridgeport Harbor
Bridgeport	12/20/1978	Sterling Block-Bishop Arcade	993-1005 Main St.
Bridgeport	4/2/1992	Sterling Hill Historic District	Bordered by Washington Ave, Pequonnock St., Harral Ave., and James St.
Monroe	1994	Stone Arch Bridge (State-register listed only)	517 Pepper Street
Monroe	4/11/1980	Thomas Hawley House	514 Purdy Hill Rd.
Trumbull	9/19/1977	Kaatz Icehouse	Former location: North Trumbull at 255 Whitney Ave.
Trumbull	8/20/1987	Nichols Farms Historic District	Center Rd., 1681--1944 Huntington Turnpike, 5--34 Priscilla Pl., and 30--172 Shelton Rd.
Trumbull	1990	Old Mine Park Archaeological Site	72.1 acres on Old Mine Road.

Only development within local historic districts requires a Certificate of Appropriateness; National Register-listed districts do not require such certification, nor is a certificate required for those properties that are within the Historic Overlay (O-H) zone but are not included in the local historic district. Bridgeport has two historic district commissions, including the Bridgeport Historic Commission #1 and the Stratfield Historic District Commission. Historic Commission #1 consists of five members and three alternates and oversees actions in this local historic district. Bridgeport also has a Historic Preservation Board. Trumbull has a Town Historian but no historic districts. Monroe has a historic district that is not listed in the National Register of Historic Places.

Despite the significant number of National Register-listed historic districts in Bridgeport, in practice they provide the City with only limited ability to control rehabilitation and new development since the focus of federal listing is to allow the granting of funds. Bridgeport is a decision-making partner in the granting of federal and state funds, since it has National Park Service Certified Local Government status. This program is a federal, state, and local partnership that allows local governments input on the granting of state and federal historic preservation funds while maintaining federal preservation standards.

3.4 Recreation and Community Resources

The Pequonnock River watershed boasts a significant amount of recreational facilities including approximately 15 parks along the riverbanks alone – encompassing more than half of the over 2,100 acres of total protected open space and parks in the watershed. Open spaces and recreational facilities within the watershed include state parks, conservation easements, town parks and open spaces, land trust properties, and school recreational facilities. Trumbull, with the largest land area in the watershed, has the distinction of having the highest proportion of land dedicated to open space and recreation (over 12% of the town) of all the member municipalities in the Greater Bridgeport Regional Planning Agency.

Major parks within the watershed include the Pequonnock Valley Wildlife Area (Trumbull), William E. Wolfe Park (Monroe), Twin Brooks Park (Trumbull), Centennial Watershed State Forest (Monroe, Trumbull, Shelton), Robert G. Beach Memorial Park (Trumbull), and Beardsley Park (Trumbull, Bridgeport). All of these park areas together comprise over 65% (1,470 acres) of the protected open space within the watershed. Park areas within the watershed offer a variety of active and passive recreational activities including bicycling (mountain/road), hiking, fishing, hunting, tennis, soccer, base/softball, golf, ice skating, swimming, boating, picnicking, playgrounds, as well as the only zoo in Connecticut.

Beardsley Zoo and Botanical Gardens, established over 80 years ago, is located within Beardsley Park in Bridgeport. The zoo contains over 300 animals representing primarily North and South American species including many endangered and threatened species, such as the Amur (Siberian) tiger, Andean condor, Ocelot, Red wolf, Andean (spectacled) bear, Maned wolf, and Golden lion tamarin. The zoo's missions include education through staff involvement and training and outreach programs and recreation through maintained park facilities and park-like grounds with both formal and informal landscaping.

The communities of the Greater Bridgeport Planning Region are working to implement a regional bikeway plan, Pequonnock Valley to the Sound, which includes the development of a continuous and interconnected 16-mile multi-use trail from the Newtown/Monroe town line to Bridgeport's Water Street Dock. This plan was introduced in 1992, and some sections have already been completed and are in use by bicyclists, pedestrians, and other users (as depicted in *Figure 3-4*). Much of the trail follows the abandoned and inactive Housatonic Railway line and the Pequonnock River.

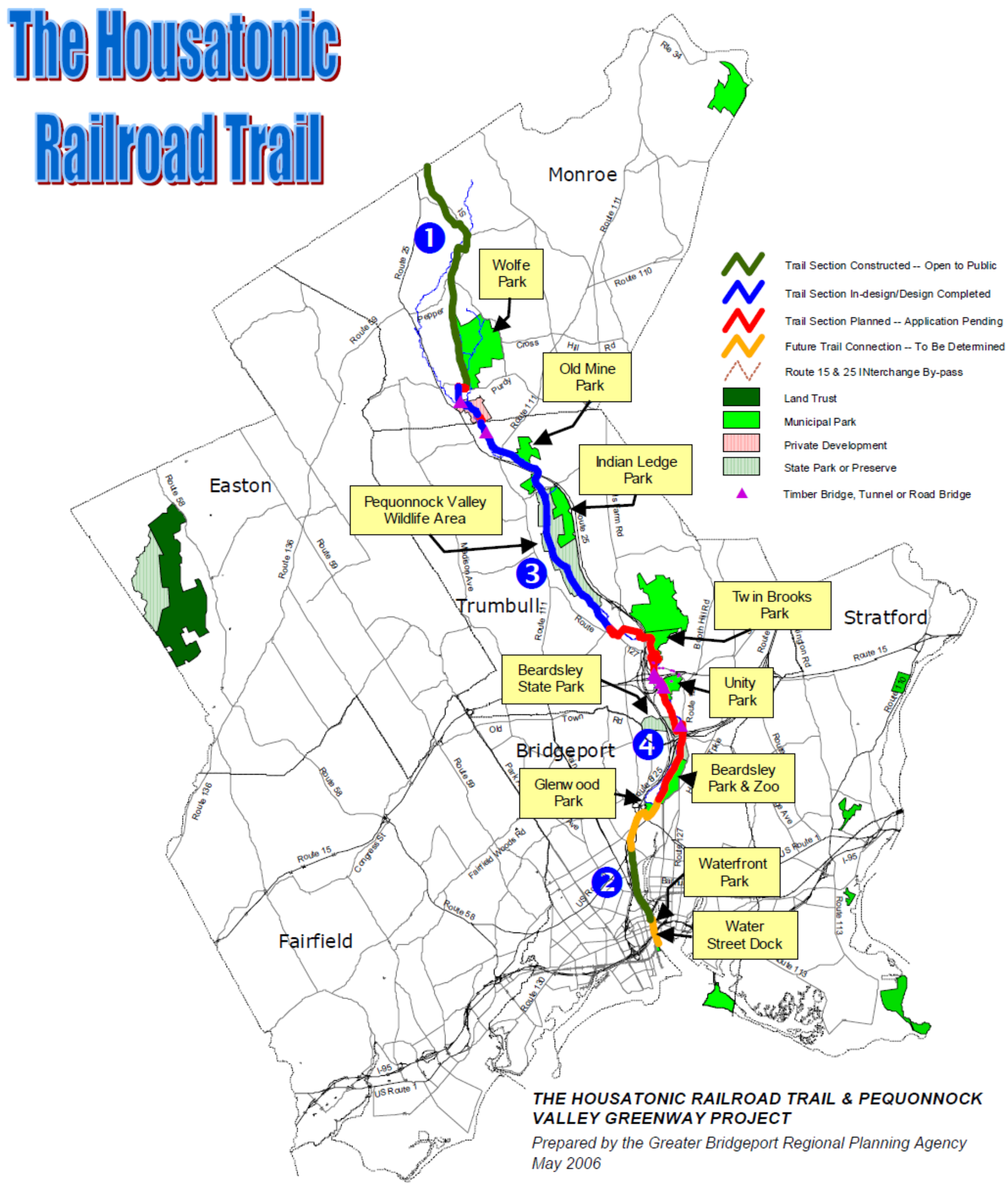


Figure 3-4. Pequonnock Valley to the Sound Bicycle Path (GRBPA, 2006)

In addition to road bicycling on the aforementioned greenway trail the Pequonnock Valley Wildlife Area and Old Mine Park (both within Trumbull) also contain several single track and dirt road mountain biking trails. As described in *Section 4.7*, the CTDEP considers the Pequonnock River as a "major trout stream" with many fishing access points along the length of the river and within the waterbodies it flows through.

4 Natural Resources

4.1 Geology and Soils

The State of Connecticut is composed 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 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 Pequonnock River watershed is within the Southwest Hills and Coastal Slope portion of the Western Upland geologic region, which is west of the Central Valley region. The Iapetos (oceanic) Terrane region of the Western Upland is composed of moderately old material (300-500 million years old) and is primarily schist, gneiss, and granite (Bell, 1985).

The Natural Resources Conservation Service Soil Survey Geographic (SSURGO) database for the State of Connecticut indentifies three predominant surficial materials in the Pequonnock River watershed (*Figure 4-1*). Till is the predominant surficial material in the watershed. Watershed areas within Bridgeport are a mix of various sand and gravel soil types, increasing in the amount of fines moving in the southerly direction until it turns completely to sand near Bridgeport Harbor. Smaller non-contiguous areas of surficial material, including various types of sand and gravel soils, alluvial material, and thick till, are found interspersed throughout the watershed.

The soil parent material (native) in the watershed is Melt-out till (various types). Till and Glaciofluvial materials make up most of the northern and central sections of the watershed. The soil profile is relatively shallow in most areas – less than 10 feet of soil above the underlying bedrock. The till in some sections has been eroded away leaving ledge outcrops and other exposed rock. The most abundant soil parent material in the entire watershed, primarily focused in the Bridgeport and southern Trumbull area, is Urban Influenced material, reflecting significant urbanization within the watershed (*Figure 4-2*).

4.2 Topography

The topography of the watershed ranges from steep slopes to rolling hills and shallow sloping areas. The Pequonnock River valley in the Town of Trumbull is notably steep, particularly surrounding Old Mine Park and Pinewood Lake; however, the grade in the City of Bridgeport is much more gradual. Slopes of 15% or greater are generally considered steep and are more susceptible to erosion both by natural (e.g., stormwater runoff and stream flow) and human-induced impacts (e.g., construction and other disturbances). The U.S. Geological Survey topographic mapping of the area presented in *Figure 4-3* shows the variation in topography across the watershed.

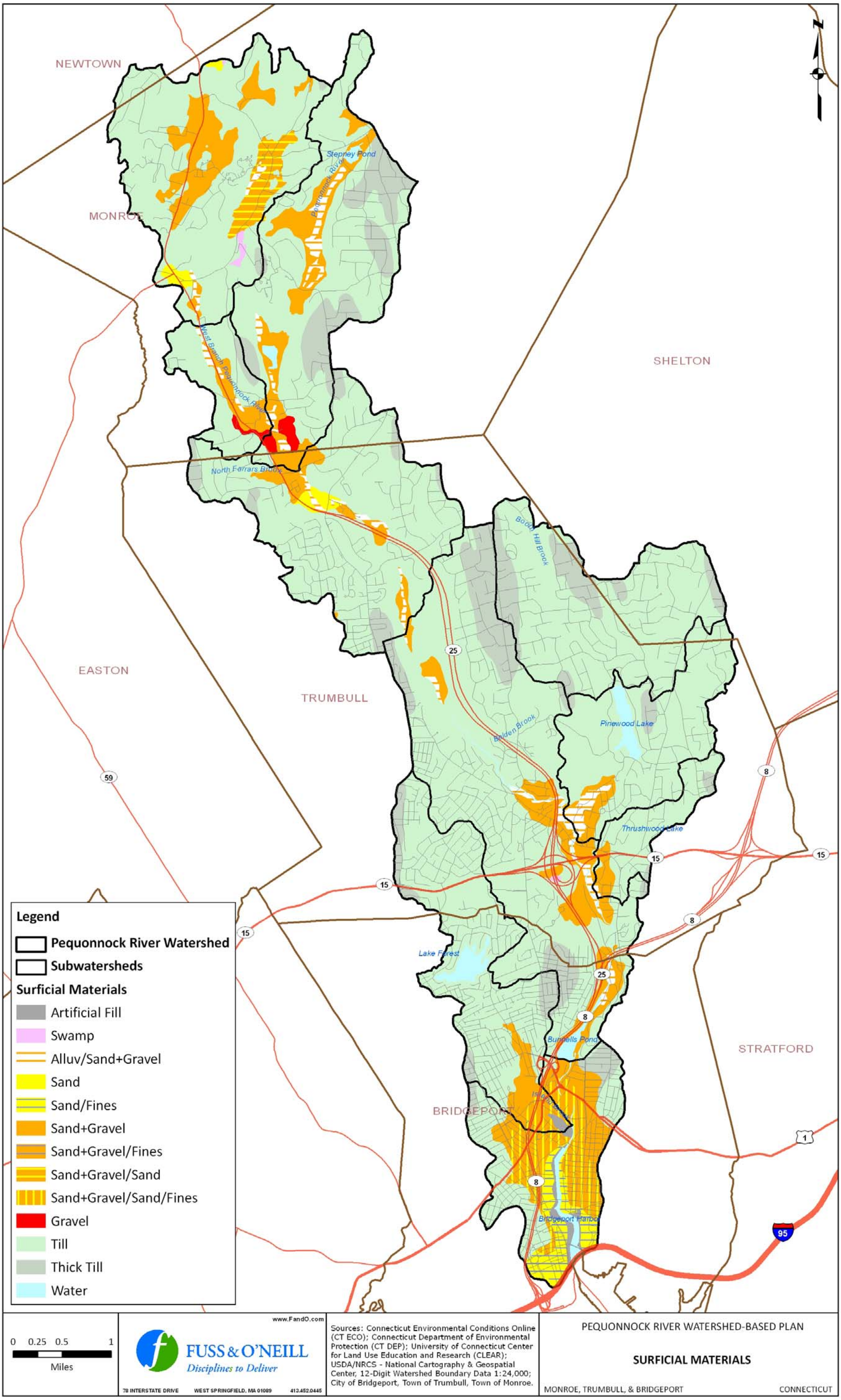


Figure 4-1. Surficial Materials

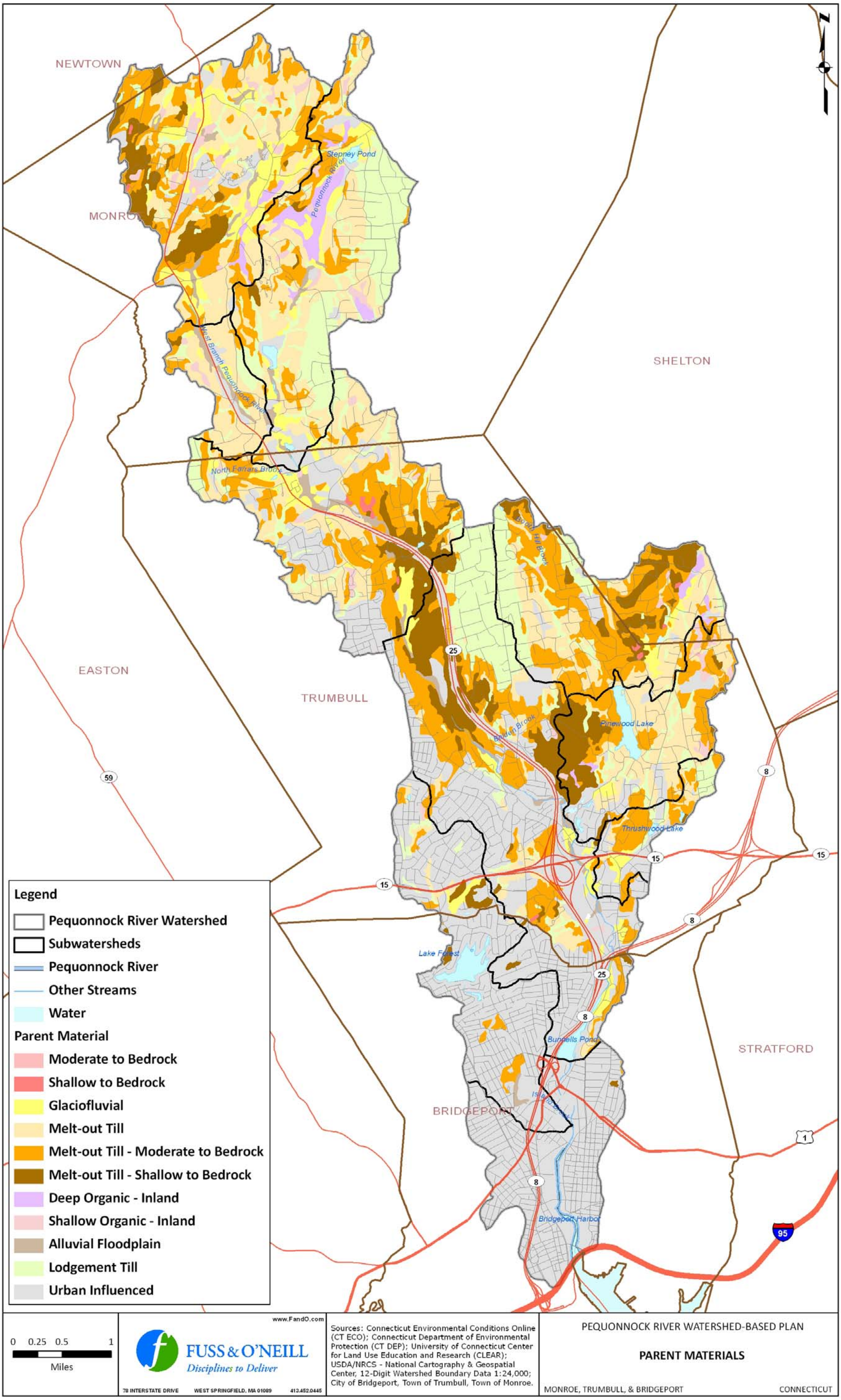


Figure 4-2. Parent Materials

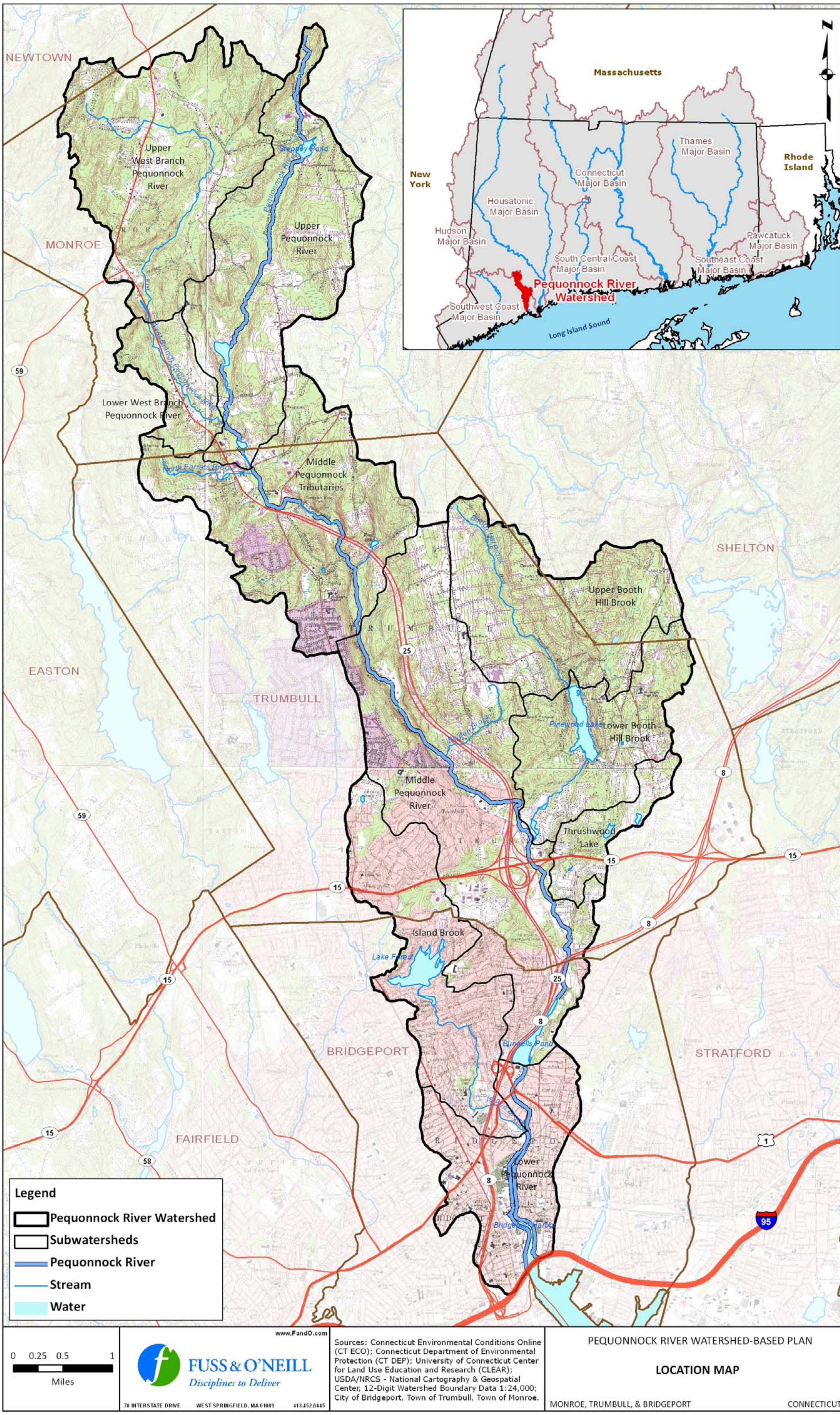


Figure 4-3. Watershed Topography

4.3 Hydrology

The Pequonnock River watershed is a coastal basin of approximately 29.1-square miles (18,639 acres) in size. The north-south length of the watershed is approximately 13 miles, whereas the east-west width of the watershed is approximately 3.5 miles, making the watershed long and relatively narrow, similar to many of the small and medium coastal watersheds in Connecticut. The watershed is located within the municipal boundaries of Bridgeport, Monroe, Newtown, Shelton, and Trumbull although greater then 96% of the watershed lies within the communities of Bridgeport, Monroe, and Trumbull. The watershed is divided into ten named subwatersheds for the purposes of this project, as described in *Section 2.3*.

Overall, there are approximately 60 miles of mapped perennial and intermittent streams within the Pequonnock River watershed. *Table 4-1* summarizes the miles of mapped streams within each subwatershed. Due to the narrow, linear shape of the watershed, headwater streams are located not only at the upper reaches of the main stem of the Pequonnock River, but also along the Pequonnock River valley in relatively close proximity to the main stem of the river.

Table 4-1.Miles of Mapped Streams Within Each Subwatershed

Subwatershed	Length of Stream (miles)
Upper Pequonnock River	8.42
Upper West Branch Pequonnock River	9.94
Lower West Branch Pequonnock River	2.02
Middle Pequonnock Tributaries	9.73
Middle Pequonnock River	9.45
Upper Booth Hill Brook	7.67
Lower Booth Hill Brook	4.32
Thrushwood Lake	2.54
Island Brook	4.05
Lower Pequonnock River	2.33

The Upper Pequonnock River begins north of Stepney Pond in Monroe. At approximately the same latitude the Upper West Branch of the Pequonnock River begins near the Newtown border. Both the main stem and the Upper West Branch flow in a southerly direction. The Upper West Branch meets the Lower West Branch and then joins the Upper Pequonnock River north of the Monroe/Trumbull border. The main stem then enters the subwatershed designated as the Middle Pequonnock Tributaries for the purposes of this project, which includes a number of small tributaries that drain into the main stem and are characterized by similar land use and natural resources. One of these tributaries, North Farrars Brook, begins near the Trumbull/Monroe town line and flows southeast to the main stem of the Pequonnock River. The downstream limit of the Middle Pequonnock Tributaries subwatershed meets the Middle Pequonnock River subwatershed south of Indian Ledge Park. Belden Brook is a named tributary in this area that flows into the Pequonnock River from the east. The southern portion of the Middle Pequonnock River subwatershed contains a major highway interchange between Routes 15 and 25.

Booth Hill Brook flows parallel and to the east of the Pequonnock River. The brook flows into Pinewood Lake in Trumbull, and then continues downstream of the lake to its confluence with the Pequonnock River. The Thrushwood Lake subwatershed is another small subwatershed located east of the Pequonnock River that flows into the Pequonnock south of Unity Park.

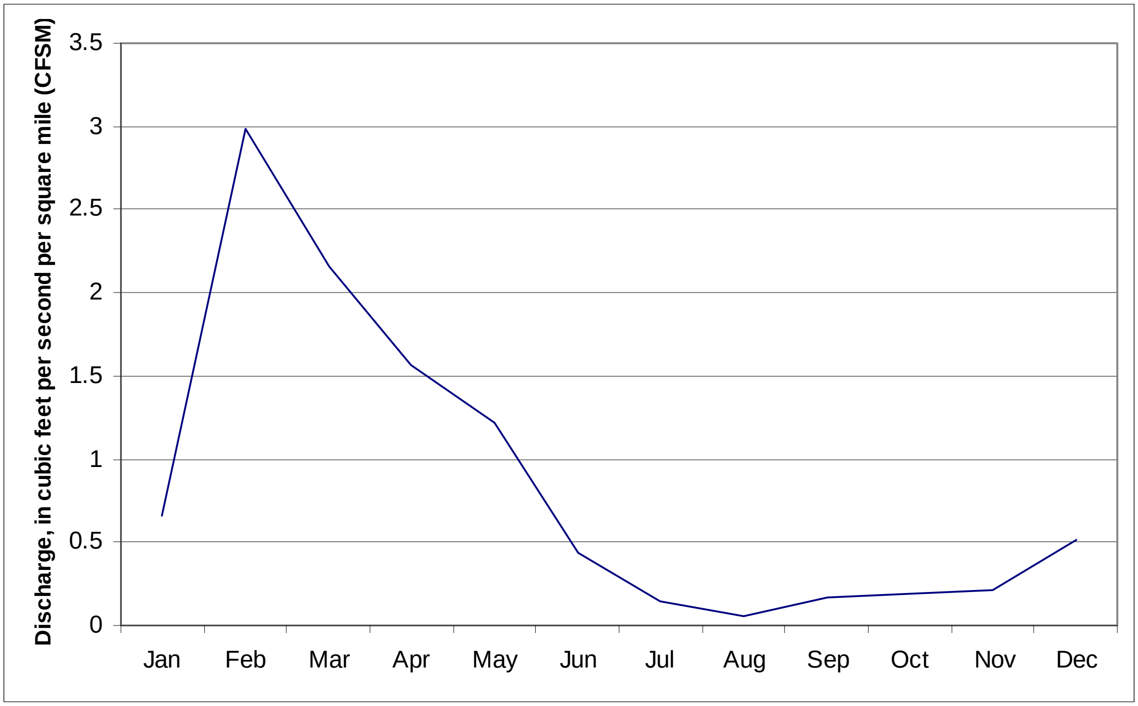
Bunnell's Pond dam forms the boundary between the Middle and Lower Pequonnock River subwatersheds. The Island Brook subwatershed, including Lake Forest, which begins north of Route 15, meets the Pequonnock River in the Enterprise Zone of Bridgeport. The final subwatershed, the Lower Pequonnock River, is entirely contained within the City of Bridgeport and is the location of the Pequonnock River's discharge point into Bridgeport Harbor and the Long Island Sound. The downstream limit of the watershed was selected as the Interstate 95 viaduct.

The main stem of the Pequonnock River flows from north to south through the center of the watershed. The headwaters of the Pequonnock River are in Monroe in a mostly wooded area with freshwater wetlands and minimal development. The watershed land use intensifies as the river flows south through the watershed towards Bridgeport Harbor. Much of the river corridor is protected by riparian vegetation and park areas; however, the most downstream sections have been significantly altered from natural conditions as a result of urban development and former industrial uses – including hardened banks (some in deteriorating conditions) with discarded materials. The most downstream sections of the river within Bridgeport are also affected by tidal, saline waters.

Figure 4-4 shows the seasonal pattern of mean monthly streamflow in the Pequonnock River measured at the stream gage at the bridge on Daniels Farm Road in Trumbull (United States Geological Survey Stream Gage 01208850, at Trumbull, CT [Latitude 41°14'48", Longitude 73°11'51", NAD27]) based on historical data (the period of record is 1964-1966). Normalized by drainage area (15.6 mi^2), the streamflow data in *Figure 4-3* are presented in units of cubic feet per second per square mile (CFSM). The highest streamflow generally occurs during February and March, while seasonal low-flows typically occur during July and August.

The United States Geological Survey (USGS) has also estimated peak-flow magnitudes for 1.5-, 2-, 10-, 25-, 50-, 100- and 500-year recurrence intervals based on historical peak streamflow measurements at the same stream gage location (Ahearn, 2003). *Table 4-2* summarizes peak flow frequency estimates for given recurrence intervals and the maximum known peak flow for the Pequonnock River.

The Fairfield County Flood Insurance Study (FIS) prepared by FEMA, effective June 2010, indicates that the largest floods on record in the Pequonnock River watershed occurred in July 1897, July 1905, March 1936, September 1938, December 1948, August 1955, October 1955, and April 2007. The maximum tidal flooding of record in the study area occurred during the September 1938 and the August 1954 hurricanes, with flood surges reaching an elevation of 9.2 feet in both cases. *Table 4-3* lists a portion of the floodway data contained in the Fairfield County FIS.



*Note: February average based on readings from one year; all other months based on measurements from two years of data collection.

Figure 4-4. Mean Monthly Streamflow of Pequonnock River

Table 4-2. Peak Flow Frequency Estimates and Maximum Peak Flow

Parameter	Peak Flow (cubic feet per second)
Peak-flow frequency estimates for given recurrence interval	
1.5 years	555
2 years	732
10 years	1,720
25 years	2,380
50 years	2,950
100 years	3,580
500 years	5,340
Maximum Known Peak Flow	
October 16, 1955	4,500[1]

[1] Estimated
Source: Based on stream flow data from USGS Gage Station 01208850, Pequonnock River at Trumbull, period of record 1955, 1962-1984 (regulated) (Ahearn, 2003).

Table 4-3. Floodway Data

Flood Source & Location	Drainage Area (sq. mi.)	Peak Discharges (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Pequonnock R. (Lower Reach) @ Connectict Turnpike	29.40	2,630	6,700	9,560	21,240
Pequonnock R. (Upper Reach) upstream of confluence of the West Branch Pequonnock River	3.58	528	1,333	1,911	4,225
Booth Hill Brook @ the confluence w/Pinewood Lake	1.49	240	610	860	1,850
Island Brook @ confluence w/Pequonnock River (Lower Reach)	2.74	700	1,000	1,250	1,800
West Branch Pequonnock River @ confluence w/Pequonnock River (Upper Reach)	4.83	477	628	783	1,350

Source: Flood Insurance Study - Fairfield County (FEMA, 2010).

4.4 Flood Hazard Areas

Figure 4-5 depicts flood hazard areas within the Pequonnock River watershed, including the 100-year and 500-year flood zones and CTDEP Stream Channel Encroachment Lines (SCELs). 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. SCELs are regulatory boundaries associated with selected rivers and streams in Connecticut that define the jurisdiction of CGS Sections 22a-342 through 22a-349a. These areas are similar to floodways and delineate the portion of the waterway that is considered necessary for passage of flood flows. There are no SCELs mapped within the Pequonnock River watershed.

According to the Fairfield County Flood Insurance Study (FIS) prepared by FEMA, effective June 2010, and anecdotal evidence from the watershed communities, the Pequonnock River routinely overtop its banks in many locations throughout its length. In the City of Bridgeport, areas adjacent to the Pequonnock River are subject to recurring flooding problems due to the highly urbanized nature of the watershed within the City. Flash-flooding can occur in these areas throughout the year including spring rains and thaw and heavy rains associated with tropical storms in the summer and fall. The lowlands adjacent to the upper reach of the Pequonnock River in Monroe are subject to frequent flooding during major storms. Flooding is also common in the Town of Trumbull due to the steep topography and limited valley storage along the Pequonnock River valley. Other sections of the Pequonnock River in Trumbull have flat gradients, which may increase the duration of flooding in these areas.

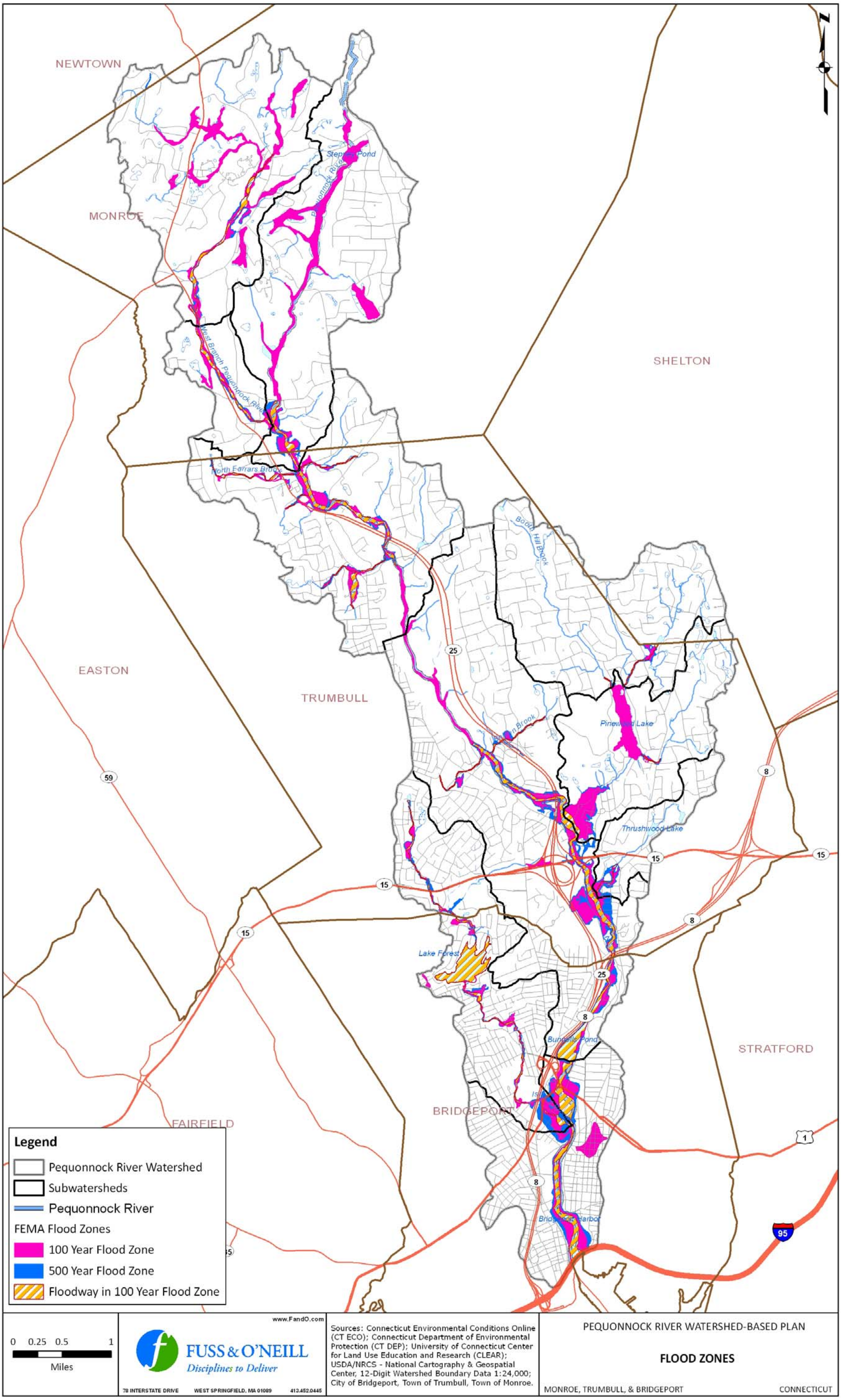


Figure 4-5. Flood Zones

Based on data included in the Fairfield County FIS, the widest portion of the floodway, at approximately 1,000 feet, is along the lower reaches of the Pequonnock River, and the narrowest portion of the floodway is along North Farrar Brook and three unnamed tributaries to the Pequonnock River ('F', 'I', and 'J'), at only 5 feet. The highest mean flow velocity is found in Island Brook, at 14.7 feet/second.

Several small dams are located in Monroe and Trumbull, but none provide significant storage for flood protection. Two general areas of chronic flooding are located in the watershed and have been the subject of several studies, although few of the recommendations have been completed to date. These include:

- *The Pequonnock/Twin Brooks Flood Control Study*. This study, which was completed in 2007, investigated the causes of flooding at the confluence of Booth Hill Brook and the Pequonnock River at Twin Brooks Park. The study examined the potential for replacing a breached dam on the Pequonnock River upstream of the park to provide flood storage. Such a structure would be intended to moderate peak flows by retaining water in a flood control reservoir during flood events while remaining dry under typical conditions. In an earlier study, the U.S. Army Corp of Engineers recommended that a dam (i.e., Trumbull Pond Dam) and reservoir be constructed on the lower reach of the Pequonnock River in Trumbull, one mile north of Daniel's Farm Road, for flood control as well as water supply, water quality improvement, and recreation. This proposed structure appears to correspond to a similar location as the 2007 study.

- *Island Brook Flood Control Studies*. Severe flooding along Island Brook downstream of Lake Forest has been the subject of a number of flood control studies. The most recent study, prepared in 1998, includes several alternatives that examined both modifications to the Lake Forest Dam spillway and increasing the capacity of the stream reach between the dam and the Pequonnock River. Modifications to the dam spillway were recently constructed, but the downstream channel has not been modified.

The Fairfield County FIS also refers to a proposed project involving the realignment of two sections of Route 25 through the watershed. The project includes the addition of nine bridge structures over the Pequonnock River, as well as channel realignments of the river itself. A December 19, 2009 article in the Stamford Advocate (Susan Silvers, *Life's often in the slow lane on Route 25*) suggests that this project was proposed in the 1990s to relieve traffic congestion in Monroe and Trumbull, but has since been cancelled due to public opposition in favor of minor intersection improvements. The larger project is not included in the Greater Bridgeport and Valley Metropolitan Planning Organization Transportation Improvement Program (TIP) for fiscal years 2010 – 2013, although the minor intersection improvements are included.

4.5 Climate

The Pequonnock River watershed is located in an area with a temperate, humid climate. The annual average precipitation is 44.15 inches (U.S. average is 37 inches). Rainfall is fairly evenly distributed throughout the year. The wettest month of the year is March with an average rainfall of 4.15 inches. During a normal winter, snowfall is approximately 36 inches. On average, the area experiences approximately 106 days per year with 0.01 inches or more of precipitation. The July high temperature is approximately 82°F, while the January low is 23°F (average annual temperature for Fairfield County is 51.7°F).

Changes in climate are anticipated to occur over the next century. The magnitude of changes in temperature, sea level, and the timing and intensity of rainfall will depend upon future emissions of carbon dioxide and other greenhouse gases driving climate change. However, using different emissions scenarios, climate modelers have predicted the following changes to the climate in the Northeast United States as summarized below (Ashton et al., 2007; Fogarty et al., 2007; Frumhoff et al., 2007; Hayhoe et al., 2008; Kirshen et al., 2008).

Over the next several decades, temperatures are anticipated to rise 2.5-4°F in winter and 1.5-3.5°F in summer. By the end of the century, winter temperatures are predicted to rise 5-12°F and summer temperatures 3-14°F compared to current conditions. As a result, days over 90°F will be more frequent, there will be a longer growing season, less winter precipitation falling as snow and more as rain, a reduced snowpack, and an earlier spring snowmelt. In addition, regional sea surface temperatures are expected to rise 4-8°F by 2100.

The Northeast is anticipated to experience an increase in total precipitation of about 10% or 4 inches on an annual basis by the end of the century. Seasonally, winter precipitation is predicted to increase 20-30%, while summer precipitation amounts will remain relatively unchanged. In addition to increased precipitation amounts, more extreme precipitation is expected. Current model predictions include an increase in the precipitation intensity, i.e., the average amount of rain falling on a rainy day, and the number of heavy precipitation events. Precipitation intensity is predicted to increase 8-9% by mid-century and 10-15% by the end of the century. An 8% increase in the number of heavy precipitation events is expected by mid-century, with a 12-13% increase by the end of the century. The anticipated hydrologic response will be higher winter and lower summer streamflow.

4.6 Wetlands

4.6.1 Resource Description

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.

Differing definitions of wetlands are used in Connecticut depending on the legal jurisdiction being considered. 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 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 a three-part criteria: 1) soil characteristics; 2) hydrophytic vegetation; and 3) hydrology. The federal wetland designation, established by Cowardin et al. (1979) defines wetlands as:

> "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."

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 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.

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, CTDEP, and the U.S. Army Corps of Engineers regulate their protection.

4.6.2 Existing Wetlands Information

Figure 4-6 depicts the extent and distribution of wetland soils in the Pequonnock River watershed based on Natural Resources Conservation Service soil classifications, following the State of Connecticut definition. *Figure 4-6* also shows wetland classifications available from the U.S. Fish & Wildlife Service National Wetlands Inventory. State-designated wetlands and surface waters comprise nearly 12% of the overall watershed (approximately 2,243 acres), while approximately 3% and 2% of the watershed area (approximately 534 acres and 283 acres, respectively) is mapped as freshwater forested/shrub wetlands and freshwater ponds, respectively, following the Federal definitions.

Mapped wetland soils are generally located in riparian and floodplain areas along the Pequonnock River and its tributaries. The concentration of wetland soils is generally higher in the less developed northern portions of the watershed such as Monroe, and significantly lower in the southern, more densely-developed areas of the watershed such as Bridgeport. *Table 4-4* summarizes wetland soils coverage by subwatershed.

Table 4-4. Wetlands in the Pequonnock River Watershed

Subwatershed	Area of Mapped State Wetlands & Surface Waters (ac)	% of Subwatershed	Area of Mapped Federal (NWI) Wetlands & Surface Waters (ac)	% of Subwatershed
Upper Pequonnock River	549.8	22.4%	252.9	10.3%
Upper West Branch Pequonnock River	433.0	17.2%	183.7	7.3%
Lower West Branch Pequonnock River	77.7	14.1%	33.8	6.1%
Middle Pequonnock Tributaries	265.6	10.9%	51.5	2.1%
Middle Pequonnock River	273.4	7.1%	70.0	1.8%
Upper Booth Hill Brook	179.3	9.5%	36.8	1.9%
Lower Booth Hill Brook	230.9	16.9%	115.9	8.5%
Thrushwood Lake	52.9	12.0%	8.5	1.9%
Island Brook	127.8	7.3%	85.1	4.9%
Lower Pequonnock River	52.3	3.7%	51.5	3.7%
Pequonnock River Watershed	**2,242.8**	**12.0%**	**889.8**	**4.8%**

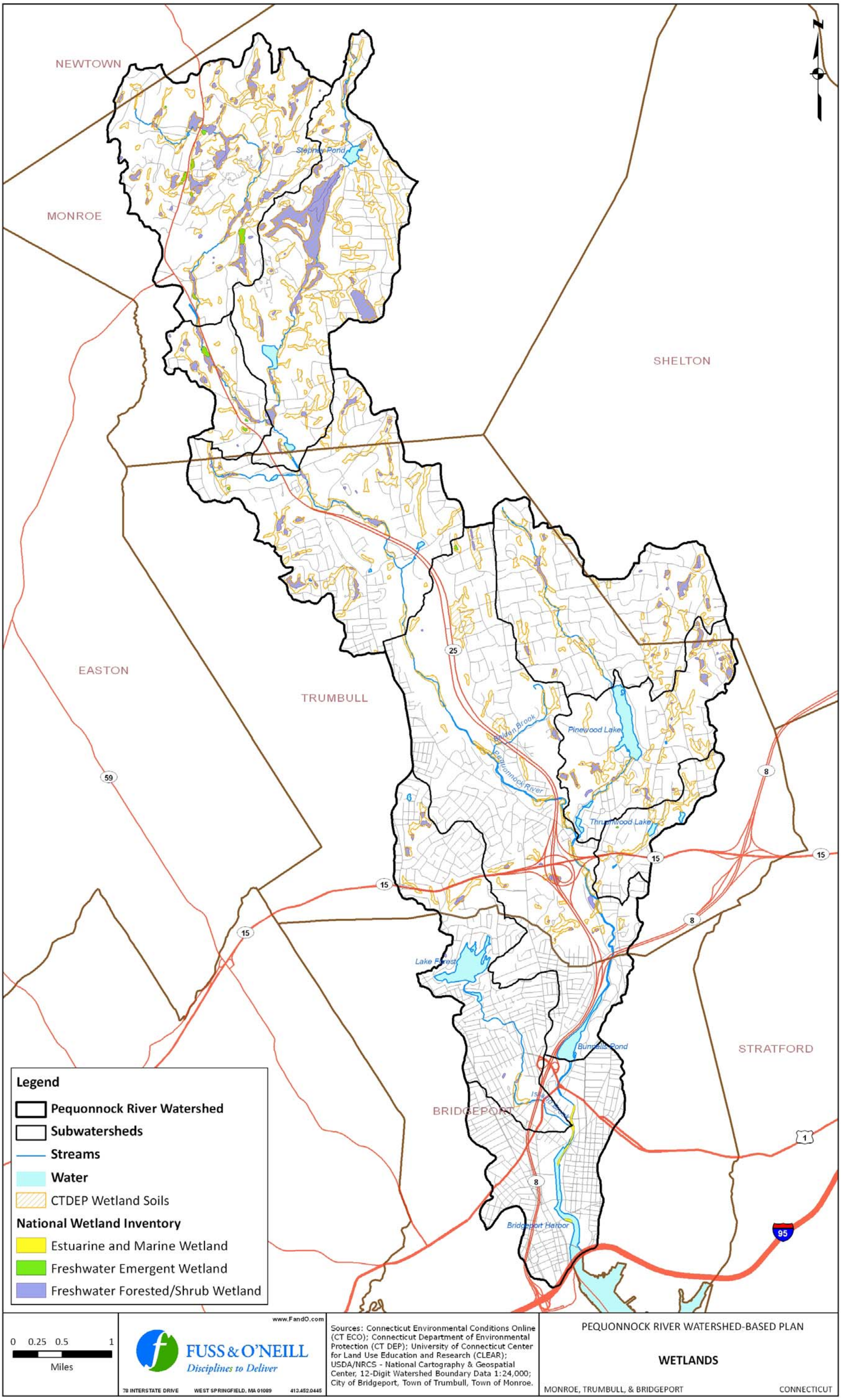


Figure 4-6. Wetlands

4.7 Fish and Wildlife Resources

4.7.1 Fish

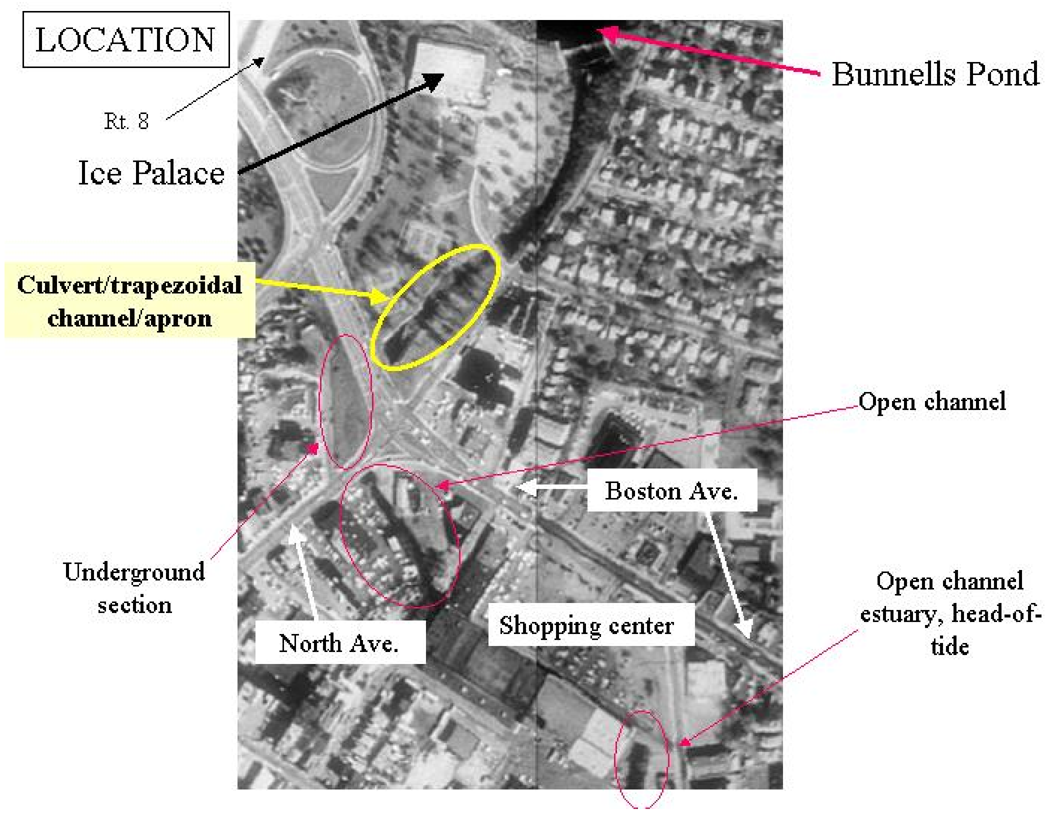
The Pequonnock River and several of its tributaries are an important urban coastal fishery for certain anadromous, migrating upriver to spawn during spring, and resident fish species. The CTDEP conducted limited fish surveys within the Pequonnock River watershed between August 1990 and June 2007. During the six surveys, 20 different species were identified at 5 locations within the watershed. The species identified included brook, brown, and rainbow trout (mix of native and stocked), largemouth and rock bass (non-native), bluegill and redbreast sunfish (mix of native and stocked), American eel (native), and yellow perch (native). River herring and blueback herring, both anadromous fish species, are present in the lower Pequonnock River and have been the focus of cooperative management and restoration efforts.

The Pequonnock River (including the Tungsten Mine Park Pond), is listed in the 2010 Connecticut Angler's Guide Inland and Marine Fishing as a "trophy trout stream" in Trumbull, from the Whitney Avenue bridge through Trumbull Basin State Park to the Daniels Farm Road bridge. The CTDEP stocks this portion of the river with a mix of large and small fish. Bunnell's Pond, a 33-acre pond located in Beardsley Park in the northern portion of Bridgeport, is stocked with trout annually. Approximately 2,500 trout are stocked per year. The impoundment has a fish- and eel-way at the dam for blueback herring, river herring (alewife), and eel. The West Pequonnock Reservoir (Monroe, 1.4 acres) contains largemouth bass, sunfish, and other species. The Great Hollow Pond within Wolfe Park (Monroe, 14 acres) is considered a trout park. The CTDEP Inland Fisheries Division also annually stocks several river locations upstream of Beardsley Park within Trumbull and Bridgeport (approximately 3,400 trout per year) and a location on the West Branch of the Pequonnock River in the Town of Monroe (approximately 350 trout per year).

Dam and Fishway at Bunnell's Pond, Bridgeport (Source: C.Cryder, Save the Sound).

An Alaskan steep-pass fishway was constructed by the City of Bridgeport at the Bunnell's Pond dam in 2002 to allow fish passage along the lower Pequonnock River upstream of Bunnell's Pond dam. The dam is currently owned by the State of Connecticut and operated by the CTDEP and is reported to be the tallest steep-pass fishway on the east coast. Thousands of blueback and river herring are estimated to use the fishway each year. Pending the availability of future funding, the CTDEP plans to install a camera at the fishway to count and identify fish and educate the general public. Bunnel's Pond dam also has an eel pass. Eels are captured in a holding tank and are then transported upstream by CTDEP staff to the pond. CTDEP is working to modify the eel pass configuration to improve eel passage at this location.

Save the Sound in conjunction with the CTDEP and U.S. Fish and Wildlife Service received funding to address a significant obstruction to fish passage in the lower portion of the Pequonnock River in Bridgeport, just downstream of Bunnell's Pond. The project would allow fish passage to the fishway and to the upstream pond and spawning area. When the highway was constructed in 1969, approximately 12 feet of the river was turned into a smooth concrete channel below the Route 8 bridge. During low flows in the river, fish passage is restricted, limiting the success of the pond's fishway. The objective of this project is to create a fish ladder in the existing concrete apron to restore safe passage of river herring and other resident fish species to the Bunnell's Pond fishway and upstream reaches within the watershed. Current estimates are that 2,000 to 5,000 alewife use the fishway per season and that improvement to this downstream obstruction will markedly improve this number. Construction of the project is anticipated to occur in 2011.



Map of Concrete Apron Retrofit Project (Source: C.Cryder, Save the Sound).

4.7.2 Birds

The Atlas of Breeding Birds of Connecticut (Askins, et al.,1994) collected information from 1982 to 1986 and found approximately 101 confirmed or probable species in the watershed. A complete species list is provided in *Appendix A*. In addition, the Trumbull Historical Society has identified the following birds as being inhabitants of the Pequonnock River Valley State Park:

- Mallard (*Anas platyrhynchos*)
- Canadian Goose (*Branta canadensis*)
- Crow (*Corvus brachyrhynchos*)
- Field Sparrow (*Spizella pusilla*)
- Tree Sparrow (*Spizella arborea*)
- Chipping Sparrow (*Spizella passering*)
- Swamp Sparrow (*Melospiza georgiana*)
- House Sparrow (*Passer domesticus*)
- Cardinal (*Richmondena cardinalis*)
- Blue Jay (*Cyanocitta cristata*)
- Robin (*Turdus migratorius*)
- Wood Thrush (*Hylocichla mustelina*)

4.7.3 Amphibians & Reptiles

Table 4-5 lists amphibians and reptiles that have been sited within at least one of the municipalities that comprise the Pequonnock River watershed, 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 Pequonnock River Watershed

Amphibians	Reptiles
Caudata *Ambystoma cf. jeffersonianum* *Ambystoma maculatum* *Ambystoma opacum* *Desmognathus fuscus* *Eurycea bislineata* *Hemidactylium scutatum* *Plethodon cinereus* *Notophthalmus viridescens*	Testudinata *Chelydra serpentina* *Chrysernys picta* *Clemmys guttata* *Clemmys insculpta* *Terrapene carolina* *Trachemys scripta*

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

Amphibians	Reptiles
Anura	Squamata
Bufo americanus	*Carphophis amoenus*
Hyla versicolor	*Diadophis punctatus*
Pseudacris crucifer	*Heterodon platirhinos*
Rana catesbeiana	*Lampropeltis triangulum*
Rana clamitans	*Nerodia sipedon*
Rana palustris	*Opheodrys vernalis*
Ratio sylvatica	*Storeria dekayi*
	Thamnophis sirtalis
	Agkistrodon contortrix

The Trumbull Historical Society has also identified the Northern Black Racer Snake (*Coluber constrictor*) as an inhabitant of the Pequonnock River Valley State Park.

4.7.4 Threatened and Endangered Species

The CTDEP 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 4-7 depicts the generalized areas of endangered, threatened, and special concern species in the Pequonnock 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. Approximately three such areas were identified throughout the watershed including one Critical Habitat Area (Tungsten Mine Park). The Tungsten Mine Park is composed of two different habitat types – the larger eastern portion is "dry subacidic forest; terrestrial forested", while the smaller western section is "subacidic rocky summit outcrop; terrestrial non-forested."

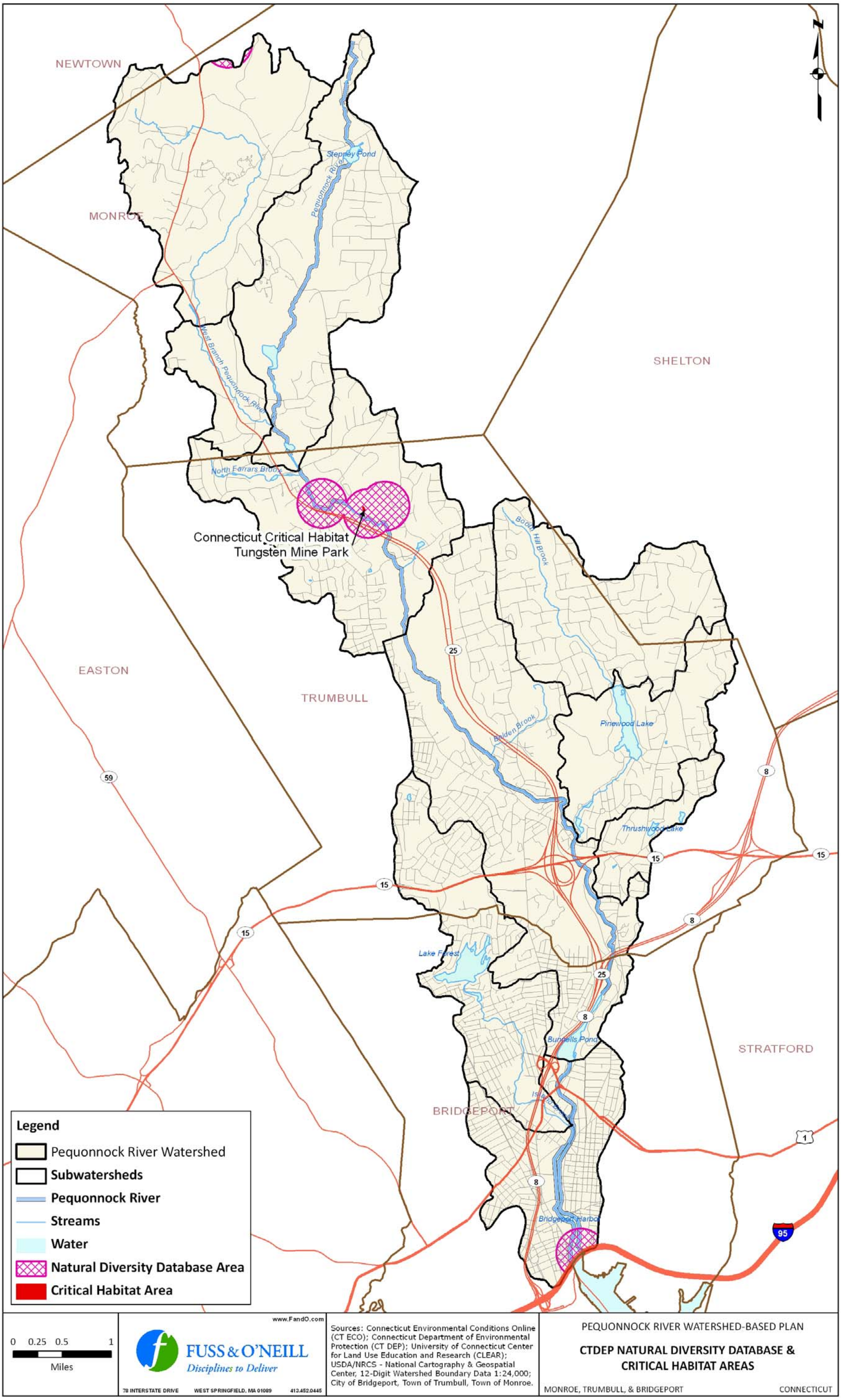


Figure 4-7. Natural Diversity Database and Critical Habitat Areas

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

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

Common Name	Scientific Name	Status
Flora		
Arethusa Beach needle grass Toothcup	*Arethusa bulbosa* *Aristida tuberculosa* *Rotala ramosior*	Special Concern Endangered Threatened
Fauna		
Peregrine Falcon Eastern pearl shell Eastern box turtle	*Falco peregrinus* *Margaritifera margaritfera* *Terrapene c. carolina*	Endangered Special Concern Special Concern
Natural Communities		
Circumneutral rocky summit/outcrop Dry circumneutral forest	--	--

Source: CTDEP Natural Diversity Data Base, 2010.

5 Watershed Modifications

5.1 Dams and Impoundments

The Pequonnock River watershed includes a number of dams and reservoirs. These hydrologic features were constructed for a variety of reasons including water supply, industrial power, and/or recreation. Some of the existing dams and reservoirs retain their original uses, while others now primarily provide recreation, habitat, and open space. The majority of small dams throughout the watershed do not provide significant storage for flood protection. Impoundments in the watershed provide aquatic and wildlife habitat and recreational opportunities, but may also limit or impede fish migration.

Table 5-1 lists state-registered dams in the Pequonnock River watershed. *Figure 5-1* shows the location and hazard classification of these dams within the watershed. According to the CTDEP Dam Safety Regulations (RCSA 22a-409-1 and 22a-409-2) (CTDEP 2001), the hazard classification of a dam is based on the damage potential from failure of the structure. For example, a Class C dam is a high hazard potential dam which, if it were to fail, would result in probable loss of life; major damage to habitable structures, residences, hospitals, and other inhabited and public gathering places; damage to main highways with greater than 1,500 average daily trips; and great economic loss.

Table 5-1. Hazard Classification of State-Registered Dams and Impoundments

Dam Name	Town	Hazard Class	Area of Impoundment (acres)
Seeley's Pond	Bridgeport	AA	<0.10
Chamberlin's Pond	Bridgeport	A	<0.10
Island Brook Lagoon	Bridgeport	B	3.80
Lake Forest	Bridgeport	C	66.58
Bunnell's Pond	Bridgeport	C	33.36
Serenity Pond	Trumbull	B	<0.10
Thrushwood Lake	Trumbull	BB	4.53
Frog Pond	Trumbull	A	2.47
Ehrsam Pond	Trumbull	B	1.14
Pinewood Lake	Trumbull	C	60.18
Stone Dam	Trumbull	A	0.25
Booth Hill Pond	Trumbull	A	<0.10
Small Pond	Trumbull	A	<0.10
Kaatz Pond	Trumbull	AA	1.95
Old Main Park Pond	Trumbull	A	1.16
Porter Hill Road Pond	Trumbull	A	0.29
North Farrar's Brook Pond	Trumbull	A	0.46
Tashua Road Pond	Trumbull	A	0.14
North Farrar's Brook	Trumbull	A	1.10
Harsh Pond	Monroe	AA	1.40
Long Pond	Monroe	AA	1.46
Stepney Pond	Monroe	A	13.35

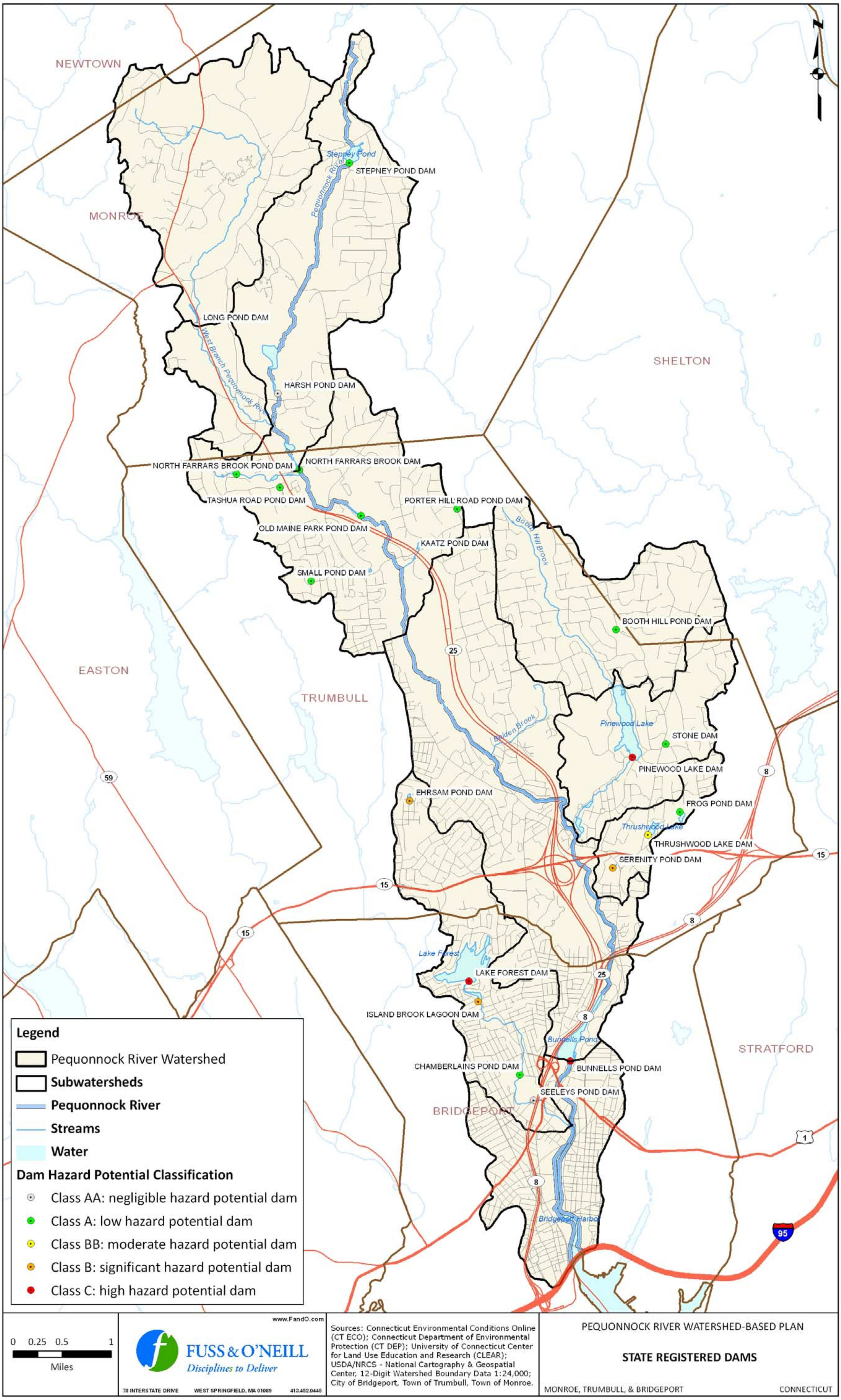


Figure 5-1. State Registered Dams

Dams that have changed use or ownership often degrade in condition and fall into a state of disrepair, increasing the likelihood of dam failure. The CTDEP Dam Safety Section is required to inspect dams periodically, with increased inspection frequency for dams with higher hazard potential.

The Federal Emergency Management Agency (FEMA) recently updated the flood insurance study for Fairfield County (FEMA, 2010). Although previous studies investigated the potential benefits of additional flood control structures on the Pequonnock River, implementation of such projects is not anticipated in the near future. Furthermore, no flood protection measures are planned for tributaries of the Pequonnock River.

In addition to dams registered with the CTDEP Dam Safety Section, there are numerous structures that affect the flow of water and obstruct the passage of fish and other riparian wildlife in the Pequonnock River and its tributaries. These structures include road and foot bridges, culverts, weirs and other in-stream control structures. Based on a review of the FEMA flood insurance study (FEMA 2010) there are over 90 such structures within the watershed.

5.2 Water Supply

Drinking water service for all of the watershed towns is supplied by Aquarion Water Company which operates a system of nine surface water reservoirs, including:

- West Pequonnock Reservoir
- Trap Falls Reservoir
- Saugatuck Reservoir
- Means Brook Reservoir
- Hemlocks Reservoir
- Fort Mill Reservoir
- Easton Lake Reservoir
- Aspetuck Reservoir

These reservoirs supply more than 97% of drinking water used by customers. The remaining 3% is supplied by groundwater form the Westport and Coleytown Well Fields, which are also operated by Aquarion Water Company.

The majority of these water sources are located outside of the Pequonnock River Watershed, with the exception of the West Pequonnock Reservoir, which is maintained as a backup water supply for diversion to Easton Reservoir in times of drought and is rarely used. As such, water supply service represents a net diversion of water into the watershed during most conditions.

Three small areas of contribution to public water supply wells are located within the northern portion of the watershed, two of which are non-transient, non-community water systems (systems that are not community systems and function for more than 6 months of the year) and one of which is a transient non-community system (a system that serves less than 25 people for less than six months of the year).

5.3 Wastewater

Wastewater management within the Pequonnock River watershed varies by municipality. The City of Bridgeport Water Pollution Control Authority (WPCA) operates two wastewater treatment facilities that discharge to Long Island Sound. Operation of these facilities is contracted to the Kelda Group, the parent company of Aquarion Water Company. The facilities provide secondary treatment and discharge to Bridgeport Harbor, south of the Pequonnock River. The eastern facility, which is the smaller of the two treatment plants, has a design capacity to treat 8 million gallons per day (MGD) of sanitary sewage and combined stormwater, and is designed for a peak flow rate of 40 MGD during storm events. It currently receives an average daily flow of 6.5 MGD. It discharges from the east bank of Bridgeport Harbor downstream of the Yellow Mill Channel, which is the tidal inlet east of the Pequonnock River. The larger treatment plant, which is reported to serve the majority of the Pequonnock River watershed, is located outside of the watershed to the west at Black Rock Harbor. This facility is a 30 MGD design flow facility that currently receives average daily flows of 23 MGD and peak flows of 90 MGD.

These two treatment facilities receive wastewater from the majority of Bridgeport (*Figure 5-2*). In addition, the Town of Trumbull has been constructing sewers to collect and convey wastewater to the Bridgeport wastewater treatment facilities since the early 1970s. Approximately 125 miles of sanitary sewer have been constructed, bringing sewer service to 8,000 homes and businesses. Sewer construction is still ongoing in its fourth phase, extending service into an area in eastern Trumbull. A fifth phase is currently under design.

In contrast, Monroe currently has no sewer service; all developed areas are served by on-site septic systems. The Town's WPCA operates several community septic systems. Monroe is in discussions with the Town of Trumbull to extend sewer service into a limited but densely-developed area along Route 25 in South Monroe.

5.4 Stormwater

Stormwater management in the watershed generally follows traditional methods. In Bridgeport, much of Trumbull, and the more densely developed portions of Monroe, stormwater is collected by curb and gutter drainage and conveyed to the nearest receiving water body via a network of storm drains and pipes.

In much of Bridgeport, stormwater is collected by the combined sewer system which conveys the stormwater along with sewage to one of the City's two water pollution control facilities. Overflows of combined stormwater and sanitary can occur during storm events when the flow volume or discharge rate exceeds the system capacity. Rooftop drainage from most residences and industrial buildings may be piped directly into the building's sewer service connection, or discharge to the ground surface where it is likely to flow into nearby catch basins.

In Trumbull, storm drainage systems are generally separate from sanitary sewers. Based on the predominance of more recent development in Trumbull, catch basins are more likely to have deep sumps than in Bridgeport. Deep sump catch basins can enhance settling of coarse-grained

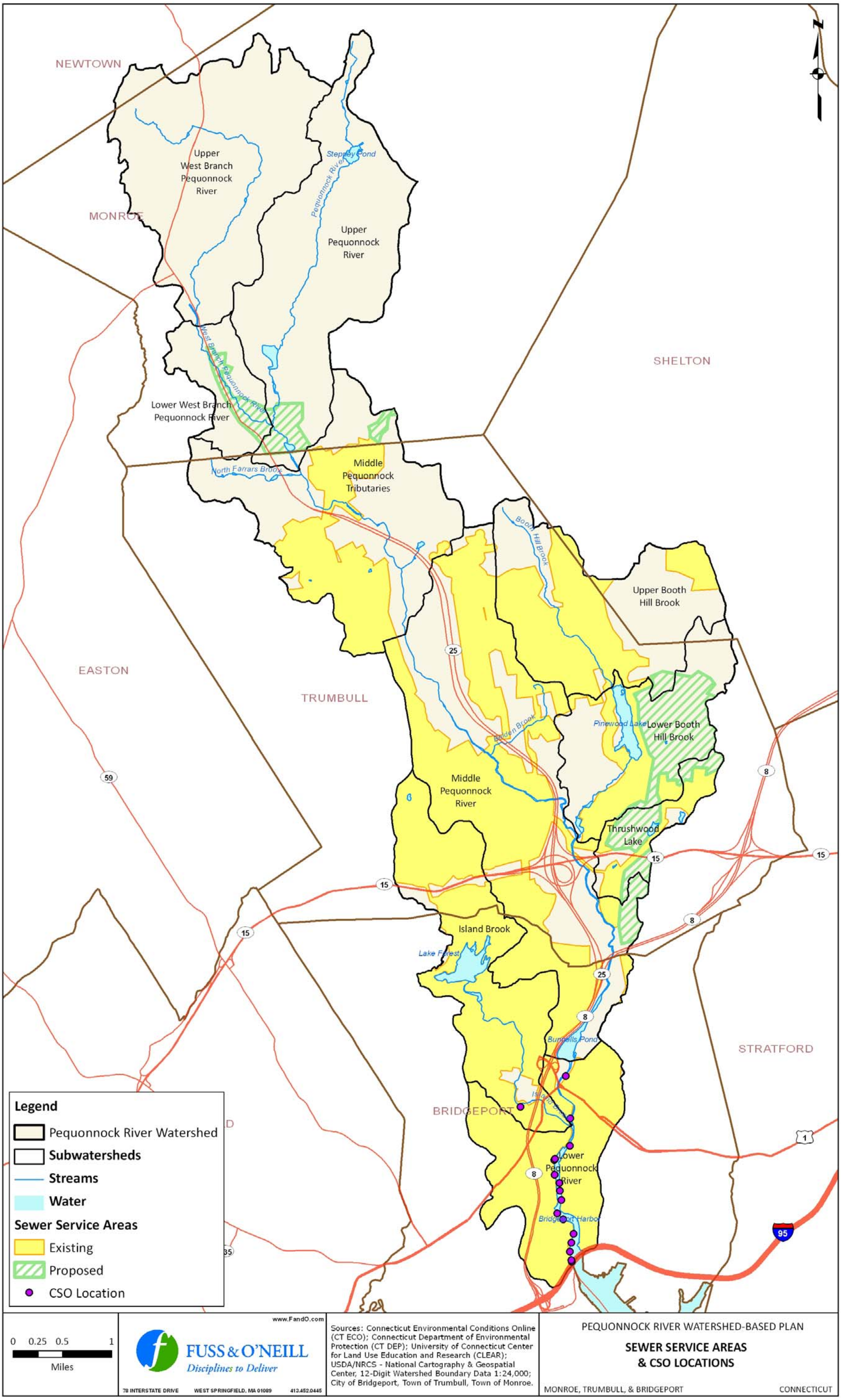


Figure 5-2. Sewer Service Areas and Combined Sewer Overflow Locations

sediment and larger debris prior to discharge if the accumulated sediment is removed on a regular basis. Rooftop drainage may be piped directly into the separate storm sewers or discharge to the ground surface where it may either infiltrate or flow overland to enter nearby catch basins. Country drainage, in which stormwater from roadways is allowed to run-off onto the roadway shoulders and adjacent ground surface, is also common in some of the less developed areas of Trumbull and Monroe.

It the present time, there are relatively few examples in the watershed of Low Impact Development (LID) stormwater management methods or end-of-pipe treatment measures for stormwater quality.

5.4.1 Municipal Phase II Stormwater Program

The CTDEP 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). The MS4 General Permit requires municipalities to register with CTDEP, 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. The CTDEP is currently in the process of revising and reissuing the MS4 General Permit.

The municipalities within the Pequonnock River watershed are regulated under the MS4 General Permit. The discussion in this section is limited to the communities of Bridgeport, Trumbull, and Monroe since these municipalities comprise the majority of the watershed land area and have the greatest potential to impact water quality resulting from the discharge of urban stormwater runoff. The following sections summarize current and ongoing municipal stormwater management practices in Bridgeport, Trumbull, and Monroe as described in the Stormwater Management Plans and most recent annual reports prepared by each municipality. An evaluation of local land use regulations, including local stormwater management regulatory requirements, will be presented in a separate, companion report to this baseline assessment document.

5.4.1.1 Bridgeport

The Water Pollution Control Authority (WPCA) for the City of Bridgeport is responsible for the administration of the City's Phase II stormwater program. The WPCA submits the City's annual report and annual stormwater sampling results to the CTDEP. Portions of the City's stormwater system are combined with the sanitary sewer system and are, therefore, not regulated under the Phase II stormwater program. The City's stormwater management-related activities and practices as reported in the 2009 Annual Report to CTDEP are summarized as follows:

- The City has developed a stormwater outfall map containing all of the outfalls within the City greater than 12-inches in diameter.
- The City has developed and implemented an illicit discharge detection and elimination program. This program includes enforcement measures that can be used to ensure compliance.
- The City's land use regulations have been revised to meet Phase II requirements.
- All roadways within the City are swept at least six times per year with some more populated downtown areas receiving additional cleaning.
- All City catch basins (8,500) are cleaned annually.
- The City has a program to clean approximately 15 miles of storm sewers and inspect an additional 15 miles of storm sewers.
- The City maintains a prioritized list of sewer pipes that need repair or replacement.
- The City collects six outfall stormwater samples per year as required by the Phase II general permit.
- The City also has a comprehensive Stormwater Management Manual (May 2008).

5.4.1.2 Trumbull

The Town of Trumbull maintains an Administrative Policy for Stormwater Management and Drainage Design Standards, which serves as a guideline for land development and drainage-related projects. Reportedly, the Town of Trumbull has not formally implemented a Phase II stormwater management program for its municipal storm sewer system and municipal operations.

5.4.1.3 Monroe

Information on the Town of Monroe's Phase II stormwater program was unavailable for review as of the writing of this report. CTDEP stormwater monitoring records indicate that the Town has submitted annual stormwater monitoring data for 2004 through 2007. Although the Town does not have a local stormwater management manual or similar guidance document, Town land use commissions rely upon design guidance contained in the CTDEP *Connecticut Stormwater Quality Manual* for review of land development projects.

5.5 Regulated Sites

Historical and current industrial and commercial development within the Pequonnock River watershed poses a potential threat to surface water and groundwater supplies in the watershed. Wastewater discharges, illegal waste disposal, improper use and disposal of chemicals such as used oil, pesticides, and herbicides, chemical spills, and historical site contamination are potential sources of contaminants from industrial and commercial facilities.

Table 5-2 summarizes the facilities in the Pequonnock River watershed with surface water discharges regulated under the National Pollutant Discharge Elimination System (NPDES) permit program, which is administered by the CTDEP. The facilities listed in *Table 5-2* have permits for discharges of wastewater or stormwater discharges either directly to surface waters or indirectly via stormwater drainage systems. The majority of these facilities in the watershed are located in Bridgeport, although a number are also located in Trumbull and Monroe. No NPDES regulated facilities exist within the Newtown or Shelton portions of the watershed.

Table 5-2. Facilities with NPDES Discharge Permits in the Pequonnock River Watershed

Type of Discharge Permit	Permit ID Prefix	Number of Facilities in the Watershed		
		Bridgeport	Trumbull	Monroe
General Permit for Cooling Water	GCW	2	0	0
General Permit for Domestic Sewage	GDS	2	2	0
General Permit for Food Processing	GFP	1	0	0
General Permit for Groundwater Remediation	GGR	1	0	0
General Permit for Miscellaneous Discharges to Sewer	GMI	1	1	0
General Permit for Pool Cleaning Contractor	GPC	0	1	0
General Permit for Photographic System	GPH	6	0	0
General Permit for Swimming Pool Filters	GPL	0	1	0
General Permit for Printing & Publishing	GPP	0	1	0
General Permit for Commercial Stormwater	GSC	1	0	0
General Permit Industrial Stormwater	GSI	3	6	8
General Permit for Municipal Separate Storm Sewer Systems (MS4s)	GSM	1	1	1
General Permit for Construction Stormwater	GSN	2	1	0
General Permit for Parts Tumbling and Cleaning	GTC	1	0	0
General Permit for Vehicle Maintenance	GVM	16	1	1
General Permit for Vehicle Service Floor Drains	GVS	1	0	0
Discharge to Septic System	UI	0	0	4
	Total:	**38**	**15**	**14**

Source: CTDEP, July, 2010.

Facilities with NPDES discharge permits are required to comply with the permit conditions and associated regulations/statutes, including source controls, pollution prevention, monitoring, treatment, and other best management practices as specified by the permits. The recent compliance records of these regulated facilities were reviewed to evaluate potential issues related to existing commercial and industrial facility practices in the watershed.

Table 5-3 lists industrial facilities in the watershed, which are registered under the CTDEP *General Permit for the Discharge of Stormwater Associated with Industrial Activity*, with stormwater sampling results that exceeded the General Permit effluent quality goals between 1995 and August 2010.

Table 5-3. Industrial Facilities that Exceed Stormwater General Permit Effluent Quality Goals

Facility	Receiving Water	Water Quality Parameters Detected Above the General Permit Effluent Quality Goals (Number of Exceedances)
City of Bridgeport Transfer Station/Enviro Express	Pequonnock River	Oil & Grease (1), Total Copper (1), Total Zinc (1), Total Lead (2), Aquatic Toxicity (LC50)(1)
Town of Trumbull Transfer Station/Enviro Express	Pequonnock River	Oil & Grease (3), Chemical Oxygen Demand (1), Total Phosphorus (1), Total Kjeldahl Nitrogen (1)
Sippen Bros. Oil Company	Pequonnock River	Nitrate (1) Aquatic Toxicity (LC50)(1)
Bridgeport Machines	Island Brook	Oil & Grease (2), Chemical Oxygen Demand (2), Total Kjeldahl Nitrogen (2), Nitrate (2), Total Lead (3)
Vitramon, Inc.	Pequonnock River	Chemical Oxygen Demand (1), Total Phosphorus (1), Total Kjeldahl Nitrogen (1), Nitrate (2), Aquatic Toxicity (LC50)(1)
Hawie Manufacturing Co.	Pequonnock River	Chemical Oxygen Demand (4), Total Suspended Solids (1), Total Phosphorus (2), Total Kjeldahl Nitrogen (3), Nitrate (4), Total Copper (5), Total Zinc (5), Total Lead (4), Aquatic Toxicity (LC50)(4)
First Student	Farrars Brook	Chemical Oxygen Demand (1), Nitrate (2), Total Zinc (1)
Cornell-Carr Company	West Branch Pequonnock River	Nitrate (1)

Source: CTDEP, August 2010.

Table 5-4 summarizes hazardous waste generators and other regulated industrial facilities within the watershed. The majority of the regulated industrial facilities are in Bridgeport (11 facilities), and the remaining are in Trumbull (2 facilities) and Monroe (3 facilities).

Hazardous waste facilities are regulated under the Resource Conservation and Recovery Act (RCRA), including Large Quantity Generators (i.e., facilities that generate 1,000 kilograms per month or more of hazardous waste, more than 1 kilogram per month of acutely hazardous waste, or more than 100 kilograms per month of acute spill residue or soil) and facilities registered with the CTDEP Corrective Action Program. Small Quantity Generators are not included in *Table 5-4*.

The Toxics Release Inventory (TRI) is a database containing detailed information on chemicals that industrial facilities manage through disposal or other releases, or recycling, energy recovery, or treatment. This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and expanded by the Pollution Prevention Act of 1990. Certain facilities are required to report to the TRI Program annually.

The Assessment, Cleanup and Redevelopment Exchange System (ACRES) is an online database for brownfields grantees for funding for brownfields assessment, cleanup, revolving loans, and environmental job training. There are no sites in the watershed that are listed as potential hazardous waste sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), otherwise known as "Superfund."

The Vishay Vitramon, Incorporated, a ceramic capacitor manufacturer, is the only permitted Major Discharger of Air Pollutants in the watershed, holding a Federal Title V permit for major emitters of air pollutants.

Table 5-4. Summary of Regulated Facilities

Facility Name	Address	Town	Resource Conservation and Recovery Act (RCRA)	Toxic Release Inventory (TRI)	Brownfields Properties (ACRES)
Acme United Corporation	100 Hicks Street	Bridgeport	--	TRI Reporter	--
Airshield	560 N Washington Avenue	Bridgeport	--	TRI Reporter	--
American Heat Treating, Inc.	16 Commerce Drive	Monroe	--	TRI Reporter	--
Avery Abrasives Inc	2225 Reservoir Avenue	Trumbull	--	TRI Reporter	--
Bridgeport Machines, Inc.	500 Lindley Street	Bridgeport	Treatment, Storage & Disposal; Corrective Action	TRI Reporter	--
Casco Products Corporation	380 Horace Street	Bridgeport	--	TRI Reporter	--
Engineered Electric Co (Dba Drs Fermont)	141 N Avenue	Bridgeport	--	TRI Reporter	--

Table 5-4. Summary of Regulated Facilities

Facility Name	Address	Town	Resource Conservation and Recovery Act (RCRA)	Toxic Release Inventory (TRI)	Brownfields Properties (ACRES)
Fermont Division	141 North Avenue	Bridgeport	Large Quantity Generators	--	--
Former Producto Property	990 Housatonic Avenue	Bridgeport	--	--	Brownfields Property
Helicopter Support Inc	124 Quarry Road	Trumbull	Large Quantity Generators	--	--
Old Bridgeport Brass Building	560 North Washington Avenue	Bridgeport	--	--	Brownfields Property
Schwerdtle Stamp Company	166 Elm Street	Bridgeport	Large Quantity Generators	TRI Reporter	--
Seymour Sheridan Inc	15 Commerce Drive	Monroe	--	TRI Reporter	--
St. Vincent S Medical Center	2800 Main Street	Bridgeport	Large Quantity Generators	--	--
United Pattern	148 Congress Street	Bridgeport	--	--	Brownfields Property
Vishay Vitramon, Incorporated	10 Main Street	Monroe	Large Quantity Generators; Treatment, Storage & Disposal; Corrective Action	TRI Reporter	--

Sources: EPA Geospatial Data Access Project. *Featured Environmental Interests.* Accessed at http://www.epa.gov/enviro/geo_data.html. Updated July, 2010;
Department of Environmental Protection. *Commercial Hazardous Waste and Connecticut Regulated Waste Facilities In Connecticut*. Accessed at http://www.ct.gov/dep/cwp/view.asp?a=2718&q=325490&depNav_GID=1646. Updated October 21, 2008;
Department of Environmental Protection. *Title V Operating Permit Program* Accessed at http://www.ct.gov/dep/cwp/view.asp?A=2684&Q=322176, updated August 12, 2010.

6 Water Quality

6.1 Classification, Standards, and Impairments

The Federal Clean Water Act (CWA) was developed 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 four different categories ranging from Class AA to D (*Table 6-1*) and coastal and marine surface waters into four categories ranging from Class SA to SD (*Table 6-2*).

Table 6-1. Connecticut Inland Surface Water Quality Classifications

Designated Use	Class AA	Class A	Class B	Class C	Class D
Existing/proposed drinking water supply	•				
Potential drinking water supply	•	•			
Fish and wildlife habitat	•	•	•	Class C and D waters may be suitable for certain fish and wildlife habitat, certain recreational activities, industrial use, and navigation	
Recreational use	•	•	•		
Agricultural and industrial use	•	•	•		

Figure 6-1 depicts the Water Quality Classifications of surface waters in the Pequonnock River watershed. The upper reaches of the Pequonnock River and the majority of tributaries to the Pequonnock River are designated as Class A water bodies and are known or presumed to meet Class A Water Quality Criteria that support the following designated uses: potential drinking water supply; fish and wildlife habitat; recreational use; agricultural, industrial supply and other legitimate uses, including navigation. *Table 6-3* summarizes the water quality classifications of various reaches and tributaries of the Pequonnock River that otherwise do not meet the Class A Water Quality Criteria.

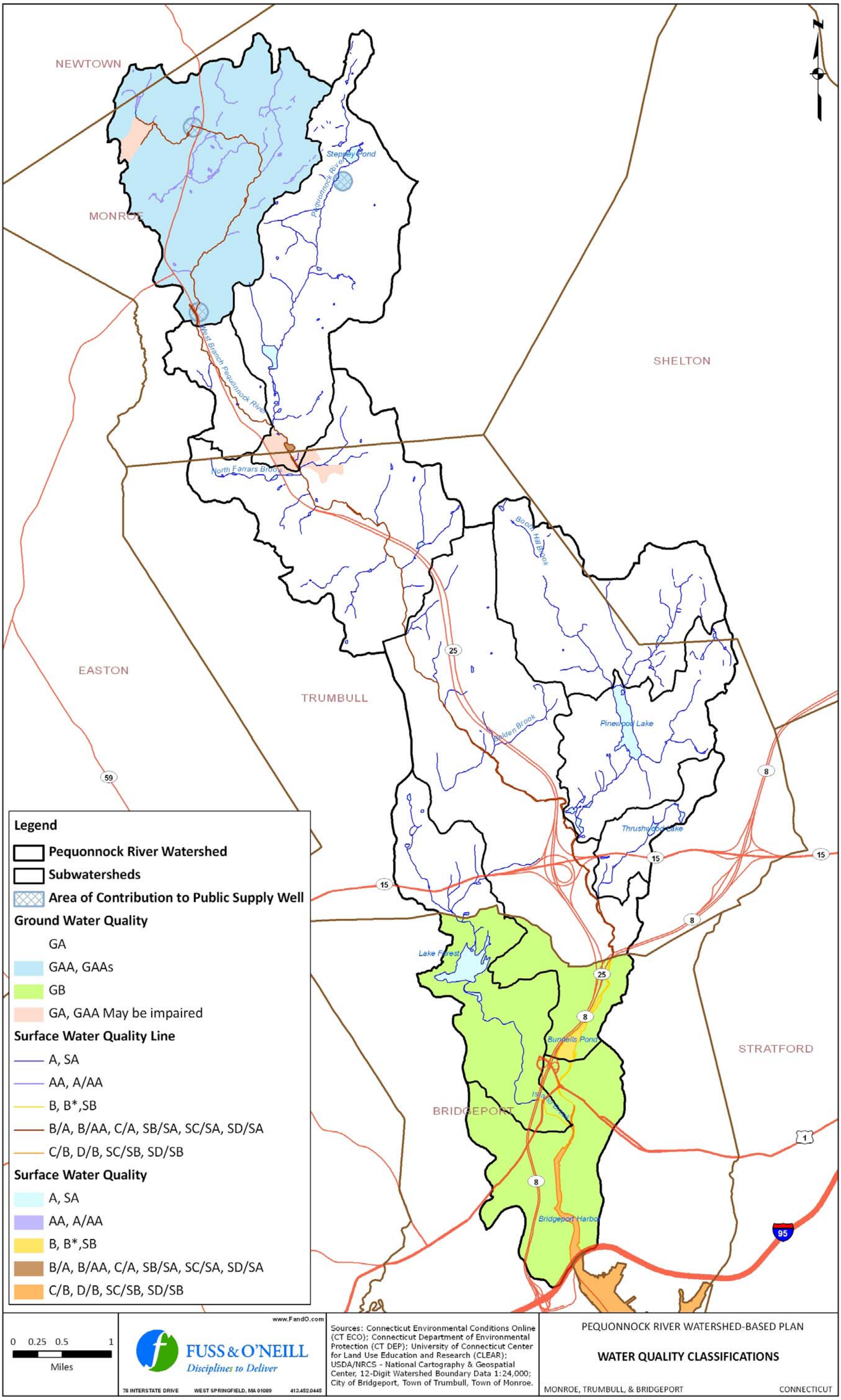


Figure 6-1. Water Quality Classifications

Table 6-2. Connecticut Coastal and Marine Surface Water Quality Classifications

<table>
<tr><th>Designated Use</th><th>Class SA</th><th>Class SB</th><th>Class SC</th><th>Class SD</th></tr>
<tr><td>Marine fish, shellfish, and wildlife habitat</td><td>•</td><td>•</td><td colspan="2" rowspan="6">Indicates unacceptable quality. The goal is SA or SB.</td></tr>
<tr><td>Shellfish harvesting for direct human consumption</td><td>•</td><td></td></tr>
<tr><td>Shellfish harvesting for transfer to approved areas for purification prior to human consumption</td><td>•</td><td>•</td></tr>
<tr><td>Recreational use</td><td>•</td><td>•</td></tr>
<tr><td>Industrial use</td><td></td><td>•</td></tr>
<tr><td>Other, including navigation</td><td>•</td><td>•</td></tr>
</table>

Table 6-3. Water Quality Classifications of the Pequonnock River and Major Tributaries

Waterbody Name	Location Description	Water Quality Classification
West Branch Pequonnock River (upper reach)	Long Pond Dam, Monroe, upstream to its headwaters near Pastors Walk, Monroe	B/AA
West Branch Pequonnock River (lower reach)	Confluence of Pequonnock River main stem with the West Branch Pequonnock River (downstream of Maple Drive), Monroe), upstream to Long Pond Dam, Monroe	B/A
Pequonnock River (lower reach)	From inlet to Bunnells (Beardsley Park) Pond (eastern side of Route 8, exit 6 area), Bridgeport, upstream to confluence of Pequonnock River main stem with the West Branch Pequonnock River downstream of Maple Drive, Monroe	B/A
Pequonnock River (lower reach)	Outlet of conduit discharging to tidal segment of Pequonnock River (west of Williams Road and south of Route 1), Bridgeport, upstream inlet to Bunnells (Beardsley Park) Pond (eastern side of Route 8, exit 6 area), Bridgeport	B
Island Brook	Confluence with Pequonnock River/Bridgeport Harbor (northeast of River Road), Bridgeport, upstream to Route 8, Bridgeport	B
Pequonnock River/Bridgeport Harbor	Confluence with Bridgeport Harbor/Long Island Sound to Outlet of conduit discharging to tidal segment of Pequonnock River (west of Williams Road and south of Route 1), Bridgeport	SC/SB

Several reaches of the Pequonnock River and the tidal sections of the river at Bridgeport Harbor are also listed as impaired in accordance with Section 303(d) of the federal Clean Water Act. The identified impairments in the tidal portions of the river (i.e., inner Bridgeport Harbor) include commercial shellfish harvesting; recreational uses; and habitat for fish, other aquatic life, and wildlife (CTDEP, 2008). *Table 6-4* summarizes the impaired designated uses, causes, and potential sources of the impairments and *Figure 6-2* depicts the locations of the impaired river and harbor segments.

Table 6-4. Pequonnock River Watershed Listed Impaired Waters (CTDEP, 2008)

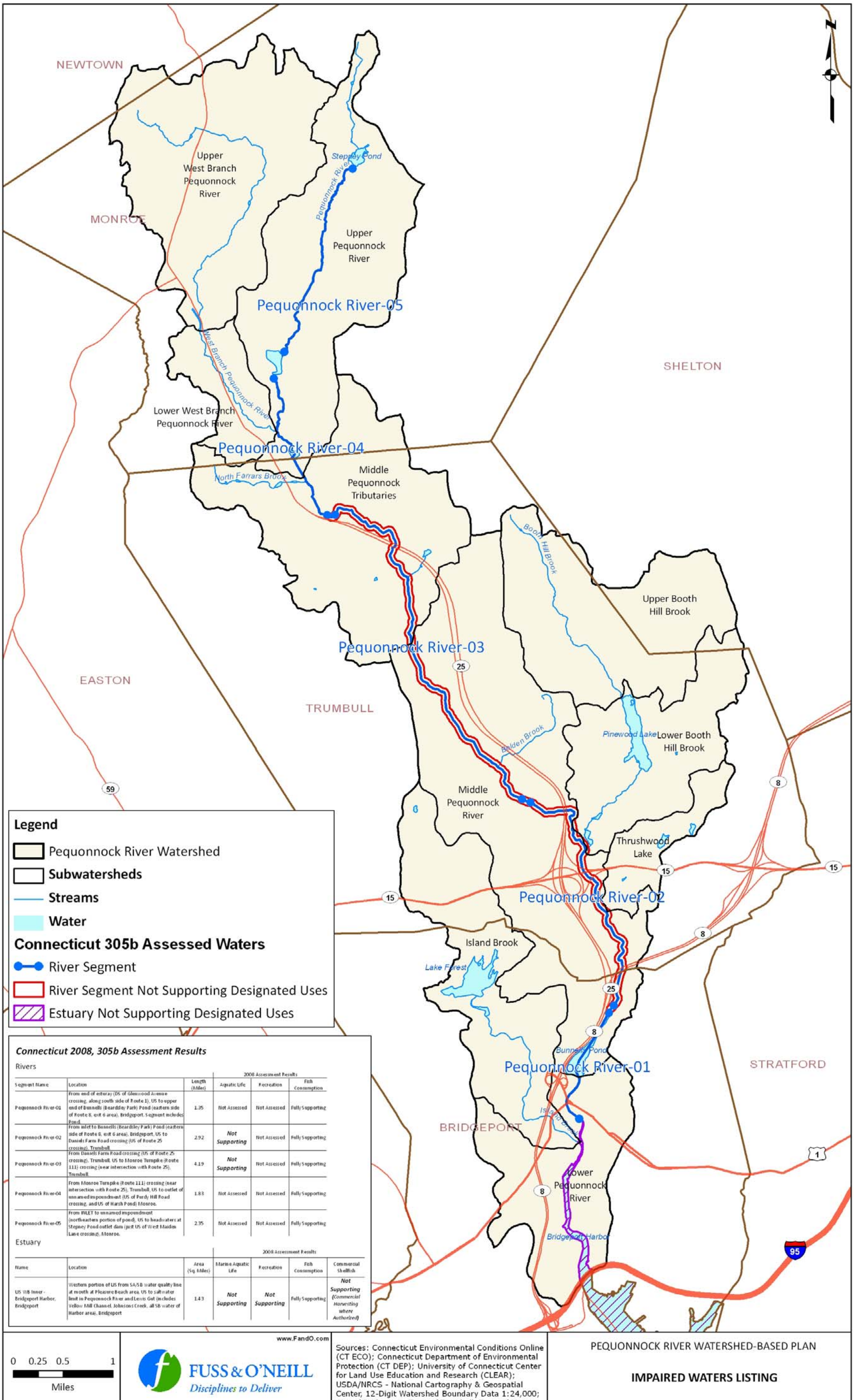
Waterbody Name/ Segment ID	Location Description	Waterbody Segment Length or Area	Impaired Designated Use	Cause	TMDL Priority[1]/ Category[2]	Potential Source
LIS WB Inner - Bridgeport Harbor, Bridgeport/ CT-W1_001-SB	Western portion of Long Island Sound from SA/SB water quality line at mouth at Pleasure Beach area, upstream to saltwater limit in Pequonnock River and Lewis Gut (includes Yellow Mill Channel, Johnsons Creek, all SB water of Harbor area), Bridgeport	1.43 mi^2	Commercial Shellfish Harvesting Where Authorized	Fecal Coliform	M/5	Unspecified Urban Stormwater, Marina/Boating Sanitary On-vessel Discharges, Combined Sewer Overflows, Waterfowl, Residential Districts, Non-Point Source
			Habitat for Marine Fish, Other Aquatic Life and Wildlife	Polychlorinated biphenyls	L/5	Contaminated Sediments
				Polycyclic Aromatic Hydrocarbons (PAHs) (Aquatic Ecosystems)	L/5	Contaminated Sediments
				Dissolved oxygen saturation	M/5	Atmospheric Depositon - Nitrogen, Residential Districts, Non-Point Source, Unspecified Urban Stormwater
				Nutrient/Eutrophication Biological Indicators	M/5	Unspecified Urban Stormwater, Atmospheric Depositon - Nitrogen, Non-Point Source, Residential Districts
				Oxygen, Dissolved	M/5	Residential Districts, Unspecified Urban Stormwater, Non-Point Source, Atmospheric Depositon - Nitrogen

Table 6-4. Pequonnock River Watershed Listed Impaired Waters (CTDEP, 2008)

Waterbody Name/ Segment ID	Location Description	Waterbody Segment Length or Area	Impaired Designated Use	Cause	TMDL Priority[1]/ Category[2]	Potential Source
			Recreation	Enterococcus	M/5	Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO), Combined Sewer Overflows
Pequonnock River (Main Stem)-02/ 7105-00_02	From inlet to Bunnells (Beardsley Park) Pond (eastern side of Route 8, exit 6 area), Bridgeport, upstream to Daniels Farm Road crossing (US of Route 25 crossing), Trumbull.	2.92 mi	Habitat for Fish, Other Aquatic Life and Wildlife	Unknown	L/5	Unknown
Pequonnock River (Main Stem)-03/ 7105-00_03	From Daniels Farm Road crossing (upstream of Route 25 crossing), Trumbull, upstream to Monroe Turnpike (Route 111) crossing (near intersection with Route 25), Trumbull	4.19 mi	Habitat for Fish, Other Aquatic Life and Wildlife	Unknown	L/5	Unknown

Source: CTDEP, 2008
[1] 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.
[2] 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.

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. The *2008 List of Connecticut Waterbodies Not Meeting Water Quality Standards* (CTDEP, 2008) includes a priority ranking system for development



			2008 Assessment Results		
Segment Name	Location	Length (Miles)	Aquatic Life	Recreation	Fish Consumption
Pequonnock River-01	From end of esturay (DS of Glenwood Avenue crossing, along south side of Route 1), US to upper end of Bunnells (Beardsley Park) Pond (eastern side of Route 8, exit 6 area), Bridgeport. Segment includes Pond.	1.35	Not Assessed	Not Assessed	Fully Supporting
Pequonnock River-02	From inlet to Bunnells (Beardsley Park) Pond (eastern side of Route 8, exit 6 area), Bridgeport, US to Daniels Farm Road crossing (US of Route 25 crossing), Trumbull.	2.92	***Not Supporting***	Not Assessed	Fully Supporting
Pequonnock River-03	From Daniels Farm Road crossing (US of Route 25 crossing), Trumbull, US to Monroe Turnpike (Route 111) crossing (near intersection with Route 25), Trumbull.	4.19	***Not Supporting***	Not Assessed	Fully Supporting
Pequonnock River-04	From Monroe Turnpike (Route 111) crossing (near intersection with Route 25), Trumbull, US to outlet of unnamed impoundment (US of Purdy Hill Road crossing, and US of Harsh Pond) Monroe.	1.83	Not Assessed	Not Assessed	Fully Supporting
Pequonnock River-05	From INLET to unnamed impoundment (northeastern portion of pond), US to headwaters at Stepney Pond outlet dam (just US of West Maiden Lane crossing), Monroe.	2.35	Not Assessed	Not Assessed	Fully Supporting

			2008 Assessment Results			
Name	Location	Area (Sq. Miles)	Marine Aquatic Life	Recreation	Fish Consumption	Commercial Shellfish
US WB Inner - Bridgeport Harbor, Bridgeport	Western portion of US from SA/SB water quality line at mouth at Pleasure Beach area, US to saltwater limit in Pequonnock River and Lewis Gut (includes Yellow Mill Channel, Johnsons Creek, all SB water of Harbor area), Bridgeport	1.43	***Not Supporting***	***Not Supporting***	Fully Supporting	***Not Supporting*** *(Commercial Harvesting where Authorized)*

Figure 6-2. Impaired Waters

of a TMDL specific to the contaminants in each impaired segment: high (H), medium (M), low (L), under study (T), or Not Applicable (N).

CTDEP has identified the need for a TMDL to address the impairment in the tidal portions of the Pequonnock River for fecal coliform, enterococcus, dissolved oxygen, and nutrients, eutrophication, and biological indicators. The priority status of TMDL development for this reach is medium. Other impaired uses (e.g. habitat for fish, other aquatic life and wildlife) have also been identified in the non-tidal lower reaches of the Pequonnock River, although these impaired waters have been assigned a low priority status. Unspecified urban stormwater, marina/boating sanitary discharges, combined sewer overflows, waterfowl, residential districts, contaminated sediments, and other nonpoint sources are suspected contributors to the impairments. It is important to note that not all segments of the Pequonnock River have been assessed for support of aquatic life or recreation due to limited data; segments of the river that have not been formally assessed by the CTDEP may also not meet Water Quality Standards, as discussed elsewhere in this section.

Currently, there is a statewide advisory that recommends limiting the consumption of freshwater fish due to elevated levels of mercury in some species. However, only those designated uses specifically identified in the Connecticut Water Quality Standards are assessed. In making water quality assessments, each designated use of a waterbody is assigned a level of support (e.g., full support, not supporting, or not assessed), which characterizes the degree to which the water is suitable for that use. The Pequonnock River is designated full support for fish consumption, although this designation is superseded by the statewide advisory.

6.2 CTDEP Ambient Water Quality Monitoring Program

Water quality monitoring within the Pequonnock River watershed is periodically conducted by the CTDEP. The water quality monitoring program is described in the following sections, followed by a discussion of the monitoring results.

6.2.1 Monitoring Program

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. 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 on five-year, two-year and annual basis.

Table 6-5 provides a summary of the CTDEP water quality monitoring programs within the Pequonnock River watershed. The monitoring locations are depicted in *Figure 6-3*. Monitoring for concentrations of fecal indicator bacteria, solids, metals and nutrients was conducted periodically over the period 1997-2007. Benthic macroinvertebrate monitoring was performed in 1997, 2000, and 2007; and fish surveys were conducted in 1990, 2000, and 2007.

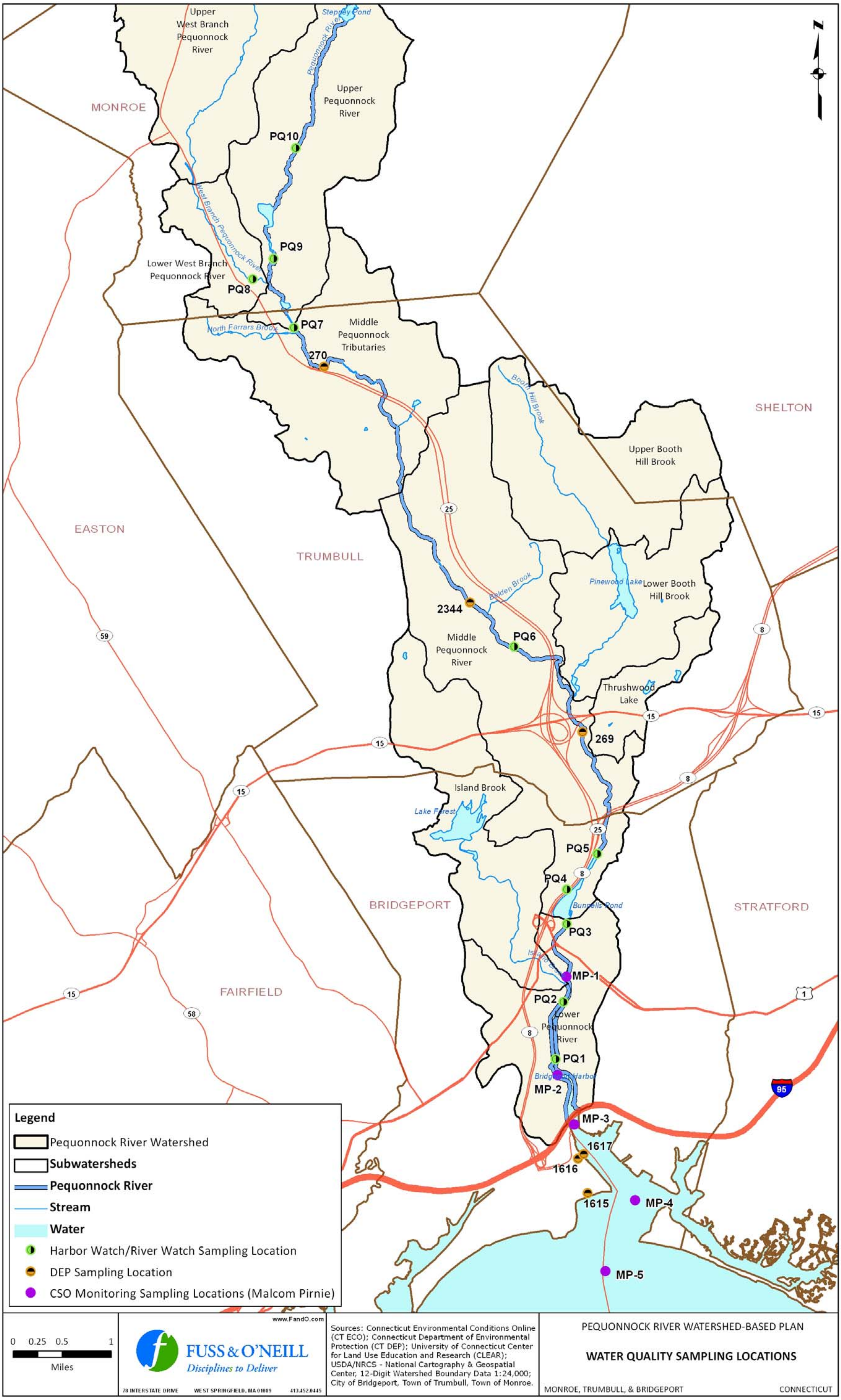


Figure 6-3. Water Quality Sampling Locations

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Table 6-5. Water Quality Monitoring in the Pequonnock River

Monitoring Location	Parameters	Dates of Monitoring
Station 270 (Rt. 111 Bridge)	Dissolved Metals, Nutrients, Alkalinity, Chloride, Hardness, pH, TSS, Total Solids, Turbidity, Fecal Coliform, Total Coliform, Fecal Streptococcus, Enterococci	11/13/1997
Station 2344 (Park Road)	Total Metals, Nutrients, pH, TSS, Turbidity, Total Solids, Alkalinity, Chloride, Harness	6/20/2007 10/2/2007
Station 269 (Unity Park)	Dissolved Metals, Nutrients, Alkalinity, Chloride, Hardness, pH, TSS, Total Solids, Turbidity, Fecal Coliform, Total Coliform, Fecal Streptococcus, Enterococci	11/6/1997
	Total and Dissolved Metals, Nutrients, Alkalinity, Chloride, Hardness, pH, TSS, Total Solids, Turbidity, Fecal Coliform, Enterococci, E.coli, 5-day BOD	7/23/1998 9/29/1998
	Total and Dissolved Metals, Nutrients, Alkalinity, Chloride, Hardness, TSS, Total Solids, Turbidity, Total Coliform, Enterococci, E.coli, 5-day BOD	10/10/2000
	Total Metals, Nutrients, Alkalinity, Chloride, Hardness, pH, TSS, Total Solids, Turbidity	6/20/2007 10/20/2007
Stations 1615, 1616, 1617 (Harbor Stations)	Total and Dissolved Metals, Nutrients, Alkalinity, Chloride, Hardness, pH, TSS, Detergent complex, Oil and Grease	5/24/2005

6.2.2 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. There is a lack of consistently collected metals data collected in the Pequonnock River, making it difficult to assess spatial or temporal trends in dissolved or total metals. For example, samples collected in the tidal portions of the river were analyzed at a higher method detection limit than samples collected upstream. In addition, Station 269 (Unity Park) is the only sampling location with multiple years of data, but the most recent sampling does not include dissolved metals concentrations and only included calcium and magnesium. Data on concentrations of copper, zinc, and lead, which are most often used as relevant indicators of impaired water quality conditions, were last collected in 2000. Consequently, it is infeasible to draw meaningful conclusions about the current relationship between metals concentrations and water quality in the Pequonnock River.

6.2.3 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 Pequonnock River discharges.

The nitrogen and phosphorus species monitored and the detection limits for those parameters varied over the period of record (1997-2007). The lack of a consistent sampling program over time makes it difficult to draw conclusions about temporal trends in nutrients in the river. Although samples were collected in the spring/summer and fall at Unity Park and Park Road stations, no seasonal influence could be determined due to the limited number of samples within each season. In the most recent sampling event in the tidal portions of the river, nitrogen levels were below detection limits. Total nitrogen levels measured in the most recent river sampling (2007) were at or above the EPA Reference Criterion for rivers in Ecoregion XIV (0.71 mg/L). This may reflect the contribution of nitrogen from sources in the watershed such as precipitation and atmospheric deposition, urban stormwater runoff, septic system effluent, and sewer overflows. Additional nutrient monitoring is proposed by EPA and Harbor Watch/River Watch, which should help to better define spatial and temporal trends in nutrient concentrations within the Pequonnock River.

6.2.4 Benthic Macroinvertebrates

Sampling of macroinvertebrates via kick net collection methods was performed by CTDEP in 1997, 2000 and 2007. Sample collection stations are shown in *Figure 6-4*. *Figure 6-5* shows the multi-metric index (MMI) score calculated for the sampling events at Station 270 (Unity Park) and Station 269 (Route 111 Bridge). The MMI is an index that combines indicators, or metrics, into a single index 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 and diagnosing ecological condition. The multi-year sampling at Station 269 indicates little change in terms of the MMI over a decade. *Figure 6-5* shows that for all sampling events at both stations, the calculated MMI falls below the target value of 50, indicating the basis of the aquatic life impairment designation.

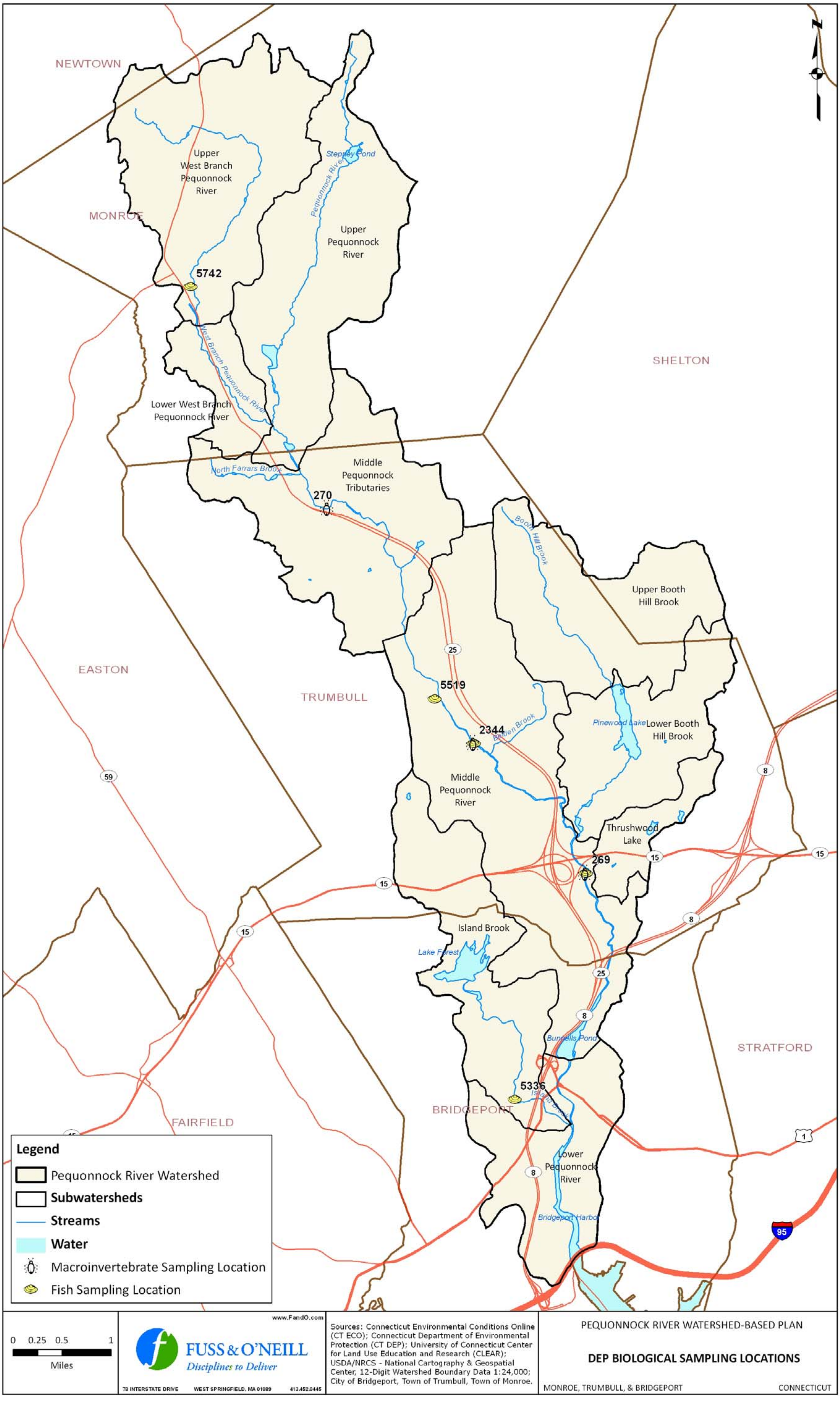

Figure 6-4. Biological Sampling Locations

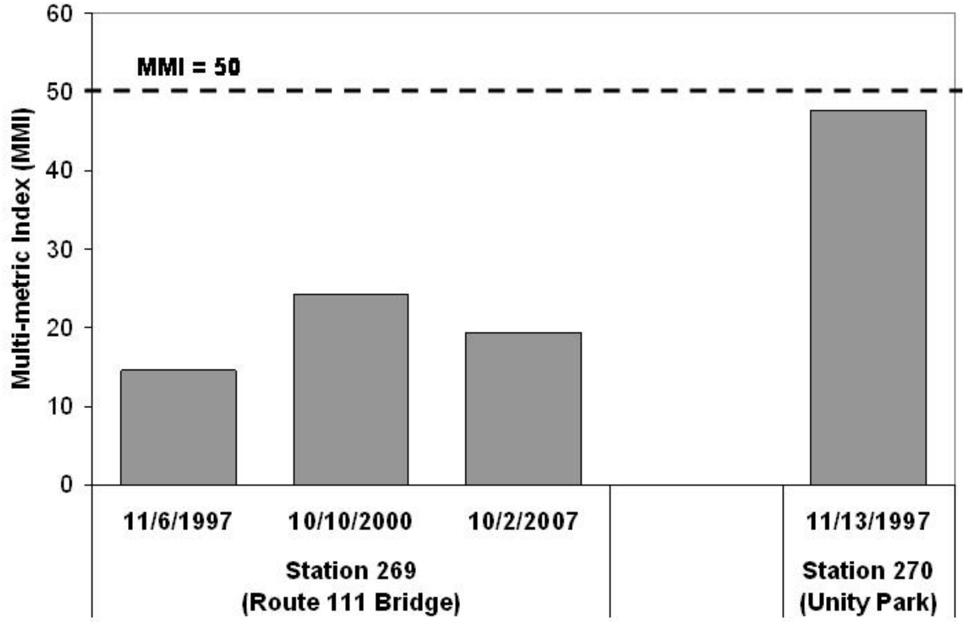

Figure 6-5. Mutli-Metric Index (MMI) Score for Benthic Macroinvertebrate Monitoring

6.3 Harbor Watch / River Watch Water Quality Monitoring Program

Harbor Watch/River Watch (HW/RW), a program of Earthplace, The Nature Discovery Center at Westport, conducted water quality monitoring of the Pequonnock River under a two-year contract with the CTDEP Water Management Bureau. Monitoring locations were located from the headwaters in the town of Monroe downstream through the Town of Trumbull to the toe of the river's estuary in the City of Bridgeport (*Figure 6-3*). All work by HW/RW was covered under an approved EPA Quality Assurance Project Plan (QAPP).

For the periods May 1st through September 30th in 2009 and again in 2010, HW/RW monitored the 10 sites two times per month. Field sampling consisted of in-situ analysis for temperature, conductivity, and dissolved oxygen (DO). In addition, HW/RW collected water samples for laboratory analysis of fecal coliform and *Escherichia coli* (*E. coli*).

Dissolved oxygen is an important indicator of habitat quality and ecosystem condition. Dissolved oxygen is necessary in aquatic systems for the survival and growth of aquatic organisms. The Connecticut Water Quality Standards establish a criterion for dissolved oxygen of 5 mg/L. Prolonged exposure to dissolved oxygen below this level may increase organisms' susceptibility to environmental stresses. Results of the 2009 monitoring for DO showed that all observed DO mean values meet the criterion of 5 mg/L or greater at all sites (*Figure 6-6*). All individual DO readings in 2009 also met the CTDEP DO criterion, with a single exception of 4.9 mg/L observed at Site PQ10 on August 26, 2009. The boxplots in *Figure 6-7* show that DO values were generally higher and less variable (i.e., shorter boxplot) downstream of Site PQ6. The location of increased DO values coincides with a change in the river morphology that leads to more turbulent flow, resulting in higher DO concentrations.

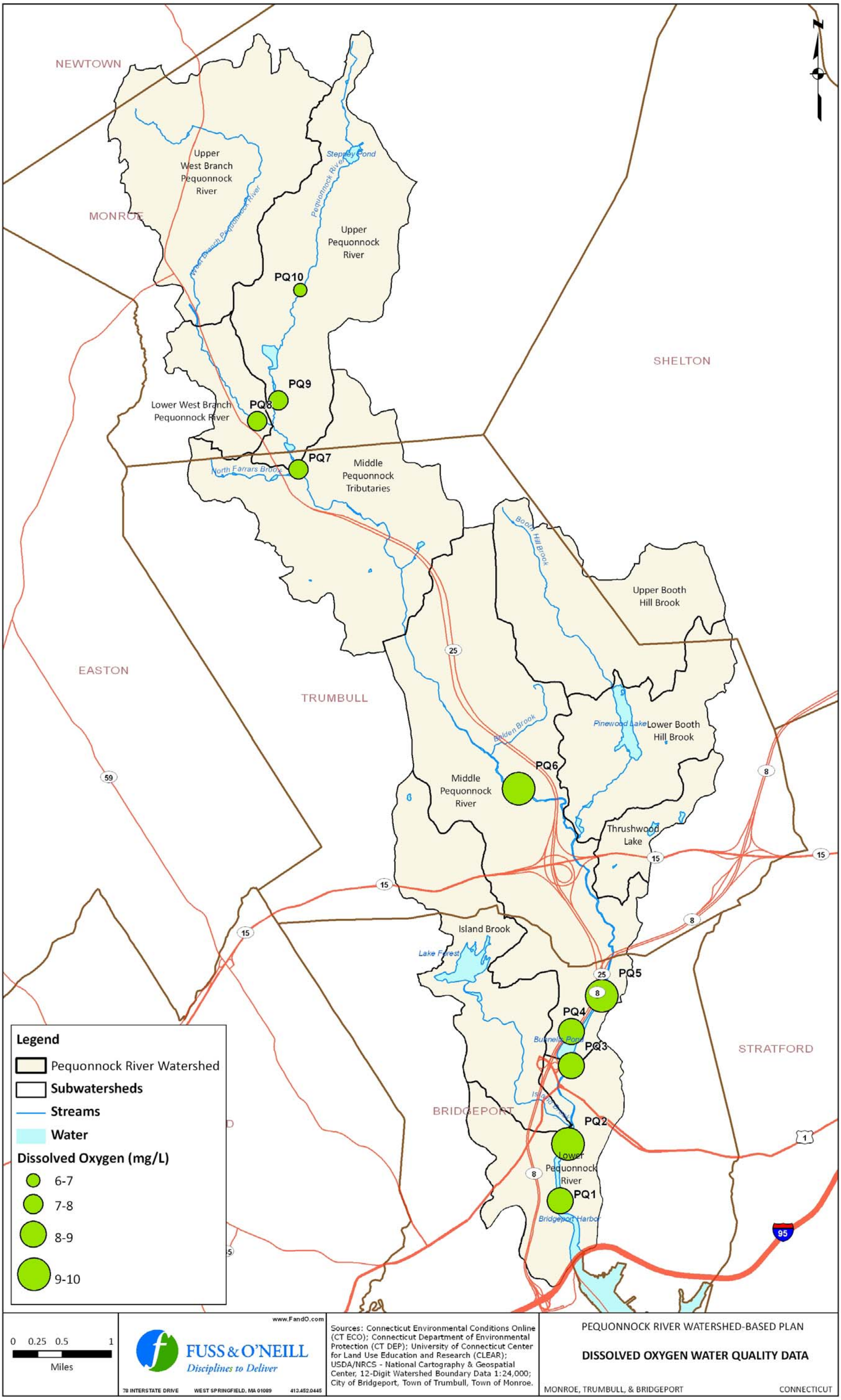

Figure 6-6. 2009 Dissolved Oxygen Monitoring Results

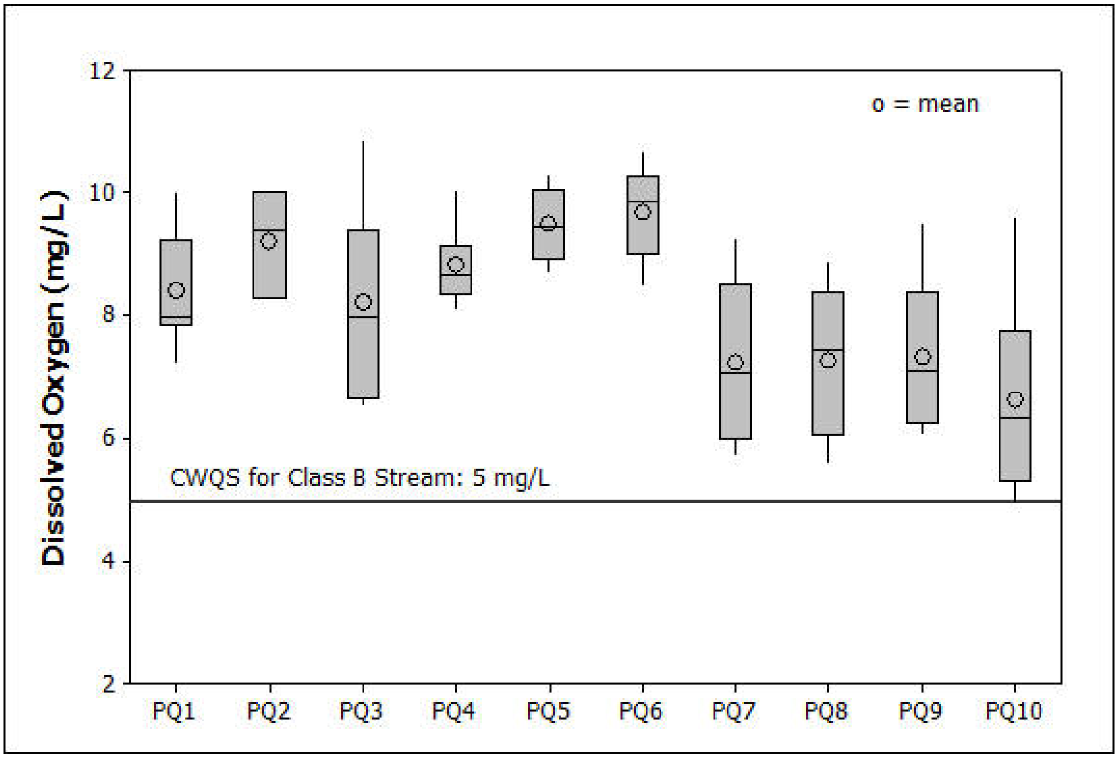

Figure 6-7. 2009 Dissolved Oxygen Boxplots

Measurement of fecal indicator bacteria, including *E.coli* and fecal coliform, is used as an indicator of potential fecal pollution and the presence of pathogenic organisms that present a risk to human health. *E.coli* are used to assess fecal pollution in fresh water and the Connecticut Water Quality Standards for other recreational uses suitable for a Class B river are geometric mean of <126 CFU/100mL and the single sample maximum (SSM) of 576 CFU/100mL at <10% of all tests.

In 2009, the results of the HW/RW monitoring (*Figure 6-8*) show that the river sites PQ9, PQ8, PQ7, PQ6 and PQ3 all meet the E. coli bacteria geometric mean of <126 CFU/100mL and the single sample maximum (SSM) of 576 CFU/100mL at <10% of all samples. Sites PQ10, PQ5, and PQ4 all exceed the CT DEP E coli criteria. Two of these sites, PQ5 and PQ4 also exceed the SSM with <10% or more of the samples exceeding 576 CFU/100mL. A maximum geometric mean of 213 CFU/mL was observed at PQ4. A minimum geometric mean of 24 CFU/100 mL was observed at Site PQ9.

Result of *E.coli* sampling from 2010 show an overall increase in concentrations (*Figure 6-9*) with the geometric mean of <126 CFU/100 mL in the Connecticut Water Quality Standards for other recreational uses suitable for a Class B river exceeded at PQ4, PQ5, PQ6, PQ7, PQ8, and PQ10. As in 2009, Site PQ4 has the the maximum geometric mean value for the freshwater monitoring sites, with a value of 534 CFU/100 mL. The minimum geometric mean (97 CFU/100 mL) was observed at Site PQ3. Sites PQ4, PQ5, PQ6, PQ8, PQ9, and PQ10 PQ4 also exceed the SSM with <10% or more of the samples exceeding 576 CFU/100mL, with the highest single sample value of 3660 CFU/100 mL measured at PQ4.

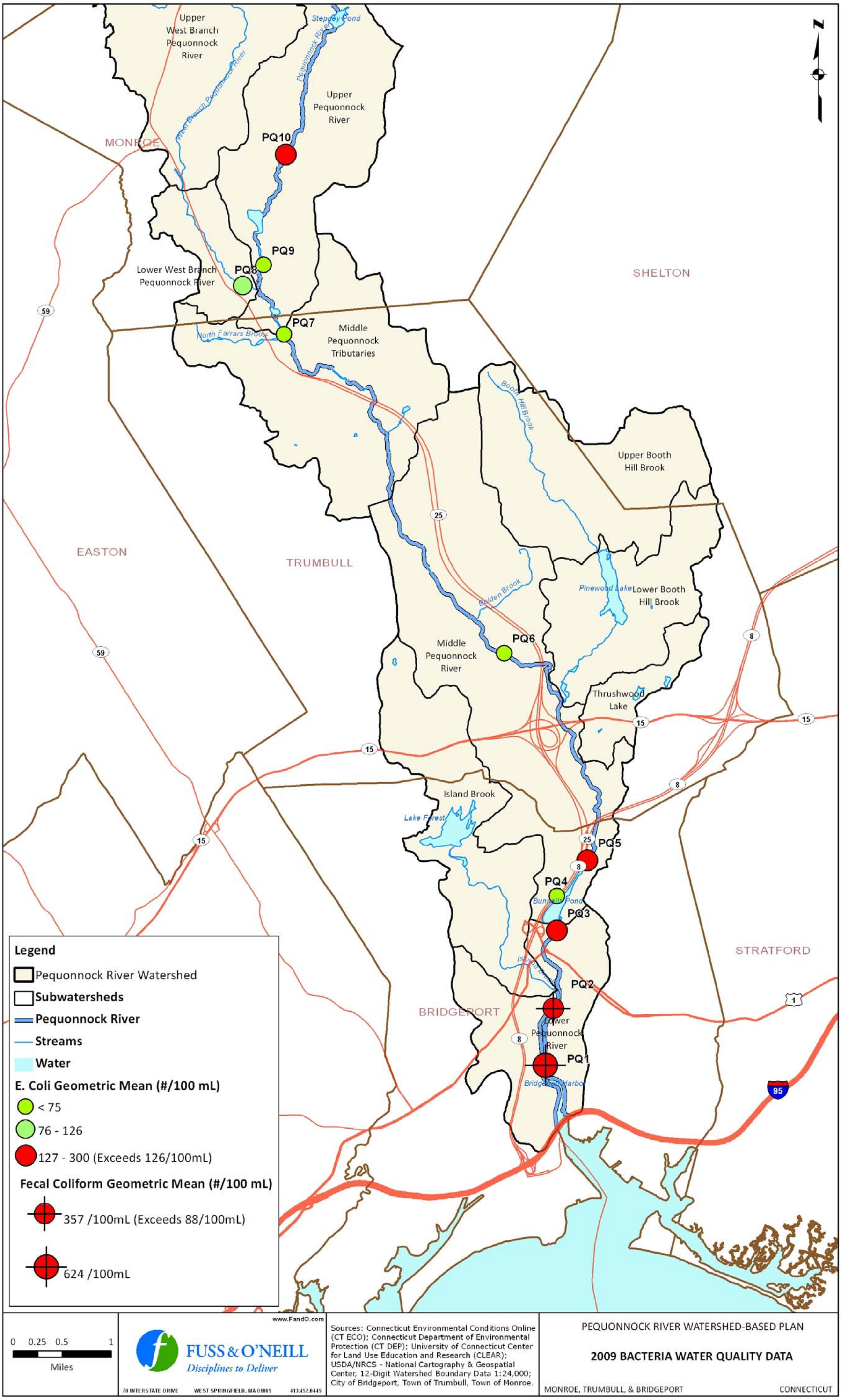

Figure 6-8. 2009 Bacteria Monitoring Results

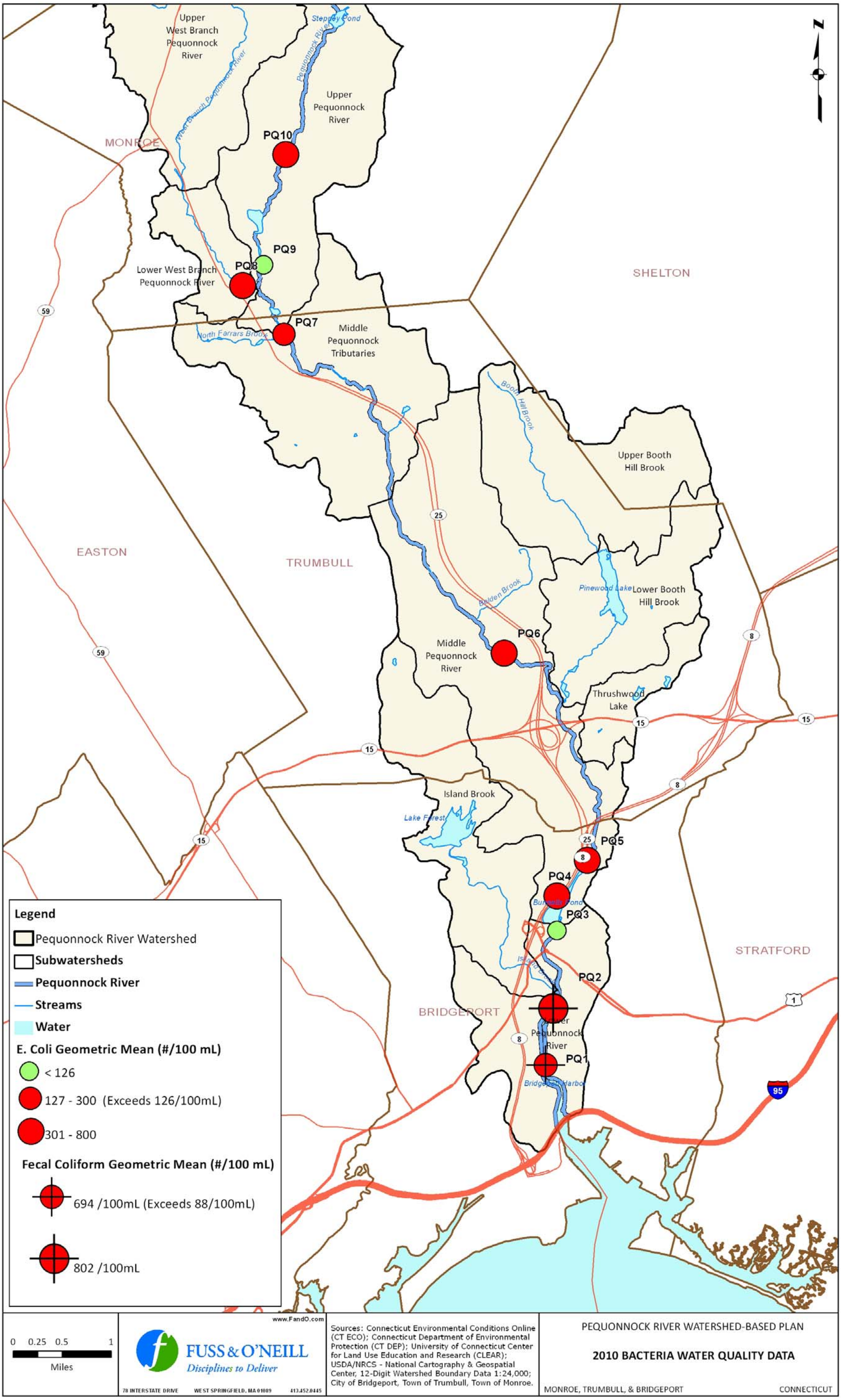

Figure 6-9. 2010 Bacteria Monitoring Results

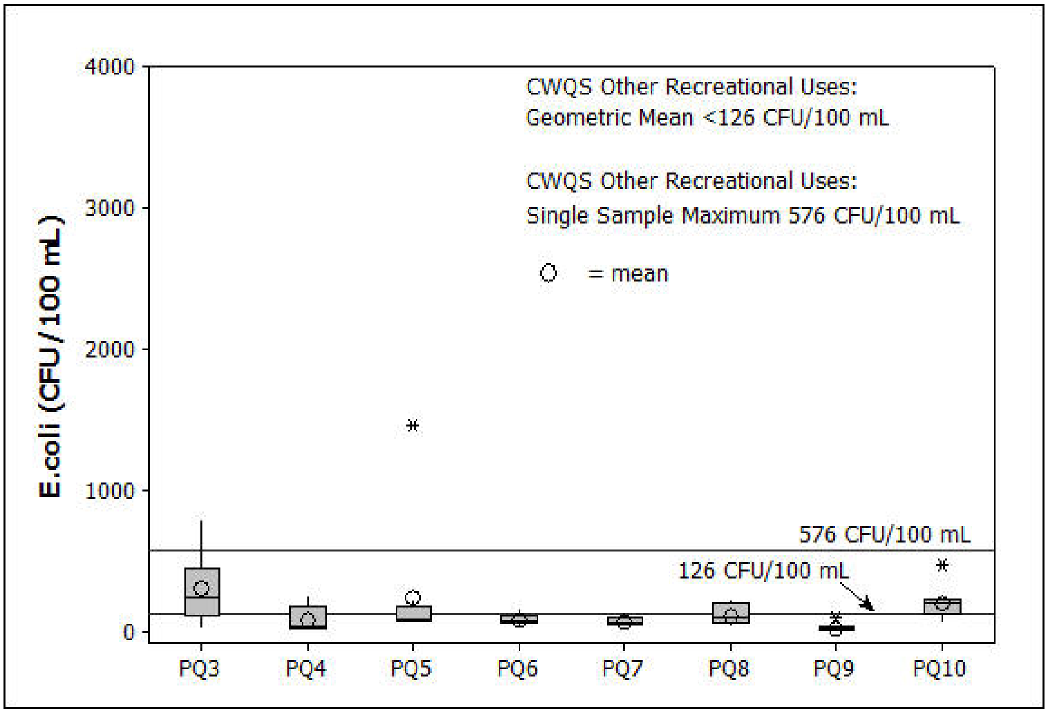

Figure 6-10. 2009 E. coli Boxplots

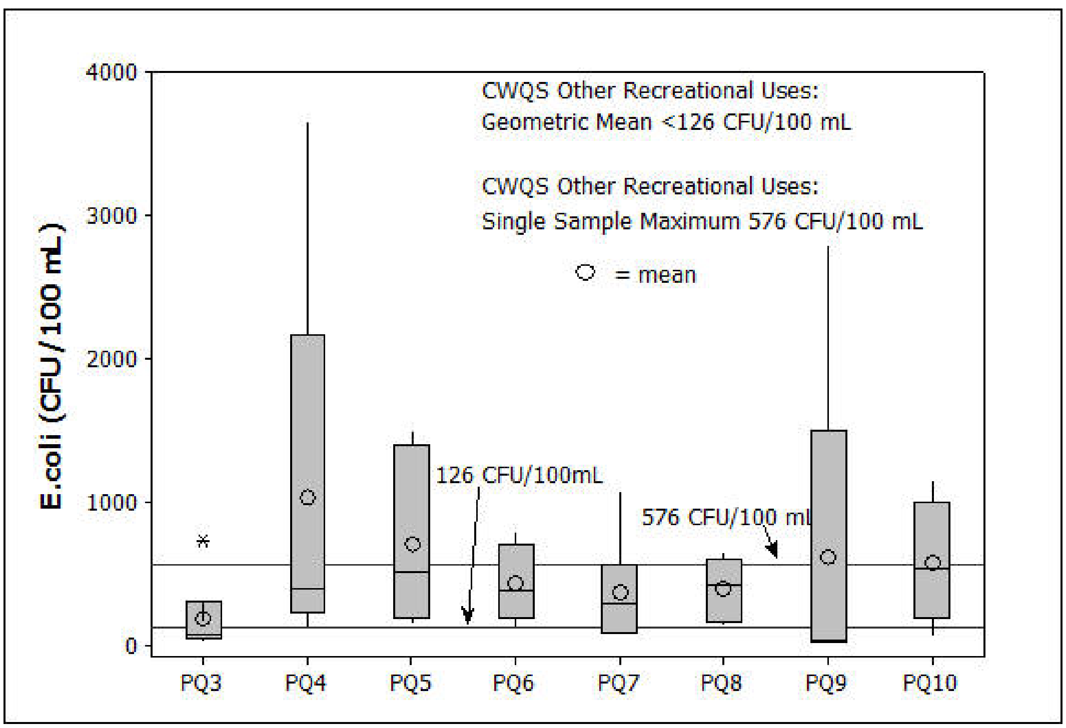

Figure 6-11. 2010 E. coli Boxplots

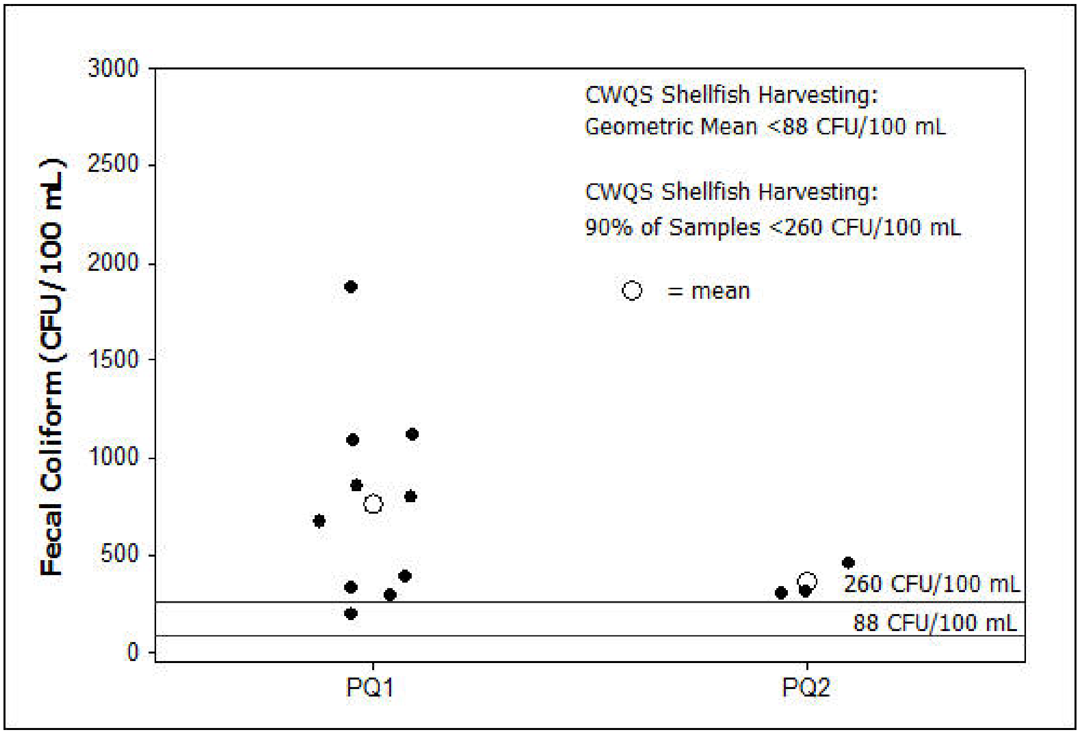

Figure 6-12. 2009 Fecal Coliform Plots

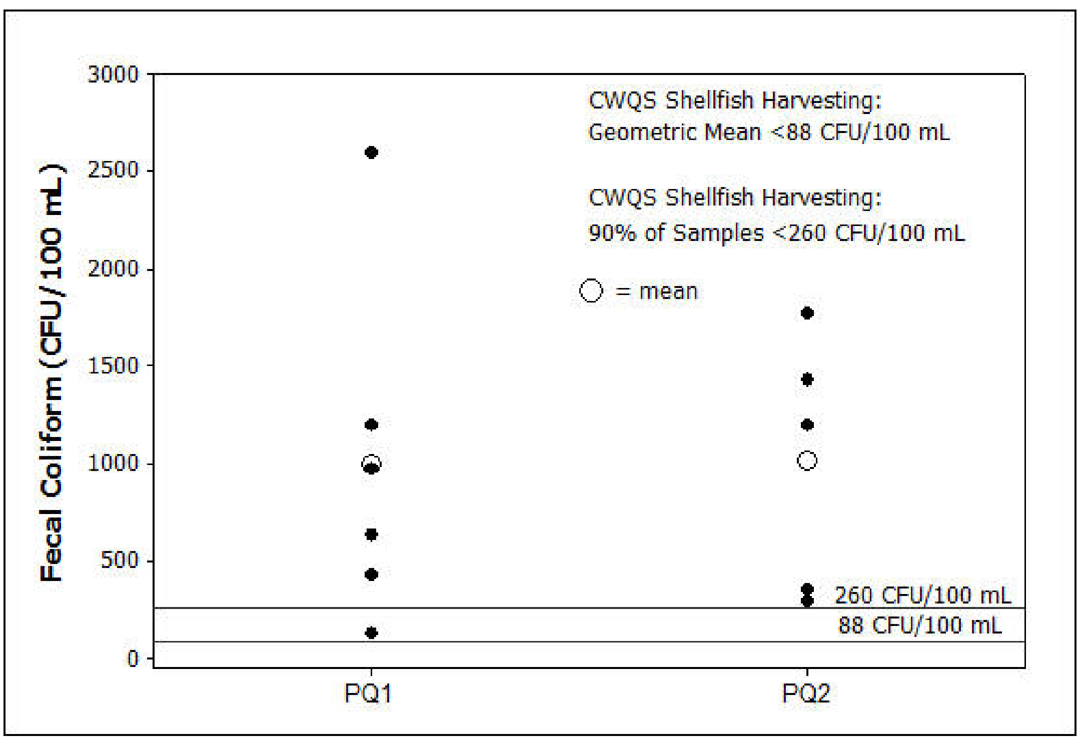

Figure 6-13. 2010 Fecal Coliform Plot

Figures 6-10 and 6-11 show that there are also shifts in the spatial characteristics of fecal indicator organisms in the river. Sites PQ6 and PQ7 are sill low compared to other stations, but PQ4 and PQ9 are noticeably higher in terms of both the median and range of values observed in 2010 compared to 2009. In contrast, a lower mean concentration and less variability was observed at PQ3 in 2010 compared to 2009. Additional years of sampling would be necessary to determine if these observations represent true temporal shifts or are just part of the variability present at those sites.

For Sites PQ1 and PQ2, the fecal coliform standard is the relevant measure of water quality given there location in brackish water sites. As shown in *Figures 6-12 and 6-13*, results at both PQ1 and PQ2 exceed the applicable Connecticut Water Quality Standards for shellfish harvesting: a geometric mean of <88 CFU/100 mL and 90% of the samples with a SSM of <260 CFU/100 mL. Geometric mean values in 2009 were 624 CFU/100 mL at PQ1 and 357 CFU/100 mL at PQ2[2]. Those standards were exceeded in 2010, with geometric mean values of 694 and 802 CFU/100 mL and PQ1 and PQ2, respectively.

At these monitoring locations, the differences between 2009 and 2010 are not adjusted for streamflow or rainfall and are not sampled under specific meteorological conditions (i.e., all dry weather, all wet weather etc). Therefore, it is difficult to determine if the increase in *E.coli* concentrations observed in 2010 is reflective of changes in source loading, the result of hydrologic conditions at the time of sampling (i.e., high versus low streamflow) and/or recent rainfall. Interestingly, there appears to be little change at PQ1, the furthest downstream station, which may suggest that overall loading from the watershed is similar in both years and the fluctuation observed at upstream stations is the result of streamflow, a factor which is not as important in the tidally-influenced area south of Interstate 95.

6.4 City of Bridgeport CSO Receiving Water Monitoring Program

In the summer and early fall of 2009, the City of Bridgeport WPCA conducted receiving water quality monitoring of portions of the Lower Pequonnock River and Bridgeport Harbor that are potentially affected by CSO discharges (Malcolm Pirnie, undated). The monitoring program was conducted in support of the WPCA's Long Term Control Plan (LTCP) to address CSO discharges, as required by a CTDEP Consent Order. Receiving water quality samples were collected during 5 dry weather events and during and after 4 storm events for analysis of indicator bacteria and field chemistry (dissolved oxygen, pH, temperature, and conductivity). Discrete samples were collected at the water surface at 15 locations, including 3 locations along the tidal portion of the lower Pequonnock River, the active flow stream of 1 CSO discharge location along the Pequonnock River, and 2 locations in Bridgeport Harbor. *Figure 6-3* depicts the Pequonnock River and Bridgeport Harbor monitoring locations (labeled as MP-1 through MP-5).

[2] Only 3 samples were collected at PQ2 in 2009 as a result of lack of access due to construction.

During dry weather events, the sampling results indicated little or no long-term residual influence of CSO discharges. The monitoring identified some potential sources of dry weather bacterial contamination in upstream reaches from sources other than CSOs. In contrast, during wet weather monitoring, the Pequonnock River sites showed elevated bacteria concentrations that indicate a more typical receiving water response to CSO discharges. The middle reaches of the Pequonnock River showed elevated bacteria concentrations that persisted for 1 to 3 days depending on the magnitude of the storm. Conversely, the Bridgeport Harbor sites did not show a clear wet weather response during the events sampled. Dilution and tidal flushing are suspected to limit the influence of CSO discharges on bacteria concentrations in the harbor during storm events (Malcolm Pirnie, undated).

7 Land Use and Land Cover

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 and potential future land use and land cover patterns in the watershed, and the implications for water quality and stream health.

7.1 Current Conditions

7.1.1 Land Use

Figure 7-1 depicts generalized land use in the Pequonnock River watershed. The data in *Figure 7-1* reflect land use categories for the watershed communities, provided by the Greater Bridgeport Regional Planning Agency (GBRPA) and the City of Bridgeport. The GBPRA data are based on conditions in 2000, while the Bridgeport data reflect 2008 conditions. The land use data were compared to 2008 aerial photography, and several updates to the data set were made to reflect land use changes since the source data were originally compiled. The land use categories in the GBPRA and City of Bridgeport data were consolidated into 11 generalized land use categories (*Table 7-1*).

Approximately 75% of the watershed consists of developed land uses, with residential uses comprising the largest percentage. Single family residential accounts for approximately 47.0% and multi-family residential for 5.5%. Highways and roads comprise approximately 11.4% of the watershed area. Industrial land use accounts for approximately 4.2% of the watershed area, with areas concentrated in downtown Bridgeport, south of Route 15 in Trumbull, and areas in northern Trumbull and northern Monroe. Approximately 18% of the watershed is classified as undeveloped (water, vacant, or forest), while the remaining 7.0% is classified as open space land use, including parkland, conservation land, and other protected and unprotected open space.

The intensity of development generally increases from the northern portions of the watershed in Monroe (approximately 67% developed land uses) and Trumbull (approximately 77% developed land uses) to the southern portion of the watershed in the urban center of Bridgeport (83% developed uses). Additionally, the development in Bridgeport tends to be higher density, with a greater percentage of multi-family housing (14%) and roadway uses (23%) as compared to the northern portions of the watershed, which primarily consist of single family residential and some industrial and commercial uses.

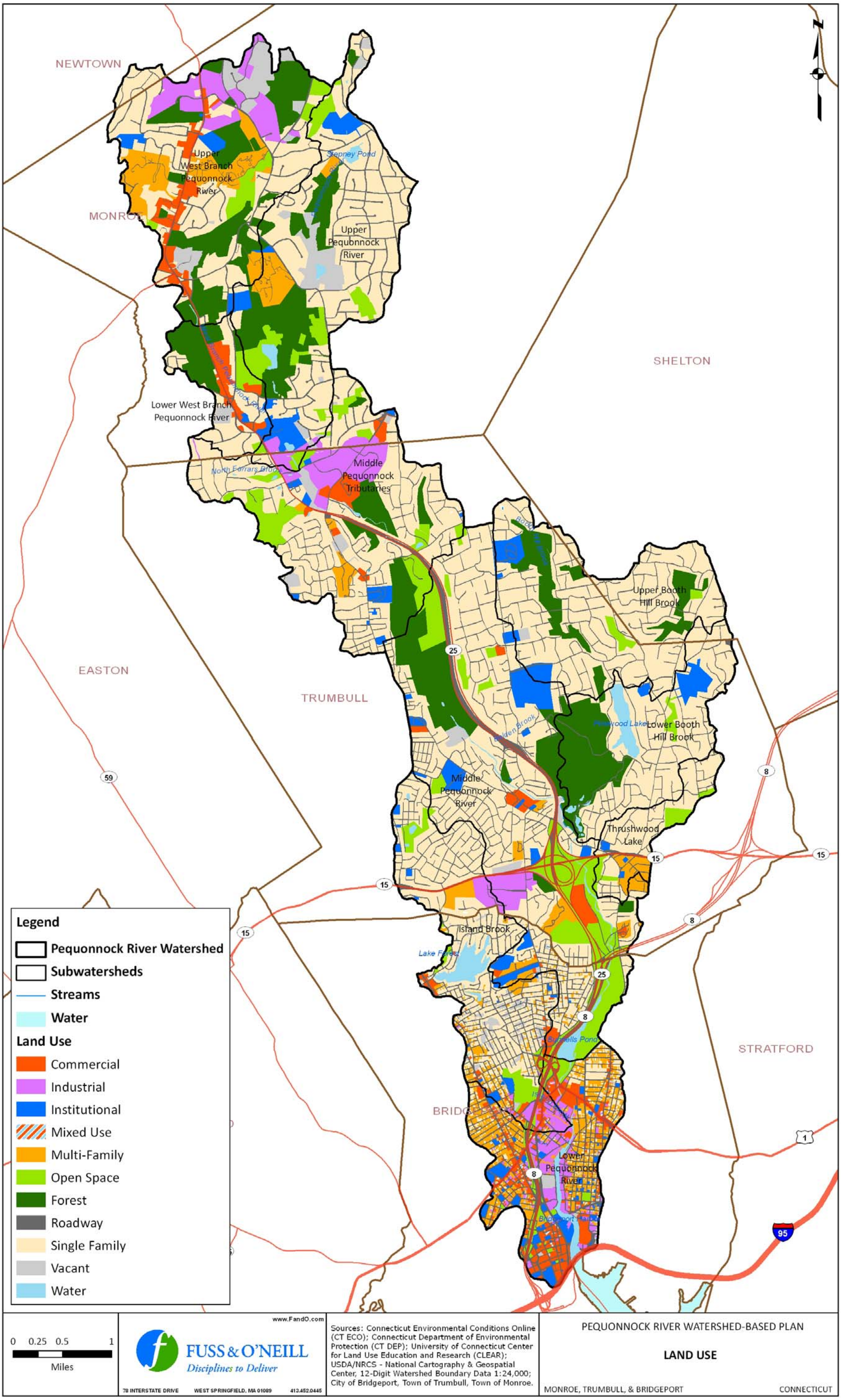

Figure 7-1. Land Use

Table 7-1. Watershed Land Use

Land Use Category	Percent of Bridgeport	Percent of Trumbull	Percent of Monroe	Watershed Total (Acres)	Percent of Watershed
Commercial	9%	2%	4%	631	3.4%
Industrial	5%	3%	5%	788	4.2%
Institutional	6%	4%	3%	671	3.6%
Mixed Use	1%	0%	0%	28	0.15%
Multi-Family	14%	2%	7%	1,023	5.5%
Open Space	8%	8%	6%	1,305	7.0%
Forest	0%	13%	20%	2,408	12.9%
Roadway	23%	10%	7%	2,116	11.4%
Single Family	25%	56%	41%	8,774	47.1%
Vacant	4%	1%	6%	578	3.1%
Water	5%	1%	1%	316	1.7%

* Percentages are based on the Town area within the watershed.
Source: Greater Bridgeport Regional Planning Agency (GBRPA), 2000; City of Bridgeport, 2008.

7.1.2 Zoning

Figure 7-2 depicts the existing zoning in the Pequonnock River watershed, which is based on a generalized compilation of the zoning designations established by the individual watershed municipalities. The specific zoning districts across the watershed are highly variable because they are defined at the city or town level. The pattern of existing zoning largely reflects the existing pattern of residential, commercial, office, and industrial uses in the watershed. The majority of the watershed (86%) is zoned as Single Family, Multi-Family, or Two-Three Family residential. Nearly 8% of the watershed is zoned industrial (*Table 7-2).*

Table 7-2. Generalized Watershed Zoning

Zoning Category	Acres	Percent of Watershed
Industrial	1,478	7.9%
Mixed Use	204	1.1%
Multi-Family	946	5.1%
Office/Retail	756	4.1%
Planned Development	186	1.0%
Single Family	14,736	79.1%
Two-Three Family	333	1.8%

Source: City of Bridgeport, 2010; Town of Trumbull, 2006; Town of Monroe, 2010.

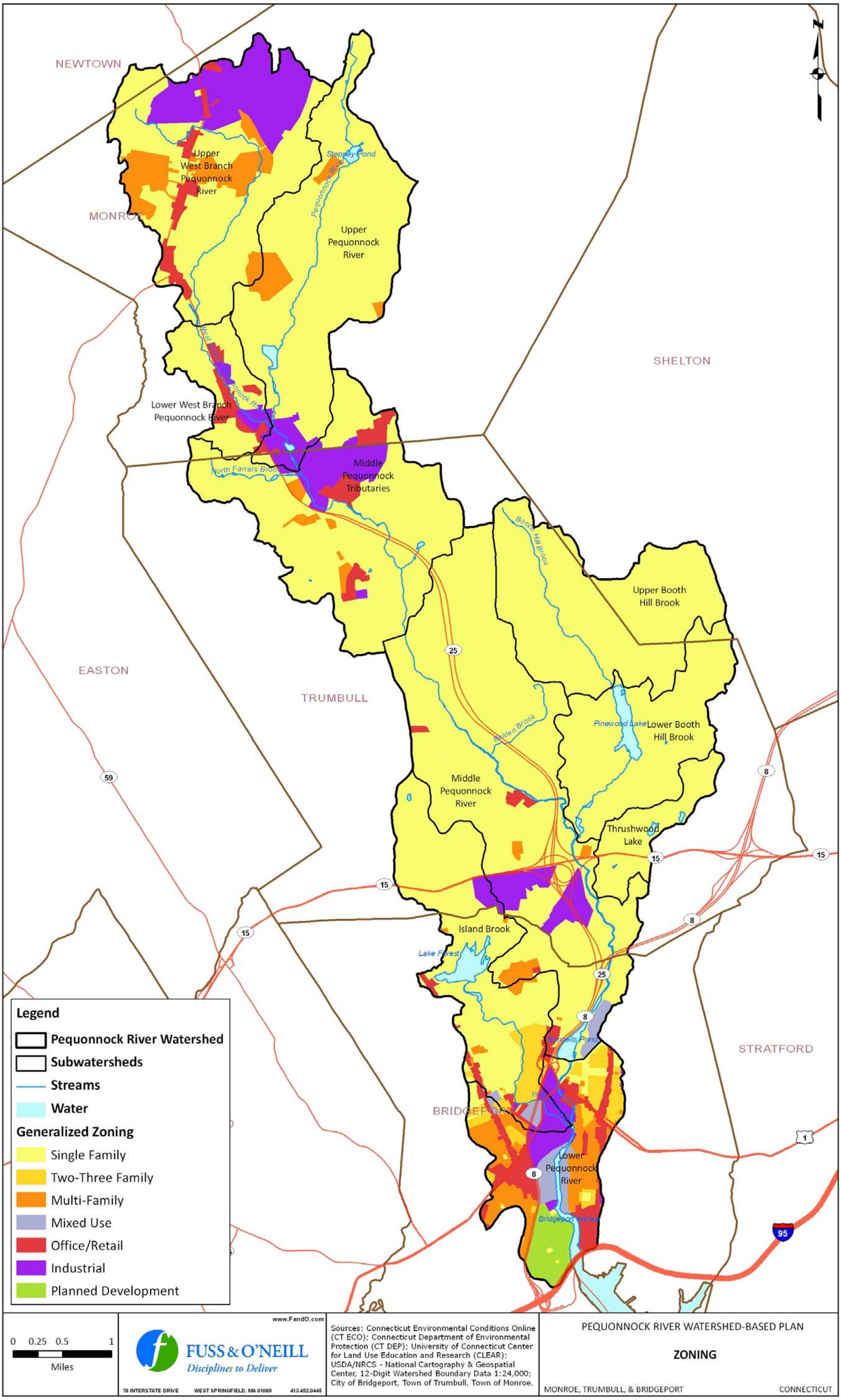

Figure 7-2. Generalized Zoning

7.1.3 Land Cover

Figure 7-3 depicts the generalized land cover in the watershed. The data shown in *Figure 7-3* are land cover types derived from 2006 Landsat satellite imagery with a ground resolution of 30 meters. The land cover data in the watershed are classified into eleven categories (*Table 7-3*), 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).

Table 7-3. Watershed Land Cover

Land Cover Type	1985		2006		Relative Change in Percent of Watershed (%)[1]	Relative Change in Acreage (%)[2]
	Acres	Percent of Watershed	Acres	Percent of Watershed		
Developed	7,062	37.9%	8,100	43.5%	5.6%	15%
Turf & Grass	2,215	11.9%	2,473	13.3%	1.4%	12%
Other Grasses	172	0.9%	171	0.9%	0.0%	0%
Agriculture	223	1.2%	157	0.8%	-0.4%	-29%
Deciduous Forest	7,756	41.6%	6,512	34.9%	-6.7%	-16%
Coniferous Forest	220	1.2%	211	1.1%	0.0%	-4%
Water	332	1.8%	316	1.7%	-0.1%	-5%
Non-forested Wetland	6	0.0%	7	0.0%	0.0%	11%
Forested Wetland	420	2.3%	370	2.0%	-0.3%	-12%
Tidal Wetland	0	0.0%	0	0.0%	0.0%	0%
Barren Land	226	1.2%	315	1.7%	0.5%	39%
Utility ROWs	6	0.0%	5	0.0%	0.0%	-12%

[1]Calculation = % land cover 2006 - % land cover 1985
[2]Calculation = (acres land cover 2006 - acres land cover 1985) / acres land cover 1985
Source: University of Connecticut Center for Land Use Education and Research (CLEAR)

The characteristics of each of these land cover types include the following:

- 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.

- Coniferous Forest – Includes Southern New England mixed softwood forests. May include isolated low density residential areas.

- 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.

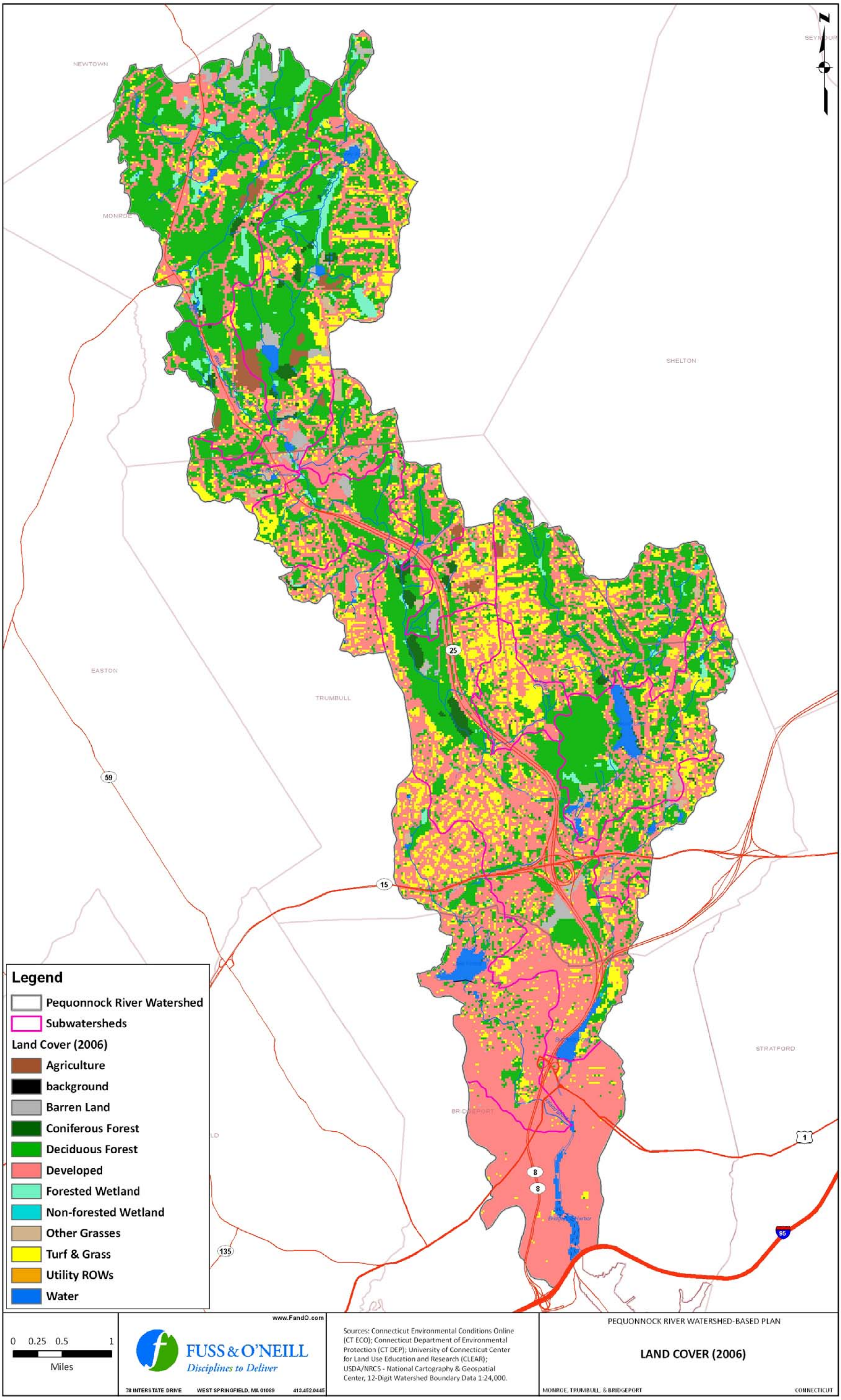

Figure 7-3. Land Cover

- 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.
- 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.
- 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.
- Other Grasses – Includes non-maintained grassy areas commonly found along transportation routes and other developed areas and also agricultural fields used for both crop production and pasture.
- 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.
- 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.
- Water – Open water bodies and watercourses with relatively deep water.

A comparison of watershed land cover between 1985 and 2006 (*Table 7-2*) shows a moderate increase in watershed development during this period (5.6% increase in developed and 1.4% increase in turf/grass cover types) and a corresponding loss of forest (6.7% decrease), agriculture (0.4% decrease) and forested wetland (0.3% decrease). There was a significant relative percentage loss of agricultural lands and a significant increase in barren lands; however these land cover categories comprise a very small percentage of the watershed area. The increase of barren lands could reflect construction activity at the time the satellite data was obtained.

The Pequonnock River watershed is characterized by roughly equal amounts of forested and developed land cover. These land cover types are described in the following sections.

7.1.4 Forest Cover

Approximately 36% of the watershed consists of deciduous and coniferous forest cover, which is associated with open space, wooded portions of low-density residential properties, and forested wetlands. *Table 7-4* compares the total acreage and percentage of forest cover by subwatershed. The percent forest cover in each subwatershed ranges from a low of approximately 1% in the Lower Pequonnock River subwatershed to a high of approximately 58% in the Upper West Branch Pequonnock River subwatershed.

Table 7-4. Forest Cover - Pequonnock Watershed

Subwatershed Name	Forest Cover in Subwatershed (acres)	Percent Forest Cover in Subwatershed	Developable Forest Cover in Subwatershed (acres)	Percent of Forest Cover that is Developable
Upper Pequonnock River	1187	48%	9.2	1%
Upper West Branch Pequonnock River	1462	58%	233.4	16%
Lower West Branch Pequonnock River	298	54%	26.3	9%
Middle Pequonnock Tributaries	996	41%	45.2	5%
Middle Pequonnock River	1061	28%	34.3	3%
Upper Booth Hill Brook	786	41%	98.2	12%
Lower Booth Hill Brook	596	44%	3.3	1%
Thrushwood Lake	116	26%	0.7	1%
Island Brook	214	12%	0	0%
Lower Pequonnock River	8	1%	0	0%
Watershed (total)	**6,724**	**36%**	**450**	**7%**

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

Based on literature threshold values documented in several studies (CLEAR, 2007), watershed forest cover of 65% or greater is typically associated with a healthy aquatic invertebrate community. None of the ten subwatersheds meets this threshold value of 65%; however the Upper West Branch Pequonnock River and Lower West Branch Pequonnock River are close with 58% and 54% forest cover, respectively. Based on a recommendation of American Forests, 40% forest cover is a reasonable overall threshold goal for urban areas. The recommended tree canopy goal in suburban residential zones is 50%; the recommended goal for urban residential zones is 25%; and the recommended goal for central business districts is 15% due to constraints on open space typical of the urban environment (American Forests, 2009).

Table 7-5 compares the existing forest cover in each subwatershed with the tree canopy goals recommended by American Forests for urban land use. The green shaded cells indicate subwatersheds that are currently at or above the 40% general tree canopy goal for urban areas and at or above their respective goal for specific urban land uses (i.e., suburban residential, urban residential, central business district). The gray shaded cells indicate subwatersheds that are currently below the 40% general tree canopy goal and below their respective goal for specific urban land uses. The watershed as a whole (36%) is slightly below the 40% tree canopy goal for urban areas. Note that while this analysis provides preliminary insight into the existing forest cover in the watershed and potential priorities for establishing urban tree canopy goals for the watershed, the results should be refined using more detailed tree canopy information gathered from field inventories or higher-resolution satellite imagery due to the relatively coarse resolution of the CLEAR land cover data.

Table 7-5. Comparison of Forest Cover and Tree Canopy Goals

Subwatershed Name	Percent Forest Cover in Subwatershed	American Forests Tree Canopy Goal
Upper Pequonnock River	48%	50%
Upper West Branch Pequonnock River	58%	50%
Lower West Branch Pequonnock River	54%	50%
Middle Pequonnock Tributaries	41%	50%
Middle Pequonnock River	28%	50%
Upper Booth Hill Brook	41%	50%
Lower Booth Hill Brook	44%	50%
Thrushwood Lake	26%	50%
Island Brook	12%	25%
Lower Pequonnock River	1%	15%
Watershed (total)	**36%**	**40%**

Source: Forest cover estimated from data provided by University of Connecticut's Center for Land Use Education and Research (CLEAR). Tree canopy goals recommended by American Forests, 2009.

7.1.4.1 Forest Fragmentation

Forest cover alone is not a complete indicator of the functional health of forested ecosystems, which can be impacted by proximity to non-forested areas. The ability of forests to provide wildlife habitat, clean water, and economically viable forest products is at least partially dependent on the ability to maintain sizeable tracts of unfragmented forest (Wilson, 2009). Larger patches of forest tend to have a greater diversity of habitat niches and therefore are more likely to support a greater richness and/or diversity of wildlife species. Very large patch sizes are also associated with total forest cover as these phenomena tend to occur simultaneously in real-world landscapes (Villard et al., 1999).

Forest fragmentation is the breaking up of large forested tracts into smaller noncontiguous pieces. The CLEAR program analyzed the current conditions and changes in forest fragmentation in Connecticut based on 1985 and 2006 land cover data. Forested areas were classified into four main categories of increasing disturbance based on a key metric called edge width. The edge width indicates the distance within which other land covers (i.e. developed land) can degrade the forest. A statewide value of 300 feet was used for the edge width. The four categories are:

- **Core Forest** is defined as being outside the "edge effect," being over 300 feet in all directions from non-forested areas. The core forest is broken into three subcategories for core forest less than 250 acres, 250 to 500 acres and greater than 500 acres.
- **Perforated Forest** is the interior edge of small non-forested areas within a core forest, such as a house built within the woods. These areas appear as "holes" or perforations

- **Edge Forest** is the exterior periphery of core forest tracts where they meet with non-forested areas.
- **Patch Forest** is the most disturbed category; small fragments of forests that are completely surrounded by non-forested areas.

Figure 7-4 depicts the distribution of forest types in the watershed. *Table 7-6* presents a comparison of forest types within the watershed for 1985 and 2006 conditions. The existing core forests in the watershed are primarily located in Monroe (59%) and Trumbull (34%), with the balance of the core forest areas located in Shelton and Newtown. In 2006, no core forest existed in the Bridgeport portion of the Pequonnock River watershed.

Between1985 and 2006, the amount of non-forested land and patch forest in the watershed increased by 3% and 0.8%, respectively, with a corresponding decrease in higher quality edge, perforated and core forest (*Figure 7-5*). In 1985, a portion of a core forest (greater than 500 acres) existed in the Upper West Branch Pequonnock subwatershed. By 2006, that same forest was fragmented by development and converted into developed area, edge forest, and smaller core forest (between 250 and 500 acres). Other core and higher quality forest areas were lost in all areas of the watershed during this time period.

Table 7-6. Forest Fragmentation (1985 - 2006)

Forest Category	Percent of Watershed in 1985	Percent of Watershed in 2006	Relative Change (%)
Non-Forest	59.0%	62.1%	3.0%
Patch Forest	10.8%	11.7%	0.8%
Edge Forest	18.8%	17.6%	-1.2%
Perforated Forest	0.7%	0.6%	-0.1%
Core Forest (<250 ac)	7.8%	7.5%	-0.4%
Core Forest (250-500 ac)	1.4%	0.5%	-0.8%
Core Forest (>500 ac)	1.4%	0.0%	-1.4%

Source: Center for Land Use Education and Research (CLEAR) Forest Fragmentation Study

7.1.5 Developed Areas

Developed land cover, characterized by significant amounts of impervious surfaces such as roofs, roads, and other concrete and asphalt surfaces, accounts for approximately 43% of the watershed. 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 57% 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 7-7*) ranges from approximately 24% in the Upper Pequonnock River and Upper West Branch Pequonnock River subwatersheds to approximately 94% in the Lower Pequonnock River subwatershed.

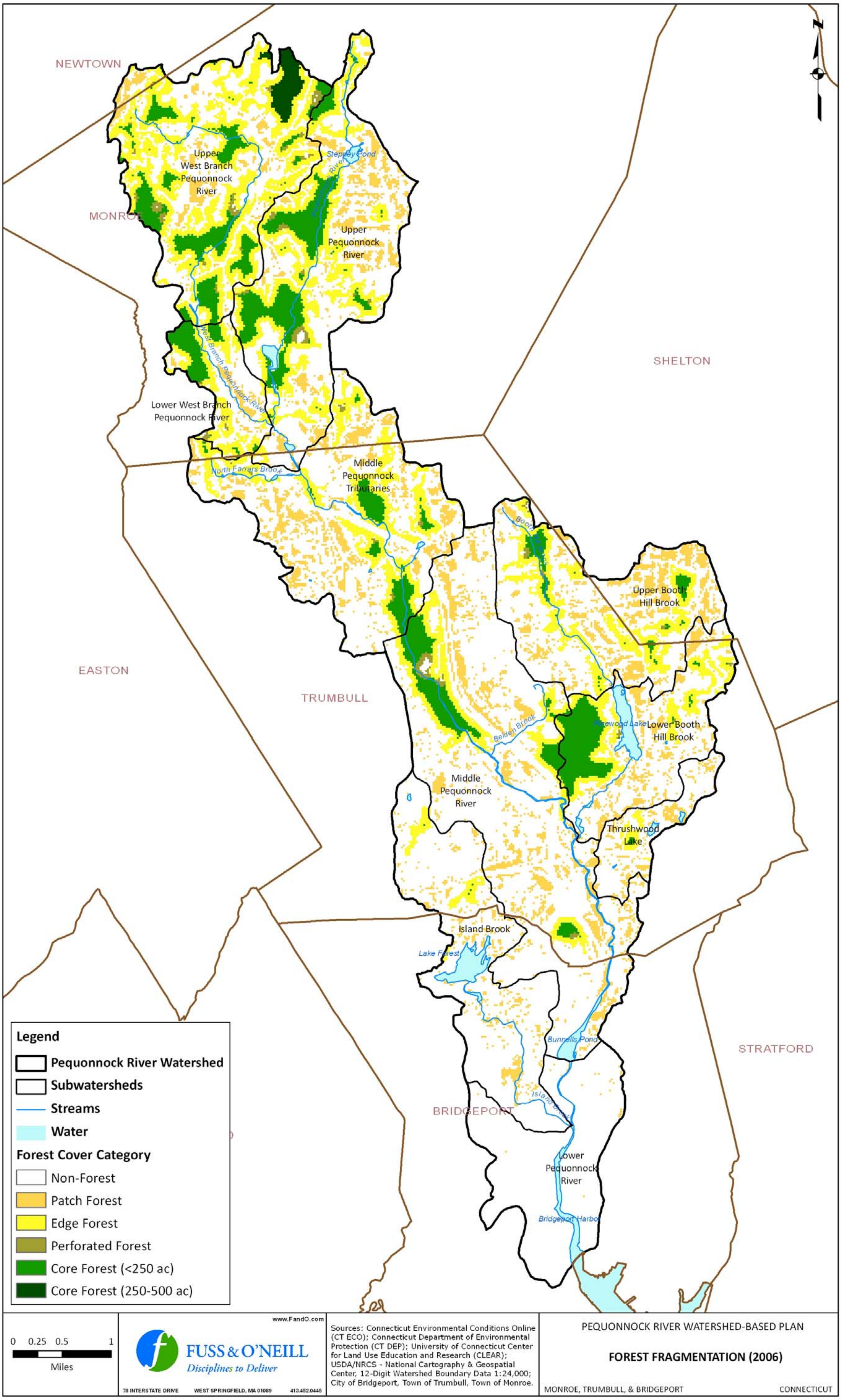

Figure 7-4. Forest Fragmentation

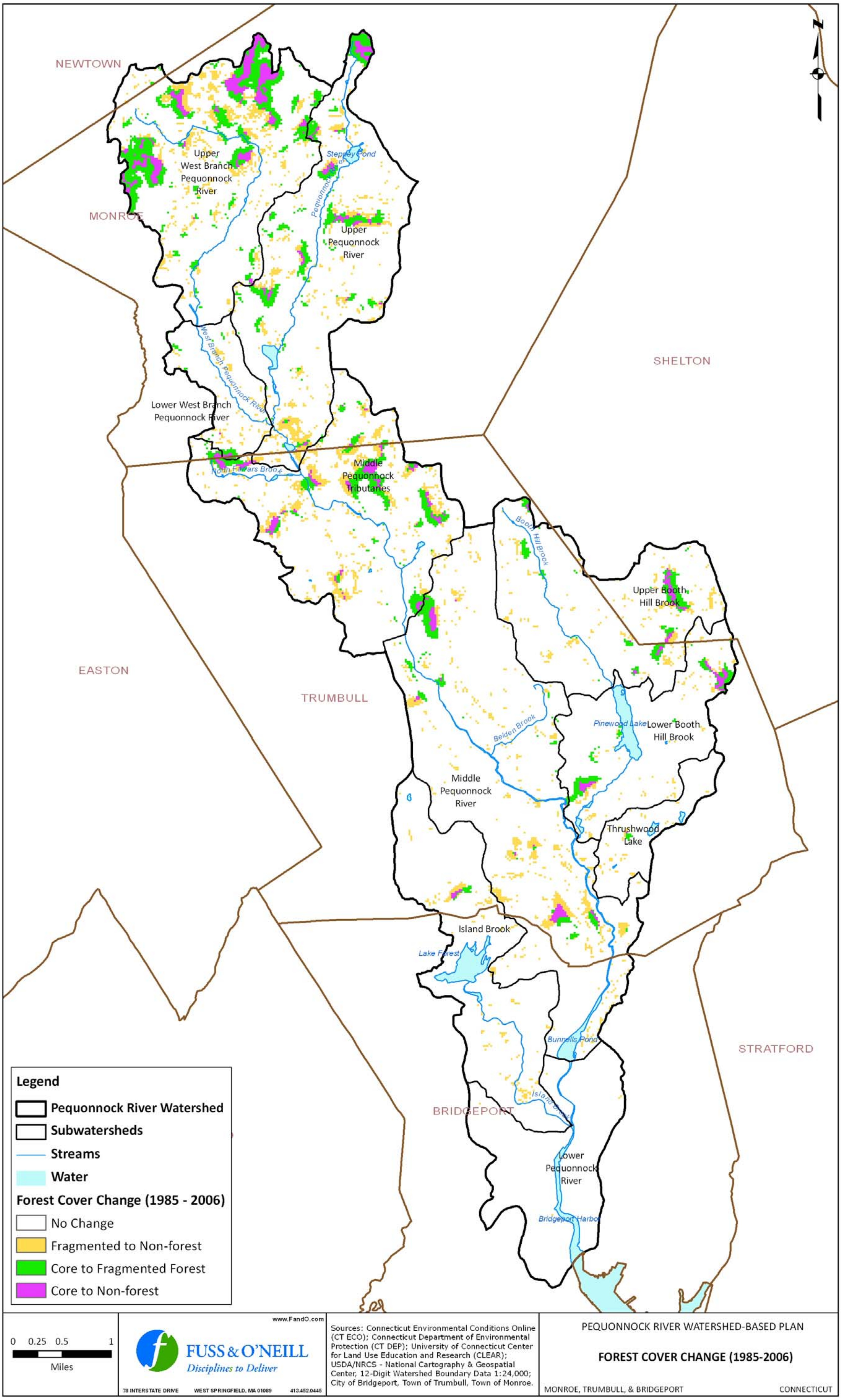

Figure 7-5. Forest Cover Change (1985 - 2006)

Table 7-7. Developed Land Cover by Subwatershed

Subwatershed Name	Developed Land Cover in Subwatershed (acres)	Percent Developed Land Cover in Subwatershed (%)
Upper Pequonnock River	596	24%
Upper West Branch Pequonnock River	613	24%
Lower West Branch Pequonnock River	139	25%
Middle Pequonnock Tributaries	1,006	41%
Middle Pequonnock River	1,878	49%
Upper Booth Hill Brook	684	36%
Lower Booth Hill Brook	426	31%
Thrushwood Lake	221	50%
Island Brook	1,219	70%
Lower Pequonnock River	1,319	94%
Watershed (total)	**8,100**	**43%**

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

7.1.6 Impervious Cover

Impervious cover has emerged as 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 7-6* illustrates this effect. These research findings have been integrated into a general watershed planning model known as the Impervious Cover Model (CWP, 2003).

Figure 7-6 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 range 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).

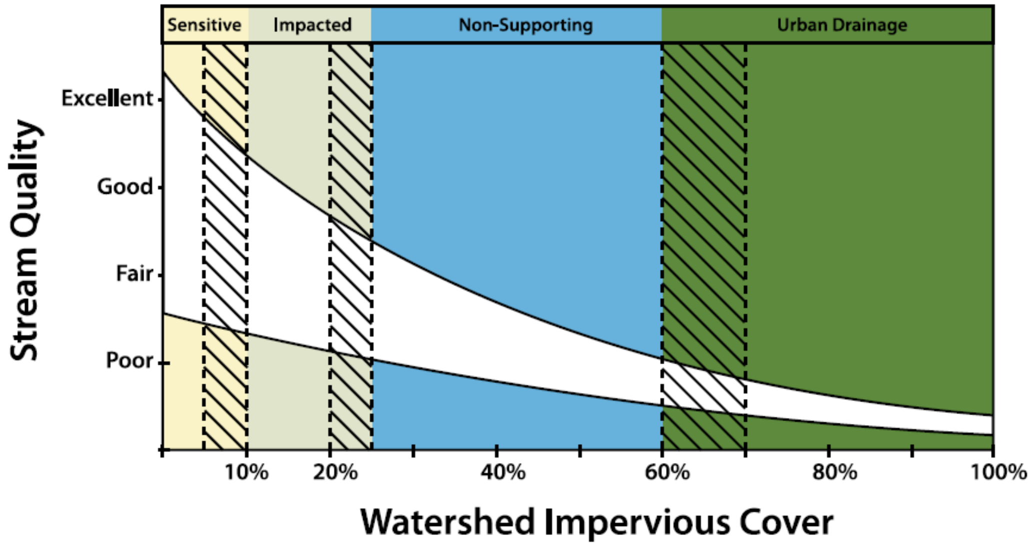

Figure 7-6. Conceptual Model Illustrating Relationship Between Watershed Impervious Cover and Stream Quality

A GIS-based impervious cover analysis was performed for the Pequonnock 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 7.1.3*. The ISAT coefficients in *Table 7-8* were derived by the University of Connecticut's Center for Land Use Education and Research (CLEAR) based on planimetric data from nine Connecticut towns.

Table 7-8. Developed Land Cover by Subwatershed

Land Cover	ISAT Coefficient (for Cities and Urban Areas)
Developed	42.26
Turf and Grass	12.87
Other Grasses and Agriculture	11.56
Deciduous Forest	5.08
Coniferous Forest	14.98
Water	4.25
Non-forested Wetland	5.98
Forested Wetland	1.2
Tidal Wetland	1.02
Barren	19.92
Utility Right-of-way	5.52

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

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 7-7 graphically summarizes the results of the impervious cover analysis. The overall effective impervious cover of the Pequonnock River watershed is estimated at approximately 15% (*Table 7-9*), which exceeds the 10% threshold in the ICM where ecological stress and stream impacts become apparent. As shown in *Figure 7-7*, effective impervious cover generally increases from south to north in the watershed. The Lower Pequonnock River and Island Brook subwatersheds have approximately 72% and 31% effective impervious cover, respectively, reflecting the dense urban development in the lower watershed. The subwatersheds in Trumbull are generally characterized by moderate levels of effective impervious cover, ranging from 4 to 12%. The three subwatersheds in the northern portion of the watershed in Monroe have the lowest effective impervious cover at approximately 4%.

As noted in *Table 7-9*, the subwatersheds can be classified for potential stream impacts based on their effective impervious cover according to the Impervious Cover Model. The Upper Pequonnock River, Upper and Lower West Branch Pequonnock River, and Upper and Lower Booth Hill Brook subwatersheds are in the "Sensitive" category, with less than 10% effective impervious cover. The Lower Pequonnock River subwatershed has the highest effective impervious cover (72%) which is consistent with the high-density development in this portion of the watershed and indicative of degraded stream conditions (i.e., urban drainage) according to the Impervious Cover Model.

Table 7-9. Existing Subwatershed Impervious Cover

Subwatershed	Mapped Impervious Cover	Effective Impervious Cover#	ICM Category*
Upper Pequonnock River	15.8%	4.4%	Sensitive
Upper West Branch Pequonnock River	15.2%	4.1%	Sensitive
Lower West Branch Pequonnock River	15.6%	4.3%	Sensitive
Middle Pequonnock Tributaries	21.9%	10.2%	Impacted
Middle Pequonnock River	24.7%	12.3%	Impacted
Upper Booth Hill Brook	20.1%	9.0%	Sensitive
Lower Booth Hill Brook	18.0%	7.6%	Sensitive
Thrushwood Lake	25.4%	12.8%	Impacted
Island Brook	37.3%	30.8%	Non-Supporting
Lower Pequonnock River	72.0%	72.0%	Urban Drainage
Watershed (total)	**25.4%**	**15.2%**	**Impacted**

* ICM = Center for Watershed Protection Impervious Cover Model Category shown in *Figure 7-6*.
# 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) 2006 Land Cover Data, Sutherland, 1995.

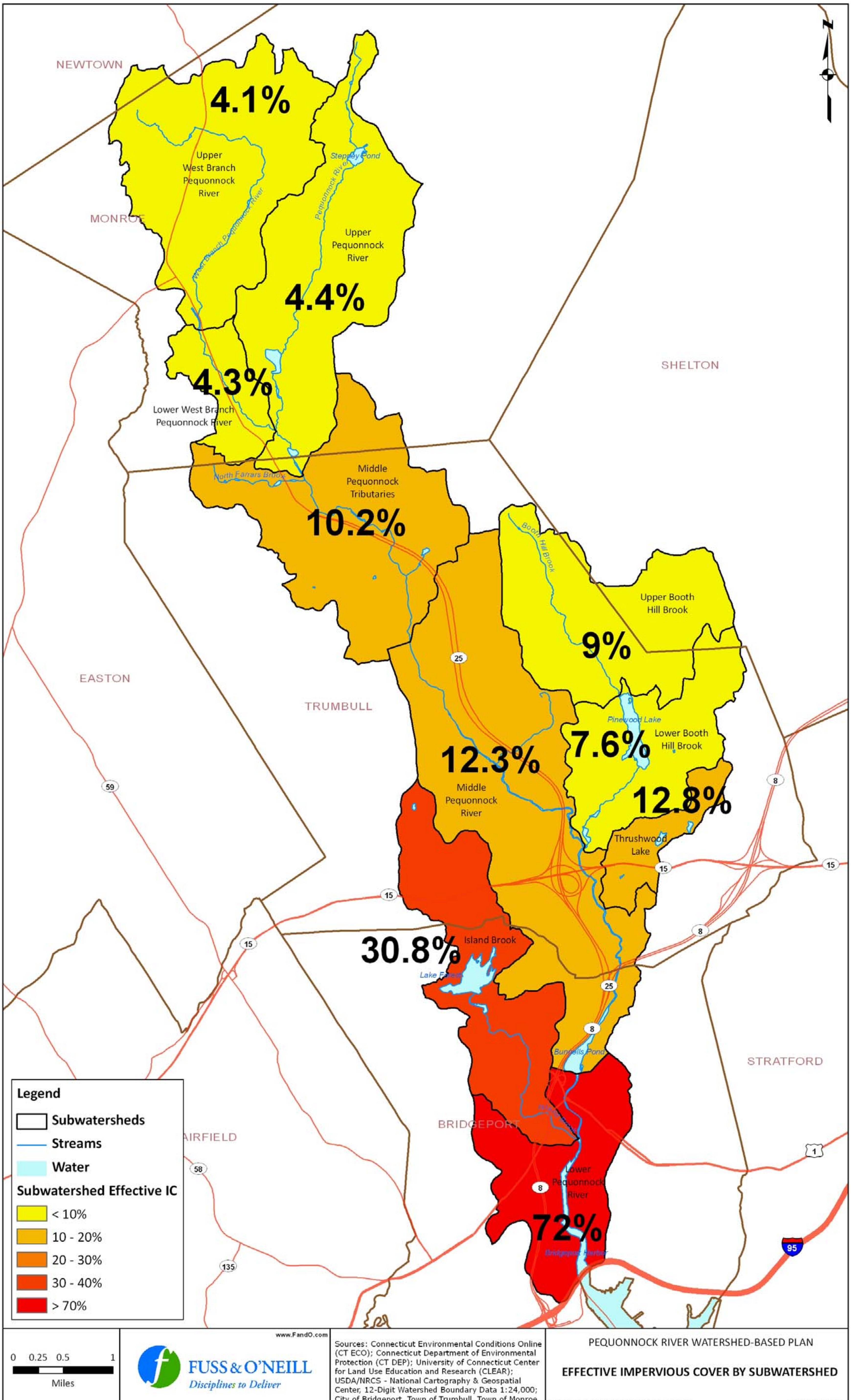

Figure 7-7. Effective Impervious Cover by Subwatershed

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 10 and 25% 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 1^{st} to 3^{rd} 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.).

7.1.7 Open Space

Active and passive open space areas were identified based on data compiled and published by the CTDEP, including federal land, state-owned property, and other municipal and private open space. Additionally, regional land use data, Tele Atlas data, and other online mapping sources were used. Approximately 16% (3,031 acres) of the watershed consists of protected open space that is primarily conservation land and public parks (*Figure 7-8*). This land is protected against future development. In addition, cemeteries and private institutional recreational open space accounts for another 185 acres (<1% of the watershed area). Future development of these parcels is unlikely, unless their continued use becomes threatened. Additional privately-held natural open space exists on existing subdivided parcels and large estates.

The Towns of Trumbull and Monroe contain the majority of the land area set aside for open space in the watershed at approximately 1,545 acres and 1,223 acres, respectively, including both active and passive recreational uses. This represents 17% of the Town of Trumbull's land area and 21% of the Town of Monroe's land area within the watershed. The City of Bridgeport has approximately 203 acres, which is approximately 7% of the City's land area within the watershed.

Some of the notable or sizable open space areas within the watershed listed by acreage include:

- Pequonnock Valley Wildlife Area (Trumbull, 380 acres): A State-owned linear park and wildlife area along Route 25. Design and construction is underway for a section of the Pequonnock Valley Greenway to extend from the beginning of the Pequonnock Valley State Wildlife Area to Wolfe Park in Monroe.
- William E. Wolfe Park (Monroe, 335 acres): An active and passive parkland with 8 tennis courts, 2 basketball courts, 7 ball fields, 4 soccer fields, an outdoor 25 meter swimming pool, hiking trails, picnic areas for groups and families, and a 16-acre lake for swimming, fishing, and non-motorized boating.
- Twin Brooks Park (Trumbull, 238 acres): Swimming area, multi-purpose field, hiking trails, and wildflower fields.
- Centennial Watershed State Forest (Monroe, Trumbull, Shelton): A State-owned park and conservation area with public access easements acquired from Aquarion Water Company. The forest land is dispersed throughout Fairfield County, Litchfield, New Haven, and Hartford Counties with approximately 217 acres in the Pequonnock River watershed.
- Robert G. Beach Memorial Park (Trumbull, 174 acres): The park amenities include a swimming pool, sprinkler park, tot lot, ice skating pond, hiking trails, and scout land camping site.
- Beardsley Park (Bridgeport & Trumbull, 126 acres): The park is home to the Beardsley Zoo, the only zoo in Connecticut and the 33–acre Bunnell's Pond.
- Lanes Mines Park (Monroe, 75 acres): The park has a system of walking trails.
- Old Mine Park (Trumbull, 73 acres): Two pavilions and a picnic area, multi-purpose field, and hiking trails.
- Booth Hill Greenbelt (Trumbull, 70.4 acres)
- Indian Ledge Park (Trumbull, 67 acres): Large, well utilized park with numerous facilities including softball, BMX racing track, multipurpose fields, amphitheater, bocce, playground, and sledding hill.
- Gardner Road Reserve (Monroe, 65 acres)
- Fairchild Memorial Park (Trumbull, 54.1 acres)
- Island Brook Park (Trumbull, 47 acres): Wildlife pond, tot lot, tennis courts, softball, and Little League field.
- Unity Park (Trumbull, 37.3 acres)
- Town Open Space on Teller Road (Trumbull, 21 acres)
- Town Open Space on Broadway (Trumbull, 20 acres)

The following open space areas are smaller, but notable public open spaces in Bridgeport nonetheless:

- Washington Park (6.1 acres)
- Riverfront Park (2.3 acres)
- Alice Street Lot (1.2 acres)
- Waterfront Park (1.1 acres)

Figure 7-8

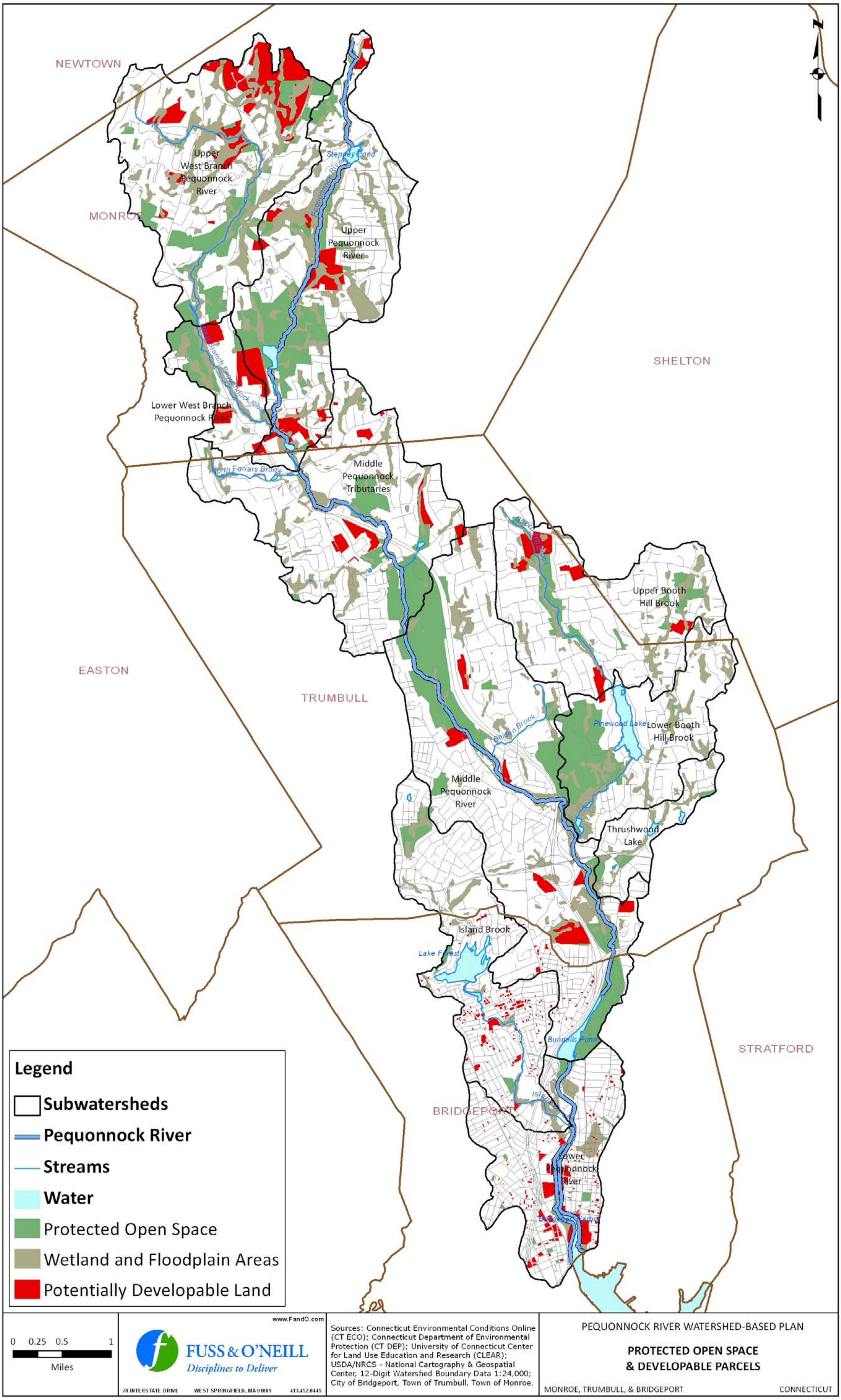

Figure 7-8. Protected Open Space and Developable Parcels

7.2 Future Conditions

7.2.1 Watershed Buildout Analysis

A watershed buildout analysis was conducted to estimate future potential land use and impervious cover conditions in the watershed as a result of maximum future development allowed by current zoning.

7.2.1.1 Developable Land and Future Land Use

Watershed lands that could be developed in the future (i.e., "developable" land) are areas that are currently undeveloped or underutilized and are not presently protected from future development or redevelopment. New development parcels were identified as vacant or undeveloped parcels and that also were not identified as protected open space based on the existing land use data. Additional developable parcels were identified through coordination with the planning departments of the watershed municipalities. The majority of the parcels in Bridgeport identified as developable land are vacant or underutilized parcels that are targeted for future redevelopment. Many of these parcels are along the Pequonnock River and are targeted for redevelopment as part of the City's waterfront redevelopment initiative. However, the bulk of the developable land within the watershed is located in Monroe given a relatively large amount of undeveloped, privately-held land in this portion of the watersheds.

For the purpose of the buildout analysis, areas having the following physical and/or regulatory constraints were removed from consideration for future development: water bodies, wetland soils, slopes exceeding 20%, and areas in the FEMA-designated 100-year flood zone. *Table 7-10* and *Figure 7-8* summarize the amount of developable land by subwatershed.

Table 7-10. Developable Land – Pequonnock River Watershed

Subwatershed	Acres	Percent in Subwatershed
Upper Pequonnock River	213	8.7%
Upper West Branch Pequonnock River	371	14.7%
Lower West Branch Pequonnock River	75	13.6%
Middle Pequonnock Tributaries	79	3.2%
Middle Pequonnock River	136	3.5%
Upper Booth Hill Brook	98	5.2%
Lower Booth Hill Brook	3.3	0.2%
Thrushwood Lake	0.7	0.2%
Island Brook	42	2.4%
Lower Pequonnock River	99	7.0%
Watershed (Total)	**1,116**	**6.0%**

The future land use buildout scenario was estimated by assigning new land uses to developable areas, while maintaining the existing land uses for developed and unbuildable land (wetland soils, steep slope soils, floodplains and committed open space). The developable areas were assigned a future land use based on the maximum degree of development allowed by existing zoning. Parcels that were developed prior to current zoning may have a land use that is inconsistent with current zoning. The current land use of these "existing, non-conforming" parcels is assumed to remain the same under future conditions for the purpose of this analysis.

Table 7-11 summarizes the future land use category assigned to each developable parcel based on the existing zoning. This analysis assumes development of Public Act 490 (which provides tax incentives to preserve farmland, forest and open space land) parcels consistent with the underlying zoning and does not account for future zone changes or future land development regulatory changes.

Table 7-11. Assigned Future Land Use Categories

Zoning Category	Assigned Future Land Use
Single Family	Single Family
Two-Three Family	Multi-Family
Multi-Family	Multi-Family
Mixed Use	Mixed Use
Office/Retail	Commercial
Industrial	Industrial
Planned Development	Mixed Use

The results of the watershed buildout analysis are summarized in *Table 7-12*, which compares acreage of existing and future land use in the watershed. The largest increases are predicted in single-family residential and industrial land uses, at 3.8% and 2.2%, respectively. Most of these increases are anticipated to occur in Monroe and, to a lesser degree, in Trumbull. Overall, the largest decreases are predicted in forested areas (3.2%), unprotected open space (0.9%), and vacant lands (2.9%). Approximately 14% or 942 acres of core forest (see *Section 7.1.4.1)* in the watershed is buildable.

Table 7-12. Watershed Buildout Analysis Results

Land Use	Existing Land Use (Acres)	Existing Land Use (% of watershed)	Future Land Use (Acres)	Future Land Use (% of watershed)	Absolute Change (Acres)	Relative Percent Change[1]
Commercial	631	3.4%	691	3.7%	60	0.32%
Industrial	788	4.2%	1,192	6.4%	404	2.17%
Institutional	671	3.6%	738	4.0%	67	0.36%
Mixed Use	28	0.2%	28	0.2%	0	0.00%
Multi-Family	1,023	5.5%	1,074	5.8%	51	0.27%
Open Space	1,305	7.0%	1,138	6.1%	-167	-0.89%
Forest	2,408	12.9%	1,811	9.7%	-597	-3.20%
Roadway	2,116	11.4%	2,132	11.4%	15	0.08%
Single Family	8,774	47.1%	9,490	50.9%	716	3.84%
Vacant	578	3.1%	29	0.2%	-549	-2.95%
Water	316	1.7%	316	1.7%	0	0.00%

[1]Calculation = % future land use - % existing land use

7.2.1.2 Impervious Cover

The watershed buildout analysis was used in conjunction with the existing conditions impervious cover analysis (*Section 7.1.3*) to estimate future impervious cover in the Pequonnock River subwatersheds. Using the 2006 land cover data, potential increases in impervious cover were estimated based on predicted changes in land use under a buildout scenario.

To estimate the relative increase in imperviousness, coefficients for urban land use were assigned based on literature values. Land use data for both existing and buildout conditions were then used to determine the change in impervious cover for each subwatershed. The predicted change in impervious cover was then added to the existing impervious cover (see *Section 7.1.3)* to estimate potential future impervious cover.

Table 7-13 presents estimates of existing and future impervious cover by subwatershed. The shaded cells in the table highlight the subwatersheds for which impervious cover is predicted to change from "sensitive" (< 10% impervious cover) to "impacted" (10% to 25% impervious cover) categories as described by the Impervious Cover Model. The Upper West Branch Pequonnock River and Lower West Branch Pequonnock River subwatersheds have the greatest predicted percent increase in impervious cover at 6.5% and 8.2%, respectively. Although the predicted change in the Upper Booth Hill Brook subwatershed is relatively small (1.2%), the subwatershed is predicted to potentially exceed the "impacted" threshold under a future buildout scenario. Based on this analysis, the overall impervious cover in the Pequonnock River watershed is predicted to increase from 15.2% to 17.4%.

Table 7-13. Percent Impervious Cover – Existing and Future Conditions

Subwatershed	Existing Percent Impervious Cover	Future Percent Impervious Cover	Percent Change (IC_{Future} - $IC_{Existing}$)
Upper Pequonnock River	4.4%	6.2%	1.8%
Upper West Branch Pequonnock River	4.1%	12.3%	8.2%
Lower West Branch Pequonnock River	4.3%	10.7%	6.5%
Middle Pequonnock Tributaries	10.2%	12.1%	1.9%
Middle Pequonnock River	12.3%	13.2%	0.9%
Upper Booth Hill Brook	9.0%	10.2%	1.2%
Lower Booth Hill Brook	7.6%	7.7%	0.1%
Thrushwood Lake	12.8%	12.9%	0.1%
Island Brook	30.8%	31.4%	0.6%
Lower Pequonnock River	72.0%	73.3%	1.2%
Watershed (Total)	**15.2%**	**17.4%**	**2.2%**

Another useful metric was developed by Goetz et al. (2003) for the Chesapeake Bay region, which combines subwatershed impervious cover and tree cover within the 100-foot stream buffer. Each of the subwatersheds within the Pequonnock watershed was analyzed with regard to the combined impervious cover/riparian zone metric, which is summarized in *Table 7-14* by Goetz et al. (2003).

Table 7-14. Impervious Cover/Riparian Zone Metric

Stream Health	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer
Excellent	<= 6%	>= 65%
Good	7-10%	60-64%
Fair	11-25%	40-59%
Poor	> 25%	< 40%

For example, a stream health rating of excellent was found to require no more than 6% impervious cover in the watershed, and at least 65% tree cover in the riparian zone. A rating of good was found to require less than 10% impervious cover and 60% tree cover in the watershed.

The existing areas of natural vegetation were determined using the 2006 CLEAR land cover data. Natural vegetation was defined to include the deciduous forest, coniferous forest, forested wetland, and non-forested wetland categories. The future natural vegetation was determined to be areas within the 100-foot stream buffer that are currently vegetated and are not included in the potentially developable land areas identified in the buildout analysis. *Table 7-15* presents the results of the combined impervious cover/riparian zone metric for existing and future conditions. The color shading in the table corresponds to the metric classifications in *Table 7-14*.

Table 7-15. Impervious Cover/Riparian Zone Metric – Existing and Future Conditions

Subwatershed	Existing (2006)		Future	
	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer	% Watershed Impervious Cover	% Natural Vegetation in 100-ft Stream Buffer
Upper Pequonnock River	4%	73%	6%	63%
Upper West Branch Pequonnock River	4%	74%	12%	61%
Lower West Branch Pequonnock River	4%	54%	11%	54%
Middle Pequonnock Tributaries	10%	64%	12%	64%
Middle Pequonnock River	12%	49%	13%	47%
Upper Booth Hill Brook	9%	80%	10%	65%
Lower Booth Hill Brook	8%	21%	8%	21%
Thrushwood Lake	13%	28%	13%	28%
Island Brook	31%	20%	31%	19%
Lower Pequonnock River	72%	3%	73%	3%
Watershed (total)	**15%**	**51%**	**17%**	**46%**

Currently, the Pequonnock River subwatersheds are highly varied and are categorized as "excellent" to "poor" based on the riparian zone metric published by Goetz et al. (2003). Generally, the watershed is classified as "excellent" and "good" in the northern portion of the watershed and the quality decreases in the southern portion of the watershed. The Island Brook and Lower Pequonnock River subwatersheds are rated "poor" in the existing and future conditions based on the combined impervious cover/riparian zone metrics.

Under a watershed buildout scenario, four of the subwatersheds are predicted to experience a decline in stream health as a result of increases in impervious cover and development within the riparian corridor. One or both of the metrics are predicted to decline from an "excellent" to "good" rating or from a "good" to a "fair" rating for the Upper Pequonnock River, Upper West Branch Pequonnock River, and Middle Pequonnock Tributaries subwatersheds. The Upper West Branch Pequonnock River and Lower West Branch Pequonnock River impervious cover rating are predicted to decreases from "excellent" to "fair."

8 Pollutant Loading

A pollutant loading analysis was performed for the Pequonnock River watershed in support of the Baseline Watershed Assessment Report to assess the potential for increases in nonpoint source (NPS) pollutant loads. The model was used to compare existing nonpoint source (NPS) pollutant loads from the watershed to projected future pollutant loads under a watershed buildout scenario. The predicted change in pollutant loads in each of the subwatersheds was used as an indicator of their relative vulnerability to future development. The pollutant loading model is used to identify and rank pollution sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollution control strategies. This section summarizes the methods and results of the analysis, which are presented in greater detail in *Appendix E*.

8.1 Model Description

A pollutant loading model was applied to the Pequonnock River watershed using the land use/land cover data described in *Section 7.0*. The model was used to compare pollutant loadings from the watershed under existing land use conditions to future pollutant loadings under a watershed buildout scenario. It is important to note that the results of this screening-level analysis are intended for the purposes of comparing existing to future conditions and not to predict future water quality.

The Watershed Treatment Model (WTM), Version 2010 (Beta), 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:

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

Reductions in future pollutant loads in the watershed can be estimated using a range of treatment measures, such as structural and nonstructural best management practices, that are included in the WTM.

Other similar screening-level pollutant loading models were considered for use in development of a watershed management plan for the Pequonnock River, including the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), the Generalized Watershed Loading Function (GWLF) model, and other similar models. While STEPL was identified as a suitable choice for the Pequonnock River, it was determined that the WTM is better suited for modeling bacterial loads and provides a larger suite of best management practices for urban areas. The ArcView GIS version of the GWLF model was also considered for use in the evaluation, although the AVGWLF model has limited capability for modeling CSOs when using the urban runoff module RUNQUAL within the GWLF model. Again, the WTM model was determined to be better suited for modeling CSOs than the AVGWLF model.

The pollutants modeled in this analysis are the default pollutants contained in the WTM model: total phosphorus, total nitrogen, total suspended solids, and total fecal coliform bacteria. These pollutants are the major NPS pollutants of concern in environmental systems. Additional loading from the CSOs during wet-weather was simulated in the Lower Pequonnock River subwatershed, where such discharges are known to exist.

8.2 Model Inputs

8.2.1 Nonpoint Source Runoff

Land use/land cover data described in *Section 7* were adapted for use in the WTM. Data were prepared in this manner for both the existing conditions and future conditions (watershed buildout) pollutant loading scenarios. The WTM 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. Since comparison between existing and proposed watershed conditions is the focus of this analysis, EMC values were selected to reflect the relative difference in NPS pollutant characteristics between existing and future land uses. The default impervious cover coefficients in the WTM were adjusted to better reflect local conditions in the Pequonnock River watershed. Impervious cover coefficients for each land use category were selected from WTM default impervious cover coefficients and literature values.

8.2.2 Other Pollutant Sources

In addition to nonpoint source runoff pollutant loads, the 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 Pequonnock River watershed.

8.2.2.1 Combined Sewer Overflows

The WTM uses a modification of the Simple Method to calculate annual loads from CSOs. The primary assumption is that CSO discharges occur when the combined volume of stormwater and wastewater exceeds the total system capacity. The system is assumed to experience approximately 50 CSO discharge events annually in the Pequonnock River. Statistical analysis of 40 years of daily precipitation data at a nearby weather station reveals that the median storm in the area is approximately 0.16 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 WTM, 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.

8.2.2.2 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 WTM makes separate assumptions for residential and business illicit connections. For residential connections, the WTM's 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 2000 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 and/or buildings on aerial mapping within the commercial, industrial, and institutional land uses.

8.2.2.3 Septic Systems

The portion of the watershed in Bridgeport and large portions of the watershed in Trumbull are served by sanitary sewers, with ongoing additions to the sewer service in Trumbull. Currently, some portions of Trumbull and all of Monroe are served by private septic systems. The number of unsewered dwelling units in each subwatershed was estimated using GIS data including the mapped sewer service area, U.S. Census data, assessor's data, 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.

8.2.2.4 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.

8.2.2.5 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 in Massachusetts 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.

8.3 Existing Pollutant Loads

Table 8-1 presents the existing modeled pollutant loads for the Pequonnock River watershed. Nonpoint source runoff accounts for approximately 82% of the total nitrogen load, 75% of the total phosphorus load, 46% of the total suspended solids load, and 48% of the fecal coliform bacteria load for the entire watershed. Road sanding accounts for nearly the entire balance of the total suspended solids load, while CSOs contribute approximately 48% of the fecal coliform load for the watershed. *Table 8-2* presents a breakdown of estimated annual loadings of total nitrogen, total phosphorus, TSS, and fecal coliform by subwatershed.

Table 8-1. Modeled Existing Pollutant Loads by Source Type

	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)
Primary Sources - Land Use	132,805	26,919	4,402,266	1,515,065	283,426
Secondary Sources	28,779	8,987	5,223,712	1,645,409	0
CSOs	4,797	959	10,344	1,508,508	0
Channel Erosion	4,402	4,402	1,467,422	0	0
Road Sanding	0	0	3,613,055	0	0
Illicit Discharges	870	507	8,154	108,589	0
Septic Systems	18,711	3,118	124,738	28,312	0
Total	**161,584**	**35,906**	**9,625,978**	**3,160,475**	**283,426**

Table 8-2. Modeled Existing Pollutant Loads

Subwatershed	N	P	TSS	Fecal Coliform	N	P	TSS	Fecal Coliform
	lb/yr	lb/yr	lb/yr	billion/yr	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/ ac-yr
Upper Pequonnock River (2,456 ac)	16,678	3,767	719,746	194,826	6.8	1.5	293.1	79.3
Upper West Branch Pequonnock River (2,522 ac)	20,947	4,523	1,023,909	201,542	8.3	1.8	406.0	79.9
Lower West Branch Pequonnock River (533 ac)	4,073	943	289,283	36,021	7.4	1.7	523.1	65.1
Middle Pequonnock Tributaries (2,434 ac)	19,193	4,465	1,477,284	208,816	7.9	1.8	606.9	85.8
Middle Pequonnock River (3,835 ac)	31,339	7,104	2,046,958	300,261	8.2	1.9	533.8	78.3
Upper Booth Hill Brook (1,895 ac)	11,758	2,890	643,760	186,440	6.2	1.5	339.7	98.4
Lower Booth Hill Brook (1,363 ac)	9,487	2,031	426,698	109,604	7.0	1.5	313.1	80.4
Thrushwood Lake (442 ac)	4,259	925	224,897	49,674	9.6	2.1	508.8	112.4
Island Brook (1,741 ac)	18,500	3,972	1,167,666	186,425	10.6	2.3	670.7	107.1

Table 8-2. Modeled Existing Pollutant Loads

Subwatershed	N	P	TSS	Fecal Coliform	N	P	TSS	Fecal Coliform
	lb/yr	lb/yr	lb/yr	billion/yr	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/ ac-yr
Lower Pequonnock River (Without CSOs) (1,398 ac)	20,553	4,325	1,595,435	178,357	14.7	3.1	1,141.2	127.6
CSOs	4,797	959	10,344	1,508,508	3.4	0.7	7.4	1,079.0
Watershed Total (18,639 ac)	**161,584**	**35,906**	**9,625,978**	**3,160,475**	**8.7**	**1.9**	**516**	**169.6**

Because the study subwatersheds vary in size, pollutant loads were also evaluated in terms of loading rates (i.e., pollutant loads per acre of land area, as shown in *Table 8-2*). A higher loading rate indicates relatively greater pollutant sources per unit area, which suggests that implementation of best management practices (BMPs) in these areas may be more effective in reducing pollutant loads. The highest loading rates for nitrogen and phosphorus are associated with the Lower Pequonnock River, Island Brook, and Thrushwood Lake subwatersheds. Lower Pequonnock River, Island Brook, and Middle Pequonnock Tributaries subwatersheds have the highest loading rates of total suspended solids. The Lower Pequonnock River subwatershed has the highest rate of stormwater runoff in the watershed and largest fecal coliform loading rate due to contributions from CSOs and nonpoint sources.

- *Lower Pequonnock River.* The Lower Pequonnock River subwatershed has a high percentage of commercial, industrial, mixed use and multi-family land uses which are associated with higher pollutant loading coefficients for nutrients, bacteria, and TSS. 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 Pequonnock River. Since this subwatershed is smaller in total land area than others, it does not have the highest absolute pollutant loading (with the exception of TSS); however the loading rates per acre are the highest in the watershed for all of the modeled pollutants and runoff volume. The estimated nonpoint source nitrogen loading rate is 14.7 lb/ac-year, the phosphorus loading rate is estimated at 3.1 lb/ac-year, the TSS loading rate is 1,141 lb/ac-year, and the estimated fecal coliform loading due to nonpoint source runoff is 127.6 billion/ac-year. The pollutant loading rates in this subwatershed are generally greater than 2 times that in the subwatersheds in the middle and northern portions of the watershed. The contribution of fecal coliform from sewer overflows is significantly larger (1,079 billion/ac-year) than the nonpoint source runoff contribution.

- *Island Brook.* Island Brook ranks second among subwatersheds in annual pollutant loading rates. The high loading is due to the proportionally high commercial/industrial, residential, and roadway land uses in this subwatershed.

- *Thrushwood Lake.* The Thrushwood Lake subwatershed is the smallest in the watershed (442 acres) and therefore has relatively low absolute pollutant loading rates. However, it is among the highest in terms of pollutant loading rates. The subwatershed primarily consists of single-family land use.

- *Middle Pequonnock River*. This subwatershed is the largest in the watershed in size (3,835 acres) and therefore has high pollutant loading values for nitrogen, phosphorus, TSS, fecal coliform, and total yearly runoff volume. The pollutant loading rates in this subwatershed are comparable to the nearby subwatersheds, with loading rates of 8.2 lb/ac-year nitrogen, 1.9 lb/ac-year phosphorus, 533 lb/ac-year TSS, 78.3 lb/ac-year fecal coliform, and 15.3 acre-feet/year runoff.

Table 8-3 summarizes the contribution of nonpoint source pollutant loads by land use for the entire watershed. The majority of the nitrogen and phosphorus loads are from roadway and residential land uses. The majority of the TSS loads is due to roadway (51.7%) and single-family residential (14.3%) land use. Single-family and multi-family residential land uses account for approximately 87.2% of the nonpoint source bacterial load. Other modeled pollutant sources contribute significantly to the watershed pollutant loads, particularly CSOs, which are the predominant source of the fecal coliform loads in the watershed.

Table 8-3. Modeled Existing Pollutant Loads by Land Use

Land Use	N	P	TSS	Fecal Coliform	N	P	TSS	Fecal Coliform
	lb/yr	lb/yr	lb/yr	billion/yr	%	%	%	%
Commercial	9,141	1,770	410,636	26,201	6.9%	6.6%	9.3%	1.7%
Industrial	10,412	1,895	489,134	42,727	7.8%	7.0%	11.1%	2.8%
Institutional	4,909	1,090	172,888	16,464	3.7%	4.0%	3.9%	1.1%
Mixed Use	346	47	10,318	1,404	0.3%	0.2%	0.2%	0.1%
Multi-Family	13,508	1,850	232,943	193,633	10.2%	6.9%	5.3%	12.8%
Open Space	4,473	1,243	49,939	5,690	3.4%	4.6%	1.1%	0.4%
Forest	171	86	59,876	1,949	0.1%	0.3%	1.4%	0.1%
Roadway	45,771	7,873	2,276,617	96,840	34.5%	29.2%	51.7%	6.4%
Single Family	38,021	10,342	628,420	1,127,472	28.6%	38.4%	14.3%	74.4%
Vacant	2,095	569	23,559	2,684	1.6%	2.1%	0.5%	0.2%
Water	3,958	155	47,934	0	3.0%	0.6%	1.1%	0.0%
Total	**132,805**	**26,919**	**4,402,266**	**1,515,065**				

8.4 Future Pollutant Loads

Anticipated future land use due to new development within the watershed was used in the WTM model to simulate potential future pollutant loads under a watershed buildout scenario. Future land use categories were derived from the watershed buildout scenario presented in *Section 7*. Future controls or best management practices were not considered in the calculation of future pollutant loads. Therefore, the predicted future pollutant loads reflect a potential worst-case scenario against which potential watershed management pollution control strategies may be evaluated. Additionally, future pollutant loads were modeled with and without CSO mitigation to evaluate the potential reductions in pollutant loads that could be achieved by the City of Bridgeport's ongoing and planned CSO abatement efforts.
Table 8-4 presents projected future pollutant loads and load increases under a watershed buildout scenario. Not considering ongoing and planned CSO mitigation efforts, a significant

increase in nutrient and bacteria pollutant loads is predicted in many of the subwatersheds. The watershed as a whole is predicted to experience a 2.3% increase in nitrogen loads, a 2.0% increase in phosphorus loads, a 3.2% increase in TSS loads, and a 41.9% *decrease* in fecal coliform loads under a future buildout scenario, assuming full implementation of the ongoing and proposed CSO mitigation plans, which will significantly improve water quality conditions in the Lower Pequonnock River. CSO abatement measures will not address bacterial loads in upstream areas. Almost all of the other subwatersheds are predicted to experience increases in fecal coliform loads (between 0.4 and 44.7% increases) under a watershed buildout scenario due to stormwater and nonpoint source runoff.

Table 8-4. Modeled Future Pollutant Loading Rate Increases and Load Increases

Subwatershed	Projected Future Loading Rate				Projected Load Increase			
	N	P	TSS	Fecal Coliform	N	P	TSS	Fecal Coliform
	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/ ac-yr	%	%	%	%
Upper Pequonnock River (2,456 ac)	7.1	1.6	308.8	91.8	5.1%	4.5%	5.4%	15.7%
Upper West Branch Pequonnock River (2,522 ac)	10.1	2.1	476.3	102.4	21.3%	18.3%	17.3%	28.1%
Lower West Branch Pequonnock River (533 ac)	8.9	2.1	559.6	94.3	20.2%	20.8%	7.0%	44.7%
Middle Pequonnock Tributaries (2,434 ac)	8.2	1.9	618.4	92.6	4.3%	3.5%	1.9%	8.0%
Middle Pequonnock River (3,835 ac)	8.3	1.9	541.0	81.3	2.0%	1.6%	1.4%	3.9%
Upper Booth Hill Brook (1,895 ac)	6.4	1.6	343.0	105.1	3.8%	4.1%	1.0%	6.8%
Lower Booth Hill Brook (1,363 ac)	7.0	1.5	313.2	80.7	0.1%	0.2%	0.0%	0.4%
Thrushwood Lake (442 ac)	9.6	2.1	509.1	113.3	0.1%	0.1%	0.1%	0.8%
Island Brook (1,741 ac)	10.7	2.3	673.2	109.9	0.5%	0.4%	0.4%	2.7%
Lower Pequonnock River (Without CSOs) (1,398 ac)	14.9	3.1	1152.6	129.8	1.6%	1.1%	1.0%	1.7%
CSOs*	0.1	0.0	0.1	21.6	-98.0%	-98.0%	-98.0%	-98.0%
Watershed Total (18,639 ac)	**8.9**	**2.0**	**533.0**	**98.5**	**2.3%**	**2.0%**	**3.2%**	**-41.9%**

*Reflects completion of ongoing and planned CSO mitigation projects.

9 Comparative Subwatershed Analysis

A Comparative Subwatershed Analysis was performed for the Pequonnock River subwatersheds to identify the subwatersheds with the greatest vulnerability and restoration potential. Various subwatershed "metrics" were evaluated in conducting this analysis. Metrics are numeric values that characterize the relative vulnerability and restoration potential of a subwatershed. The results of this analysis will be used to prioritize field assessment efforts in future phases of this study and to guide plan recommendations.

The analysis involves a screening-level evaluation of selected subwatershed metrics that are derived by analyzing available GIS layers and other subwatershed data sources. The basic approach used to conduct the Comparative Subwatershed Analysis consisted of:

1. Delineation of subwatershed boundaries and review of available data.
2. Selection and calculation of metrics that best describe subwatershed vulnerability and restoration potential. (The metrics used to rank subwatershed vulnerability were selected separately from the metrics used to rank subwatershed restoration potential.)
3. Developing weighting and scoring rules to assign values to each metric.
4. Computing aggregate scores and developing subwatershed rankings.

Subwatersheds with higher aggregate "vulnerability" scores are more sensitive to future development and should be the focus of watershed conservation efforts to maintain existing high-quality resources and conditions. Subwatersheds with higher aggregate "restoration potential" scores are more likely to have been impacted and have greater potential for restoration to improve upon existing conditions. This approach enables watershed planners to allocate limited resources on subwatersheds where restoration and conservation efforts have the greatest chances of success.

The following sections present the metrics used, the rationale for their selection, how numerical values for the various metrics were calculated, and the results of the analysis. Available GIS mapping and other data were used to assign a value for each metric.

9.1 Priority Subwatersheds for Conservation

Ten metrics were used to evaluate each subwatershed for vulnerability to future development, with a numerical value assigned for each metric based on the analyses presented in previous sections of this Baseline Watershed Assessment. *Table 9-1* presents the metrics used for determining the relative vulnerability of each subwatershed. Many of the metrics evaluate the potential changes in watershed in land use, land cover, impervious cover, and pollutant loading between existing and future conditions, as presented in previous sections of this report. Note that the pollutant loading metric does not account for pollutant loadings associated with combined sewer overflows and only compares loadings from non-point sources (land use). Each metric was assigned a value of between 1 and 10, with 1 indicating the lowest vulnerability and 10 indicating the highest vulnerability to future development. The scores for each of the metrics were then added to arrive at an overall score for each subwatershed. The total number of points possible for each subwatershed is 100.

Table 9-1. Summary of Subwatershed Vulnerability Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Vulnerability Potential When	Metric Points
1. Impervious Cover Change	% increase in impervious cover in subwatershed	**Increase in IC is high**, suggesting greater development potential and stream impacts	Award 1 pt for each 1% increase in impervious cover
2. Impervious Cover Threshold	Comparison of current and future IC relative to ICM threshold	**Predicted IC crosses "impacted" (12%) threshold**, development could result in significant stream impacts	Award 5 pts for each exceedance into higher category (0-10%; 10-25%; 25-60%, >60%)
3. Stream Order	% of subwatershed streams that are 1st or 2nd order	**Subwatershed consists of more lower order streams**, vulnerability of headwater streams for habitat and water quality protection	Add 1 pt for each 10% of streams in subwatershed that are 1st or 2nd order
4. Increase in Pollutant Loading	Average % increase of N, P, TSS, and bacteria in pollutant loading in subwatershed	**Increase in pollutant loading is high**, suggesting water quality impacts from future development	Award 1 pt for each 2.5% increase in the average pollutant loading
5. Commercial & Industrial Land change	% increase of commercial & industrial land in subwatershed	**Commercial & Industrial land is high**, greater potential for water quality impacts from pollutant hot spot	0% = 0 pts; 1 to 10% = 3 pts; 11 to 50% = 5 pts; 51 to 100% = 7 pts, > 100 % = 10 pt
6. Developable Forest Cover	% of subwatershed with developable forest cover	**Area of developable forest cover is high**, potential for significant future reductions in forested land	Award 1 pt for each 1.5% of developable forest cover
7. Developable Natural Vegetation in Stream Corridor	% of vegetated stream corridor that is developable	**Unprotected corridor forest & wetlands cover is high**, potential for significant future reductions in vegetated riparian areas	Add 1 pt for each 1% developable natural vegetation cover in stream corridor (maximum 10 pts)
8. Impervious Cover/Riparian Zone Metric	Comparison of current and future combined IC and Riparian Zone Metric	**Predicted combined impervious cover/riparian zone metric crossed a rating threshold**, development could result in significant stream health impacts	Award 5 pts for each quality decrease into a lower quantitative category
9. Road Crossings	number of road crossings / square mile	**Number of road crossings is high**, greater potential for direct stormwater discharges from roadways	Award 0.5 pts for each stream crossing /sq mi (maximum 10 pts)
10. Developed Areas with Septic	% of subwatershed served by septic	**Area served by septic is high**, indicating potential for pollutant loadings from failing septic systems	Award 1 pt for each 10% of subwatershed area served by septic

The results of the vulnerability analysis are summarized in *Table 9-2*. The overall subwatershed vulnerability scores range from 14 to 73 points out of a possible 100 points. The highlighting identifies subwatersheds with high (orange), moderate (yellow), and low (green) relative vulnerability in the Pequonnock River watershed.

Table 9-2. Results of Subwatershed Vulnerability Analysis

Subwatershed	Impervious Cover Change	Impervious Cover Threshold	Stream Order	Increase in Pollutant Loading	Commercial & Industrial Land Change	Developable Forest Cover	Developable Vegetation in Stream Corridor	Impervious Cover/Riparian Zone Metric	Road Crossings	Developed Areas with Septic	Total	Rank
Upper West Branch Pequonnock River	8	5	10	9	7	10	10	10	4	0	**73**	**1**
Lower West Branch Pequonnock River	6	5	10	9	5	5	0	5	3	0	**48**	**2**
Upper Booth Hill Brook	1	5	7	2	0	8	10	0	5	5	**43**	**3**
Middle Pequonnock Tributaries	2	0	7	2	5	3	0	5	8	5	**37**	**4**
Upper Pequonnock River	2	0	4	3	10	0	9	5	2	0	**35**	**5**
Island Brook	1	0	10	0	3	0	1	0	8	8	**31**	**6**
Thrushwood Lake	0	0	10	0	0	0	0	0	10	4	**24**	**7**
Middle Pequonnock River	1	0	3	1	5	2	1	0	4	7	**24**	**8**
Lower Pequonnock River	1	0	0	1	3	0	0	0	5	10	**20**	**9**
Lower Booth Hill Brook	0	0	5	0	0	0	0	0	7	2	**14**	**10**

As shown in *Table 9-2*, the following subwatersheds are considered most vulnerable to future development impacts and should be given higher priority for conservation efforts to maintain existing resource conditions:

- *Upper West Branch Pequonnock River* – The Upper West Branch Pequonnock River (UWB) subwatershed is ranked as the most vulnerable subwatershed to future development. The subwatershed contains headwater streams (1st and 2nd order streams), which are important components of ecosystem health because they are a critical food source for the river, influence downstream conditions, and support biodiversity. The subwatershed is predicted to experience a significant decrease in forest cover under a future watershed buildout scenario, with a large potential increase in industrial land use. Based on the combined impervious cover/riparian zone metric discussed in *Section 7.2.1.2*, the stream health condition in this subwatershed has the potential to decrease from "excellent" to "fair" and the vegetated stream buffer rating from "excellent" to "good."

- *Lower West Branch Pequonnock River* – The Lower West Branch Pequonnock River (LWB) subwatershed is the second most vulnerable subwatershed and has similar land use changes and vulnerable stream resources as the UWB subwatershed. The LWB subwatershed has no developable land within a 100-foot corridor along the West Branch Pequonnock River that is also currently vegetated. In addition, the percentage of the subwatershed that consists of developable forest cover is lower than that of the UWB subwatershed.

- *Upper Booth Hill Brook* – This subwatershed is rated the third most vulnerable to future development due to the high percentage of developable forest cover, developable vegetation within the 100-foot stream corridor, and the presence of headwater streams. However, the subwatershed has smaller predicted increases in impervious cover or industrial and commercial land uses, which typically have greater pollutant loading rates than forest, open space, or residential land uses.

- *Middle Pequonnock Tributaries* – There is a high density of stream crossings in this watershed, which suggests a potential for increased stormwater runoff from roads as the subwatershed becomes more developed. In addition, this subwatershed is also characterized by headwater streams and is moderately vulnerable to a future increase in industrial and commercial land uses.

9.2 Priority Subwatersheds for Restoration

Ten metrics were used to evaluate each subwatershed for restoration potential, with a numerical value assigned for each metric based on the analyses presented in previous sections of this Baseline Watershed Assessment. *Table 9-3* presents the metrics used for determining the relative restoration potential of each subwatershed. Each metric was assigned a value of between 1 and 10, with 1 indicating the lowest restoration potential and 10 indicating the highest restoration potential. The scores for each of the metrics were then added to arrive at an overall score for each subwatershed. The total number of points possible for each subwatershed is 100.

Table 9-3. Summary of Subwatershed Restoration Potential Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Restoration Potential When	Metric Points
1. Existing Impervious Cover	% effective impervious cover in subwatershed	Current impervious cover is low, suggesting range of possible sites for storage retrofits and stream repairs	< 10% = 10pts; 10 to 25% = 7 pts; 26 to 40 = 5 pts; 41 to 60% = 3 pts; > 60% = 1 pts

Table 9-3. Summary of Subwatershed Restoration Potential Metrics

Subwatershed Metric	How Metric is Measured	Indicates Higher Restoration Potential When	Metric Points
2. Forest Cover	% forest cover in subwatershed	**Forest cover is low**, suggesting potential for upland and riparian reforestation	< 10% = 10 pts; 11 to 20% = 7 pts; 21 to 30% = 5 pts; 31 to 50% = 3 pts, > 50 % = 1 pt
3. Subwatershed Development Potential	% of subwatershed that is developable	**No more development is expected,** suggesting stable conditions exist and improve feasibility, particularly for stream repairs and storage retrofits	< 0% = 10 pts; 1 to 4% = 7 pts; 5 to 8% = 5 pts; 9 to 12% = 3 pts, > 13 % = 1 pt
4. Publicly-owned land	% of subwatershed that is publicly owned	**Public land ownership is high**, providing range of potential sites for restoration practices	Award 1 pt for ea 2% in public ownership (maximum 10 pts)
5. Single-family Residential Land	% of subwatershed residential land use	**Detached residential land is high**, suggests strong feasibility for neighborhood source control, on-site retrofits and upland forestry	Award 1 pt for each 7% single-family land use
6. Commercial Land	% of subwatershed that is commercial land	**Commercial land use is high**, suggesting potential for source controls, discharge prevention, and on-site retrofits	Award 1 pt for each 2% of subwatershed classified as commercial land use
7. Forest, Parks and Wetlands	% of subwatershed that is forest & wetland land cover	**Natural cover is high**, suggesting potential for upland and riparian reforestation, stream repairs, and storage retrofits	Award 1 pt for each 6% of watershed area
8. Stream Density	stream miles / square mile	**Stream density is high**, suggesting greater feasibility of corridor practices	Award 2.5 pts for each mile of stream/sq mi
9. Regulated Site Density	regulated sites / sq mi. (CTDEP General Permits)	**Regulated site density is high,** suggests strong potential to implement source control, discharge prevention and on-site retrofits	0 to 1 = 1 pt; 1 to 2 = 3 pts; 2 to 5 = 5 pts; 5 to 10 = 7 pts; > 10 = 10 pts
10. Road Crossings	crossings / stream mile	**Road crossings are numerous,** suggesting strong potential for stream repairs, culvert modification, and stream adoption	Award 1 pts for each road crossing /sq mi

The results of the subwatershed restoration potential analysis are summarized in *Table 9-4*. The restoration potential scores range from 43 to 61 points out of a possible 100 points. The highlighting identifies subwatersheds with high (orange), moderate (yellow), and low (green) relative restoration potential in the Pequonnock River watershed.

Table 9-4. Results of Subwatershed Restoration Potential Analysis

Subwatershed	Existing Impervious Cover	Forest Cover	Subwatershed Development Potential	Publicly-Owned Land	Single-family Residential Land	Commercial Land	Forest, Parks and Wetlands	Stream Density	Regulated Site Density	Road Crossings	Total	Rank
Lower Booth Hill Brook	10	3	10	10	8	0	7	6	1	6	**61**	**1**
Thrushwood Lake	7	5	10	2	9	0	4	10	1	9	**57**	**2**
Middle Pequonnock Tributaries	7	3	7	5	7	1	6	7	5	5	**53**	**3**
Upper Pequonnock River	10	3	5	10	6	0	8	6	3	1	**52**	**4**
Upper Booth Hill Brook	10	3	5	4	10	0	7	7	1	3	**50**	**5**
Island Brook	5	7	7	2	7	1	2	4	3	10	**48**	**6**
Lower Pequonnock River	1	10	5	1	1	7	0	3	10	8	**46**	**7**
Lower West Branch Pequonnock River	10	1	1	0	5	7	9	6	5	1	**45**	**8**
Middle Pequonnock River	7	5	7	4	6	1	4	4	1	4	**43**	**9**
Upper West Branch Pequonnock River	10	1	1	3	4	2	10	7	3	2	**43**	**9**

As shown in *Table 9-4*, the following subwatersheds are considered to have the greatest restoration potential:

- *Lower Booth Hill Brook* – This subwatershed is ranked highest for restoration potential. The current impervious cover is low, which suggests a range of possible sites for storage retrofits and stream repairs. The future development potential is also low, which implies that the subwatershed is in a more stable condition and retrofit efforts would be more effective. The stream density is moderate and there are adequate road crossings, which provide ample opportunity for riparian buffer restoration, stream repairs, culvert modification, and/or stream adoption. Additionally, this subwatershed has a high percentage of publicly-owned land, thereby providing greater retrofit opportunities.

- *Thrushwood Lake* – The Thrushwood Lake subwatershed is a strong candidate for retrofit opportunities since the watershed has little development potential and is believed to be in a stable condition, making restoration more effective. Additionally, the subwatershed has a high density of streams and road crossings, providing numerous opportunities for stream restoration, stormwater retrofits, and stream cleanups.

- *Middle Pequonnock Tributaries* – The Middle Pequonnock Tributaries subwatershed a high restoration potential through urban retrofit practices since much of its land area is developed, with a high percentage of impervious cover and relatively little buildable land. The subwatershed also has a high stream density and numerous road crossings, which could yield potential opportunities for stormwater retrofits and stream restoration. Potential reforestation opportunities also exist along the stream corridor and in upland areas.

- *Upper Pequonnock River* – This subwatershed has a moderate overall restoration potential. The current impervious cover is low, which suggests a range of possible sites for storage retrofits and stream repairs, and the subwatershed has a high percentage of publicly-owned land which may provide retrofit opportunities.

9.3 Subwatersheds Recommended for Field Assessments

The Comparative Subwatershed Analysis results were used to guide the selection of "priority subwatersheds" that should be targeted for subsequent field assessments. The objective of the field assessments is to further evaluate subwatershed conditions and identify potential candidate restoration sites and opportunities. The priority subwatersheds generally include those subwatersheds that are ranked "high" in terms of potential vulnerability to future development or restoration potential.

The following subwatersheds are those that were ranked among the top four subwatersheds in terms of vulnerability or restoration potential, based on the results of the Comparative Subwatershed Analysis:

- Upper Pequonnock River
- Upper West Branch Pequonnock River
- Lower West Branch Pequonnock River
- Middle Pequonnock Tributaries
- Upper Booth Hill Brook
- Lower Booth Hill Brook
- Thrushwood Lake

The above list was subsequently refined for the final selection of subwatersheds recommended for field assessments. The objective of these refinements was to reduce potential redundancy, achieve relatively uniform geographic coverage, and select subwatersheds that reflect the full range of conditions that exist throughout the entire Pequonnock River watershed. Since the Upper and Lower West Branch Pequonnock River subwatersheds are similar in terms of development characteristics and vulnerability/restoration potential, the larger Upper West Branch Pequonnock River subwatershed was retained for field assessments as representative of both subwatersheds. Similarly, the Upper Pequonnock River and Middle Pequonnock River Tributaries subwatersheds are similar in terms of restoration potential, so the Middle Pequonnock River Tributaries subwatershed was selected as representative of both subwatersheds. The Lower Booth Hill Brook subwatershed was also eliminated from the final list since it is similar to both the Upper Booth Hill Brook and Thrushwood Lake subwatersheds. Two other subwatersheds, Island Brook and the Lower Pequonnock River, were added to the final list to include areas of urban development in the lower portions of the watershed.

Therefore, the resulting subwatersheds recommended for field assessments consist of (*Figure 9-1*):

- Upper West Branch Pequonnock River
- Middle Pequonnock Tributaries
- Upper Booth Hill Brook
- Thrushwood Lake
- Island Brook
- Lower Pequonnock River

The field assessments will include stream corridor assessments, upland subwatershed site reconnaissance (neighborhood source assessment, hotspot confirmation, and streets and storm drain assessment), and upland stormwater retrofit inventories

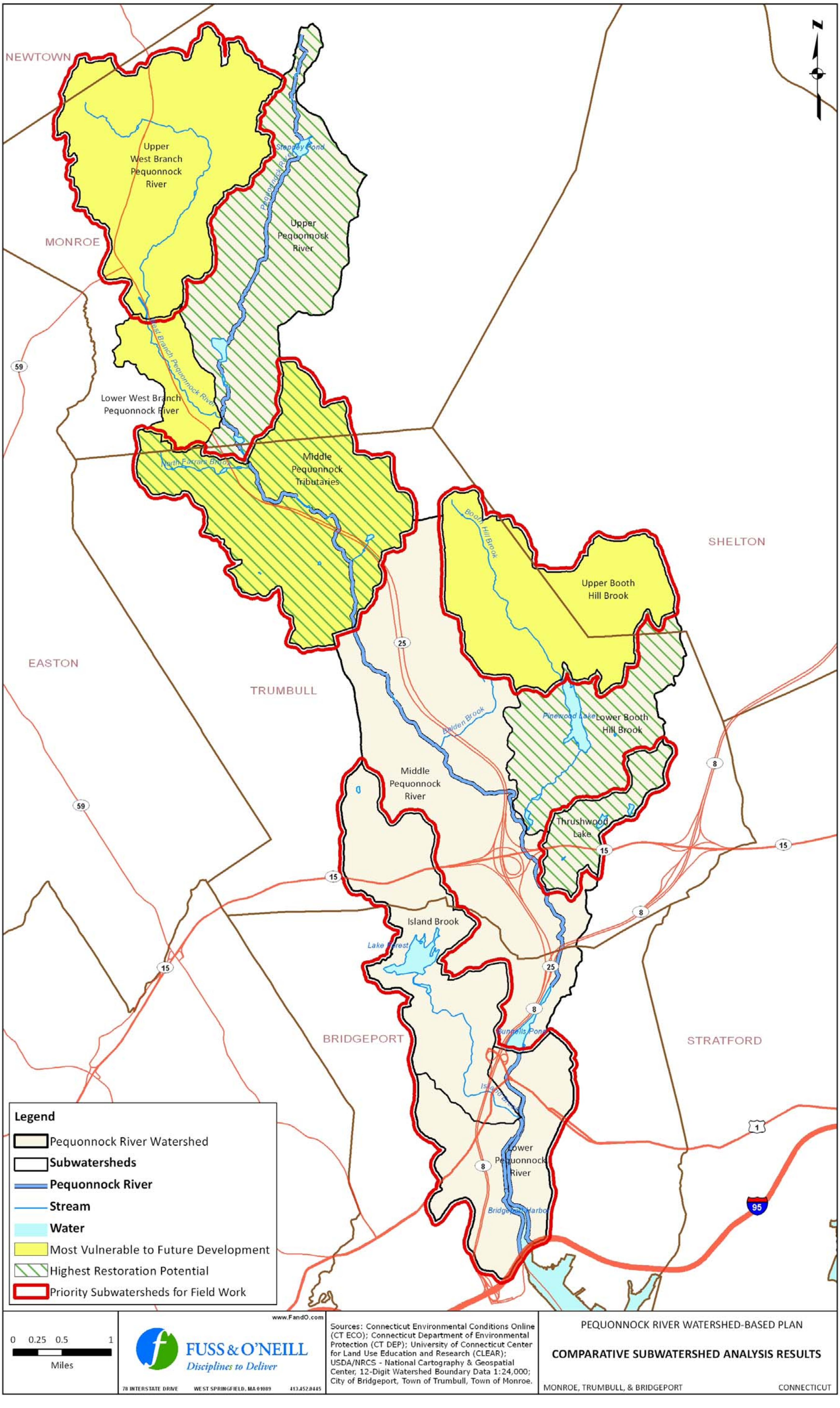

Figure 9-1. Priority Subwatersheds Recommended for Field Assessments

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Appendix A

Species List

Bird Species within the Pequonnock River Watershed (Confirmed or Probable)
The Atlas of Breeding Birds of Connecticut.1994

- Pied-billed Grebe (*Podilymbus podiceps*)
- Least Bittern (*Ixobrychus exilis*)
- Great Blue Heron (*Ardea herodias*)
- Green Heron (*Butorides virescens*)
- Mute Swan (*Cygnus olor*)
- Canada Goose (*Branta canadensis*)
- Green-winged Teal (*Anas crecca*)
- American Black Duck (*Anas rubripes*)
- Mallard (*Anas platyrhynchos*)
- Gadwall (*Anas strepera*)
- Turkey Vulture (*Cathartes aura*)
- Red-shouldered Hawk (*Buteo lineatus*)
- Broad-winged Hawk (*Buteo platypterus*)
- Red-tailed Hawk (*Buteo jamaicensis*)
- American Kestrel (*Falco sparverius*)
- Ring-necked Pheasant (*Phasianus colchicus*)
- Ruffed Grouse (*Bonasa umbellus*)
- Northern Bobwhite (*Colinus virginianus*)
- Clapper Rail (*Rallus longirostris*)
- Piping Plover (*Charadrius melodus*)
- Killdear (*Charadrius vociferous*)
- Willet (*Catoptrophorus semipalmatus*)
- Spotted Sandpiper (*Actitis macularia*)
- Upland Sandpiper (*Bartramia longicauda*)
- Common Tern (*Sterna hirundo*)
- Least Tern (*Sterna antillarum*)
- Black Skimmer (*Rynchops niger*)
- Rock Dove (*Columba livia*)
- Mourning Dove (*Zenaida macroura*)
- Barn Owl (*Tyto alba*)
- Common Nighthawk (*Chordeiles minor*)
- Chimney Swift (*Chaetura pelagica*)
- Belted Kingfisher (*Ceryle alcyon*)
- Red-bellied Woodpecker (*Melanerpes carolinus*)
- Downy Woodpecker (*Picoides pubescens*)
- Hairy Woodpecker (*Picoides villosus*)
- Northern Flicker (*Colaptes auratus*)
- Eastern Wood-Pewee (*Contopus virens*)
- Willow Flycatcher (*Empidonax traillii*)
- Eastern Phoebe (*Sayornis phoebe*)
- Great Crested Flycatcher (*Myiarchus crinitus*)

- Eastern Kingbird (*Tyrannus tyrannus*)
- Horned Lark (*Eremophilia alpestris*)
- Tree Swallow (*Tachycineta bicolor*)
- Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)
- Barn Swallow (*Hirundo rustica*)
- Blue Jay (*Cyanocitta cristata*)
- American Crow (*Corvus brachyrhynchos*)
- Fish Crow (*Corvus ossifragus*)
- Black-capped Chickadee (*Parus atricapillus*)
- Tufted Titmouse (*Parus bicolor*)
- White-breasted Nuthatch (*Sitta carolinensis*)
- Brown Creeper (*Certhia americana*)
- Carolina Wren (*Thryothorus ludovicianus*)
- House Wren (*Troglodytes aedon*)
- Marsh Wren (*Cistothorus palustris*)
- Blue-gray Gnatcatcher (*Polioptila caerulea*)
- Eastern Bluebird (*Sialia sialis*)
- Veery (*Catharus fuscescens*)
- Wood Thrush (*Hylocichla mustelina*)
- American Robin (*Turdus migratorius*)
- Gray Catbird (*Dumetella carolinensis*)
- Northern Mockingbird (*Mimus polyglottos*)
- Brown Thrasher (*Toxostoma rufum*)
- Cedar Waxwing (*Bombycilla cedrorum*)
- European Starling (*Sturnus vulgaris*)
- White-eyed Vireo (*Vireo griseus*)
- Yellow-throated Vireo (*Vireo flavifrons*)
- Red-eyed Vireo (*Vireo olivaceus*)
- Blue-winged Warbler (*Vermivora pinus*)
- Yellow Warbler (*Dendroica petechia*)
- Chestnut-sided Warbler (*Dendroica pensylvanica*)
- Black-and-white Warbler (*Mniotilta varia*)
- American Redstart (*Setophaga ruticilla*)
- Worm-eating Warbler (*Helmitheros vermivorus*)
- Ovenbird (*Seiurus aurocapillus*)
- Louisiana Waterthrush (*Seiurus motacilla*)
- Common Yellowthroat (*Geothlypis trichas*)
- Scarlet Tanager (*Piranga olivacea*)
- Northern Cardinal (*Cardinalis cardinalis*)
- Rose-breasted Grosbeak (*Pheucticus ludovicianus*)
- Indigo Bunting (*Passerina cyanea*)
- Rufous-sided Towhee (*Pipilo erythrophthalmus*)
- Chipping Sparrow (*Spizella passerina*)
- Field Sparrow (*Spizella pusilla*)

- Sharp-tailed Sparrow (*Ammodramus caudacuts*)
- Seaside Sparrow (*Ammodramus maritimus*)
- Song Sparrow (*Melospiza melodia*)
- Swamp Sparrow (*Melospiza georgiana*)
- White-throated Sparrow (*Zonotrichia albicollis*)
- Dark-eyed Junco (*Junco hyemalis*)
- Bobolink (*Dolichonyx oryzivorus*)
- Red-winged Blackbird (*Agelaius phoeniceus*)
- Eastern Meadowlark (*Sturnella magna*)
- Common Grackle (*Quiscalus quiscula*)
- Brown-headed Cowbird (*Molothrus ater*)
- Orchard Oriole (*Icterus spurious*)
- Northern Oriole (*Icterus galbula*)
- House Finch (*Carpodacus mexicanus*)
- American Goldfinch (*Carduelis tristis*)
- House Sparrow (*Passer domesticus*)

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Appendix B

Pollutant Loading Analysis

Appendix B

Pollutant Loading Analysis
Pequonnock River Watershed

Appendix B

Pollutant Loading Analysis
Pequonnock River Watershed

Tables

End of Report

1 Introduction

A pollutant loading analysis was performed for the Pequonnock River watershed in support of the Baseline Watershed Assessment Report to assess the potential for increases in nonpoint source (NPS) pollutant loads. The model was used to compare existing nonpoint source (NPS) pollutant loads from the watershed to projected future pollutant loads under a watershed buildout scenario. The predicted change in pollutant loads in each of the subwatersheds was used as an indicator of their relative vulnerability to future development. The pollutant loading model is used to identify and rank pollution sources, as well as assist in identifying, prioritizing, and evaluating subwatershed pollution control strategies.

2 Model Description

A pollutant loading model was applied to the Pequonnock River watershed using the land use/land cover data described in *Section 7.0* of the Baseline Watershed Assessment Report. The model was used to compare pollutant loadings from the watershed under existing land use conditions to future pollutant loadings under a watershed buildout scenario. It is important to note that the results of this screening-level analysis are intended for the purposes of comparing existing to future conditions and not to predict future water quality.

The Watershed Treatment Model (WTM), Version 2010 (Beta), 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:

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

Reductions in future pollutant loads in the watershed can be estimated using a range of treatment measures, such as structural and nonstructural best management practices, that are included in the WTM.

Other similar screening-level pollutant loading models were considered for use in development of a watershed management plan for the Pequonnock River, including the Spreadsheet Tool for the Estimation of Pollutant Load (STEPL), the Generalized Watershed Loading Function (GWLF) model, and other similar models. While STEPL was identified as a suitable choice for the Pequonnock River, it was determined that the WTM is better suited for modeling bacterial loads and provides a larger suite of best management practices for urban areas. The ArcView GIS version of the GWLF model was also considered for use in the evaluation, although the AVGWLF model has limited capability for modeling CSOs when using the urban runoff module RUNQUAL within the GWLF model. Again, the WTM model was determined to be better suited for modeling CSOs than the AVGWLF model.

The pollutants modeled in this analysis are the default pollutants contained in the WTM model: total phosphorus, total nitrogen, total suspended solids, and total fecal coliform bacteria. These pollutants are the major NPS pollutants of concern in environmental systems. Additional loading from the CSOs during wet-weather was simulated in the Lower Pequonnock River subwatershed, where such discharges are known to exist.

Nitrogen and phosphorus are nutrients that promote the growth of algae and plants in water. When this biomass dies and settles to the bottom of water bodies, its decomposition consumes oxygen which is needed by other organisms for survival. Nitrogen is generally present in relatively small quantities compared to other nutrients in salt water systems, such as Long Island Sound, so limiting its concentration limits the growth of algae. In fresh water systems, such as the streams and impoundments in the non-tidal portions of the Pequonnock River watershed, phosphorus is the nutrient that is relatively scarce and thus limits algal growth. Nitrogen is generally the nutrient of concern in the tidal portion of the Pequonnock River and Bridgeport Harbor.

Total suspended solids (TSS) is a measure of both biodegradable and mineral sediment. Its discharge to a water body results in turbidity and sedimentation. TSS may also have secondary effects; biodegradable TSS exerts a biological oxygen demand (BOD), and mineral TSS can be associated with particulate phosphorus.

Fecal coliform is commonly used as a surrogate parameter to indicate the possible presence of disease-causing bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming or contact recreation might be a health risk. Fecal coliform is present in stormwater runoff due to contamination with the fecal material of humans or animals and can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage (EPA, 2006).

3 Model Inputs

3.1 Nonpoint Source Runoff

Land use/land cover data described in the Baseline Watershed Assessment Report were adapted for use in the WTM. Data were prepared in this manner for both the existing conditions and future conditions (watershed buildout) pollutant loading scenarios. Land use categories were based on GIS data from the Greater Bridgeport Regional Planning Agency (GBRPA) and the City of Bridgeport. The GBPRA data reflect conditions in 2000, while the Bridgeport data were compiled in 2008. The land use data were compared to 2008 aerial photography, and the data were revised where necessary to reflect land use changes that have occurred since the data sets were originally developed. The WTM allows the user to enter custom land use categories. The land use categories that are chosen for the model were selected based on the parameter-specific land use categories listed in *Table B-2*. *Table B-3* summarizes the assignment of WTM land use categories for each of the GBPRA and City of Bridgeport land use categories. The open space land use category includes a variety of general uses, including cemeteries, golf courses, recreational parks, and open space areas with turf cover. The forested land use category was used for larger contiguous areas of forest cover.

The WTM 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. Since comparison between existing and proposed watershed conditions is the focus of this analysis, EMC values were selected to reflect the relative difference in NPS pollutant characteristics between existing and future land uses. *Table B-2* at the end of this report shows EMC values from several sources for the pollutants of interest, with the selected values displayed at the bottom of the table.

The default impervious cover coefficients in the WTM were adjusted to better reflect local conditions in the Pequonnock River watershed. Impervious cover coefficients for each land use category were selected from WTM default impervious cover coefficients and literature values. The selected impervious cover coefficients are presented in *Table B-1*.

3.2 Other Pollutant Sources

In addition to nonpoint source runoff pollutant loads, the 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 Pequonnock River watershed.

3.2.1 Combined Sewer Overflows

The WTM uses a modification of the Simple Method to calculate annual loads from CSOs. The primary assumption is that CSO discharges occur when the combined volume of stormwater and wastewater exceeds the total system capacity. The system is assumed to experience approximately 50 CSO discharge events annually in the Pequonnock River. Statistical analysis of 40 years of daily precipitation data at a nearby weather station reveals that the median storm in the area is approximately 0.16 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 WTM, 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, summarized in *Table B-5*.

3.2.2 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 WTM makes separate assumptions for residential and business illicit connections. For residential connections, the WTM's 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 2000 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 and/or buildings on aerial mapping within the commercial, industrial, and institutional land uses.

3.2.3 Septic Systems

The portion of the watershed in Bridgeport and large portions of the watershed in Trumbull are served by sanitary sewers, with ongoing additions to the sewer service in Trumbull. Currently, some portions of Trumbull and all of Monroe are served by private septic systems. The number of unsewered dwelling units in each subwatershed was estimated using GIS data including the mapped sewer service area, U.S. Census data, assessor's data, and aerial photographs. The approximate number of unsewered dwelling units in each subwatershed is provided as *Table B-6*. The WTM default values were used for septic system failure rate (30%) and effluent concentrations from both working and failing septic systems.

3.2.4 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.

3.2.5 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 in Massachusetts 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. Note that winter road application is typically a 50/50 mixture of road sand and salt. The volume of salt is not included in this calculation, so the result is for total suspended solids only. Since road sand consists of relatively large sediment particle sizes, not all of the sediment will reach the receiving water body due to gravity settling. The default WTM assumption is that 90% of road sand is delivered to the receiving water in closed section roads, while only 35% is delivered in open section roads.

4 Existing Pollutant Loads

Table B-7 presents the existing modeled pollutant loads for the Pequonnock River watershed. Nonpoint source runoff accounts for approximately 82% of the total nitrogen load, 75% of the total phosphorus load, 46% of the total suspended solids load, and 48% of the fecal coliform bacteria load for the entire watershed. Road sanding accounts for nearly the entire balance of the total suspended solids load, while CSOs contribute approximately 48% of the fecal coliform load for the watershed. *Table B-8* presents a breakdown of estimated annual loadings of total nitrogen, total phosphorus, TSS, and fecal coliform by subwatershed.

Because the study subwatersheds vary in size, pollutant loads were also evaluated in terms of loading rates (i.e., pollutant loads per acre of land area, as shown in *Table B-8*). A higher loading rate indicates relatively greater pollutant sources per unit area, which suggests that implementation of best management practices (BMPs) in these areas may be more effective in reducing pollutant loads. The highest loading rates for nitrogen and phosphorus are associated with the Lower Pequonnock River, Island Brook, and Thrushwood Lake subwatersheds. Lower Pequonnock River, Island Brook, and Middle Pequonnock Tributaries subwatersheds have the highest loading rates of total suspended solids. The Lower Pequonnock River subwatershed has the highest rate of stormwater runoff in the watershed and largest fecal coliform loading rate due to contributions from CSOs and nonpoint sources.

- *Lower Pequonnock River*. The Lower Pequonnock River subwatershed has a high percentage of commercial, industrial, mixed use and multi-family land uses which are associated with higher pollutant loading coefficients for nutrients, bacteria, and TSS. 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 Pequonnock River. Since this subwatershed is smaller in total land area than others, it does not have the highest absolute pollutant loading (with the exception of TSS); however the loading rates per acre are the highest in the watershed for all of the modeled pollutants and runoff volume. The estimated nonpoint source nitrogen loading rate is 14.7 lb/ac-year, the phosphorus loading rate is estimated at 3.1 lb/ac-year, the TSS loading rate is 1,141 lb/ac-year, and the estimated fecal coliform loading due to nonpoint source runoff is 127.6 billion/ac-year. The pollutant loading rates in this subwatershed are generally greater than 2 times that in the subwatersheds in the middle and northern portions of the watershed. The contribution of fecal coliform from sewer overflows is significantly larger (1,079 billion/ac-year) than the nonpoint source runoff contribution.

- *Island Brook*. Island Brook ranks second among subwatersheds in annual pollutant loading rates. The high loading is due to the proportionally high commercial/industrial, residential, and roadway land uses in this subwatershed.

- *Thrushwood Lake*. The Thrushwood Lake subwatershed is the smallest in the watershed (442 acres) and therefore has relatively low absolute pollutant loading rates. However, it is among the highest in terms of pollutant loading rates. The subwatershed primarily consists of single-family land use.

- *Middle Pequonnock River*. This subwatershed is the largest in the watershed in size (3,835 acres) and therefore has high pollutant loading values for nitrogen, phosphorus, TSS, fecal coliform, and total yearly runoff volume. The pollutant loading rates in this subwatershed are comparable to the nearby subwatersheds, with loading rates of 8.2 lb/ac-year nitrogen, 1.9 lb/ac-year phosphorus, 533 lb/ac-year TSS, 78.3 lb/ac-year fecal coliform, and 15.3 acre-feet/year runoff.

Table B-9 summarizes the contribution of nonpoint source pollutant loads by land use for the entire watershed. The majority of the nitrogen and phosphorus loads are from roadway and residential land uses. The majority of the TSS loads is due to roadway (51.7%) and single-family residential (14.3%) land use. Single-family and multi-family residential land uses account for approximately 87.2% of the nonpoint source bacterial load. Other modeled pollutant sources contribute significantly to the watershed pollutant loads, particularly CSOs, which are the predominant source of the fecal coliform loads in the watershed.

5 Future Pollutant Loads

Anticipated future land use due to new development within the watershed (*Table B-10)* was used in the WTM model to simulate potential future pollutant loads under a watershed buildout scenario. The predicted changes in land use under a watershed buildout scenario are presented in *Table B-11*. Future land use categories were derived from the watershed buildout scenario presented in the Baseline Watershed Assessment Report. Future controls or best management practices were not considered in the calculation of future pollutant loads. Therefore, the predicted future pollutant loads reflect a potential worst-case scenario against which potential watershed management pollution control strategies may be evaluated. Additionally, future pollutant loads were modeled with and without CSO mitigation to evaluate the potential reductions in pollutant loads that could be achieved by the City of Bridgeport's ongoing and planned CSO abatement efforts.

Table B-12 presents projected future pollutant loads and load increases under a watershed buildout scenario. Not considering ongoing and planned CSO mitigation efforts, a significant increase in nutrient and bacteria pollutant loads is predicted in many of the subwatersheds. *Table B-13* presents the projected future pollutant loads in terms of the projected load increase based on existing loads (percent increase) and loading rate increase for each subwatershed.

The watershed as a whole is predicted to experience a 2.3% increase in nitrogen loads, a 2.0% increase in phosphorus loads, a 3.2% increase in TSS loads, and a 41.9% *decrease* in fecal coliform loads under a future buildout scenario, assuming full implementation of the ongoing and proposed CSO mitigation plans, which will significantly improve water quality conditions in the Lower Pequonnock River. CSO abatement measures will not address bacterial loads in upstream areas. Almost all of the other subwatersheds are predicted to experience increases in fecal coliform loads (between 0.4 and 44.7% increases) under a watershed buildout scenario due to stormwater and nonpoint source runoff.

The Upper and Lower West Branch Pequonnock River subwatersheds are predicted to experience significantly higher increases in pollutant loads and loading rates under a watershed buildout scenario corresponding to areas with significant developable land. An increase in nutrient loadings (nitrogen and phosphorus) of 39 to 41% is predicted, and fecal coliform loads could increase by as much as 45% in the Lower West Branch Pequonnock River subwatershed. Runoff volumes in these subwatersheds are predicted to increase by between 1.9 and 2.4%, although the increase in runoff volume in the overall watershed is expected to increase by only 0.5%.

6 References

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Tables

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Table B-1. Impervious Cover Coefficients

Land Use	Impervious Cover Coefficients			
	STEPL	NEMO[1]	WTM	Selected
Commercial	0.85	0.205 - 0.557	0.72	0.7
Industrial	0.7	0.264 - 0.557	0.53	0.5
Institutional	0.5	-	-	0.3
Mixed Use	-	-	-	0.55
Multi-Family	0.75	0.09 - 0.39	0.44	0.44
Open Space	0.01	0.001 - 0.094		0.01
Forest	-	-	-	0
Roadway	0.95	0.433	0.8	0.8
Single Family	0.3	0.065 - 0.12	0.21	0.21
Vacant	-	-	-	0.02
Water	-	-	-	0

[1]Sleavin et al. (2000) and Prisloe et al. (2003)

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

Source	Pollutant	Open Space (Urban)	Commercial	Multi-Family	Single Family	Institutional	Industrial	Mixed Use	Vacant	Forest	Roadway	Water	Units
STEPL	N	1.5	2	2.2	2.2	1.8	2.5	-	1.5	0.2	3	-	mg/L
	P	0.15	0.2	0.4	0.4	0.3	0.4	-	0.15	0.1	0.5	-	mg/L
	FC	-	-	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	70	75	100	100	67	120	-	70	-	150	-	mg/L
NSQD	N*	1.2	2.2	2	-	-	2.1	-	-	-	2.3	-	mg/L
	P	0.25	0.22	0.3	-	-	0.26	-	-	-	0.25	-	mg/L
	FC	-	-	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	51	43	48	-	-	77	-	-	-	99	-	mg/L
NURP	N*	1.5	1.75	2.6	-	-	-	1.85	-	-	-	-	mg/L
	P	0.1	0.201	0.38	-	-	-	0.262	-	-	-	-	mg/L
	FC	-	-	-	-	-	-	-	-	-	-	-	#/100mL
	TSS	70	57	101	-	-	-	67	-	-	-	-	mg/L
WTM	N*	-	2	2	2	-	-	-	-	-	2	12.8 (lb/acre)	mg/L
	P	-	0.26	0.26	0.26	-	-	-	-	-	0.26	0.5 (lb/acre)	mg/L
	FC	-	20,000	20,000	20,000	-	-	-	-	-	20,000	155 (lb/acre)	#/100mL
	TSS	-	55	55	55	-	-	-	-	-	55	0 (# billion/acre)	mg/L
RUNQUAL	N*	-	-	-	-	-	-	-	-	-	-	-	mg/L
	P	-	-	-	-	-	-	-	-	-	-	-	mg/L
	FC	-	9,600	9,600	9,600	9,600	9,600	-	-	-	-	-	#/100mL
	TSS	-	-	-	-	-	-	-	-	-	-	-	mg/L
CH2M HILL	N*	1.1	-	2.7	1.2	-	-	-	-	-	-	-	mg/L
	P	0.2	-	0.3	0.2	-	-	-	-	-	-	-	mg/L
	FC	500	1,400	8,700	8,700	1,400	2,300	-	-	500	1,400	-	#/100mL
	TSS	20	-	47.7	22.1	-	-	-	-	70	-	-	mg/L
Selected	**N***	**1.5**	**2.2**	**2.7**	**1.2**	**1.8**	**2.5**	**2.2**	**1.5**	**0.2**	**3**	**0**	**mg/L**
	P	**0.15**	**0.4**	**0.3**	**0.2**	**0.3**	**0.4**	**0.25**	**0.15**	**0.1**	**0.5**	**0**	**mg/L**
	FC	**500**	**1,400**	**8,700**	**8,700**	**1,400**	**2,300**	**2,000**	**500**	**500**	**1,400**	**0**	**#/100mL**
	TSS	**20**	**100**	**47.7**	**22.1**	**67**	**120**	**67**	**20**	**70**	**150**	**0**	**mg/L**

N=Total Nitrogen; P=Total Phosphorus; FC=Fecal Coliform; TSS=Total Suspended Solids
*Nitrate and nitrite only **N, P, TSS units are lb/acre, FC units are (# billion/acre)
See References for Source Information

Table B-3. Modeled Land Use Categories

WTM Land Use Category	Greater Bridgeport Regional Planning Agency (GBRPA) Land Use Category	City of Bridgeport Land Use Category
Open Space	Agricultural; BHC Land**; Recreational	Park/Open Space
Commercial	Commercial	Commercial
Multi-Family	Residential High Density	2-4 Family; 5+ Family
Single Family	Residential Low Density; Residential Medium Density	1 Family
Institutional	Institutional	Institutional
Industrial	Industrial	Light Industrial; Heavy Industrial; Utility
Mixed Use	--	Mixed Use
Vacant	Vacant	Vacant
Forest	Agricultural; BHC Land**; Recreational	Park/Open Space
Roadway	Utility or Transportation	Roadway*
Water	Waterbody	Water*

* Areas of roadway and surface water bodies were not included in the Bridgeport land use GIS data. These categories were added based on other GIS data sets and aerial photography.
** BHC Land is Bridgeport Hydraulic Company Lands which are now owned by Aquarion Water Company.

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Table B-4. Existing Land Use Composition by Subwatershed

Subwatershed	Existing Modeled Land Use Composition (acres)										
	Commercial	Industrial	Institutional	Mixed Use	Multi-Family	Open Space	Forest	Roadway	Single Family	Vacant	Water
Upper Pequonnock River (2,456 ac)	0	47	72	0	101	195	428	175	1206	196	37
Upper West Branch Pequonnock River (2,522 ac)	131	252	51	0	285	98	567	168	827	141	2
Lower West Branch Pequonnock River (533 ac)	82	0	16	0	0	35	160	42	198	0	0
Middle Pequonnock Tributaries (2,434 ac)	75	209	49	0	44	233	235	227	1293	59	10
Middle Pequonnock River (3,835 ac)	97	78	202	0	116	492	411	529	1801	52	55
Upper Booth Hill Brook (1,895 ac)	0	0	72	0	0	31	271	154	1359	8	0
Lower Booth Hill Brook (1,363 ac)	0	0	63	0	0	21	336	95	775	0	73
Thrushwood Lake (442 ac)	0	0	8	0	46	50	1	51	285	0	0
Island Brook (1,741 ac)	41	79	33	3	119	95	0	304	922	65	80
Lower Pequonnock River (1,398 ac)	204	123	105	25	312	54	0	370	114	39	52
Total (Watershed)	**631**	**788**	**671**	**28**	**1023**	**1305**	**2408**	**2116**	**8781**	**559**	**309**

Table B-5. Model Parameters – CSOs and Illicit Connections

Pollutant Source	Parameter	Description (Source)
Combined Sewer Overflows (LPR subwatershed only)	Median Storm Event (inches) = 0.16 Sewershed Area (acres) = 1,398 Sewershed Impervious Cover (%) = 51% # of CSOs/year = 50 Critical CSO value (rainfall depth in inches) = 0.1	WTM, 2001- Model default values; NOAA precipitation data
Household and Business Illicit Connections	Household Fraction of Population Illicitly Connected = 0.001 Business Fraction of Businesses with Illicit Connections = 0.1 Fraction of Business Connections that are Wash Water Only = 0.9	WTM, 2001; Model default values

Table B-6. Model Input Data - Septic Systems, Illicit Connections, and Road Sanding

Subwatershed	Dwelling Units	Approximate Number of Unsewered Dwelling Units	Unsewered Dwelling Units (% of total)	# of businesses	Length of Roads (mi)	Road Sanding (lbs/yr)*
Upper Pequonnock River	1704	1704	100%	25	25.9	259,150
Upper West Branch Pequonnock River	1591	1591	100%	140	29.7	296,804
Lower West Branch Pequonnock River	417	417	100%	50	8.0	79,534
Middle Pequonnock Tributaries	2664	1252	47%	50	47.3	472,610
Middle Pequonnock River	6161	1785	29%	25	103.4	1,033,812
Upper Booth Hill Brook	2156	902	42%	0	32.3	323,317
Lower Booth Hill Brook	1815	1386	76%	0	19.9	198,883
Thrushwood Lake	967	567	59%	0	12.8	128,498
Island Brook	7206	1251	17%	300	59.3	592,714
Lower Pequonnock River	11383	0	0%	1000	80.1	800,967

*Massachusetts average 5 tons/lane-mile (annual); assume 2 lane roads; assume 50/50 sand-salt mix. (Source: Transportation Research Board. (1991). Highway Deicing Comparing Salt and Calcium Magnesium Acetate. National Research Council. Washington, D.C. 1991. Special Report 235.)

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

	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)
Primary Sources - Land Use	132,805	26,919	4,402,266	1,515,065	283,426
Secondary Sources	28,779	8,987	5,223,712	1,645,409	0
CSOs	4,797	959	10,344	1,508,508	0
Channel Erosion	4,402	4,402	1,467,422	0	0
Road Sanding	0	0	3,613,055	0	0
Illicit Discharges	870	507	8,154	108,589	0
Septic Systems	18,711	3,118	124,738	28,312	0
Total	**161,584**	**35,906**	**9,625,978**	**3,160,475**	**283,426**

Table B-8. Modeled Existing Pollutant Loads

Subwatershed	Existing Pollutant Loads					Existing Pollutant Loading Rates				
	N	P	TSS	Fecal Coliform	Runoff Volume	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/ac-yr	(acre-feet/year)
Upper Pequonnock River (2,456 ac)	16,678	3,767	719,746	194,826	31,402	6.8	1.5	293.1	79.3	12.8
Upper West Branch Pequonnock River (2,522 ac)	20,947	4,523	1,023,909	201,542	36,653	8.3	1.8	406.0	79.9	14.5
Lower West Branch Pequonnock River (533 ac)	4,073	943	289,283	36,021	7,361	7.4	1.7	523.1	65.1	13.3
Middle Pequonnock Tributaries (2,434 ac)	19,193	4,465	1,477,284	208,816	37,338	7.9	1.8	606.9	85.8	15.3
Middle Pequonnock River (3,835 ac)	31,339	7,104	2,046,958	300,261	58,504	8.2	1.9	533.8	78.3	15.3
Upper Booth Hill Brook (1,895 ac)	11,758	2,890	643,760	186,440	26,389	6.2	1.5	339.7	98.4	13.9
Lower Booth Hill Brook (1,363 ac)	9,487	2,031	426,698	109,604	16,037	7.0	1.5	313.1	80.4	11.8
Thrushwood Lake (442 ac)	4,259	925	224,897	49,674	7,265	9.6	2.1	508.8	112.4	16.4
Island Brook (1,741 ac)	18,500	3,972	1,167,666	186,425	30,534	10.6	2.3	670.7	107.1	17.5
Lower Pequonnock River (Without CSOs) (1,398 ac)	20,553	4,325	1,595,435	178,357	31,942	14.7	3.1	1,141.2	127.6	22.8
CSOs	4,797	959	10,344	1,508,508	0	3.4	0.7	7.4	1,079.0	0.0
Watershed Total (18,639 ac)	161,584	35,906	9,625,978	3,160,475	283,426	8.7	1.9	516	169.6	15.2

Table B-9. Modeled Existing Pollutant Loads by Land Use

Land Use	N	P	TSS	Fecal Coliform	Runoff Volume	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)	%	%	%	%	%
Commercial	9,141	1,770	410,636	26,201	18,170	6.9%	6.6%	9.3%	1.7%	6.4%
Industrial	10,412	1,895	489,134	42,727	18,036	7.8%	7.0%	11.1%	2.8%	6.4%
Institutional	4,909	1,090	172,888	16,464	11,418	3.7%	4.0%	3.9%	1.1%	4.0%
Mixed Use	346	47	10,318	1,404	681	0.3%	0.2%	0.2%	0.1%	0.2%
Multi-Family	13,508	1,850	232,943	193,633	21,608	10.2%	6.9%	5.3%	12.8%	7.6%
Open Space	4,473	1,243	49,939	5,690	11,048	3.4%	4.6%	1.1%	0.4%	3.9%
Forest	171	86	59,876	1,949	3,785	0.1%	0.3%	1.4%	0.1%	1.3%
Roadway	45,771	7,873	2,276,617	96,840	67,157	34.5%	29.2%	51.7%	6.4%	23.7%
Single Family	38,021	10,342	628,420	1,127,472	125,820	28.6%	38.4%	14.3%	74.4%	44.4%
Vacant	2,095	569	23,559	2,684	5,212	1.6%	2.1%	0.5%	0.2%	1.8%
Water	3,958	155	47,934	0	490	3.0%	0.6%	1.1%	0.0%	0.2%
Total	**132,805**	**26,919**	**4,402,266**	**1,515,065**	**283,426**					

Table B-10. Modeled Future Land Use Composition

Subwatershed	Land Use Composition (acres)										
	Commercial	Industrial	Institutional	Mixed Use	Multi-Family	Open Space	Forest	Roadway	Single Family	Vacant	Water
Upper Pequonnock River (2,456 ac)	4	94	76	0	101	153	385	175	1431	0	37
Upper West Branch Pequonnock River (2,522 ac)	135.5	552.1	55.8	0.0	311.0	83.0	248.8	168.4	962.3	3.3	1.8
Lower West Branch Pequonnock River (533 ac)	104.5	0.1	15.7	0.0	0.0	5.5	134.0	42.1	251.1	0.0	0.0
Middle Pequonnock Tributaries (2,434 ac)	86.7	232.7	48.7	0.0	57.0	218.1	160.7	226.8	1,392.4	0.3	10.2
Middle Pequonnock River (3,835 ac)	105.3	92.1	249.9	0.3	116.1	430.6	376.9	544.5	1,863.0	1.2	54.9
Upper Booth Hill Brook (1,895 ac)	0.0	0.0	79.7	0.0	0.0	30.7	172.6	154.2	1,457.5	0.0	0.3
Lower Booth Hill Brook (1,363 ac)	0.0	0.0	63.0	0.0	0.0	21.0	332.8	94.8	778.5	0.0	72.8
Thrushwood Lake (442 ac)	0.0	0.0	8.2	0.0	46.4	47.7	0.0	51.4	288.0	0.0	0.0
Island Brook (1,741 ac)	43.6	81.6	33.2	2.8	121.3	94.9	0.0	304.4	956.6	22.5	80.3
Lower Pequonnock River (1,398 ac)	211.0	139.0	107.4	24.9	321.2	53.8	0.0	370.5	116.2	1.9	52.3
Total (Watershed)	**691**	**1192**	**738**	**28**	**1074**	**1138**	**1811**	**2132**	**9496**	**29**	**309**

Table B-11. Modeled Change in Land Use Composition by Subwatershed

Subwatershed	Change in Land Use Composition (acres)										
	Commercial	Industrial	Institutional	Mixed Use	Multi-Family	Open Space	Forest	Roadway	Single Family	Vacant	Water
Upper Pequonnock River (2,456 ac)	4.5	47.0	3.9	0.0	0.0	-42.1	-42.1	0.0	224.7	-195.8	0.0
Upper West Branch Pequonnock River (2,522 ac)	4.3	299.7	5.0	0.0	26.3	-15.2	-318.0	0.0	135.5	-137.6	0.0
Lower West Branch Pequonnock River (533 ac)	22.7	0.0	0.0	0.0	0.0	-29.9	-26.3	0.0	52.8	0.0	0.0
Middle Pequonnock Tributaries (2,434 ac)	11.5	24.0	0.0	0.0	13.2	-15.0	-74.1	0.0	99.3	-59.0	0.0
Middle Pequonnock River (3,835 ac)	7.9	14.3	47.8	0.0	0.0	-61.9	-34.3	15.2	61.7	-50.8	0.0
Upper Booth Hill Brook (1,895 ac)	0.0	0.0	7.8	0.0	0.0	0.0	-98.2	0.0	98.2	-7.8	0.0
Lower Booth Hill Brook (1,363 ac)	0.0	0.0	0.0	0.0	0.0	0.0	-3.3	0.0	3.3	0.0	0.0
Thrushwood Lake (442 ac)	0.0	0.0	0.0	0.0	0.0	-2.5	-0.7	0.0	3.2	0.0	0.0
Island Brook (1,741 ac)	2.2	2.6	0.0	0.0	2.3	0.0	0.0	0.0	35.1	-42.2	0.0
Lower Pequonnock River (1,398 ac)	6.8	16.4	2.2	0.0	9.4	0.0	0.0	0.0	1.9	-36.6	0.0
Total (Watershed)	**59.9**	**404.0**	**66.7**	**0.0**	**51.2**	**-166.6**	**-596.9**	**15.2**	**715.6**	**-529.7**	**0.0**

Table B-12. Modeled Future Pollutant Loads and Load Increases*

Subwatershed	Projected Future Pollutant Loads					Projected Load Increase				
	N	P	TSS	Fecal Coliform	Runoff Volume	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)	lb/yr	lb/yr	lb/yr	billion/yr	(acre-feet/year)
Upper Pequonnock River	17,530	3,935	758,512	225,457	31,598	852	168	38,766	30,631	196
Upper West Branch Pequonnock River	25,417	5,350	1,201,129	258,242	37,365	4,470	827	177,220	56,700	712
Lower West Branch Pequonnock River	4,896	1,139	309,451	52,121	7,540	823	196	20,167	16,100	178
Middle Pequonnock Tributaries	20,019	4,623	1,505,075	225,489	37,490	826	158	27,791	16,672	152
Middle Pequonnock River	31,951	7,218	2,074,710	311,834	58,608	612	114	27,752	11,573	105
Upper Booth Hill Brook	12,207	3,008	650,038	199,147	26,499	448	118	6,278	12,707	110
Lower Booth Hill Brook	9,501	2,035	426,850	110,022	16,040	14	4	153	419	3
Thrushwood Lake	4,264	927	225,013	50,074	7,267	5	1	116	400	2
Island Brook	18,601	3,990	1,172,067	191,420	30,560	100	18	4,401	4,995	25
Lower Pequonnock River (Without CSOs)	20,886	4,371	1,611,405	181,428	31,985	334	46	15,970	3,071	43
CSOs*	96	19	207	30,170	0	-4,701	-940	-10,137	-1,478,338	0
Watershed Total	**165,369**	**36,616**	**9,934,456**	**1,835,404**	**284,952**	**3,784**	**709**	**308,478**	**-1,325,071**	**1,527**

*Reflects completion of ongoing and planned CSO mitigation projects.

Table B-13. Modeled Future Pollutant Loading Rate Increases and Load Increases

Subwatershed	Projected Future Loading Rate					Projected Load Increase				
	N	P	TSS	Fecal Coliform	Runoff Volume	N	P	TSS	Fecal Coliform	Runoff Volume
	lb/ac-yr	lb/ac-yr	lb/ac-yr	billion/ac-yr	feet/year	%	%	%	%	%
Upper Pequonnock River (2,456 ac)	7.1	1.6	308.8	91.8	12.9	5.1%	4.5%	5.4%	15.7%	0.6%
Upper West Branch Pequonnock River (2,522 ac)	10.1	2.1	476.3	102.4	14.8	21.3%	18.3%	17.3%	28.1%	1.9%
Lower West Branch Pequonnock River (533 ac)	8.9	2.1	559.6	94.3	13.6	20.2%	20.8%	7.0%	44.7%	2.4%
Middle Pequonnock Tributaries (2,434 ac)	8.2	1.9	618.4	92.6	15.4	4.3%	3.5%	1.9%	8.0%	0.4%
Middle Pequonnock River (3,835 ac)	8.3	1.9	541.0	81.3	15.3	2.0%	1.6%	1.4%	3.9%	0.2%
Upper Booth Hill Brook (1,895 ac)	6.4	1.6	343.0	105.1	14.0	3.8%	4.1%	1.0%	6.8%	0.4%
Lower Booth Hill Brook (1,363 ac)	7.0	1.5	313.2	80.7	11.8	0.1%	0.2%	0.0%	0.4%	0.0%
Thrushwood Lake (442 ac)	9.6	2.1	509.1	113.3	16.4	0.1%	0.1%	0.1%	0.8%	0.0%
Island Brook (1,741 ac)	10.7	2.3	673.2	109.9	17.6	0.5%	0.4%	0.4%	2.7%	0.1%
Lower Pequonnock River (no CSOs) (1,398 ac)	14.9	3.1	1152.6	129.8	22.9	1.6%	1.1%	1.0%	1.7%	0.1%
CSOs*	0.1	0.0	0.1	21.6	0.0	-98.0%	-98.0%	-98.0%	-98.0%	0.0%
Watershed Total (18,639 ac)	**8.9**	**2.0**	**533.0**	**98.5**	**15.3**	**2.3%**	**2.0%**	**3.2%**	**-41.9%**	**0.5%**

*Reflects completion of ongoing and planned CSO mitigation projects.