Wood-Pawcatuck Watershed Baseline Assessment

Wood-Pawcatuck Watershed Flood Resiliency Management Plan

Wood-Pawcatuck Watershed Association

October 2016

FUSS & O'NEILL

Project No. 20111470.B10

Table of Contents

Wood-Pawcatuck Watershed Baseline Assessment

Table of Contents

Wood-Pawcatuck Watershed Baseline Assessment

List of Tables

List of Figures

List of Appendices

1 Introduction

The Pawcatuck River and its major tributary, the Wood River, are located in southwestern Rhode Island and portions of southeastern Connecticut (Figure 1-1). The lower Pawcatuck River forms the border between Rhode Island and Connecticut and flows into the eastern end of Long Island Sound at Little Narragansett Bay. The area of land that drains to the Pawcatuck and Wood Rivers – commonly referred to as the "Wood-Pawcatuck watershed" – is approximately 300 square miles and includes numerous tributaries (Queen, Usquepaug, Chickasheen, Chipuxet, Ashaway, Beaver, Shunock, and Green Falls Rivers) and portions of 14 communities. The Wood-Pawcatuck is the most rural and least developed major watershed in Rhode Island, with a majority of the development focused in the southern part of the watershed in Westerly, RI and Stonington, CT as well as small towns and villages along the Pawcatuck and its tributaries.

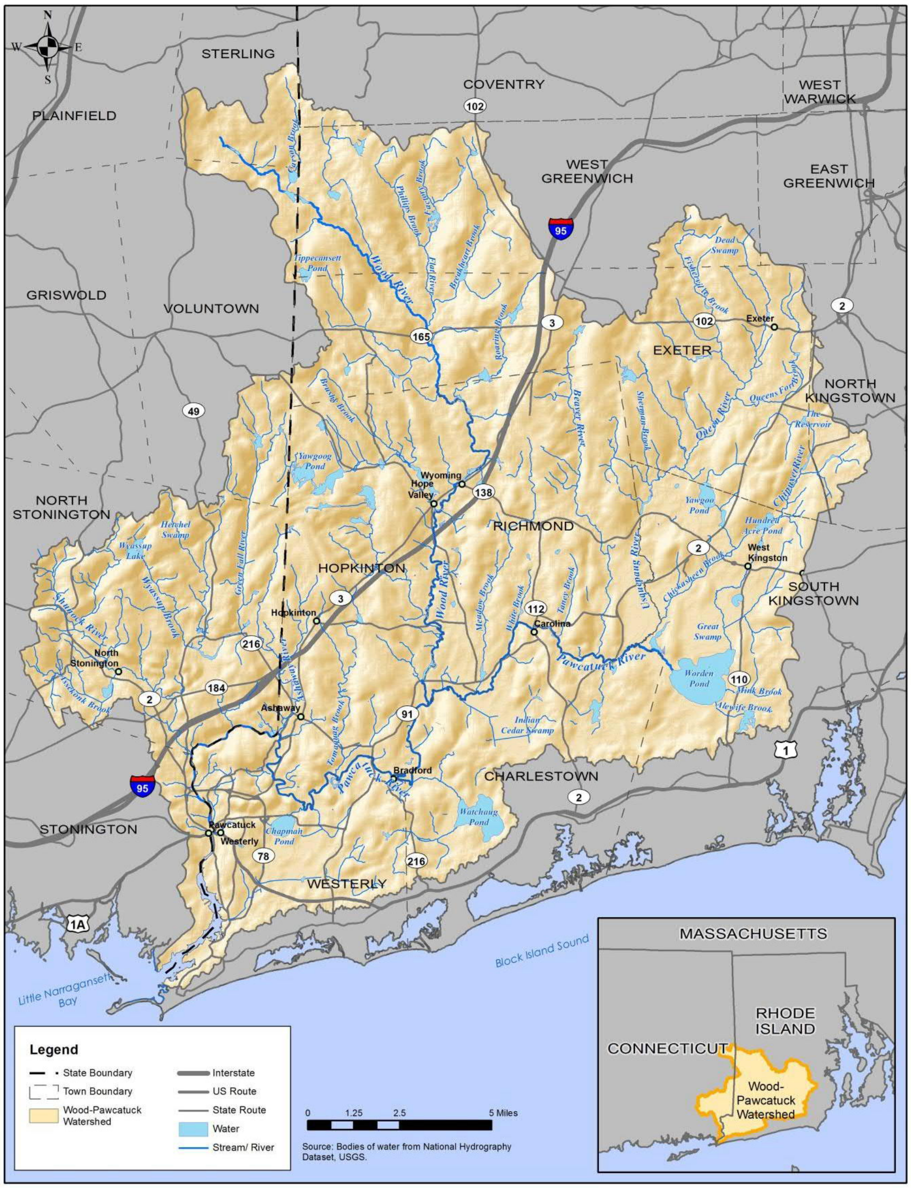

Figure 1-1. Wood-Pawcatuck watershed.

1.1 Flooding in the Wood-Pawcatuck

Riverine flooding and drainage-related flooding in developed areas are relatively common in the Wood-Pawcatuck watershed. The watershed communities have suffered extensive flooding and flood-related damages, with the most extreme flooding on record having occurred in the March and April floods of 2010 (Figure 1-2). The incredible amount of precipitation (over 16 inches) that fell in February and March 2010, along with saturated soils, high water tables, lack of leaf cover and limited pervious surfaces all contributed to the worst flooding ever experienced along the Pawcatuck River and many other areas of Rhode Island (RIEMA, 2011).

Figure 1-2. Flooding in the Wood-Pawcatuck watershed during March and April 2010.
Aerial photo of flooding in Westerly, RI (top left). Route 91 underwater in Westerly can barely be seen crossing wetlands east of Chapman's Pond. Flooding in the Friendship Street area of Westerly, RI (top right). Flooding at the Potter Hill Dam and fish ladder, Ashaway, RI (bottom left). Flooding along Beaver River at Hillsdale Road (bottom right).

Riverine flooding – which occurs when persistent moderate to heavy rain falls over a period of time causing local rivers and streams to overflow their banks and flow into the adjacent floodplain – is the most common type of flooding in the Wood-Pawcatuck watershed. Urban drainage flooding is also common in the more urbanized areas of the watershed as a result of outdated and undersized storm drainage systems. Communities that were most severely affected by the 2010 flooding include Westerly, Stonington, Charlestown, Hopkinton, Richmond, and Exeter. Flood damages consisted of flooding and washout of roadways, damages to bridges and culverts, damages to and failure of dams, flooding of properties and structures, erosion and sediment deposition in watercourses and wetlands, and sediment and pollutant loads carried downstream to Little Narragansett Bay.

Several factors contribute to flooding in the watershed. Historical development in the watershed has resulted in filling of wetlands, floodplains, and floodways, which has reduced natural flood storage and placed development in flood-prone areas. Many of the streams in the watershed, as is common in New England, have also been physically modified (i.e., moved, straightened, hardened). Development of the landscape with roads, parking lots, and buildings – impervious surfaces that prevent rainfall from infiltrating into the ground naturally – has increased the amount of storm runoff. Stormwater drainage infrastructure in developed areas also conveys runoff quickly to rivers and streams. Undersized bridges and culverts have also contributed to flooding and erosion. Dams within the watershed create flood hazards by backing up water during major floods and by releasing very large quantities of flow, sediment, and debris in the event of a sudden failure.

According to the National Climate Assessment, "the Northeast has experienced a greater increase in extreme precipitation over the past few decades than any other region in the United States; between 1958 and 2010, the Northeast saw a 74% percent increase in the amount of precipitation falling in very heavy events" (Melillo, Richmond, T.C., & Yohe, G.W.). Rainfall in New England is expected to continue to increase due to climate change, which is expected to increase the risk of river-related flooding in the future. Given this trend, the communities in the Wood-Pawcatuck watershed face an increasing risk of flooding and storm-related damages as large storms and floods become more common. In addition to climate change, some parts of the watershed are susceptible to future development pressure that, if not appropriately controlled, could increase floodplain encroachments, reduce the natural water-absorbing capacity of the land, increase impervious surfaces and stormwater runoff, and worsen flooding impacts.

> What is Flood Resiliency?
>
> The term "resiliency" or "resilience" has many definitions. In general, it is the ability to become strong, healthy, or successful again after something bad happens – the ability to spring back into action. In the context of flooding, resiliency refers to a community's ability to plan for, respond to, and recover from floods. It includes measures taken to reduce the vulnerability of communities to damages from flooding and to support long-term recovery after an extreme flood (EPA, 2014).

1.2 Other Issues Facing the Watershed

Flooding is not the only water-related issue facing the Wood-Pawcatuck watershed. Water quality, habitat, and species diversity have also been affected by floodplain development, stream corridor modifications, and impervious cover. The Wood-Pawcatuck has some of the highest quality surface water, groundwater, and ecological resources in the State of Rhode Island given the high percentage of undeveloped and forested land in the watershed. However, surface water quality has been degraded in the more developed portions of the watershed, including the lower part of the Pawcatuck River and Little Narragansett Bay, in other developed areas along the main stem of the Pawcatuck and its major tributaries, and near the headwaters in South Kingstown. Excessive quantities of nutrients, sediment, and indicator bacteria from various point and nonpoint pollutant sources, including urban and agricultural stormwater runoff, are among the causes of water quality problems in the watershed. The impacts of commercial turf farms and other significant surface water users on streamflow and aquatic habitat is an ongoing concern in the watershed. In addition to contributing to flood hazards, undersized road stream crossings (i.e., culverts and bridges) and dams in the watershed are also potential obstacles to aquatic organism passage, preventing fish and other wildlife from using certain portions of the river system and isolating some populations.

1.3 Why Develop a Watershed-Based Management Plan?

Watershed-based planning is an effective approach for addressing flooding and water quality. The Wood-Pawcatuck Watershed Association (WPWA) and its project partners, including the watershed municipalities, the Rhode Island Department of Environmental Management (RIDEM), the Connecticut Department of Energy and Environmental Protection (CTDEEP), and other groups, recognize the need to increase flood resiliency and protect and restore water quality and ecological conditions of the Wood-Pawcatuck using a watershed-based approach. This can be accomplished by developing and implementing a comprehensive watershed management plan. A watershed plan provides a blueprint to help groups within a watershed work across municipal boundaries to protect and restore water resource conditions throughout the watershed.

> Watershed Management
>
> A ***watershed*** is the land area that drains to a common outlet such as a river, stream, lake, or bay. Watersheds ignore political boundaries. ***Watershed planning*** is a process that identifies ways to protect and restore the water quality and other natural resources in a watershed. The outcome of the watershed planning process is documented in a ***watershed management plan***.

Development of a comprehensive, watershed-based flood resiliency management plan for the Wood-Pawcatuck watershed will:

- Characterize current conditions and relevant issues in the watershed.
- Identify a prioritized list of actions and projects that can be undertaken by the watershed communities to increase flood resiliency, and protect and enhance natural ecosystems.
- Protect and enhance the resiliency of the watershed communities to future flood damages.
- Strengthen and restore natural ecosystems, including water quality, species and habitat, while increasing flood resiliency.
- Help the watershed communities (local and state governments and private land owners) prepare for and mitigate the impacts of future severe storms.
- Protect critical community infrastructure and the ability of communities to deliver vital municipal services.
- Help communities understand watershed and riverine processes so that better land use and infrastructure investments can be made.
- Help improve the quality of life and economic viability of the watershed communities.
- Facilitate capacity-building and engage the watershed municipalities and other stakeholder groups in the watershed planning process and future plan implementation
- Promote collaboration across municipal boundaries, bringing the watershed communities and groups together to cooperate around shared issues of concern and objectives without compromising their "home rule" principles
- Create a plan that satisfies EPA, RIDEM, and CTDEEP requirements for watershed-based plans to better position the watershed communities for future grant funding from certain State and Federal sources.

1.4 Purpose and Organization of the Baseline Assessment Report

This Baseline Assessment report documents current flooding and related water resource conditions in the Wood-Pawcatuck watershed. The baseline assessment, combined with other watershed technical evaluations – fluvial geomorphic assessment, assessment of hydraulic structures (i.e., bridges, culverts, and dams) in the watershed, green infrastructure assessment, wetlands assessment, and land use regulatory review – will inform the management plan recommendations and serve as a background reference document to support future implementation activities within the watershed.

The Baseline Assessment report is organized as follows:

- Section 1 contains an introduction to flooding and related water resource issues in the watershed and the benefits of developing a watershed-based flood resiliency plan.
- Section 2 describes the physical characteristics of the Wood-Pawcatuck watershed (topography, geology, soils, and hydrology).
- Section 3 describes ecological resources in the watershed, including terrestrial and aquatic habitat, rare species, and unique habitats.
- Section 4 provides a summary of watershed land use/land cover, demographics, impervious cover, and open space.
- Section 5 describes the man-made water infrastructure in the watershed including dams, bridges and culverts, and stormwater and wastewater management systems.
- Section 6 describes flood hazards and flood-prone areas in the watershed, common types of flooding, and existing flood mitigation programs in the watershed.
- Section 7 summarizes the current water quality conditions in the watershed, including high quality surface and groundwater and degraded or impaired waters.

2 Watershed Physical Characteristics

2.1 Watershed Overview

The Wood and Pawcatuck Rivers are situated in southwestern Rhode Island and southeastern Connecticut. The area of land that drains to the Wood and Pawcatuck Rivers – commonly referred to as the "Wood-Pawcatuck watershed" – encompasses just over 300 square miles, or one quarter the size of Rhode Island. The watershed resides in all or portions of ten towns in Rhode Island (Charlestown, Coventry, East Greenwich, Exeter, Hopkinton, North Kingstown, Richmond, South Kingstown, Westerly, West Greenwich) and four towns in Connecticut (North Stonington, Sterling, Stonington and Voluntown) (Figure 1-1, Table 2-1). The towns of Hopkinton, Richmond, Exeter, Westerly, North Stonington, Charlestown, West Greenwich and South Kingstown account for just over 92% of the total watershed area (Table 2-1).

Table 2-1. Towns located within the Wood-Pawcatuck watershed.

Town	State	Area of Town within Watershed (mi^2)	% Area of Town within Watershed	% of Watershed Area
Charlestown	RI	24.9	66.3	8.3
Coventry	RI	0.9	1.4	0.3
East Greenwich	RI	0.1	0.6	0.0
Exeter	RI	53.4	91.4	17.7
Hopkinton	RI	44.1	100.0	14.6
North Kingstown	RI	3.2	7.3	1.1
Richmond	RI	40.8	100.0	13.5
South Kingstown	RI	27.9	46.4	9.3
Westerly	RI	23.2	77.1	7.7
West Greenwich	RI	26.2	51.1	8.7
North Stonington	CT	38.4	69.8	12.7
Sterling	CT	6.0	22.0	2.0
Stonington	CT	4.4	11.4	1.5
Voluntown	CT	8.2	20.5	2.7

More than 83,000 people live in the Wood-Pawcatuck watershed. There are two main population centers within the watershed – one in Westerly, Rhode Island and Pawcatuck, Connecticut along the estuary portion of the Pawcatuck River, and another in South Kingstown, Rhode Island, home to the University of Rhode Island, on the eastern side of the watershed. The rest of the watershed consists of a predominantly rural wooded landscape amongst a series of towns that developed as mill villages along the Pawcatuck River and its tributaries. The watershed is also home to Narragansett Indian tribal land in Charlestown, Rhode Island.

Several major rivers and their tributaries drain to the watershed's outlet at Little Narragansett Bay: the Pawcatuck, Wood, Chipuxet, Chickasheen, Beaver, Queen-Usquepaug, and Ashaway Rivers in Rhode Island, and the Shunock and Green Fall Rivers in Connecticut. The Pawcatuck River is approximately 38 miles long and the Wood River is roughly 27 miles long, and there are approximately 490 miles of mapped rivers and streams in the entire watershed. The major rivers in the watershed generally flow from northeast to southwest, directed to the west by the Charlestown moraine along the watershed's southern boundary. The subwatersheds that correspond to the major tributaries of the Wood-Pawcatuck are shown in Figure 2-1 and summarized in Table 2-2.

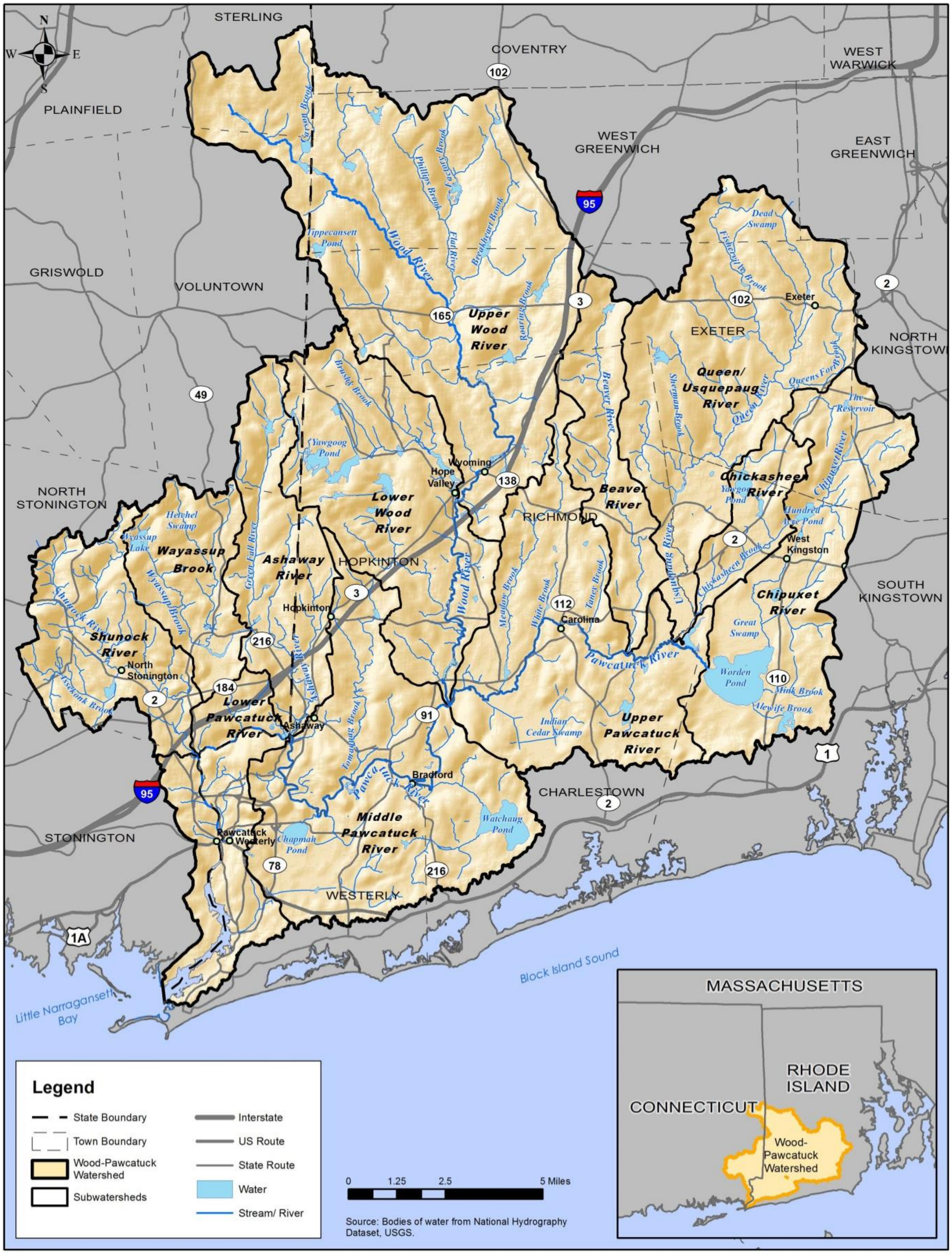

Figure 2-1. Major subwatersheds of the Wood-Pawcatuck.

Table 2-2. Subwatersheds in the Wood-Pawcatuck watershed.

Subwatershed Name	Area (mi^2)	Length of Mapped Streams (Miles)
Upper Wood River	61.0	82.71
Lower Wood River	28.6	53.349
Upper and Middle Pawcatuck River	71.0	100.58
Lower Pawcatuck River	15.8	27.06
Shunock River	16.6	46.21
Waysssup Brook	11.5	19.77
Ashaway River	16.4	34.44
Queen/Usquepaug River	37.1	62.23
Beaver River	12.4	18.53
Chickasheen Brook	6.6	11.59
Chipuxet River	25.7	33.50
Total	303	490

The following paragraphs describe the major rivers/streams and associated subwatersheds of the larger Wood-Pawcatuck watershed.

- Wood River: The headwaters of the Wood River begin in a swamp near Porter Pond in Sterling, Connecticut. From there, it flows southeast to Hazard Pond, where the river crosses into Rhode Island. From the state line, it flows southeast over Stepstone Falls, then south through Beach Pond State Park where it receives the Flat River. (The upper Wood River is also known locally as the Falls River.) After receiving the Flat River, the Wood continues south through the Arcadia Management Area and into the towns of Richmond and Hopkinton, where it flows through the villages of Wyoming and Hope Valley. The river continues south through Hopkinton where it converges with the Pawcatuck River at the village of Alton. The Wood River serves as the border between Richmond and Hopkinton. Almost 90% of the Wood River watershed is undeveloped, with much of this land protected as part of the Arcadia Management Area. The Wood River and its tributaries are notable for their high biodiversity, pristine water quality, cold water fisheries, and significant recreational value.

- Green Fall/Ashaway River and Waysssup Brook: The Green Fall River originates at a swamp south of Rockville Road in Voluntown, Connecticut. The river then flows south to Green Fall Pond and continues south through North Stonington and into Hopkinton, Rhode Island where the river joins with Parmenter Brook near Route 216 to form the Ashaway River. The Ashaway River flows south parallel to Laurel Street through a residential area before it empties into the Pawcatuck River along the Connecticut border. Wyassup Lake located in North Stonington, Connecticut drains southeast into Wyassup Brook, which flows into the Green Fall/Ashaway Rivers and eventually the Pawcatuck River. The overall watershed covers approximately 28 square miles, with the majority of the watershed located in Connecticut. The watershed is largely undeveloped (84%), with Pachaug State Forest comprising a large portion of the upper watershed. Developed uses (including residential and commercial uses) occupy approximately 5%, agricultural land uses occupy 7%, and wetlands and other surface waters occupy 4% (RIDEM, 2011).

- Shunock River: The headwaters of the Shunock begin in the northern portion of North Stonington, Connecticut. The river flows in a southeasterly directly through the center of North Stonington and crosses Route 184, Interstate 95, and Route 49 before emptying into the

Pawcatuck River just north of the Stonington-North Stonington town line. Assekonk Brook is a tributary of the Shunock River. The Shunock River watershed, which historically supported a thriving mill industry in the 19th century, is approximately 63% forested, 15% urban area, 12% agriculture, and 10% water (CTDEEP, 2012).

- Beaver River: The Beaver River watershed is an approximately 12.4 square mile area of land situated east of the Queen-Usquepaug River watershed. The river begins at James Pond in Exeter. From there, it flows roughly due south for approximately 11 miles through Exeter and Richmond to its mouth at the Pawcatuck River near the village of Shannock. There are several dams along the Beaver River, and the river crosses major roads including New London Turnpike and Route 138. The northern and middle portions of the watershed are primarily forested, while the lower watershed contains a larger percentage of agricultural land use including some turf farms.

- Queen/Usquepaug River: The approximately 37 square mile Queen/Usquepaug River watershed is situated in the northwest portion of the Wood-Pawcatuck basin between the Beaver River and Chickasheen/Chipuxet watersheds. The Queen River originates at Dead Swamp in West Greenwich, Rhode Island and flows approximately 11 miles due south through Exeter and into South Kingstown where it converges with Glen Rock Brook to become the Usquepaug River just upstream of the village of Usquepaug. The Usquepaug River flows into Glen Rock Reservoir, then south through Usquepaug and eventually empties into the Pawcatuck River. There are a few large and a number of smaller impoundments in the watershed, and approximately 90-95% of the watershed is forested. The remainder of the basin is agricultural, recreational (golf courses), commercial, and medium-to-low-density residential land. The Queen/Usquepaug also has a wide and relatively undisturbed riparian corridor, and a fair amount of land has been preserved by Rhode Island Audubon Society, The Nature Conservancy, and private landowners (Armstrong & Parker, G.W., 2003).

- Chickasheen Brook: The Chickasheen Brook watershed is located in Exeter and South Kingstown, Rhode Island. The headwaters of Chickasheen Brook originate in Maple Swamp near a residential area east of Route 2. The brook flows west under Route 2 and enters Arrow Swamp. The brook flows southwesterly through Arrow Swamp, then through a culvert under the Miskiania Trail, before continuing southerly to the inflow of Yawgoo Pond at the border with South Kingstown. Chickasheen Brook then leaves Yawgoo Pond and flows southeast where it joins with Mud Brook and eventually Barber Pond. The brook eventually joins the Usquepaug River, which flows to the upper reaches of the Pawcatuck River. The watershed is largely undeveloped (over 80%), with residential and commercial uses comprising less than 10% of the land area (RIDEM, 2011). Agricultural land uses (primarily turf farms) are also present in the watershed.

- Chipuxet River: The Chipuxet River watershed comprises approximately 26 square miles within Exeter, North Kingstown, and South Kingstown, Rhode Island. The Chipuxet River flows approximately 13 miles, paralleling the Amtrak train line through Slocum, crossing Route 138 near Plains Road/Route 110, passing through the Great Swamp, before entering Worden Pond. Groundwater in the watershed, namely the Chipuxet Aquifer, is a source of drinking water for the University of Rhode Island (URI) and the Kingston Water District. There is also a significant water demand from turf farms in the watershed. Consequently, the Chipuxet River (and to a lesser extent, Chickasheen Brook) is considered a "stressed" basin for streamflow, with water demands sufficient to dry up the Chipuxet River at times (Audubon Society of Rhode Island).

- Pawcatuck River: The Pawcatuck River begins as the outflow from Worden Pond in South Kingstown, Rhode Island and flows southwest through Richmond, Charleston, Hopkinton, and Westerly, Rhode Island, before forming the border between Westerly, Rhode Island and North Stonington, Connecticut. For the purposes of this assessment, the Pawcatuck River is separated into three segments and associated watershed areas:

    - Upper Pawcatuck River: The Upper Pawcatuck River forms the border between Charlestown and Richmond between Worden Pond and its confluence with the Wood River. Major tributaries to this segment include the Usquepaug River, Beaver River, Taney Brook, White Brook, and Meadow Brook. The Upper Pawcatuck flows through Great Swamp as it leaves Worden Pond and continues flowing west through the villages of Kenyon, Shannock, Carolina, and Alton.

    - Middle Pawcatuck River: The Middle Pawcatuck River segment begins at the confluence with the Wood River and flows south-southwest through primarily forested and wetland areas, crossing the Amtrak rail line several times, through the village of Bradford along the Hopkinton-Westerly town border, and ending at the confluence of the Ashaway River. Tomaquaug Brook is the major tributary to this segment of the Pawcatuck River.

    - Lower Pawcatuck River: The Lower Pawcatuck River is defined as the portion of the river downstream of the Ashaway River, as the Pawcatuck forms the border between Rhode Island and Connecticut. The river flows southwest from Potter Hill in semi-circle towards downtown Westerly, Rhode Island and Pawcatuck, Connecticut. As the River travels downstream of Route 78, the watershed becomes more urbanized and developed (RIDEM, 2011). The estuarine portion of the river begins at the Route 1 crossing and extends south to Little Narragansett Bay. The Shunock River and several smaller tributaries that drain more urbanized portions of Westerly and Stonington flow into this lower segment of the Pawcatuck River.

2.2 Topography, Geology and Soils

Glaciers formed the topography of the watershed roughly 16,000-17,000 years ago leaving behind a landscape of low rolling hills with associated valleys that trend north to south with a slight east to west component. The highest point in the watershed is just over 629 feet on Bald Hill in West Greenwich, Rhode Island, while the low point is in the estuary portion of the watershed where the Pawcatuck River meets Little Narragansett Bay (Bent, et al., 2011) (Figure 2-2).

The surficial geology of the Wood-Pawcatuck watershed (Figure 2-3) is characterized by deposits of glacial till overlaying areas of crystalline bedrock (Bent, et al., 2011; Breault, et al., 2009). The glacial deposits vary in thickness throughout the watershed but average 20-25 feet with thicker deposits ranging from 0-200 feet thick. Post glacial deposits of floodplain alluvium, organic peat, and muck are also present (Bent, et al., 2011; Breault, et al., 2009).

The most distinct geologic feature within the watershed is the Charlestown moraine, which makes up the southern boundary of the watershed. The Charlestown moraine is a glacial deposit that represents the long-term recessional position of the retreating glacier (Schafer, 1965). The moraine varies in thickness with a maximum of approximately 300 feet (Masterson, Sorenson, Stone, Moran, & Hougham, 2007). As the glacier retreated the moraine effectively dammed the formerly southerly draining rivers in the area and directed the flow to the southwest (Masterson, Sorenson, Stone, Moran, & Hougham, 2007).

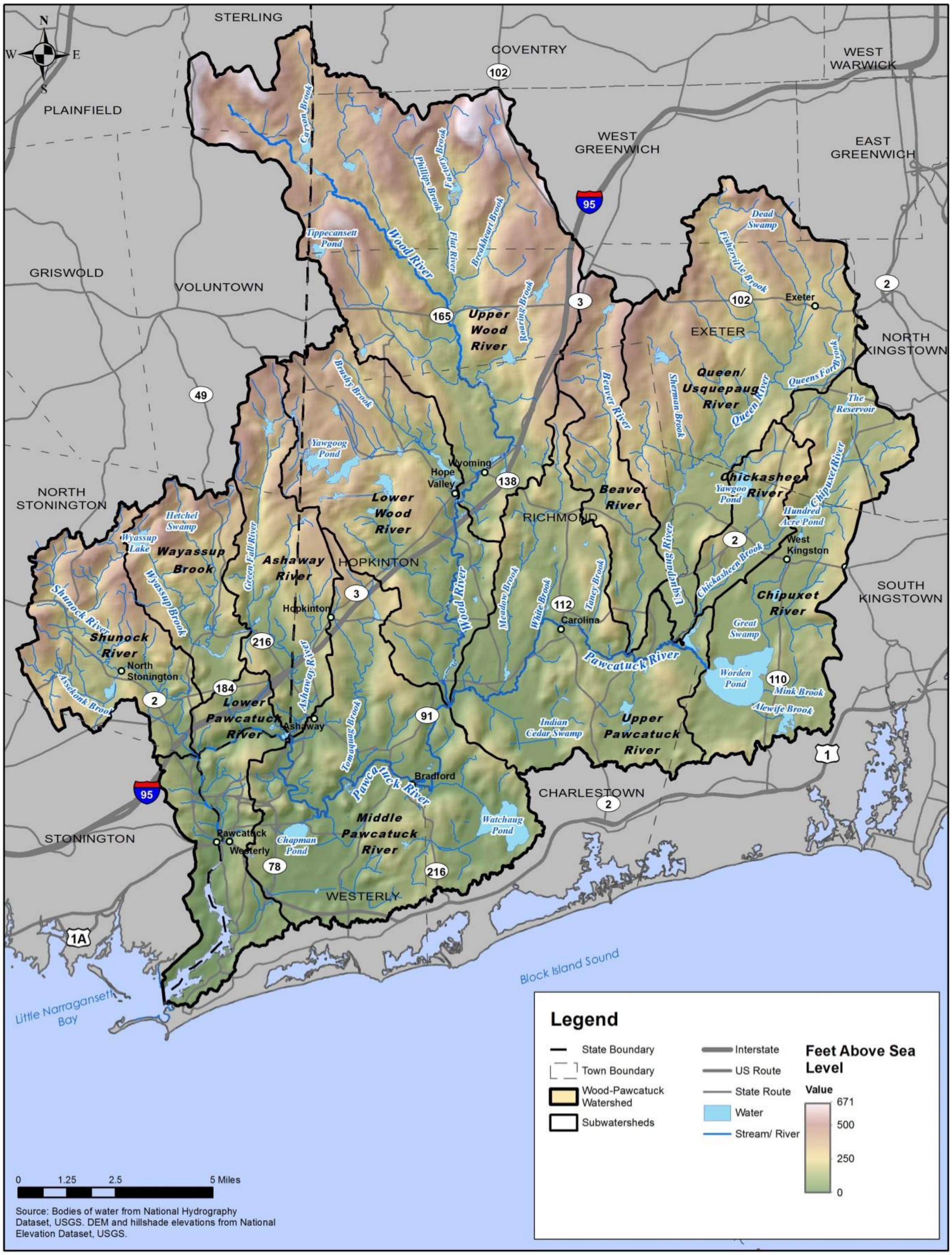

Figure 2-2. Topography of the Wood-Pawcatuck watershed

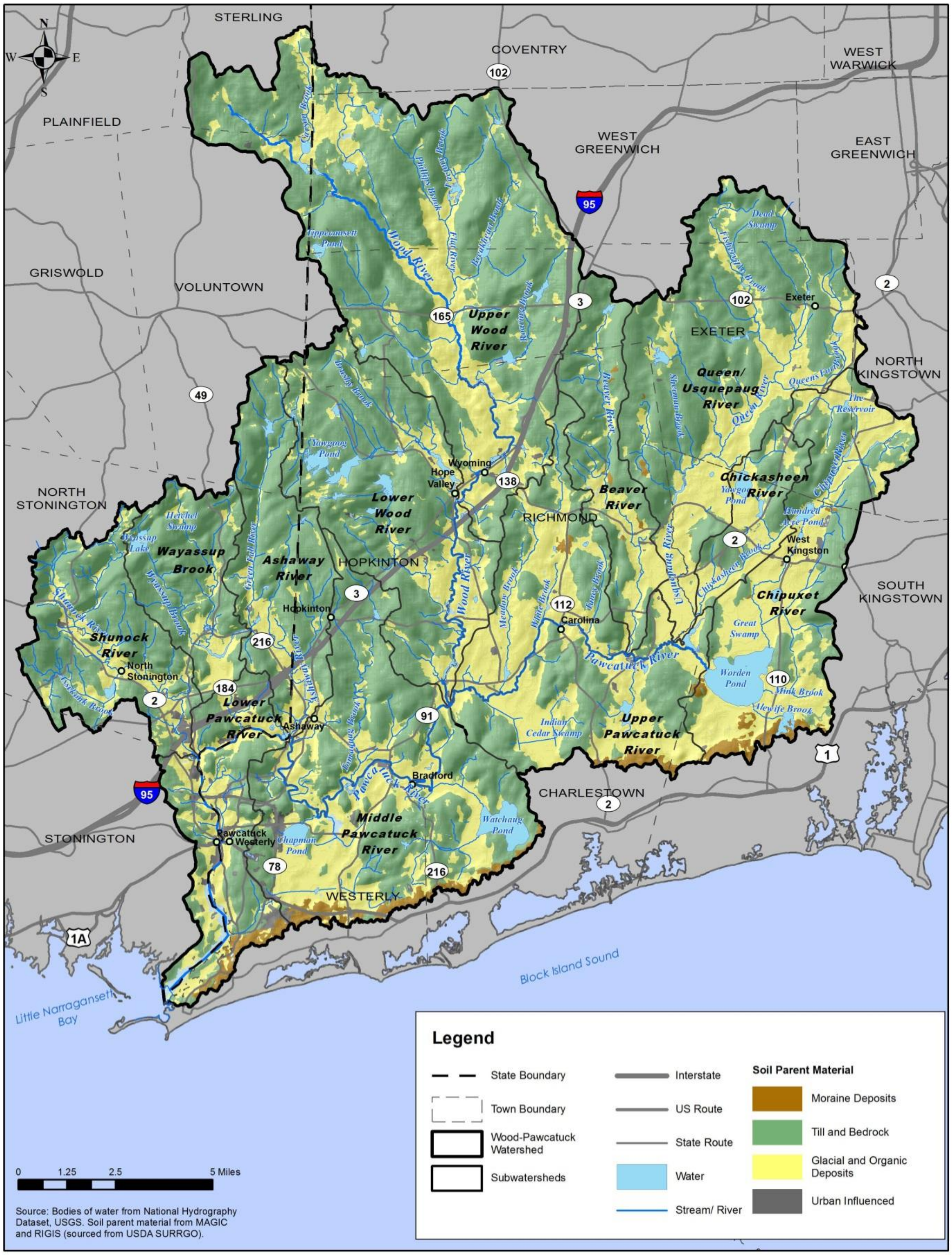

Figure 2-3. Surficial geology of the Wood-Pawcatuck watershed.

The glacial deposits in the watershed have contributed to a legacy of fairly well draining soils throughout the watershed. Hydrologic Soil Group classifications assigned by the Natural Resources Conservation Service (NRCS) are a good indicator of the runoff and infiltration potential of soil types in a watershed. Group A soils generally have low runoff potential and high infiltration rates, while Group D soils have high runoff potential and very slow infiltration rates (Natural Resources Conservation Service, 2009).

Group A and B soils make up approximately 65% of the watershed with B soils being the predominant Hydrologic Soil Group (Table 2-3 and Figure 2-4). The majority of the well-draining A soils appear to run north to south along the length of the Upper Wood River through the Towns of West Greenwich, Exeter and Hopkinton, Rhode Island. Generally, the poorest draining soils coincide with wetland complexes located in the southern portion of the watershed and glacial till/bedrock areas in the northwestern areas of the watershed.

Table 2-3. Composition of the Wood-Pawcatuck watershed by Hydrologic Soil Group.

Hydrologic Soil Group	Acres	% of Watershed
A	24,006	12.4
B	102,211	52.8
C	22,917	11.8
D	37,962	19.6
Variable	2,759	1.4
Water	3,845	2.0

2.3 Hydrology

Annual precipitation in the Wood-Pawcatuck watershed is, on average, approximately 52 inches per year, based on data obtained from the University of Rhode Island (URI) meteorological station for the 30-year period from 1971 to 2000 (Bent, et al., 2011). Mean annual precipitation varies between approximately 40 and 53 inches at the six National Weather Service stations (including URI) across Rhode Island, which can be attributed to slight differences in local weather patterns. Mean monthly precipitation peaks in March (5.11 inches), while July is the driest month (3.31 inches) (Bent, et al., 2011) (Table 2-4). Average monthly temperature ranges from a low of 28.6°F in January to 70.7°F in July.

Table 2-4. Climatological data from the URI meteorological station for the period 1971-2000 (Bent, et al., 2011).

Parameter	Value	Month
Mean Annual Precipitation (inches)	51.28	
Mean Monthly Precipitation (inches)	4.27	
Mean Monthly Low Precipitation (inches)	3.31	July
Mean Monthly High Precipitation (inches)	5.11	March
Average Annual Temp (°F)	49.7	
Average Monthly High (°F)	70.7	July
Average Monthly Low (°F)	28.6	January

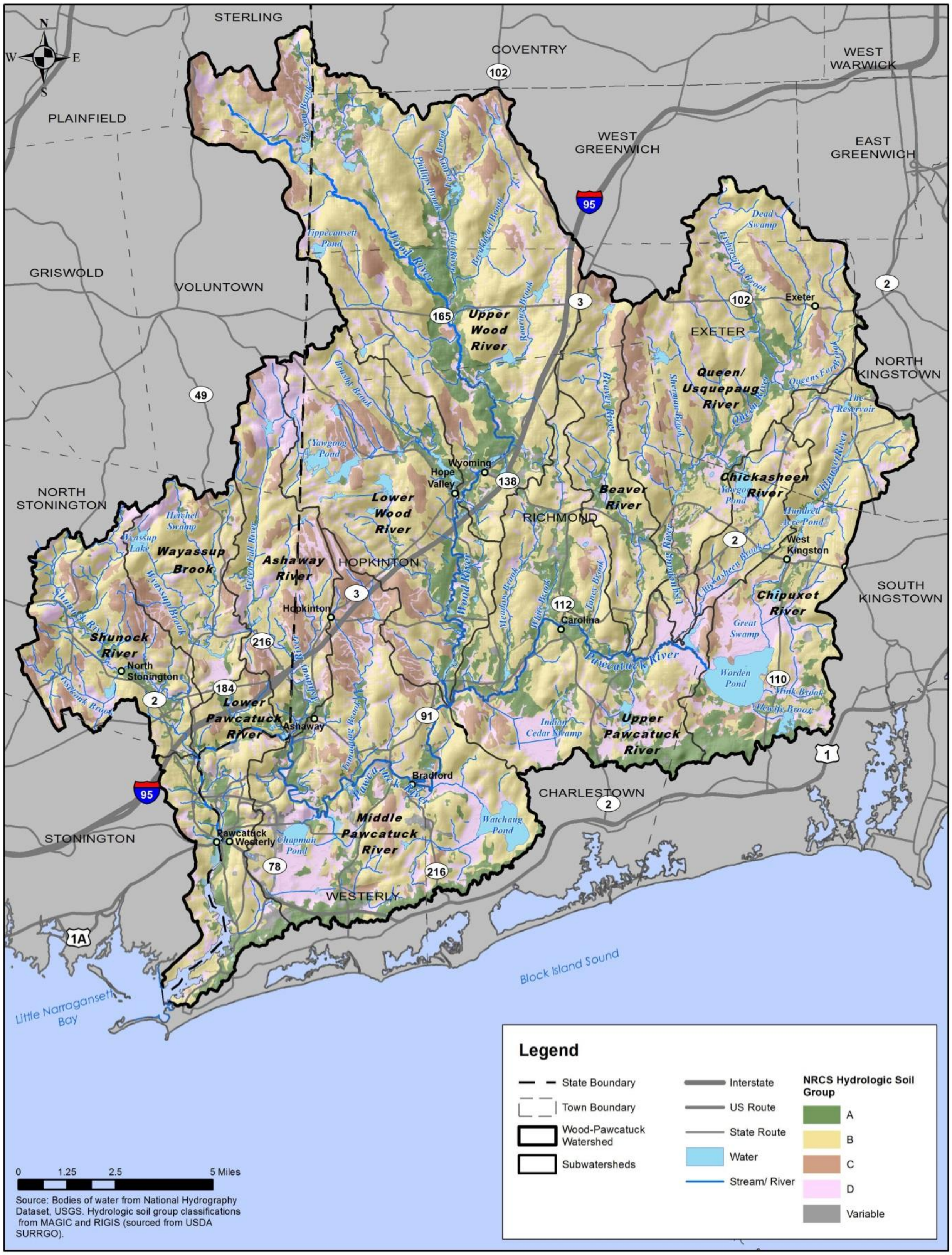

Figure 2-4. Composition of the Wood-Pawcatuck watershed by Hydrologic Soil Group.

A portion of the precipitation that falls in the Wood-Pawcatuck watershed eventually reaches surface waters (rivers, streams, lakes, and ponds) and groundwater. Approximately 50% of the average annual precipitation in the watershed leaves the basin as streamflow near the mouth of the river in Westerly. The remaining 50% of the precipitation leaves the basin by a combination of evaporation, plant transpiration, and water withdrawals/transfers out of the basin (Breault, et al., 2009).

The United States Geological Survey (USGS) has several stream gaging stations located throughout the Wood-Pawcatuck watershed (Figure 2-5). Streamflow data from 2000-2013 is summarized in Table 2-5. Mean annual streamflow (ft^3/s or "cfs") varies significantly across the watershed. When normalized by drainage area, mean annual streamflow yield ($ft^3/s/mi^2$ or "csm") is relatively consistent, ranging from 2.1-2.5 csm.

Table 2-5. Summary of USGS streamflow data in the Wood-Pawcatuck watershed (2000-2013).

Stream Gage #	Name/Location	Station Drainage Area (mi^2)	Mean Annual Streamflow (ft^3/s)	Mean Annual Streamflow Yield ($ft^3/s/mi^2$)
01118500	Pawcatuck River @ Westerly, RI	295.0	638.9	2.2
01118300	Pendelton Hill Brook near Clarks Falls, CT	4.0	9.8	2.4
01118000	Wood River @ Hope Valley, RI	72.4	165.6	2.3
01117800	Wood River near Arcadia, RI	35.2	76.4	2.2
01117500	Pawcatuck River @ Wood River Junction, RI	100.0	214.1	2.1
01117468	Beaver River near Usquepaug, RI	9.2	21.1	2.3
01117420	Usquepaug River near Usquepaug, RI	36.1	78.9	2.2
01117370	Queen River at Liberty Road @ Liberty, RI	19.6	40.5	2.1
01117350	Chipuxet River @ West Kingston, RI	9.6	24.1	2.5
01117430	Pawcatuck River @ Kenyon, RI	72.7	156.0	2.1

Significant groundwater resources underlie large portions of the Wood-Pawcatuck watershed. Groundwater serves as the sole source of drinking water for more than 60,000 residents and supplements water supplies outside of the watershed. The Pawcatuck Basin Aquifer System boundary generally follows the watershed boundary, except for an area in the northeast portion of the watershed (Upper Chipuxet, and Queen-Usquepaug) where groundwater and surface-water divides do not coincide. It is comprised of hydrogeologically interconnected stratified drift aquifers, which are generally located in the lowland areas of the basin. The recharge areas or highland portions of the basin consist of interfingered stratified drift and till deposits (Figure 2-6) (Federal Register, 1988).

In 1988, groundwater resources in the Wood-Pawcatuck were designated by EPA as a Sole Source Aquifer (Federal Register, 1988). This designation indicates that groundwater is the primary public drinking water supply in the basin and, if contaminated, would create a significant hazard to public health. In addition to public water supply, water resources in the basin are also used for irrigation, particularly by the large number of turf farms in the watershed. In the Wood-Pawcatuck, drinking water is supplied solely from groundwater sources and irrigation is primarily withdrawn from surface water sources.

The quantity and quality of groundwater and surface water in the watershed are interconnected. Groundwater is recharged by precipitation and then discharges to surface waterbodies like streams and ponds (Pawcatuck Watershed Partnership, 1999). During periods of drought, the groundwater contribution (also referred to as baseflow) is often the only component of streamflow. During extreme drought conditions, rivers and streams can discharge to groundwater. Groundwater withdrawals can reduce streamflow by capturing baseflow or inducing infiltration from the stream (Breault, et al., 2009).

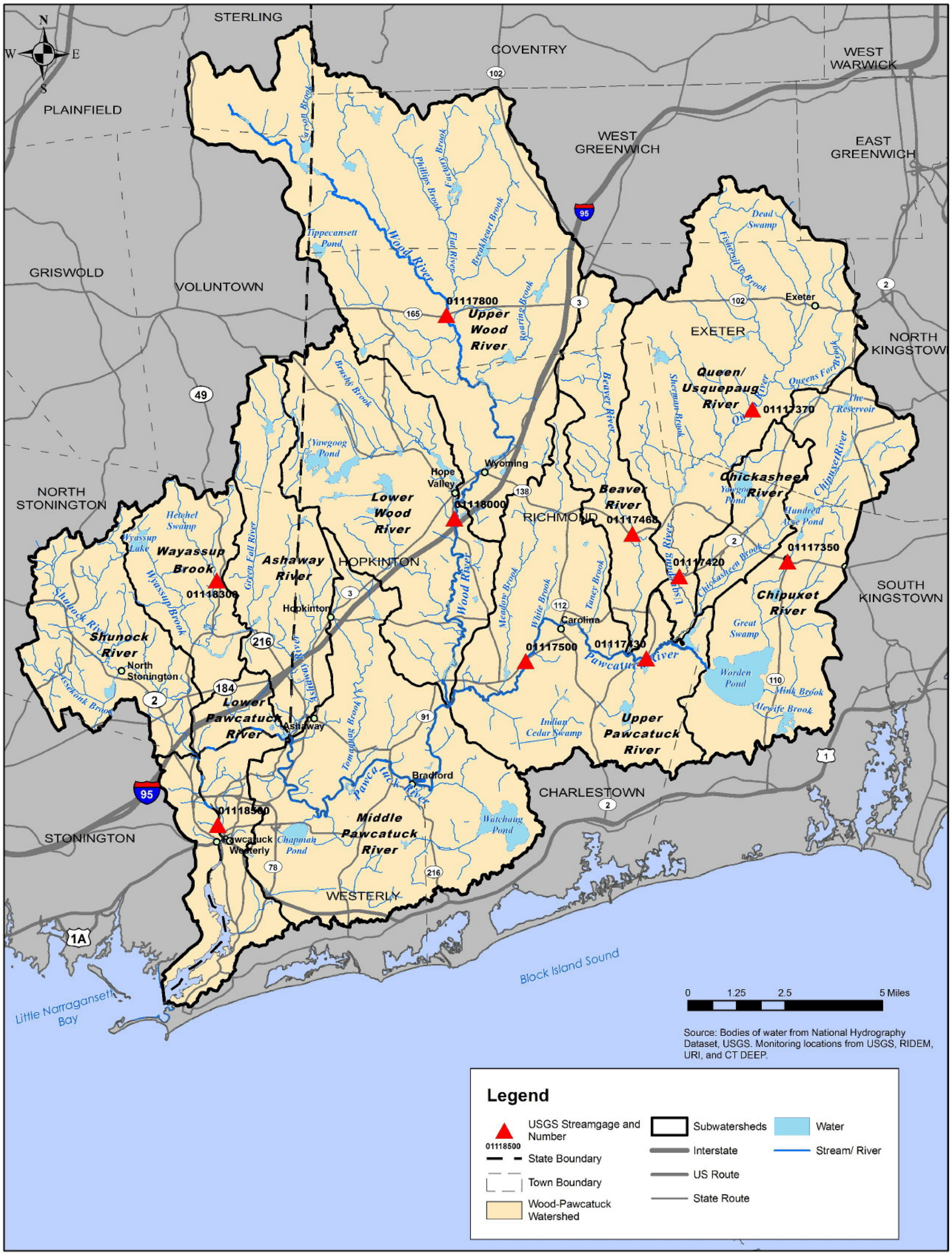

Figure 2-5. USGS stream gage locations in the Wood-Pawcatuck watershed.

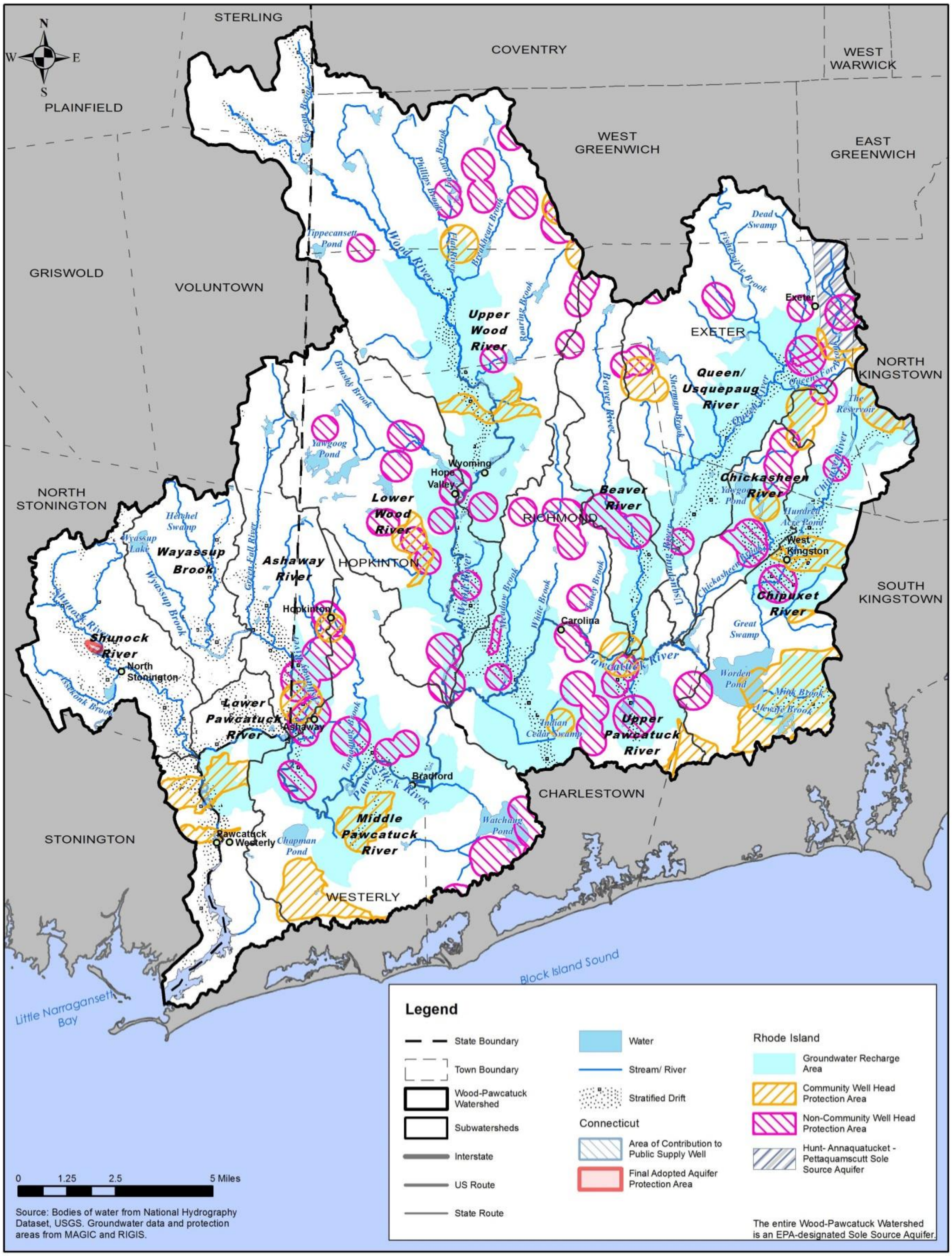

Figure 2-6. Stratified drift aquifers and groundwater recharge areas within the Wood-Pawcatuck watershed.

2.4 Fluvial Geomorphology

The science of fluvial geomorphology is devoted to understanding how the natural setting and human land use in a watershed effect river channel processes and form (i.e., channel dimensions and shape). A river adjusts its slope, channel dimensions, and planform geometry in order to reach an equilibrium condition where both the water discharge and sediment are conveyed through the channel without causing significant changes in the channel's morphology. A channel adjusts its morphology through erosion or deposition in response to alterations in the amount of water and sediment supplied from the watershed. Through these adjustments, the channel eventually achieves a state of equilibrium where the channel dimensions remain relatively constant as long as no significant watershed perturbations occur.

A geomorphic assessment of the Wood-Pawcatuck watershed was conducted in 2015 as part of the flood resiliency planning effort for the Wood-Pawcatuck watershed. The assessment revealed that many of the bridges and culverts in the watershed are geomorphically undersized and consequently exhibit deposition upstream and/or scour downstream. Historic artificial channel straightening has occurred along most of the watershed's watercourses and greatly reduced flow complexity and the quality of aquatic habitat throughout the watershed. In areas more sensitive to change (i.e., upstream of dams and undersized crossings), meanders are reforming as the straightened channels widen, sediment is deposited, and flow is deflected into the banks or onto the adjacent floodplain. A straightened configuration persists to this day in areas less sensitive to change such as downstream of dams.

Fluvial Geomorphic Assessment of the Wood-Pawcatuck Watershed

The 2015 geomorphic assessment of the Wood-Pawcatuck watershed is documented in *Fluvial Geomorphic Assessment and River Corridor Planning in the Wood-Pawcatuck Watershed, RI and CT* (Field, 2015). Based on the results of the geomorphic assessment, river corridor planning guidance for the Wood-Pawcatuck watershed was developed to identify restoration projects that could reduce flood hazards and downstream sediment loading and improve aquatic habitat (Field, 2016).

3 Natural Resources

The Wood-Pawcatuck watershed has a high degree of species and habitat diversity, with some of the most pristine and undisturbed natural resources in all of southern New England. Preservation of these unspoiled natural areas (i.e., existing "green infrastructure") has helped to maintain excellent water quality, a variety of high-quality habitat types, and natural flood resiliency in much of the watershed (National Park Service, 2013) (Pawcatuck Watershed Partnership, 1999).

3.1 Forests

The Wood-Pawcatuck watershed is characterized by its large tracts of deciduous forest and is noted for having the largest, most undisturbed forest lands remaining between Boston and New York City (National Park Service, 2013). The forest landscape is home to many unique habitats and rare species that exist in the watershed. Figure 3-1 shows the existing land cover in the Wood-Pawcatuck watershed. Nearly 60% of the watershed consists of deciduous, evergreen, or mixed forests (Table 3-1). Forest cover ranges from a low of approximately 22% in the Lower Pawcatuck River subwatershed to a high of approximately 70% in the Upper Wood River subwatershed (Wood-Pawcatuck Watershed Association, 2015). An additional 9% of the watershed is categorized as undeveloped upland habitat including shrub/scrub and grassland habitats. Forested wetlands also make up a large percentage of the various wetland types in the watershed.

Table 3-1. Estimated land cover by percentage and acreage within the Wood-Pawcatuck watershed.

Land Cover	Percent of Watershed	Watershed Area (Acres)
Water	2.4%	4,690
Urban Open Space	5.4%	10,445
Developed, Low Intensity	4.0%	7,694
Developed, Medium Intensity	2.4%	4,669
Developed, High Intensity	0.3%	587
Barren Land	0.5%	912
Deciduous Forest	47.8%	92,579
Evergreen Forest	6.7%	13,013
Mixed Forest	3.2%	6,214
Shrub/Scrub	0.8%	1,482
Grass/Fields	7.9%	15,323
Cultivated Crops	1.0%	1,981
Wetlands	17.6%	34,122

Several studies have documented threshold values for watershed forest cover as a measure of stream stability (Brabec, Schulte, S., & Richards, P.L., 2002; Booth, Hartlet, D., & Jackson, R., 2002). Watershed forest cover of 65% or greater is typically associated with a healthy aquatic invertebrate community in rural watersheds. Applying the model developed by Booth et al. (2002), the Shunock, Ashaway, Upper Wood, Lower Wood, Queen/Usquepaug, and Beaver River subwatersheds are predicted to have stable stream channels; two are predicted to have unstable stream channels (Lower Pawcatuck and Chipuxet River subwatersheds); and the Queen/Usquepaug and Upper/Middle Pawcatuck River subwatersheds are borderline uncertain/unstable (Wood-Pawcatuck Watershed Association, 2015).

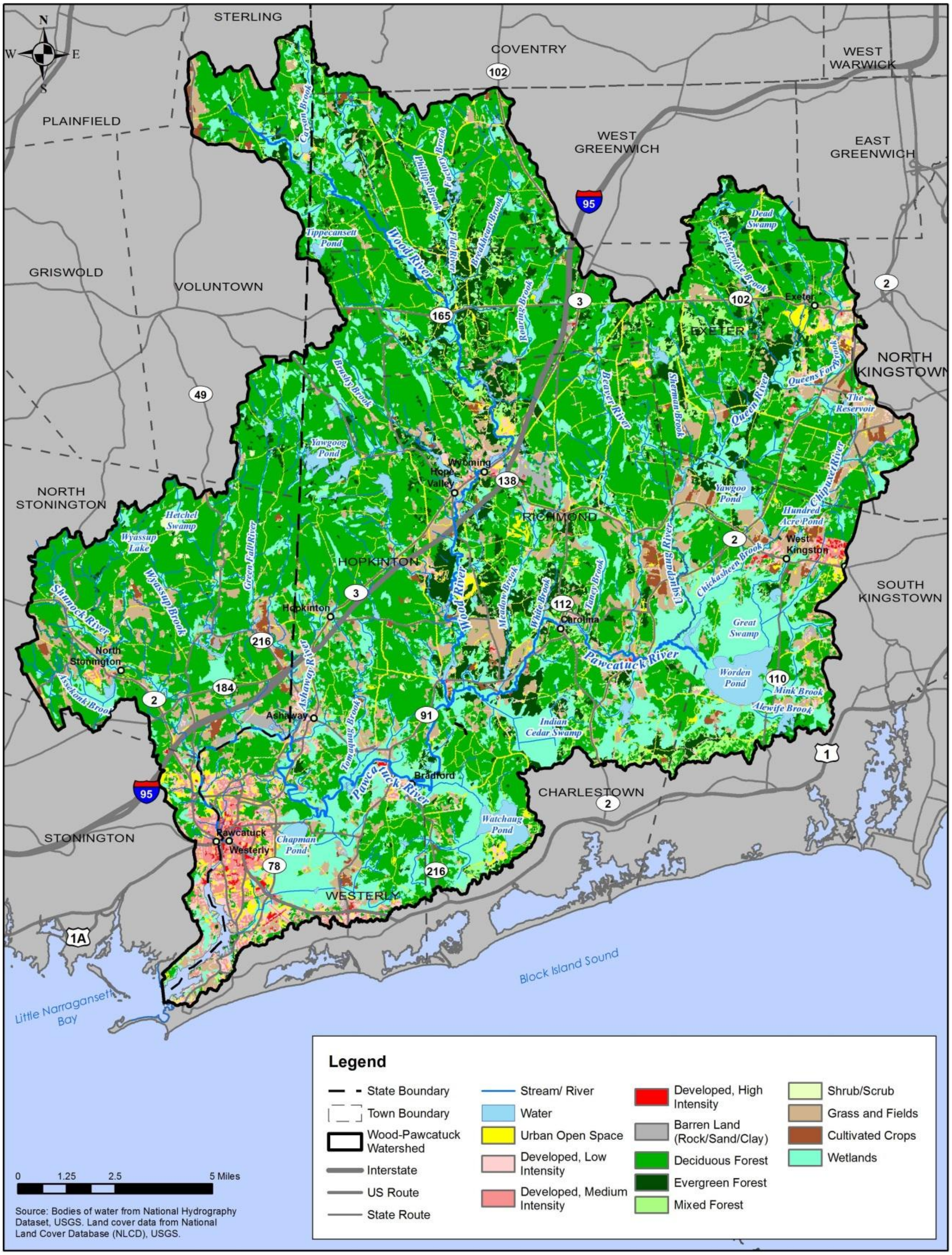

Figure 3-1. Land cover in the Wood-Pawcatuck watershed.

3.2 Wetlands and Floodplains

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 include marshes, swamps, bogs, and fens. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands are critical to protect water quality, to provide wildlife habitat, to mitigate flooding, to recharge groundwater, and to provide other important natural functions.

Wetlands comprise nearly 18%, or over 34,000 acres, of the Wood-Pawcatuck watershed (Table 3-1). The watershed is home to a variety of wetland types from forested swamps to marshes, bogs and fens. The watershed is dominated by forested wetlands (approximately 71% of the wetlands in the Rhode Island portion of the watershed). Shrub swamps make up the next largest category of wetlands at just over 10% of the total acreage of wetlands in the watershed (Miller & Golet, 2000). Figure 3-2 shows the distribution of wetland types throughout the watershed, including wetland classifications available from the U.S. Fish & Wildlife Service National Wetlands Inventory and state-designated wetlands.

> Watershed-Scale Wetlands Assessment of the Wood-Pawcatuck Watershed
>
> A technical assessment was conducted to evaluate potential wetland protection, enhancement, and restoration opportunities in the Wood Pawcatuck watershed to enhance flood resiliency, habitat, and water quality. The assessment is documented in a separate technical memorandum entitled *Watershed-Scale Wetlands Assessment, Wood-Pawcatuck Watershed Flood Resiliency Management Plan* (Fuss & O'Neill, 2016a).

The watershed has one of the largest deciduous floodplain forests (forested wetlands) in Rhode Island, located where the Pawcatuck River originates at Worden's Pond. The 300-acre "Great Swamp" is a Rhode Island State Management Area and a National Natural Landmark. Red maple swamps are the largest category of wetland types in the watershed, although the watershed also contains some of the region's largest stands of Atlantic White Cedar evergreen swamps found in locations such as the Great Swamp, Indian Cedar Swamp, and Chapman's Swamp (Pawcatuck Watershed Partnership, 1999).

Floodplains are the low, flat, periodically flooded lands adjacent to rivers, lakes and other waterbodies and are subject to geomorphic and hydrologic processes (RIEMA, 2014). Floodplains of rivers and streams absorb runoff and buffer upland areas from flood damage. Floodplains in the Wood-Pawcatuck watershed were historically developed for agricultural and industrial uses and later for commercial and residential uses. Development of the floodplain results in increased flood risk, and it reduces the natural ability of floodplains to store water, which can increase flooding in downstream areas. Flooding and floodplain issues in the Wood-Pawcatuck watershed are further addressed in Section 6 of this report.

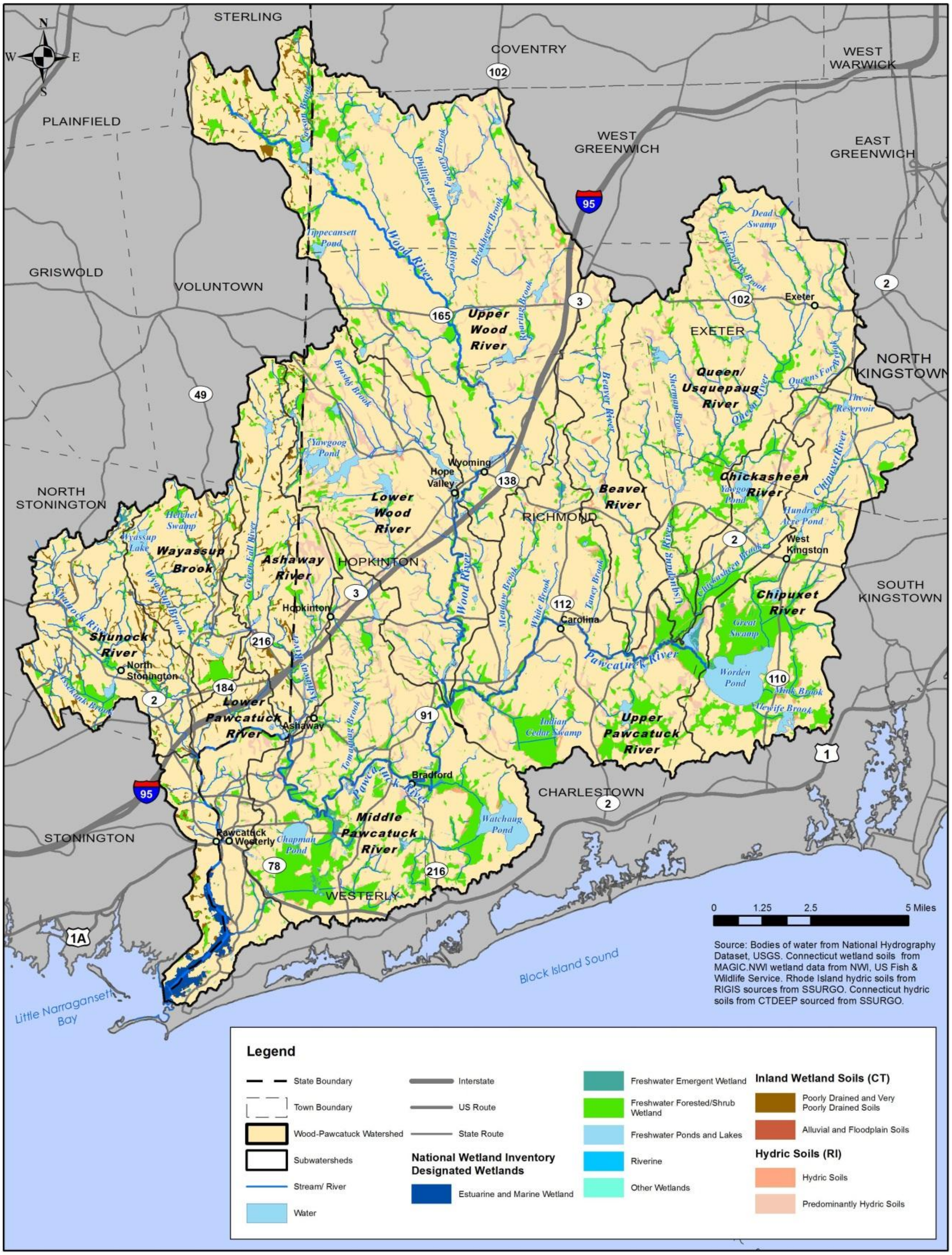

Figure 3-2. Wetland resources in the Wood-Pawcatuck watershed.

3.3 Riparian Zones

A riparian zone or riparian area is the interface between land and a river or stream. Riparian buffers are naturally vegetated areas adjacent to streams, ponds, and wetlands. Vegetative buffers help encourage infiltration of rainfall and runoff, and provide absorption for high stream flows, which helps reduce flooding and drought. The buffer area provides a living cushion between upland land use and water, protecting water quality, the hydrologic regime of the waterway and stream structure. The naturally vegetated buffer filters out pollutants, captures sediment, regulates stream water temperature and processes many contaminants through vegetative uptake. The vegetative community of riparian buffers provides habitat for plants and animals, many of which are dependent on riparian habitat features for survival. Changes to the natural riparian buffer zone can reduce the effectiveness of the buffer. According to a literature review conducted by Sweeney and Newbold (2014), a riparian buffer of at least 30 meters is needed to protect the physical, chemical and biological integrity of small streams.

Given the large amount of contiguous forest and the relatively small amount of development in the watershed, the riparian zone in the Wood-Pawcatuck can be characterized as moderately to completely intact throughout much of the watershed. Development along the stream corridors in the Lower Pawcatuck River subwatershed, in the more densely developed villages, and in residential and agricultural areas of the watershed has resulted in substantial loss of riparian vegetation in some locations.

3.4 Fisheries

Historically, coastal watersheds in southern New England, including the Wood-Pawcatuck system, contained thriving populations of anadromous fish species (species that migrate from sea to freshwater to spawn). It is believed that the Pawcatuck River was of regional importance to diadromous fisheries, including Atlantic salmon and American shad, according to a 2006 feasibility study by the Wood-Pawcatuck Watershed Association (Wood-Pawcatuck Watershed Association, 2005). The system may have also supported a strong brook trout population. It has been suggested that the salter brook trout were mistaken for Atlantic salmon, leading some to question whether Atlantic salmon truly was a significant species in the Pawcatuck River watershed (Wood-Pawcatuck Watershed Association, 2005).

Most of the anadromous runs in Rhode Island were destroyed in the 1800s when many rivers were dammed for industrial uses. The numerous culverts and bridges in the watershed also restrict or limit passage for fish and other aquatic organisms. The Pawcatuck River has been targeted for fisheries restoration efforts over the last few decades, focusing on anadromous species such as American shad and river herring (which include alewife and blueback herring). Other target diadromous fish species in the Wood-Pawcatuck system include rainbow smelt and sea-run brown trout, as well as the American eel, a catadromous species (U.S. Fish and Wildlife Service, 1991).

Using fisheries data provided by RIDEM and CTDEEP, the Narragansett Bay Estuary Program's recent "State of Our Watershed" project evaluated brook trout habitat in the Wood-Pawcatuck watershed and found that 46% of the watershed provides areas that support brook trout, which is the most significant habitats for brook trout within the entire Narragansett Bay study area. The Wood River and Lower Pawcatuck River subwatersheds also had the highest maximum fluvial fish richness of any site within the Little Narragansett Bay watershed (Narragansett Bay Estuary Program, 2016).

The Pawcatuck River watershed is stocked with hatchery-reared Atlantic salmon fry, parr, and smolts (Erkan, 2002). As discussed in Section 5.1 of this report, several fish passage projects have been completed in recent years including removal of Lower Shannock Falls Dam and White Rock Dam, and construction of fish passage structures at Kenyon Mills Dam and Horseshoe Falls Dam, in addition to the older existing fishways at Potter Hill Dam and Bradford Dam, which have had mixed success. The Nature Conservancy is currently pursuing fish passage restoration at Bradford Dam through the construction of a rock ramp fish passage structure or dam removal. The USGS gaging station in Richmond is passable to some fish species but needs to be retrofitted to pass species such as river herring.

RIDEM's *Strategic Plan for the Restoration of Anadromous Fishes to Rhode Island Coastal Streams* (Erkan, 2002) identified the Pawcatuck River as having the potential for restoration of anadromous species and the only watershed in the plan as having potential for significant areas of salmon habitat. The 2002 plan recommended the mainstem of the Pawcatuck River and the Queen/Usquepaug River as the most realistic targets for restoration of anadromous fisheries. Many of the tributaries to the Pawcatuck River have water quality that supports cold water fish species. Opening up the full length of the mainstem of the Pawcatuck River would support fisheries restoration efforts throughout the rest of the watershed.

The RIDEM Division of Fish and Wildlife is in the process of updating the 2002 plan. In addition to adding new sites for diadromous habitat restoration, the update is intended to allow information on the best available fish passage techniques, including dam removal and rock ramps. Other aspects of the update will involve improving the precision of the estimated habitat sizes using updated mapping techniques, incorporating more recently available data from ongoing fish community sampling. The plan will be updated to reflect completed projects for fish passage, dam removal or obstruction removal, and expanded to identify actions needed for upstream obstructions not previously addressed (Monroy, 2016).

In the Connecticut portion of the watershed, the Shunock River and Green Fall River have the greatest fisheries restoration potential. The recent removal of White Rock Dam potentially opens up the Shunock River to river herring and other resident species from the lower Pawcatuck. Fishways or dam removal would need to be considered for several of the dams on the Shunock to allow access to the upstream portions of the Shunock subwatershed. Several dams on the Ashaway River currently block access to the Green Fall River (the Green Fall River becomes the Ashaway River at the Rhode Island state line). The dams along the Ashaway River would need fishways or removal to restore connectivity in the lower portion of the Green Fall River subwatershed, which may have supported historic runs of river herring (Gephard, 2015).

The Wood-Pawcatuck Watershed Association has also undertaken a number of studies examining the effects of dams in the watershed on fish species composition and abundance (Wood-Pawcatuck Watershed Association, 2004a; Wood-Pawcatuck Watershed Association, 2004b; Wood-Pawcatuck Watershed Association, 2005). The findings of these studies indicate that dams within the Wood-Pawcatuck watershed, in addition to serving as physical barriers to fish migration, alter environmental conditions that affect fish species composition by increasing suitable warm water habitat and competition from warm water fish species that may result in reduced growth and survival of cold water species such as brook trout. The findings of these studies support the continued restoration of cold water and resident fish species in the Wood-Pawcatuck watershed through fish passage projects such as fishways, nature-like rock ramps, dam removal, and culvert replacement.

3.5 Pawcatuck River Estuary

An estuary is a partially enclosed body of water where fresh water from rivers and streams mixes with salt water from the ocean. Estuaries are areas of transition between the land and the sea, and are among the most productive environments on earth, providing diverse habitats for wildlife and aquatic life, flood protection, and pollutant reduction, and supporting local economies through commercial and recreational activities.

The Pawcatuck River estuary forms the border between Stonington, Connecticut, and Westerly, Rhode Island. The estuary extends approximately five miles from between the Route 1 crossing and Stillman Avenue Bridge in Westerly to the mouth of the river at Pawcatuck Point where it meets Little Narragansett Bay. The estuary is considered to be highly stratified, with a layer of freshwater from the Pawcatuck River riding over a saline bottom layer originating from the Block and Fishers Island Sounds (Dillingham, Abrams, Dasbonnet, & Willis, 1993). Land use along the estuary is significantly more urbanized than the rest of the watershed. Present land use adjacent to the estuary is primarily residential, with some commercial-business use (Dillingham, Abrams, Dasbonnet, & Willis, 1993).

The Pawcatuck River estuary and Little Narragansett Bay contain a wide diversity of natural habitats including open water and aquatic habitats, wetland systems, and upland areas adjacent to the estuary. Many of these are high-quality habitats that support commercially important fisheries, rare and endangered species, as well as provide the foundation for the estuarine ecosystem (Dillingham, Abrams, Dasbonnet, & Willis, 1993). Due largely to the presence of sewage treatment facilities (Westerly and Pawcatuck) in the upper reaches of the estuary, shellfishing is prohibited in all of the estuarine waters of Little Narragansett Bay, and the Pawcatuck River has historically been closed for shellfishing (Narragansett Bay Estuary Program, 2016). A detailed description of the various habitats and species within the Pawcatuck River estuary and Little Narragansett Bay is provided in *The Pawcatuck River Estuary and Little Narragansett Bay: An Interstate Management Plan* (Dillingham, Abrams, Dasbonnet, & Willis, 1993).

3.6 Rare Species and Unique Habitats

The Wood-Pawcatuck watershed supports a high diversity of species and habitats. The variety of high-quality habitats can be attributed to the watershed's unique glacial history and topography setting. These habitats include pitch pine barrens, rhododendron swamps, laurel thickets, floodplain forests, marshes, bogs, fens, vernal pools, lakes and ponds, and estuary. Approximately 75 percent of all animal species found in Rhode Island can be found within the watershed – this includes 36 mammals, 16 amphibians, 18 reptiles, 123 nesting birds, 33 freshwater fish and thousands of insects (Pawcatuck Watershed Partnership, 1999). The watershed is also home to over 70% of the species considered to be rare or endangered in Rhode Island, several of which are found nowhere else in the state (Pawcatuck Watershed Partnership, 1999).

Figure 3-3 depicts generalized areas of endangered, threatened, and special concern species in the Wood-Pawcatuck watershed. These areas represent a buffered zone around known species or community locations, based upon information compiled and maintained by RIDEM (Natural Heritage Areas) and CTDEEP (Natural Diversity Database Areas). Many of these areas coincide with large tracts of preserved open space throughout the watershed (see Section 4.4). For example, large portions of both the Arcadia Management Area and the Pachaug State Forest contain mapped Natural Heritage Areas or Natural Diversity Database according to data provided by both state programs.

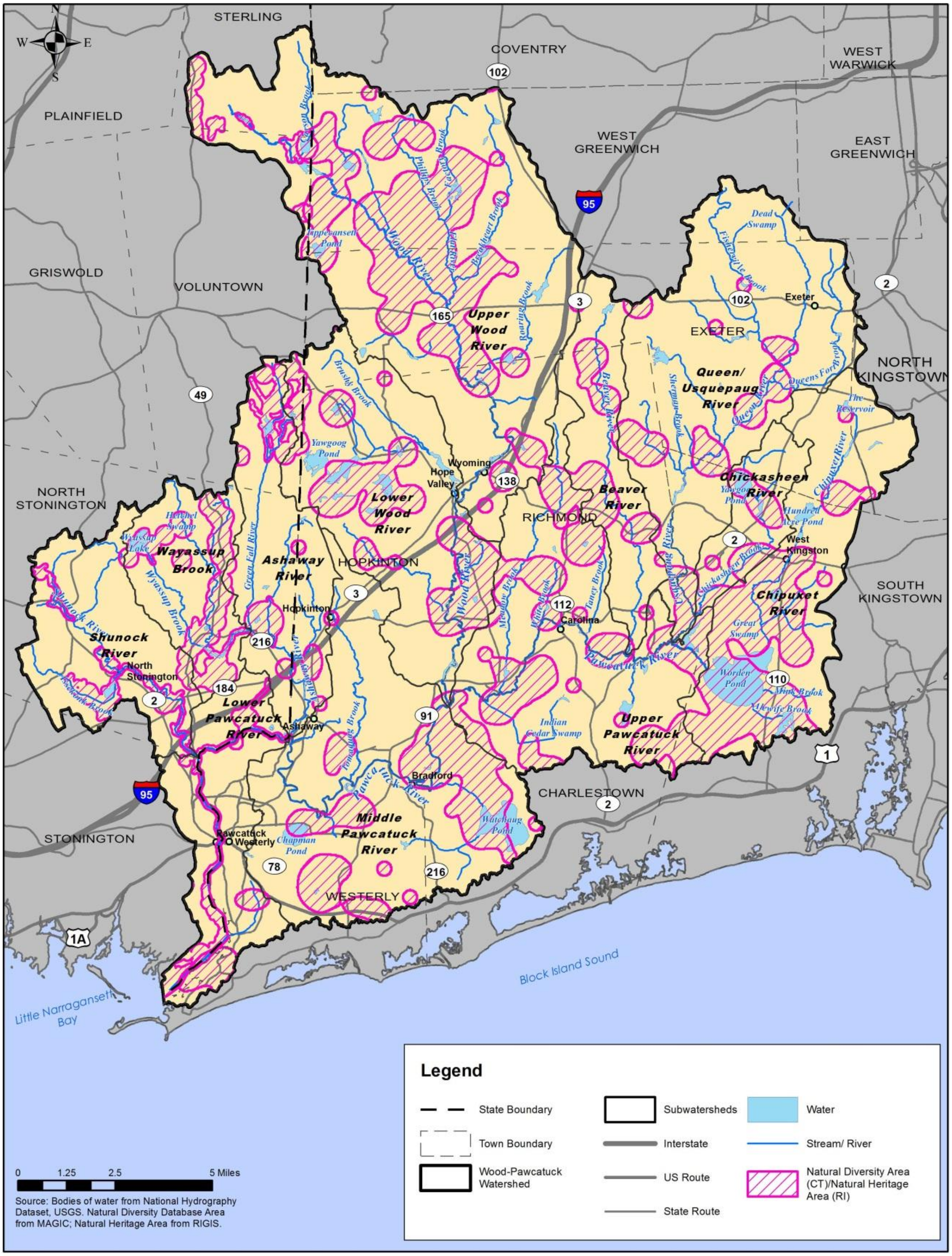

Figure 3-3. Areas of endangered, threatened, and special concern species in the Wood-Pawcatuck watershed.

4 Demographics and Land Use

4.1 Population and Demographics

According to population estimates from the Rhode Island Statewide Planning Program (RISPP) and the Connecticut Economic Resource Center (CERC), the total population of towns located either entirely or partially within the Wood-Pawcatuck watershed is just over 194,000 people (Rhode Island Statewide Planning Program, 2013; Connecticut Economic Resource Center, Inc., 2014a; Connecticut Economic Resource Center, Inc., 2014b; Connecticut Economic Resource Center, Sterling, 2014c; Connecticut Economic Resource Center, Voluntown, 2014d). The population within the watershed is estimated at approximately 84,000 people. Of the 14 communities located within the Wood-Pawcatuck watershed, the towns of Westerly, South Kingstown, Hopkinton, Richmond and Stonington make up nearly 70% of the population in the watershed (Table 4-1). The watershed population is expected to grow by 4% by 2020, with the largest percentage increases projected for Richmond and West Greenwich (Table 4-2).

Population growth and development in the watershed has the potential to increase impervious surfaces and runoff quantity, degrade water quality through increased pollutant loads, and exacerbate flood hazards by allowing development in flood-prone areas.

Table 4-1. 2010 population estimates for the Wood-Pawcatuck watershed.

Town	State	Town Population	Watershed Population
Charlestown	RI	7,827	5,479
Coventry	RI	35,014	216
East Greenwich	RI	13,146	359
Exeter	RI	6,425	6,350
Hopkinton	RI	8,188	8,188
North Kingstown	RI	26,486	3,899
Richmond	RI	7,708	7,708
South Kingstown	RI	30,639	13,454
Westerly	RI	22,787	21,421
West Greenwich	RI	6,135	3,207
North Stonington	CT	5,252	4,292
Sterling	CT	3,727	685
Stonington	CT	18,497	7,640
Voluntown	CT	2,603	760
	Total	194,434	83,658

Table 4-2. Population projections for the Wood-Pawcatuck watershed.

Town	State	Watershed Population (2010)	Estimated Population Growth Rate	Projected Population (2020)
Charlestown	RI	5,479	5.9%	5,801
Coventry	RI	216	3.0%	223
East Greenwich	RI	359	2.3%	367
Exeter	RI	6,350	5.1%	6,673
Hopkinton	RI	8,188	4.4%	8,549
North Kingstown	RI	3,899	4.1%	4,057
Richmond	RI	7,708	11.2%	8,574
South Kingstown	RI	13,454	6.5%	14,324
Westerly	RI	21,421	0.4%	21,504
West Greenwich	RI	3,207	14.1%	3,658
North Stonington	CT	4,292	0.3%	4,306
Sterling	CT	685	16.6%	799
Stonington	CT	7,640	0.7%	7,693
Voluntown	CT	760	-2.3%	742
	Total	83,658	4.3%	87,271

4.2 Land Use

The National Land Cover Database 2011 developed by the Multi-Resolution Land Characteristics Consortium (Homer, et al., 2015) was used as a surrogate for land use in the Wood-Pawcatuck given the lack of a consistent land use data set for the entire watershed. Land cover, as its name implies, refers to what is present on the land surface, which differs from land use, which is what is permitted, practiced or intended for a given area (University of Connecticut Center for Land Use Education and Research (CLEAR), 2010). Figure 3-1 depicts 2011 land cover for the Wood-Pawcatuck watershed. Table 3-1 summarizes the percentage of each land cover type within the watershed.

The NLCD 2011 land cover types have the following characteristics:

- Urban Open Space: Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of the total cover. These areas most commonly include large-lot single family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- Developed, Low Intensity: Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% of total cover. These areas most commonly include single-family housing units.
- Developed, Medium Intensity: Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
- Developed, High Intensity: highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.

- Barren Land (Rock/Sand/Clay): Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of the total cover
- Deciduous Forest: Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of the total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
- Evergreen Forest: Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of the total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
- Mixed Forest: Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of the total vegetation cover. Neither deciduous or evergreen species are greater than 75% of total tree cover
- Shrub/Scrub: Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
- Grass and Fields: Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing. Also, areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
- Cultivated Crops: Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
- Wetlands: Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. Also, areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Approximately 60% of the watershed consists of deciduous, evergreen, or mixed forest. Wetlands and open water account for 20% of the watershed. Developed land uses make up approximately 20% of the watershed. According to the draft "State of Our Watershed Technical Report" recently prepared by the Narragansett Bay Estuary Program (NBEP), which includes the Little Narragansett Bay watershed, the Rhode Island portion of the watershed gained an estimated 614 acres of urban land and lost an estimated 662 acres of forest land from 2001 to 2011. All of the major HUC 12 subwatersheds in the Wood-Pawcatuck experienced an increase in urban land and all except the Ashaway River subwatershed experienced a loss in forest acres (Narragansett Bay Estuary Program, 2016).

4.3 Impervious Cover

Impervious surfaces prevent precipitation from naturally soaking into the ground, resulting in a variety of hydrologic changes in a watershed. Impervious cover is a measure of the amount of impervious surfaces covering the landscape and is a useful indicator of ecological conditions in a watershed. Numerous studies have documented the cumulative effects of urbanization on stream and watershed ecology (Schueler T. , Site Planning for Urban Stream Protection, 1995) (Schueler T. K., 1992) (Booth D. a., 1993) (Arnold, 1996)

(Shaver, 1996) (Center for Watershed Protection, 2003). The percent of impervious cover in a watershed negatively affects many aspects of stream health including: shape and instability of stream channels; habitat quality (e.g., pools and riffles, overhead cover); water quality (more pollutants including chemicals and bacteria, higher temperature, reduced dissolved oxygen concentration); fish spawning; and biodiversity of macroinvertebrates and fish (Schueler T. , 1994). 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 waterbodies 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 (Lehner, Aponte Clark, Cameron, & Frank, 1999). Watershed imperviousness in excess of 60 percent is generally indicative of watersheds with significant urban drainage. Figure 4-1 illustrates this effect. These research findings have been integrated into a general watershed planning model known as the Impervious Cover Model (Center for Watershed Protection, 2003).

Figure 4-1 also demonstrates the wide variability in stream response found in less-urban watersheds at lower levels of impervious cover (generally less than 10 percent). Stream quality at lower ranges of impervious cover is generally influenced more by other watershed metrics, such as forest cover, road density, extent of riparian vegetative cover, and cropping practices. Less variability exists in the stream quality at higher levels of impervious cover because most streams in highly impervious, urban watersheds exhibit fair or poor stream health conditions, regardless of other conditions (Hirshman, 2008).

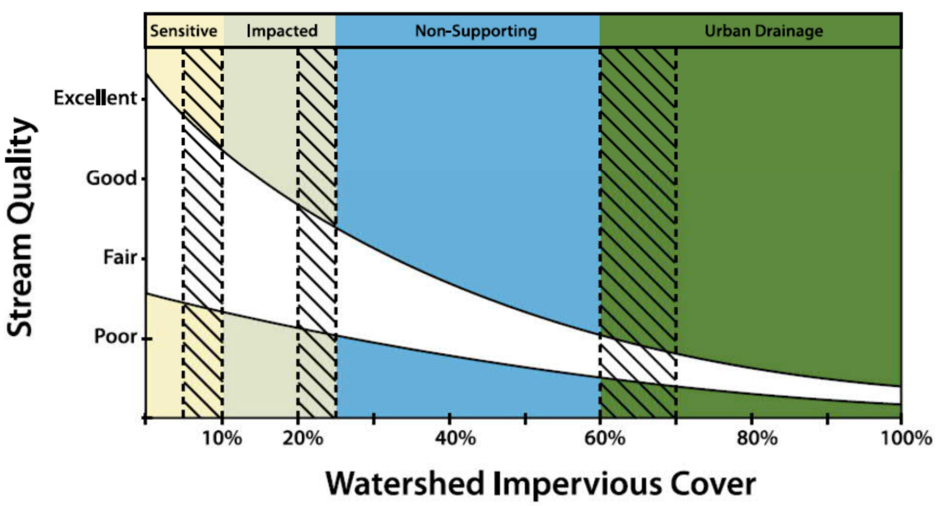

Figure 4-1. Conceptual model illustrating relationship between watershed impervious cover and stream quality.

Table 4-3 summarizes the amount and percentage of impervious cover in the Wood-Pawcatuck subwatersheds that have been defined for this study. These impervious cover estimates are based on the NLCD 2011 percent impervious surface data for the Wood-Pawcatuck watershed (Xian, Homer, C., Dewitz, J., Fry, J., Hossain, N., & Wickham, J., 2011). As shown in Figure 4-2 and Table 4-3, impervious surfaces account for less than 5% of the land area in most of the Wood-Pawcatuck subwatersheds, with the exception of the Lower Pawcatuck River subwatershed where impervious cover exceeds 20%. In terms of the watershed communities, Westerly, North Kingstown, and East Greenwich, Rhode Island and Stonington, Connecticut have the highest percentage of impervious cover (10-20%) in the watershed.

When evaluated using the conceptual model in Figure 4-1, the majority of subwatersheds in the Wood-Pawcatuck fall within the "Sensitive" category with only one subwatershed (Lower Pawcatuck) ranking as "Impacted." This suggests that impervious cover is not likely to be the fundamental or singular driver of decreased water quality in subwatersheds where the impervious cover percentage is below the "Impacted" threshold or the transition zone. While impervious cover might not be the primary reason why some waterbodies within the watershed fail to meet water quality standards, it can have more localized impacts and negatively impact receiving waters on a smaller scale.

Table 4-3. Impervious surfaces by subwatershed in the Wood-Pawcatuck watershed.

Subwatershed Name	Area (acres)	Amount of Impervious Surface (acres)	Percent Impervious
Upper Wood River	39,073	775.2	2.0
Lower Wood River	18,309	400.4	2.2
Upper and Middle Pawcatuck River	45,408	1943.6	4.3
Lower Pawcatuck River	10,147	2216.9	21.8
Shunock River	10,591	268.4	2.5
Waysssup Brook	7,340	45.2	0.6
Ashaway River	10,492	222.3	2.1
Queen/Usquepaug River	23,768	381.8	1.6
Beaver River	7,901	142.3	1.8
Chickasheen Brook	4,230	174.3	4.1
Chipuxet River	16,451	673.1	4.1

Table 4-4. Impervious surfaces by town in the Wood-Pawcatuck watershed.

Town	State	Amount of Impervious Surface (acres)	Percent Impervious
Charlestown	RI	1,222	5.1
Coventry	RI	2,966	7.4
East Greenwich	RI	1,554	14.9
Exeter	RI	669	1.8
Hopkinton	RI	802	2.8
North Kingstown	RI	4,679	16.7
Richmond	RI	820	3.1
South Kingstown	RI	2,871	7.5
Westerly	RI	3,382	17.6
West Greenwich	RI	789	2.4
North Stonington	CT	564	1.6
Sterling	CT	230	1.3
Stonington	CT	2,485	10.2
Voluntown	CT	210	0.8

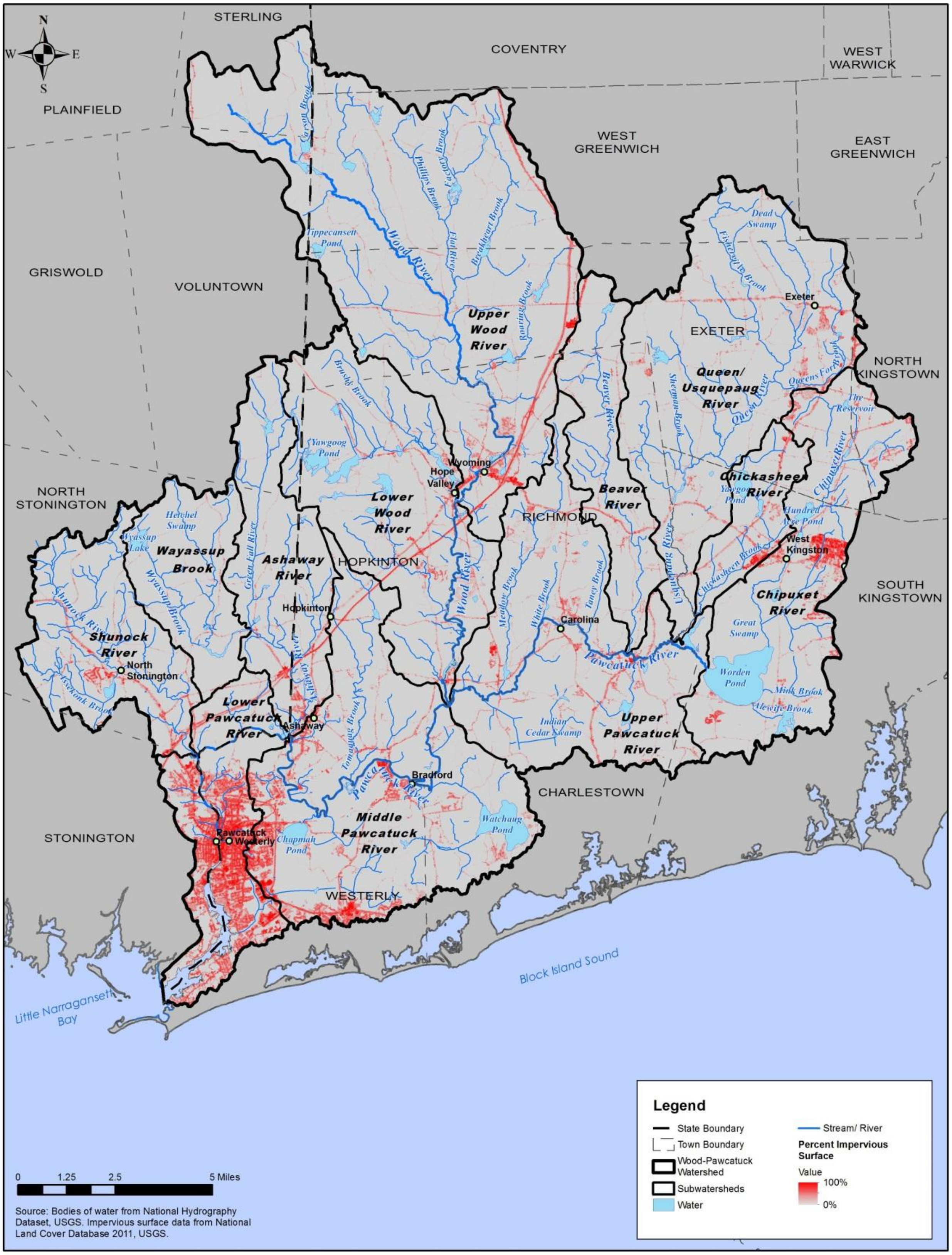

Figure 4-2. Percent impervious cover within the Wood-Pawcatuck watershed.

4.4 Open Space

Open space lands consists of undeveloped land characterized by natural features such as forests, riparian zones, and vegetated areas, as well as developed land including agricultural lands, recreational lands (e.g., parks, golf courses, and playing fields), and other developed open space areas. Natural open space lands provide important ecosystem and community benefits including water quality protection, groundwater recharge, flood protection, wildlife and plant habitats, biodiversity, and many others. Federal, state, and local agencies protect areas of natural, undeveloped lands through regulation (e.g., wetlands) and incentive-based programs. High-value natural areas are threatened by fragmentation and commercial/ residential development of forested and agricultural land that is not protected by regulatory programs.

Open space protection provides the permanent preservation of lands in a watershed by limiting development and impervious coverage, preserving the integrity of floodplains and other lands critical to flood mitigation, preserving natural pollutant attenuation characteristics, and supporting other planning objectives such as farmland preservation, community preservation, and passive recreation. Open space planning aimed at acquiring or protecting vulnerable land in river corridors and floodplains can be an effective approach for enhancing flood resiliency and protecting water quality.

Nearly 60,000 acres of land in the Wood-Pawcatuck watershed are already protected as open space or conservation land, which is a primary reason for the watershed's high-quality natural resources. Figure 4-3 shows the location and type of protected open space in the Wood-Pawcatuck watershed. These areas are comprised primarily of state and municipally-owned wildlife management areas and preserves, along with cemeteries, golf courses and recreational fields. This land is protected against future development or is unlikely to be developed in the future. Some of the notable (based on size and/or high quality) natural protected open space areas within the watershed are listed in Table 4-5.

Table 4-5. Notable protected open space land within the Wood-Pawcatuck watershed.

Rhode Island	Managed By	Acres
Arcadia Management Area	RIDEM	14,000
Burlingame Management Area	RIDEM	4,043
Carolina Management Area	RIDEM	2,325
Tillinghast Pond Management Area	TNC	2,054
Rockville Management Area	RIDEM	810
Woody Hill State Management Area	RIDEM	736
Great Swamp Wildlife Reservation	RIDEM	618
Beaver River Preserve	TNC	241
Grass Pond Preserve	TNC	180
Connecticut		
Pachaug State Forest	CTDEEP	25,135
Assekonk Swamp Wildlife Management Area	CTDEEP	694

RIDEM – Rhode Island Department of Environmental Management
CTDEEP – Connecticut Department of Energy and Environmental Protection
TNC – The Nature Conservancy

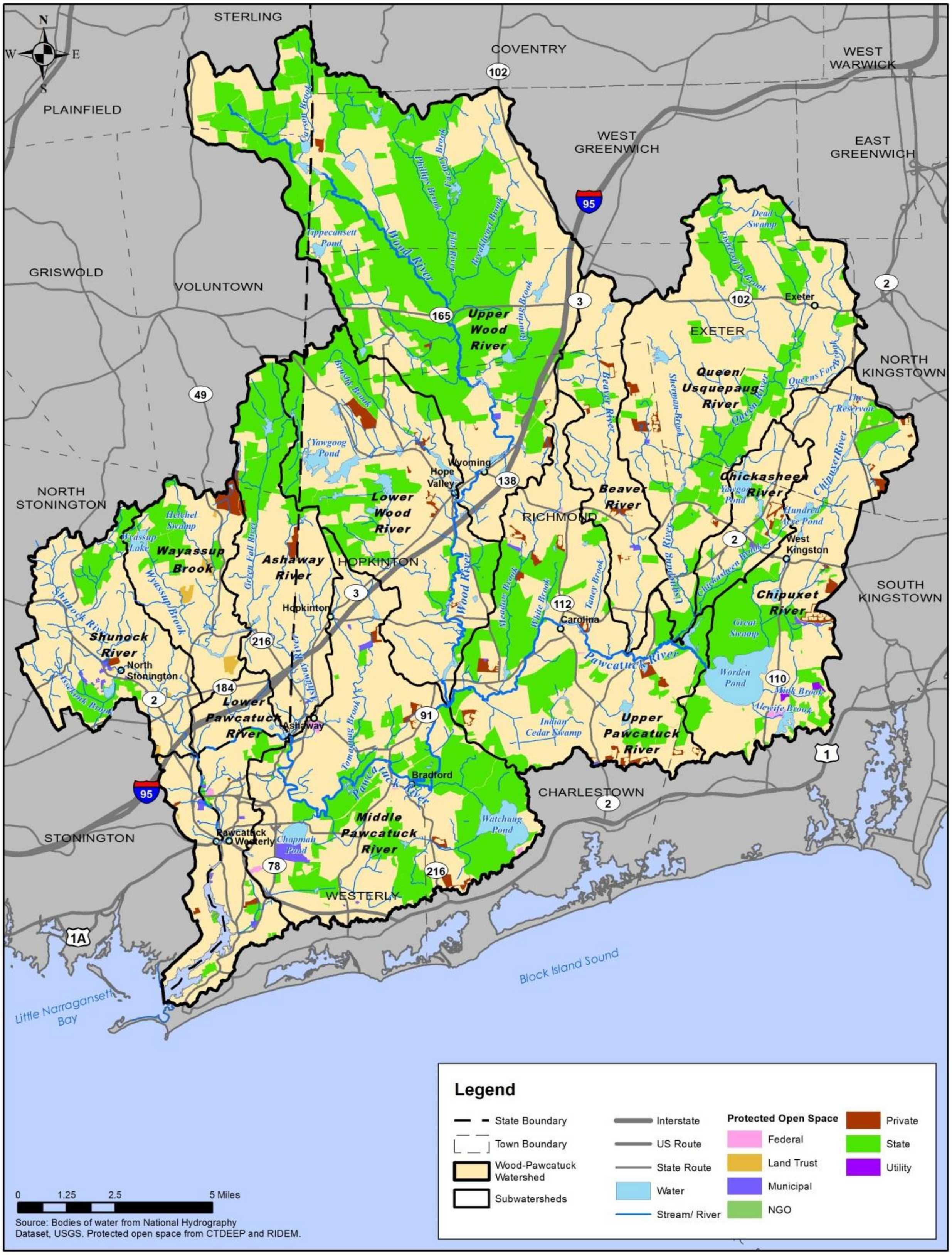

Figure 4-3. Areas of protected open space within the Wood-Pawcatuck watershed.

Based on the draft report entitled "State of Our Watershed" prepared by the Narragansett Bay Estuary Program (NBEP) for the Narragansett Bay watershed, which includes the Little Narragansett Bay watershed, nearly 38% of the Rhode Island portion of the Wood-Pawcatuck watershed is protected open space, and the vast majority of this land (55,000 acres) is preserved as natural lands. The remaining protected open space (2.5%) consists of agricultural lands, recreational lands, or other developed open space lands. Over 40,000 acres of unpreserved land in the Rhode Island portion of the watershed (26%) has high ecological value, which presents both a challenge and opportunity for further land preservation. Between 25% and 40% of the land in the major Wood-Pawcatuck subwatersheds is unpreserved natural land (Narragansett Bay Estuary Program, 2016).

There are several common methods that undeveloped land can be preserved and protected as open space. These include outright purchase, conservation easements, restrictive covenants, purchase or transfer of development rights, tax lien procedures, land donations, and conservation development procedures for residential cluster subdivisions. Regardless of the mechanism, critical to the success of protecting open space land is the ability to readily leverage financing when windows of opportunity arise to acquire or preserve significant parcels and the willingness of landowners to sell.

5 Water Infrastructure

This section describes the water infrastructure within the Wood-Pawcatuck watershed including stream crossings (dams, bridges, and culverts), stormwater infrastructure, wastewater collection and treatment, and water supply, as it relates to flooding and water quality issues.

5.1 Dams

Dams are artificial barriers designed to impound or retain water for a variety of purposes, including water supply, irrigation, power generation, flood control, recreation and pollution control. There are over 160 documented dams in existence in the Wood-Pawcatuck watershed (Figure 5-1). Many of these are relatively small dams built to power small industry mills of the 17th and 18th centuries and are no longer used for their original purpose. Many of the remaining dams in the watershed and their associated impoundments provide recreational opportunities, aquatic and wildlife habitat, and water supply. None of the dams in the watershed were originally constructed for flood control purposes; the dams therefore provide limited, if any, flood control benefit.

The dams in the Wood-Pawcatuck watershed pose upstream flood hazards by backing up water during floods and present a hazard to downstream areas in the event of a breach or failure, potentially releasing large quantities of flow, sediment, and debris. The state dam safety programs run by the Rhode Island Department of Environmental Management (RIDEM) and the Connecticut Department of Energy and Environmental Protection (CTDEEP) assign a rating or "hazard class" to each dam reflecting the probable consequences of failure of the dam. Hazard classifications are based on dam height, potential hazard to downstream infrastructure, potential loss of human life, and potential property damage in the event of failure. Hazard class does not relate to the current condition of the dam or the probability that the dam might fail.

> Assessment of Existing Dams in the Wood-Pawcatuck Watershed
>
> An assessment of the existing dams in the Wood-Pawcatuck watershed was conducted to evaluate flood risk potential in the event of failure and to identify management recommendations (i.e., dam removal, repair or modification) to increase flood resiliency as well as improve aquatic habitat, river continuity, and fish passage. The assessment involved file reviews and limited visual condition assessments of approximately 70 dams in the watershed. The assessment is documented in a separate report entitled *Dams, Bridges and Culverts Assessment Technical Memorandum* (Fuss & O'Neill, 2016b).

In Rhode Island, RIDEM classifies dams as High Hazard, Significant Hazard, or Low Hazard. High Hazard dams are dams where failure or misoperation will result in a probable loss of human life. Significant Hazard dams are those dams where failure or misoperation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact to other concerns detrimental to the public's health, safety or welfare. Low Hazard refers to a dam where failure or misoperation results in no probable loss of human life and low economic losses. Connecticut uses a similar classification system, but with five categories – High Hazard, Significant Hazard, Moderate Hazard, Low Hazard, and Negligible Hazard. Figure 5-1 identifies the hazard classifications of the dams in the Wood-Pawcatuck watershed.

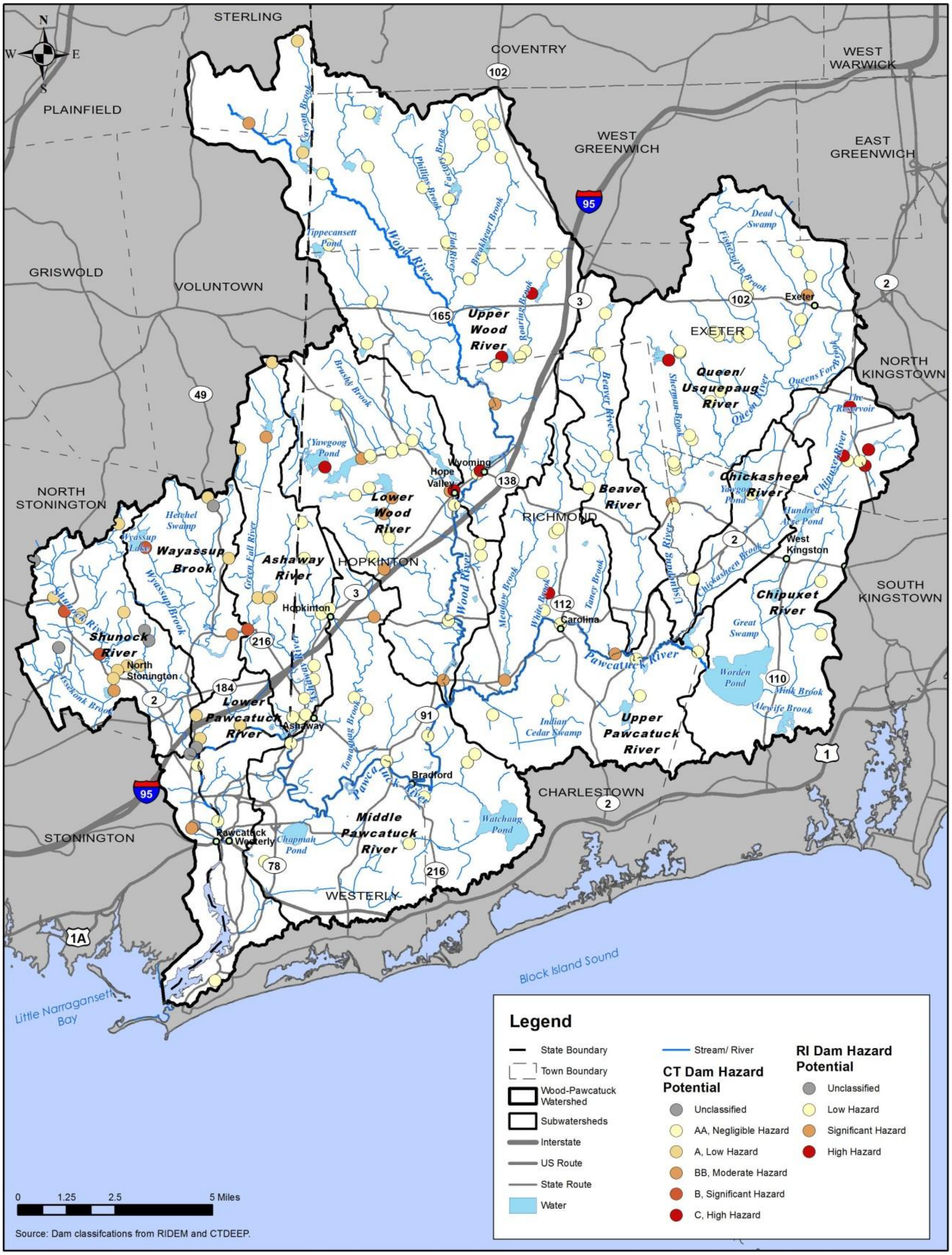

Figure 5-1. Hazard classifications of dams in the Wood-Pawcatuck watershed.

As described in Section 3.4 of this report, the Pawcatuck River has been targeted for fisheries restoration efforts over the last few decades, focusing on anadromous species such as American shad and river herring (which include alewife and blueback herring) and other cold and warm water species. Several projects have been completed along the mainstem of the Pawcatuck River aimed at improving aquatic habitat, river connectivity, and fish passage. Full dam removals at Lower Shannock Falls in 2010 and more recently at White Rock Dam in 2015 have helped to improve anadromous fish passage along the lower Pawcatuck. A rock ramp fishway and Denil fish ladder were also recently installed at Kenyon Mills Dam and Horseshoe Falls Dam, respectively. Potter Hill Dam and Bradford Dam have existing Denil fishways, although the U.S. Fish and Wildlife Service has identified numerous issues associated with fish passage effectiveness at these dams, leaving dam removal as the most effective, sustainable option for providing fish passage at these structures (Sojkowski, Morales, J., & Orvis, C., 2014). With the removal of White Rock Dam, Potter Hill and Bradford Dams are now the first and second barriers, respectively, on the Pawcatuck River. The Nature Conservancy is currently pursuing fish passage restoration at Bradford Dam through the construction of a rock ramp fish passage structure or dam removal.

The impoundments created by dams can also affect water quality. Impoundments increase summer water temperatures by creating larger, slower moving waterbodies that are exposed to sun and warm air temperatures. Warmer temperatures decrease the dissolved oxygen content of the water in the impoundment and typically for some distance downstream of the dam. A study by the Wood-Pawcatuck Watershed Association found that small dams on low order streams (i.e., smaller headwater streams) can result in elevated water temperatures for miles downstream of the dam, which can impact sensitive cold water fisheries habitat (Wood-Pawcatuck Watershed Association, 2004a). Excess inputs of nutrients from stormwater, nonpoint source runoff, and nutrient-rich sediments can lead to the growth of algae and nuisance aquatic vegetation.

5.2 Bridges and Culverts

Undersized stream crossings (i.e., bridges and culverts) can contribute to flooding by restricting flood flows, causing backwater, sediment deposition, bifurcating flow, and sudden formation of new channels upstream of the crossing as well as scour downstream of the crossing. Undersized crossings increase the risk of floods inundating the associated road or railroad and can potentially cause floods to breach through a section of road fill adjacent to the existing channel. Culverts can also serve as barriers to the passage of fish and other aquatic organisms along a river system, altering aquatic habitat and disrupting river and stream continuity. The Wood-Pawcatuck watershed contains nearly 600 structures (roads, rail lines, and developed bike/hiking trails) that cross mapped streams (Figure 5-2).

A number of organizations are involved in efforts in the region to identify and prioritize stream barriers that should be further examined for removal, enhancement, or restoration. The primary objective of most of this work to date has been to increase stream continuity and enhance aquatic organism passage, although increasing stream continuity through culvert replacement typically also provides significant flood resiliency benefits as well.

> Assessment of Existing Bridges and Culverts in the Wood-Pawcatuck Watershed
>
> A watershed-wide assessment was conducted of the bridges and culverts in the watershed. Culverts and bridges were assessed relative to hydraulic capacity under current and future (i.e., climate change) conditions, flooding impact potential, geomorphic vulnerability, and aquatic organism passage. Structures were prioritized for upgrade or replacement based on the assessment findings. The assessment is documented in a separate report entitled *Dams, Bridges and Culverts Assessment Technical Memorandum* (Fuss & O'Neill, 2016b).

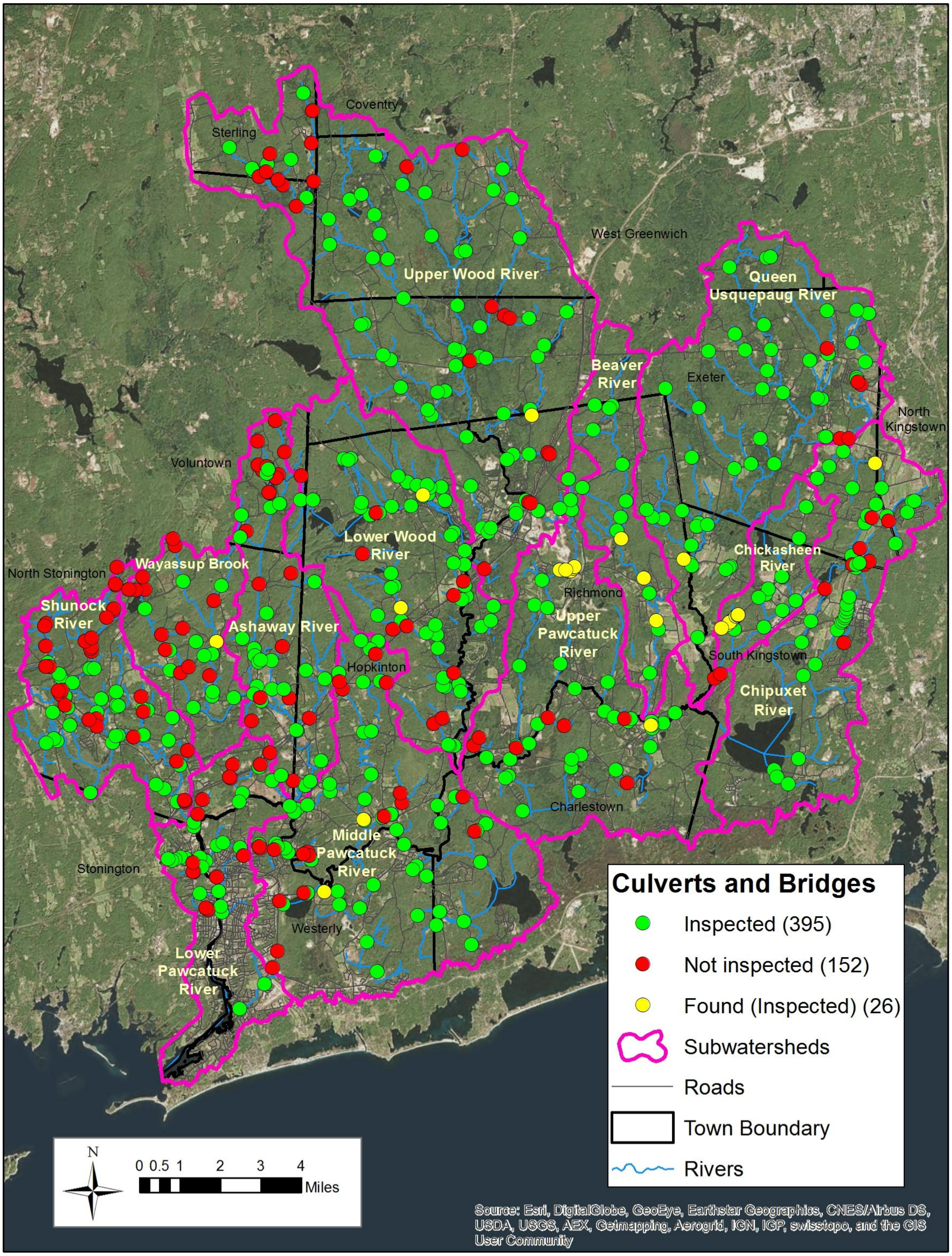

Figure 5-2. Stream crossings (culverts and bridges) of mapped streams in the Wood-Pawcatuck watershed.

The North Atlantic Aquatic Connectivity Collaborative (NAACC) is a partnership between 13 states to enhance aquatic connectivity through protocols for road-stream crossing assessments that can help identify bridges and culverts that are problematic from an aquatic connectivity perspective. This effort supports planning with tools to identify restoration projects that are likely to have the greatest benefits for aquatic connectivity and resiliency. Both Rhode Island and Connecticut are partners in the NAACC.

Similar efforts were conducted through the Rhode Island River and Stream Continuity Project funded by the Natural Resources Conservation Service and implemented by the Rhode Island Resource Conservation and Development Council (RIRC&D) with assistance from Trout Unlimited and the Wood-Pawcatuck Watershed Association. Over 800 stream crossings were assessed by volunteers in selected watersheds throughout Rhode Island, including the Upper and Lower Wood, Upper Pawcatuck, Queen, and Beaver Rivers. These data were also submitted to the database managed through the NAACC.

A new project is being funded by the Rhode Island Natural Resources Conservation Service, modeled after the North Atlantic Aquatic Connectivity Collaborative. The University of Rhode Island has been selected to lead this project and the objective is to identify potential stream crossings on private lands that need improvement and can provide passage to fish and amphibians. This will help target private landowners to apply for funding to implement Natural Resources Conservation Service's conservation practices and the result can lead to enhanced connectivity as well as the protection of other critical areas such as riparian areas within the watershed (Monroy, 2016).

5.3 Stormwater Management

Stormwater runoff generated in developed areas from buildings, pavement, and other compacted or impervious surfaces contributes to flooding problems and is a source of nonpoint source pollution in the Wood-Pawcatuck watershed. Impervious surfaces prevent infiltration of rainfall and runoff into the ground. Stormwater generated from impervious surfaces typically contains increased pollutants from the atmosphere, vehicles, industry, lawns, construction sites, humans and animals. Without treatment, these pollutants are conveyed from the impervious surfaces to storm drainage systems and eventually to the receiving waterbodies during storms. Impervious surfaces and traditional piped storm drainage systems increase the volume, peak flow rates, and velocity of stormwater runoff to receiving waters. This can contribute to channel erosion, sedimentation, and reduced stream baseflow during dry periods. The amount of impervious cover in the West River watershed and the implications for water quality and overall stream health are discussed in Section 4.3.

As noted previously, impervious surfaces account for less than 5% of the land area in most of the major Wood-Pawcatuck subwatersheds, with the exception of the Lower Pawcatuck River subwatershed where impervious cover exceeds 20%. Consistent with the Impervious Cover Model relationship between impervious cover and stream health, water quality impairments are more prevalent in the lower, more urbanized portion of the Wood-Pawcatuck watershed.

Stormwater discharges from municipalities and other state/federal agencies in the watershed are regulated under the USEPA Phase II municipal stormwater permit program, which required the operators of small municipal separate storm sewer systems (MS4s) in urbanized areas to obtain permit coverage and implement stormwater management programs to control polluted stormwater discharges. The Rhode Island Department of Environmental Management (RIDEM) and Connecticut Department of Energy and Environmental Protection (CTDEEP) implement their state's respective Phase II programs through MS4 general permits.

All of the Rhode Island communities in the watershed developed Stormwater Management Plans (SWMPs) around 2005 in response to the MS4 General Permit. Given the expansion of urbanized areas based on the 2010 U.S. Census, portions of Westerly, Charlestown, Hopkinton, Exeter, and North Kingstown are expected to be regulated under the new Rhode Island MS4 Permit, which is anticipated to be issued in the next several years. In the Connecticut portion of the watershed, only Stonington is a regulated MS4 community. The Connecticut MS4 Permit was re-issued in January 2016 and will become effective in July 2017. Under the new MS4 Permits in both states, regulated communities will be required to review and update their local land use regulations to require post-construction stormwater management for new development and redevelopment, as well as promote and remove barriers to the use of Low Impact Development (LID).

Green Infrastructure Assessment and Land Use Regulatory Review for the Wood-Pawcatuck Watershed

A green infrastructure assessment was performed for the Wood-Pawcatuck watershed. The assessment identified opportunities for site-specific green stormwater infrastructure retrofits that would increase flood resiliency by reducing runoff volumes and peak flows and improve or protect water quality by reducing pollutant loads to receiving waters. The assessment identified approximately 30-site-specific project concepts in the watershed and is documented in a separate technical memorandum entitled *Green Infrastructure Assessment, Wood-Pawcatuck Watershed Flood Resiliency Management Plan* (Fuss & O'Neill, 2016c).

A review was conducted of the existing land use policies, plans, and regulations of the municipalities in the Wood-Pawcatuck watershed relative to flood management, stormwater management, and related issues. The objective of the review is to recommend new or modified land use policies and/or regulations that could be implemented by the watershed municipalities to enhance flood resiliency in the Wood-Pawcatuck watershed. The review is documented in a separate technical memorandum entitled *Land Use Regulatory Review, Wood-Pawcatuck Watershed Flood Resiliency Management Plan* (Fuss & O'Neill, 2016d).

Both states have separate stormwater design manuals that contain design guidance and standards for new development and redevelopment projects, and both establish LID (also known as "green infrastructure" or "green stormwater infrastructure") as the standard for managing stormwater. Municipalities in both states also have the authority to adopt the state stormwater design guidance or standards, or more stringent requirements, in their local land use regulations.

RIDEM developed an ordinance checklist entitled *Ordinance Checklist for LID Stormwater Site Planning and Design*, which was completed by each of the municipalities in the Rhode Island portion of the watershed. The Ordinance Checklist is designed to allow communities to determine what specific LID site planning and design techniques they have adopted or may need to adopt to more effectively encourage LID practices for new development and redevelopment.

5.4 Wastewater Management

Only a small portion of the watershed is served by sanitary sewers. These include the downtown areas of Westerly and Pawcatuck, and a small portion of South Kingstown and the University of Rhode Island (Figure 5-3). Two municipal wastewater treatment facilities serving Westerly and Pawcatuck/Stonington are located in the lower Pawcatuck River subwatershed along the Pawcatuck Estuary. Treated effluent from the treatment plants influences water quality in the estuary and Little Narragansett Bay. Kenyon Industries in the towns of Charlestown and Richmond is the only industrial facility with a Rhode Island Pollution Discharge Elimination System (RIPDES) wastewater permit currently discharging into the Pawcatuck River.

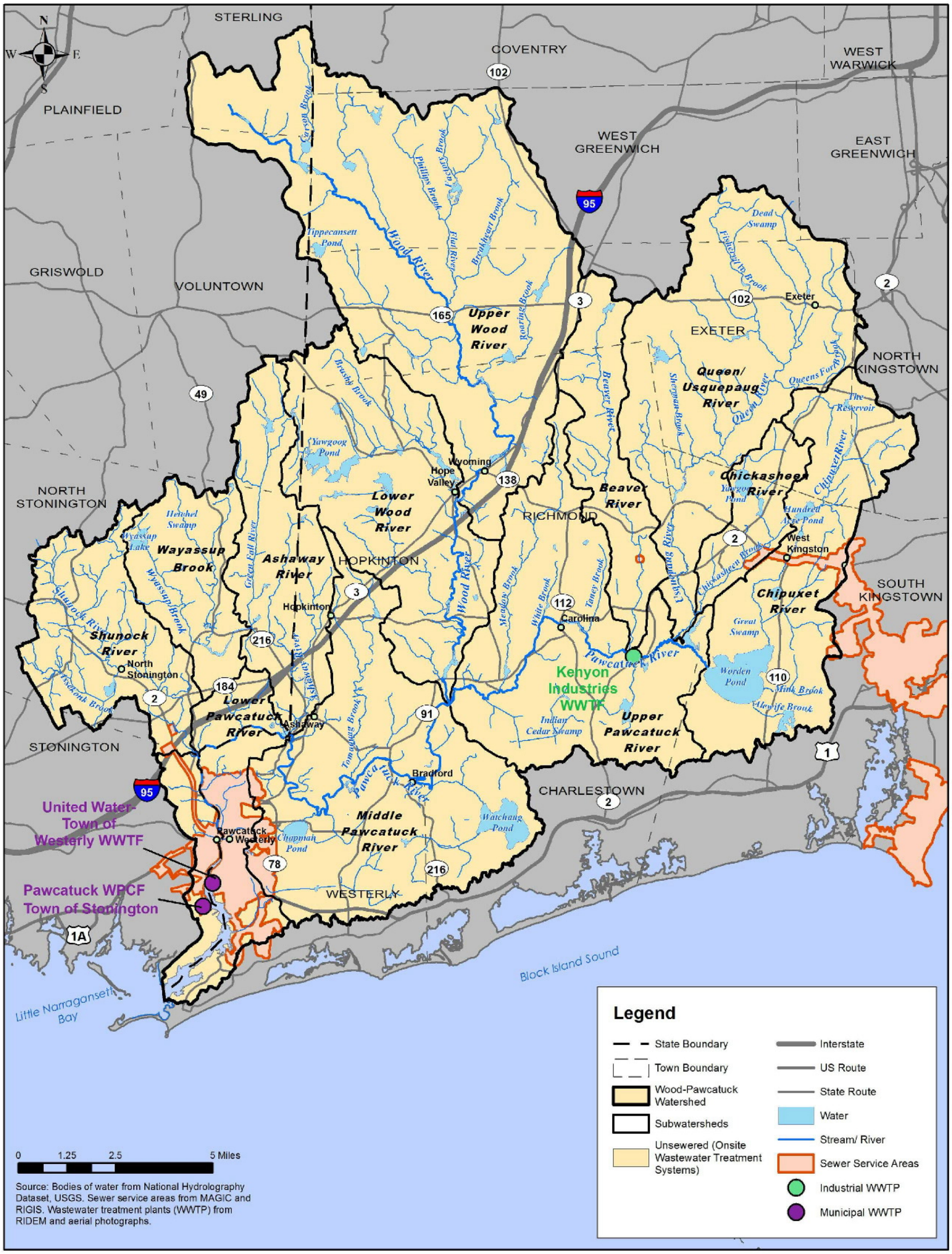

Figure 5-3. Wastewater infrastructure in the Wood-Pawcatuck watershed.

The rest of the Wood-Pawcatuck watershed is served by on-site wastewater treatment systems (OWTS) such as septic systems and cesspools, which can also impact water quality. Inadequate, failing or poorly maintained OWTS can be a significant threat to groundwater and surface waters in environmentally-sensitive areas resulting from loadings of pathogens, nutrients, and other pollutants.

In Rhode Island, OWTS are regulated under the *Rules Establishing Minimum Standards Relating to the Location, Design, Construction, and Maintenance of OWTS*. In addition, RIDEM has several programs to minimize the potential impact of OWTS to receiving waterbodies, including:

- On-site Wastewater Management Plans (OWMP): The plans outline goals for a wastewater management program and create an inspection and maintenance program.

- Community Septic System Loan Program (CSSLP): The CSSLP provides low-interest loans through municipalities for homeowners to repair or replace OWTS.

- The Rhode Island Cesspool Act: The Act required the replacement of cesspools located within 200 feet of public wells or a drinking water supply intake by January 1, 2014.

In Connecticut, OWTS are regulated by local health departments, CTDEEP, or the Connecticut Department of Public Health (CT DPH) depending on the design flow capacity and the type of treatment and disposal system. Unlike neighboring New England States, Connecticut does not currently require inspections and upgrades of subsurface sewage disposal systems when properties are sold (CTDEEP, 2014).

The Rhode Island communities within the Wood-Pawcatuck watershed implement the following OWTS management practices (RIDEM, 2014). Information on OWTS management practices for the Connecticut municipalities in the watershed was limited or unavailable.

- Charlestown: Charlestown has an approved OWMP and has a robust municipal onsite wastewater management program in place. The town charter includes a dedicated staff Summary of RI Municipal Onsite Wastewater Programs 1 person to run the onsite wastewater program. The town has a wastewater management ordinance requiring periodic inspection of onsite systems. The town also maintains a web-based septic system inventory and tracking program, and is in the midst of a townwide cesspool phase-out program. Charlestown also participates in the CSSLP.

- Coventry: Coventry has an approved OWMP and participates in the CSSLP. The approved OWMP proposes phased implementation of a management program based on improving homeowner awareness, creating a septic system inventory, and promoting voluntary system inspections. The management program focuses on making financial assistance available to repair or replace failed systems and cesspools.

- East Greenwich: East Greenwich has a municipal sewer system for the area east of Route 2, serving approximately two-thirds of the town's population, all of which are located outside of the Wood-Pawcatuck watershed. The rest of the town is served by onsite systems. The town does not have an approved OWMP.

- Exeter: Exeter has an approved OWMP. The plan calls for education and outreach efforts to encourage homeowners to properly maintain septic systems and recommends voluntary system inspections.

- Hopkinton: Hopkinton has an approved OWMP. The plan calls for education and outreach efforts to encourage homeowners to properly maintain septic systems and recommends voluntary system inspections.

- North Kingstown: The Town of North Kingstown has an approved OWMP and has a municipal onsite wastewater management program in place. The town has an onsite wastewater management ordinance requiring septic system inspection and maintenance at regular intervals. The town participates in the CSSLP with loan funds administered by the Water Department.

- Richmond: Richmond has an approved OWMP. The plan calls for education and outreach efforts to encourage homeowners to properly maintain septic systems and recommends voluntary system inspections.

- South Kingstown: South Kingstown has an approved OWMP and has an onsite wastewater management program in place. The town has a wastewater management ordinance requiring inspection of onsite systems. A town-wide cesspool phase-out is nearly complete with all required deadlines having passed. Cesspools discovered via the inspection program had to be upgraded within 5 years of discovery. Cesspools were also required to be upgraded within 12 months of the sale of a property. The South Kingstown zoning ordinance contains more stringent setbacks from natural features than the state requirements. South Kingstown uses a web-based inventory and tracking program and participates in the CSSLP.

- West Greenwich: The Town of West Greenwich does not have an active municipal onsite wastewater management program at this time.

- Westerly: The Town of Westerly has a municipal sewer system serving the downtown area, corresponding to approximately half the town's population. The rest of the town is served by onsite systems. Westerly has an approved OWMP which calls for creation of a wastewater management district for areas not currently served by sewers and where the Wastewater Facilities Plan indicates sewer extensions are not planned. Within this district, the Town will create a homeowner education and outreach program and create a computerized inventory containing results of voluntary inspections. The town participates in the CSSLP.

6 Flooding

Locations in the Wood-Pawcatuck watershed experience flooding during moderate and heavy rainfall events. Flooding, although often a localized occurrence, is among the most frequent and costly natural disasters in terms of human hardship and economic loss (RIEMA, 2014). The most damaging and widespread flooding in the watershed occurred during the March and April floods of 2010. Flood damages included flooding and washout of roadways, damages to bridges and culverts, damages to and failure of dams, flooding of properties and structures, erosion and sediment deposition in watercourses and wetlands, and transport of sediment and other pollutants downstream to Little Narragansett Bay.

6.1 Types of Flooding

Flooding is generally the result of excessive precipitation. Riverine flooding is the most common type of flooding in the Wood-Pawcatuck watershed. Riverine flooding occurs when rivers or streams overflow their banks and flow into the adjacent floodplain. The recurrence interval of a flood is defined as the average time interval, in years, expected to take place between the occurrence of a flood of a particular magnitude to an equal or larger flood. Flood magnitude increases with increasing recurrence interval (RIEMA, 2014).

Urban drainage flooding is also common in the more urbanized areas of the watershed as a result of outdated and undersized storm drainage systems. Urbanization contributes to flooding by increasing impermeable surfaces, increasing the speed of drainage collection, and reducing the carrying capacity of the land, all of which can overwhelm storm drainage collection systems. High groundwater levels and poor soils, which are common in highly developed areas, can exacerbate urban drainage flooding (RIEMA, 2014).

Dam failure or breach can also result in sudden downstream flooding (i.e., flash flooding). Dam failures can result from natural or human-induced events, or some combination of the two. Failures due to natural events such as prolonged periods of rainfall and flooding can result in overtopping, which is the most common cause of dam failure. Overtopping occurs when a dam's spillway capacity is exceeded and portions of the dam, which are not designed to convey flow, begin to pass water, erode away and ultimately fail. Other causes of dam failure include design flaws, foundation failure, internal soil erosion, inadequate maintenance or operational failure. Complete failure of a dam can release a high-velocity wall of debris-laden water that rushes downstream, damaging or destroying everything in its path (Town of Charlestown Natural Hazard Mitigation Committee, 2016). The Blue Pond Dam in Hopkinton experienced a significant breach during the 2010 flood. Flooding and damage to roads was experienced along the inundation area downstream of the dam. Alton Pond Dam, the next downstream dam, was overtopped but did not fail (Hopkinton Hazard Mitigation Committee, 2011).

Coastal flooding is typically a result of storm surge and wind-driven waves caused by hurricanes, nor'easters, and other large coastal storms. Storm surges may push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff (RIEMA, 2014). In the Wood-Pawcatuck watershed, coastal flooding is limited to the estuarine portion of the Pawcatuck River.

6.2 History of Flooding in the Watershed

Flood events have caused significant damage in the Wood-Pawcatuck watershed over the years. Some of the more notable historic floods in the region include:

- November 1927: Based on historical information obtained for the USGS gaging stations on the Wood River at Hope Valley and on the Pawcatuck River at Westerly, the worst flood since 1886 occurred in November 1927, which was caused by a tropical storm.

- March 1968: Prior to the 2010 floods, the March 1968 flood constituted the record flood for the State of Rhode Island. The March 1968 flood resulted from heavy rainfall that followed a period of sustained snowmelt which had caused stream flows to be much above normal.

- June 1982: A torrential storm on June 5-6, 1982, produced as much as 8 inches of rain and caused Statewide flooding. The Pawcatuck and Pawtuxet Rivers were among the hardest hit in the region.

- March 2010: Rhode Island (and southeastern Connecticut) experienced the worst flooding in its recorded history on a number of the State's largest rivers, including, but not limited to the Pawtuxet, Pawcatuck and Woonasquatucket. The incredible amount of precipitation in February and March 2010, along with saturated soils, high water tables, lack of leaf cover and limited pervious surfaces all contributed to the disastrous flooding during March.

- Hurricane Sandy (2012): Hurricane Sandy caused significant coastal damage in southern New England, including Little Narraganset Bay and coastal areas south of the watershed.

Table 6-1 summarizes significant rainfall and flooding events in Washington County since the early 1990s, according to information compiled by the National Climatic Data Center (Town of Charlestown Natural Hazard Mitigation Committee, 2016). Figure 6-1 shows flood flow hydrographs for selected USGS stream gaging stations in the Wood-Pawcatuck watershed, including recent and historical floods.

Table 6-1. Significant rainfall and flooding events in Washington, County, Rhode Island.

Date	Rainfall (inches)	Comments
April 1, 1993	Flash Flood	Pawcatuck River flooding onto Driftwood Dr.
September 18, 1996	2"-3.5"	Early season coastal storm
December 7, 1996	2"	No damage reported
January 10, 1997	Coastal Flood	A new moon in combination with strong SE winds resulted in a 2'-4' storm tidal surge in Narragansett Bay.
August 29, 1997	2.5"-5"	Extensive flooding along Route 1
November 1, 1997	2"- 3"	No damage reported
February 18, 1998	2"-3.5"	Flooding in poor drainage areas
March 8, 1998	2"-3"	Flooding in poor drainage areas and flood prone property
April 1, 1998	2"	No damage reported
June 13, 1998	6"-8"	Numerous small streams flooded their banks
May 23, 1999	3.15"	No damage reported
September 10, 1999	2"-5"	No property damage reported
September 16, 1999	2"-5"	Several trees downed, no flood damage reported
March 29, 2003	2"-3"	Flooding in poor drainage areas
October 15, 2005	2.5"-4.5"	Heavy rain caused flooding across the region and forced

Table 6-1. Significant rainfall and flooding events in Washington, County, Rhode Island.

Date	Rainfall (inches)	Comments
		some roads to close as a result.
October 28, 2006	2”-4”	Rainfall produced significant urban flooding and caused some minor flooding of rivers and streams.
March 2, 2007	2”-3”	Snow quickly changed to heavy rain and caused widespread urban and small stream flooding.
April 16, 2007	3”-5”	Slow moving coastal storm produced heavy rain and gusty winds, minor to moderate coastal flooding.
March 8, 2008	2”-3”	Heavy rain coinciding with snowmelt caused some river flooding. Along the coast high astronomical tides combined with rough seas and storm surge to produce minor coastal flooding.
August 22, 2009	2”-4”	Tropical depression caused heavy rain and high surf in the area. Several driveways on Charlestown Beach Road were flooded with ocean waters.
March 14, 2010	3”-6”	Heavy rain caused flooding of small steams, urban and poor drainage areas. Strong winds associated with the storm also downed trees, limbs and wires.
March 29, 2010	5”-10”	The Pawcatuck River set a record of nearly 15 ½' and overflowed its banks in Charlestown closing Route 91 and Shannock Road. Numerous roads and basements were flooded. The entire state was impacted by this event and a Presidential Disaster Declaration was made. It is estimated that there were over $26 million in damages.
August 10, 2012	Wind Damage	Southerly winds drew tropical moisture over the area, resulting in very heavy rain in showers and thunderstorms that developed. In addition, strong winds in the upper levels and 30-40 knots of deep layer shear resulted in wind damage with the strongest of these storms.
June 7, 2013	3”-6”	Three to six inches of rain fell across Washington County. In Charlestown, Route 1, Route 112, Old Coach Road, and Klondike Road all were flooded.
March 30, 2014	2”-5”	Anywhere from two to five inches of rain fell across southern New England with the highest amounts falling along the south coast of RI and MA. This resulted in flash flooding across much of this area.
July 15, 2015	Flood/Flash Flood	Showers and thunderstorms developed across the area as a result of an upper level disturbance and a cold front. A couple of these slow moving storms resulted in flooding or flash flooding.
July 28, 2015	Damaging Winds/Heavy Rains	A strong upper level disturbance sparked showers and thunderstorms across much of southern New England. A few of these storms became severe, producing damaging winds. Others produced heavy rain that resulted in flooding.

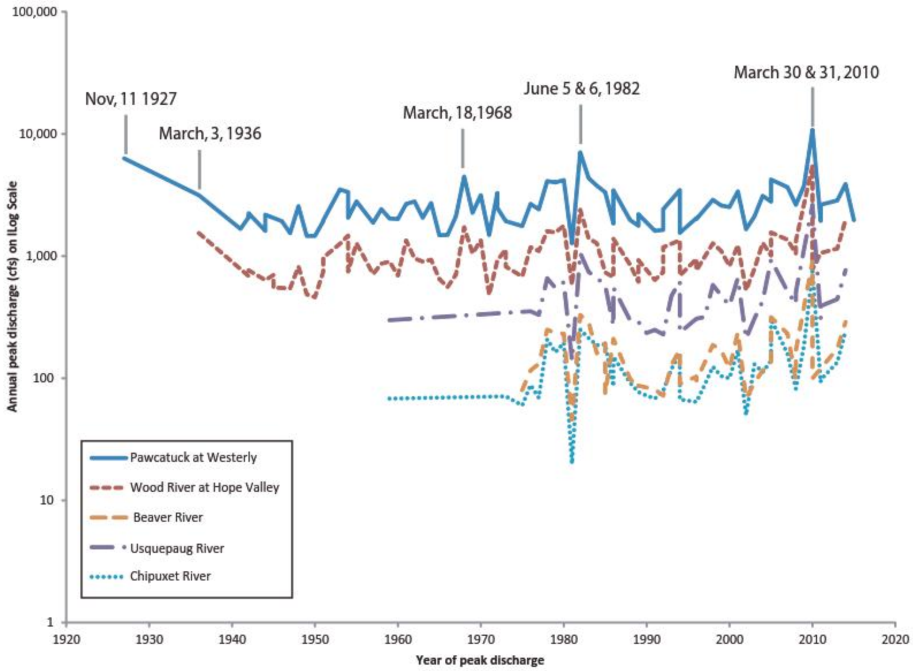

Figure 6-1. Plot of annual peak discharge at several USGS stream gages in the Wood-Pawcatuck watershed (Field, 2015).

Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) are used by federal and state agencies and local communities for implementing floodplain management programs and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year (FEMA, Revised 2013). For example, a 100-year flood is not a flood that occurs every 100 years. In fact, the 100-year flood has a 26-percent chance of occurring during a typical 30-year mortgage (RIEMA, 2014).

Table 6-2 summarizes peak flow estimates for the Pawcatuck River at Westerly and Wood River Junction for various recurrence intervals. USGS estimates that most gaged locations in the Wood-Pawcatuck watershed experienced 500-year return interval peak flows during the 2010 flood (Zarriello, Ahearn, & Levin, 2012).

Table 6-2. Estimated magnitude of flood flows for selected annual exceedance probabilities at selected stream gages on the Pawcatuck River.

		Peak Flow Estimate (cfs)	
AEP (%)	Return Interval (years)	Pawcatuck River at Westerly, RI (01118500)	Pawcatuck River at Wood River Junction, RI (01117500)
20	5	3,300	1,030
10	10	4,080	1,280
4	25	5,230	1,660
2	50	6,220	1,990
1	100	7,340	2,370
0.5	200	8,610	2,790
0.2	500	10,600	3,440

6.3 Future Flooding and Climate Change

The observed increasing trend in severe storms, heavy rainfall, and flooding in the region is expected to continue. According to the National Climate Assessment, "the Northeast has experienced a greater increase in extreme precipitation over the past few decades than any other region in the United States; between 1958 and 2010, the Northeast saw a 74% percent increase in the amount of precipitation falling in very heavy events" (Melillo, Richmond, T.C., & Yohe, G.W.). Rainfall in New England is expected to continue to increase due to climate change, which is expected to increase the risk of river-related flooding in the future. Bridges, roads and dams will be more susceptible to flood damage because of more severe storms and heavy rainfall. Sea level rise and increased frequency of storms may threaten coastal infrastructure, while increased flooding could affect inland infrastructure (URI Climate Change Collaborative, 2011).

Given this trend, the communities in the Wood-Pawcatuck watershed face an increasing risk of flooding and storm-related damages as large storms and floods become more common. In addition to climate change, some parts of the watershed are susceptible to future development pressure that, if not appropriately controlled, could increase floodplain encroachments, reduce the natural water-absorbing capacity of the land, increase impervious surfaces and stormwater runoff, and worsen flooding impacts.

6.4 Flood Zones

Flood zones are defined by the Federal Emergency Management Agency (FEMA) as the area below the high water level that occurs during a flood of a specified recurrence interval. Special Flood Hazard Areas (SFHA) are defined on FEMA Flood Insurance Rate Maps (FIRM) as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. Moderate flood hazard areas, also shown on the FIRM, are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. Figure 6-2 depicts Special Flood Hazard Areas in the Wood-Pawcatuck watershed.

FEMA is working with the U.S. Geological Survey (USGS) and other federal, state, and local partners to identify flood risk and help reduce that risk through the Risk Mapping, Assessment and Planning (Risk MAP) program. Risk MAP is designed to help increase the purchase of flood insurance and increase the public's awareness of flood prone structures and potential mitigation measures (RIEMA, 2014). FEMA and USGS are nearing completion of a Risk MAP project for major portions of the Wood-Pawcatuck watershed including the Chipuxet, Queen-Usquepaug, Beaver, Wood, Ashaway, Shunock, and Pawcatuck Rivers. The project will result in updated flood mapping for the watershed, which will support community-based flood mitigation planning efforts. Updated flood mapping for the watershed is expected to be released by late 2016.

6.5 Documented Areas of Flooding

Appendix A contains a tabular summary of documented areas of flooding in the Wood-Pawcatuck watershed. The summary is a compilation of information obtained from the following sources:

- FEMA Flood Insurance Studies for Washington County and Kent County (RI) and New London County and Windham County (CT)
- Local hazard mitigation plans and municipal comprehensive plans of the watershed communities

- Project Steering Committee members and municipal staff in response to a survey that was distributed by the Wood-Pawcatuck Watershed Association as part of the watershed planning process.

The documented flooding locations include both individual sites such as specific road-stream crossings, bridges, streets, etc., as well as more generalized areas of flooding such as entire neighborhoods or stream reaches. These documented flooding locations are shown on the flood hazard map in Figure 6-2. While the documented flooding in the watershed includes drainage-related flooding in the more developed portions of the watershed, the majority of the flooding problems in the watershed are associated with mapped flood hazard areas along river and stream corridors (i.e., riverine flooding) as shown in Figure 6-2.

6.6 Existing Flood Mitigation and Resiliency Programs

National Flood Insurance Program (NFIP)

The National Flood Insurance Program (NFIP), established by Congress in 1968, provides flood insurance to property owners in participating communities. This program is a direct agreement between the federal government and the local community that flood insurance will be available to residents in exchange for the community's compliance with minimum floodplain management requirements such as the adoption of a floodplain management or flood damage prevention ordinance.

In order for property owners to purchase flood insurance through the NFIP, their community must be in good participant standing in the NFIP. Communities participating in the NFIP must (RIEMA, 2014):

- Adopt the FIRMs as an overlay regulatory district or through another enforceable measure
- Require that all new construction or substantial improvement to existing structures in the SFHA will be compliant with the construction standards of the NFIP and State building code, which is implemented at the local level by municipal building officials
- Require additional design techniques to minimize flood damage for structures being built in high hazard areas, such as floodways or velocity zones.

All of the watershed communities and the Narragansett Indian Tribal Nation are members of the NFIP and are in good standing. For most of the watershed communities, floodplain and flood management requirements are incorporated into municipal zoning and subdivision regulations.

Land Use Regulatory Review for the Wood-Pawcatuck Watershed

A review was conducted of the existing land use policies, plans, and regulations of the municipalities in the Wood-Pawcatuck watershed relative to floodplain and flood management. The objective of the review is to recommend new or modified land use policies and/or regulations that could be implemented by the watershed municipalities to enhance flood resiliency in the Wood-Pawcatuck watershed. The review is documented in a separate technical memorandum entitled *Land Use Regulatory Review, Wood-Pawcatuck Watershed Flood Resiliency Management Plan* (Fuss & O'Neill, 2016d).

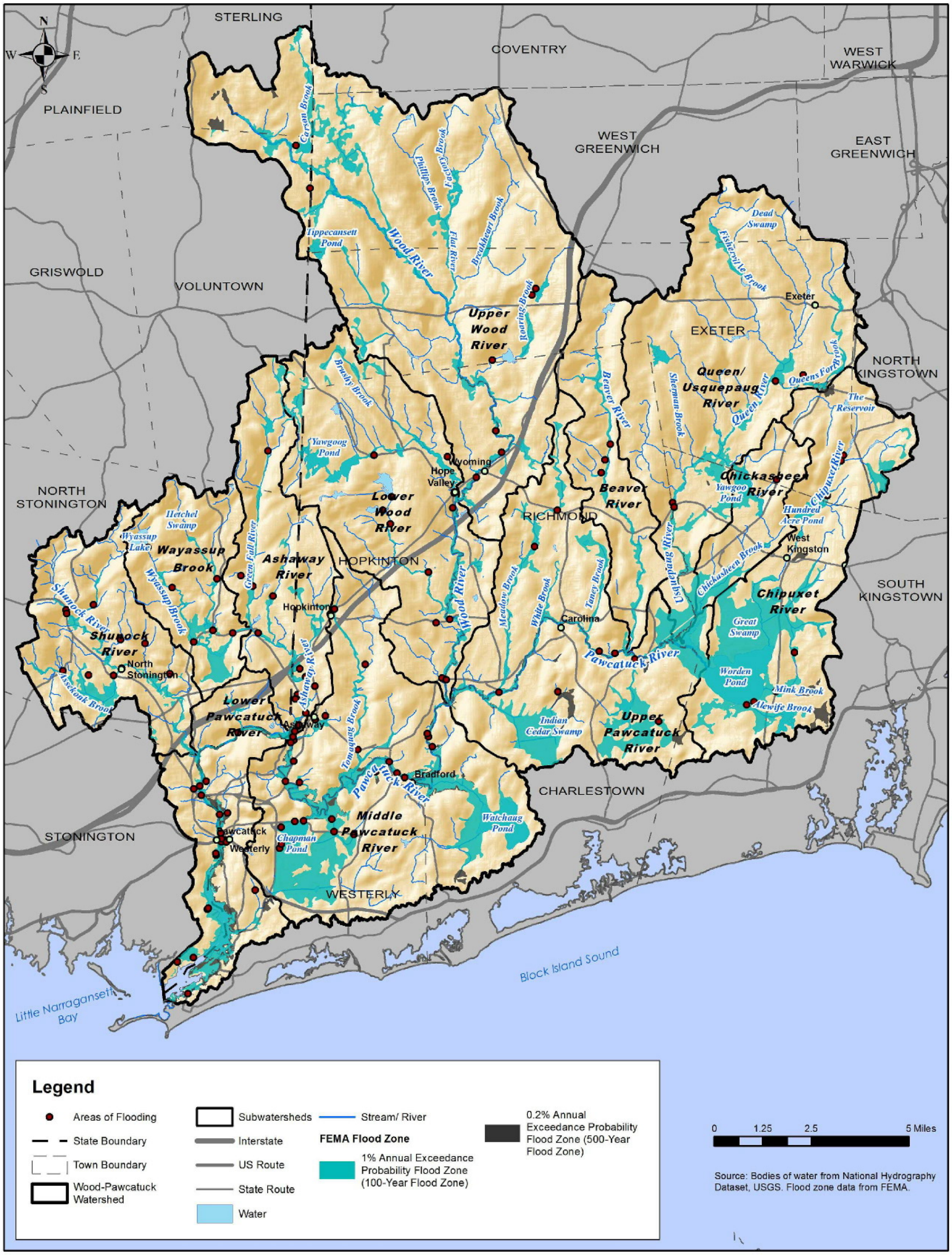

Figure 6-2. Special Flood Hazard Areas and areas of flooding in the Wood-Pawcatuck watershed.

Community Rating System (CRS)

The Community Rating System (CRS) is a voluntary program that recognizes and encourages a community's efforts that exceed the NFIP minimum requirements for floodplain management. The CRS program emphasizes the reduction of flood losses, facilitating accurate insurance rating, and promoting the awareness of flood insurance. By participating in the CRS program, communities can earn a discount for flood insurance premiums based upon the activities that reduce the risk of flooding within the community. Currently, four (4) communities in the Wood-Pawcatuck watershed – Charlestown, North Kingstown, Westerly, and Stonington –participate in the CRS program, receiving discounts for flood insurance premiums of between 5% and 15% (RIEMA, 2016; Community Rating System (CRS), 2016).

Flood Mitigation Funding Programs

FEMA, the U.S. Department of Housing and Urban Development, and the U.S. Department of Transportation are the primary federal funding agencies for flood mitigation projects. The FEMA Hazard Mitigation Assistance Program provides funding through the Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), and Public Assistance grant programs. HUD provides flexible grants to help cities, counties, and States recover from Presidentially- declared disasters, especially in low-income areas, through the Community Development Block Grant – Disaster Recovery Funding (CDBG-DR) program. The U.S. Army Corps of Engineers (USACE) also builds and repairs major flood control projects such as dams and levees, sometimes requiring a state or local match for the investment (USEPA, 2014).

Pawcatuck Flood Risk Management Feasibility Study

The USACE is currently completing a multi-year flood risk management feasibility study for the lower Pawcatuck River in response to the 2010 flooding. The project is expected to result in recommended flood risk mitigation alternatives (structural and non-structural) for the lower sections of the Pawcatuck River and be completed by the end of 2016.

7 Water Quality

Water quality is a primary indicator of the ecological health of a river system and its ability to support specific uses such as drinking water supply, recreation, habitat, and industrial uses. Water quality is also inherently linked to the activities that take place in a watershed. Surface water and groundwater quality in the Wood-Pawcatuck is generally excellent due to the large amount of forested and natural lands in the watershed. Water quality challenges exist in the more urbanized portions and downstream reaches of the watershed. This section summarizes the existing surface water and groundwater quality in the watershed, including high-quality waters and degraded or impaired waters.

7.1 Surface Waters

Water Quality Classifications

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

The Rhode Island Department of Environmental Management (RIDEM) and the Connecticut Department of Energy and Environmental Protection (CTDEEP) are responsible for complying with the CWA requirements in their respective states. Water Quality Standards (WQS) are used to establish priorities for pollution abatement efforts. Based on the WQS, Water Quality Classifications establish designated uses for surface and groundwater and identify the criteria necessary to support these uses.

In Rhode Island, surface water classifications for freshwaters include AA, A, B, B1 and C, and saltwater resources are classified as SA, SB, SB1 and SC. In Connecticut, freshwater surface waters are classified into three different categories, Class AA, Class A and Class B and two categories, SA and SB for saltwater systems. Table 7-1 and Table 7-2 summarize the various designated uses approved for each of these water classifications in the two states. Figure 7-1 depicts the surface water quality classifications throughout the Wood-Pawcatuck watershed

Table 7-1. Designated uses for Connecticut surface waters.

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

Table 7-2. Designated uses for Rhode Island surface waters.

Designated Use	Inland Surface Waters					Coastal and Marine Surface Waters			
	Class AA	Class A	Class B	Class B1[1]	Class C	Class SA	Class SB	Class SB1[1]	Class SC
Designated as a source of public drinking water supply or as tributary waters within a public drinking water supply watershed	●								
Primary Contact Recreation (e.g., swimming)	●	●	●	●		●	●	●	●
Secondary Contact Recreation (e.g., boating)	●	●	●	●	●	●	●	●	●
Habitat for fish, other aquatic life and wildlife habitat	●	●	●	●	●	●	●	●	●
Suitable for compatible industrial processes and cooling, hydropower, aquaculture uses, navigation , and irrigation and other agricultural uses		●	●	●	●	●	●	●	●
Shellfish harvesting for direct human consumption						●			
Shellfish harvesting for controlled relay and depuration							●	●	
Aesthetic Value	Excellent	Excellent	Good	Good	Good	Good	Good	Good	Good

[1] Primary contact recreation may be impacted due to pathogens from approved wastewater discharges

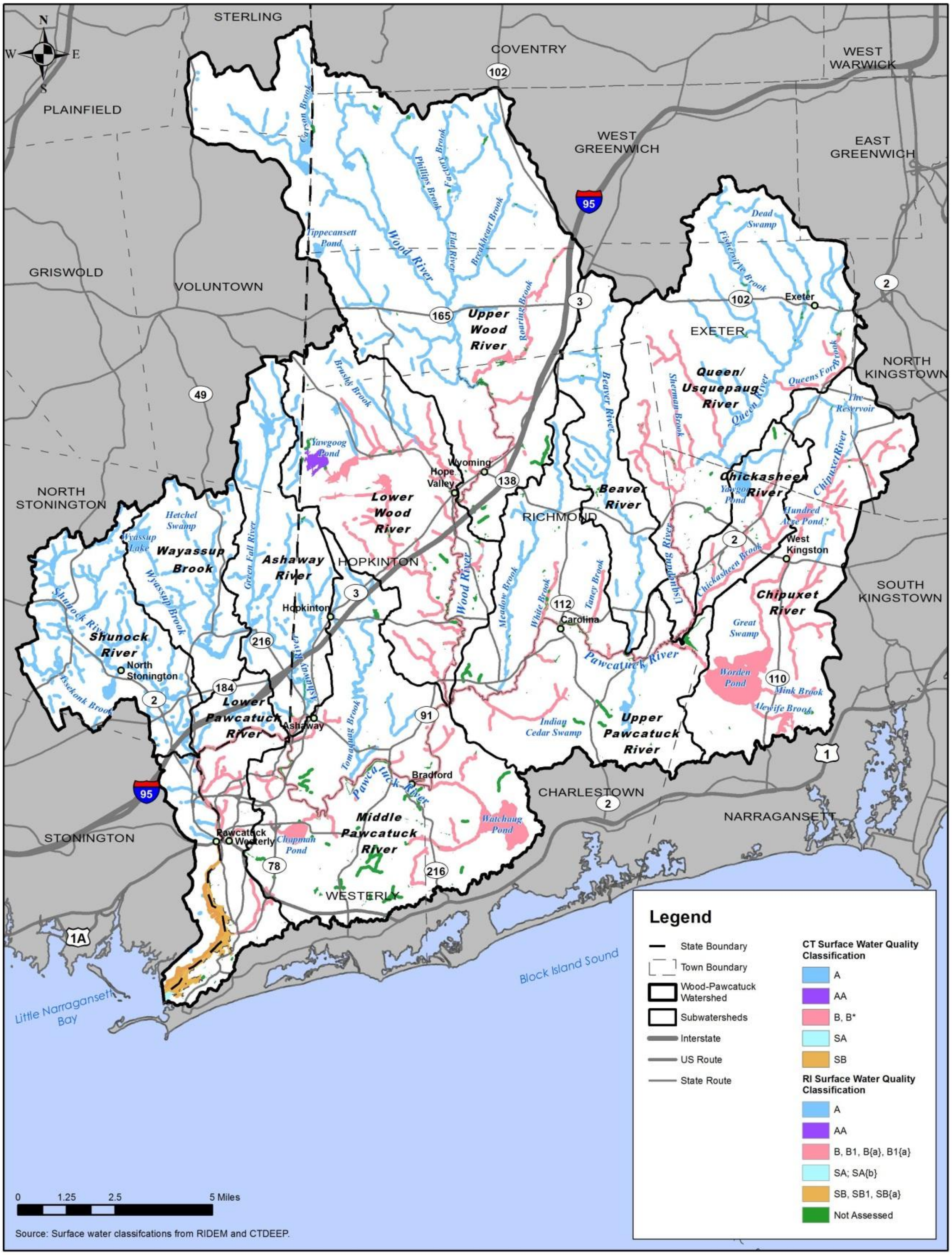

Figure 7-1. Surface water quality classifications in the Wood-Pawcatuck watershed.

In the Wood-Pawcatuck, class A/AA waters make up just over 59% of the stream miles in the watershed. These high quality waters are typically located in the northern, headwater areas of the watershed (Table 7-3 and Figure 7-1). Class B waters, which are not considered potential drinking water sources, are located along the mainstem of the Pawcatuck River and several of its major tributaries including the Lower Wood River, Usquepaug River, Chipuxet River, and Chickasheen Brook. The majority of the Pawcatuck River estuary is designated as Class SB waters.

Table 7-3. Surface water quality classifications by stream length in the Wood-Pawcatuck watershed.

Surface Water Quality Classification	Length of Streams (miles)	Percent of Watershed by Stream Length	Area (acres)[4]
A/AA	268.1	59.1%	1227.1
B[1]	164.7	36.3%	2710.6
SA[2]	0.0	0.0%	3.1
SB[3]	6.7	1.5%	274.7
NA[*]	14.4	3.2%	937.8

[1] All B rated waterbodies (B, B* in CT, B, B1, B{a}, B1{a} in RI)
[2] All SA rated waterbodies (SA in CT, SA, SA{b} in RI)
[3] All SB rated waterbodies (SB in CT, SB, SB1, SB{a} in RI)
[4] Includes River Areas wide enough to be included in IWQ Lakes Layer
[*] NA = Stream segments with no designation

Water Quality Monitoring and Assessment

Wood-Pawcatuck Watershed Association Volunteer Monitoring Program

The Wood-Pawcatuck Watershed Association (WPWA), working closely with the University of Rhode Island's Watershed Watch program, other local partners, and volunteers, conducts water quality monitoring at various locations throughout the watershed. Over the past 26 years, WPWA has performed water quality sampling at 165 sites in the watershed (see Figure 7-2), accumulating over 70,000 data points. At present, there are approximately 50 active monitoring locations that are sampled for a suite of parameters from April to October each year (Wood-Pawcatuck Watershed Association, 2015).

The overall goals of WPWA's water quality sampling program are to track the status of waterbodies in the watershed, to monitor trends in water quality (stable, improving, or declining), and to identify water quality problems which need further investigation (Wood-Pawcatuck Watershed Association, 2015). The current monitoring program is based on random selection of sites (RIDEM Rotating Basin Program) and ambient monitoring conducted within the watershed since 1985 by volunteers. WPWA is in the process of modifying its monitoring program to develop a more targeted program that will help focus on locations with water quality and flooding issues, which will be more effective in helping to identify potential sites for water quality improvement.

State Water Quality Monitoring Programs

Water quality in the Wood-Pawcatuck watershed is monitored on a regular basis by RIDEM and CTDEEP to support designated use assessments. RIDEM conducts routine water quality monitoring for physical, chemical, and biological parameters at nearly 60 sites in the Wood-Pawcatuck watershed. CTDEEP performs similar routine water quality monitoring at several locations along the lower Pawcatuck River. The map in Figure 7-2 shows the water quality monitoring locations in the watershed.

FUSS & O'NEILL

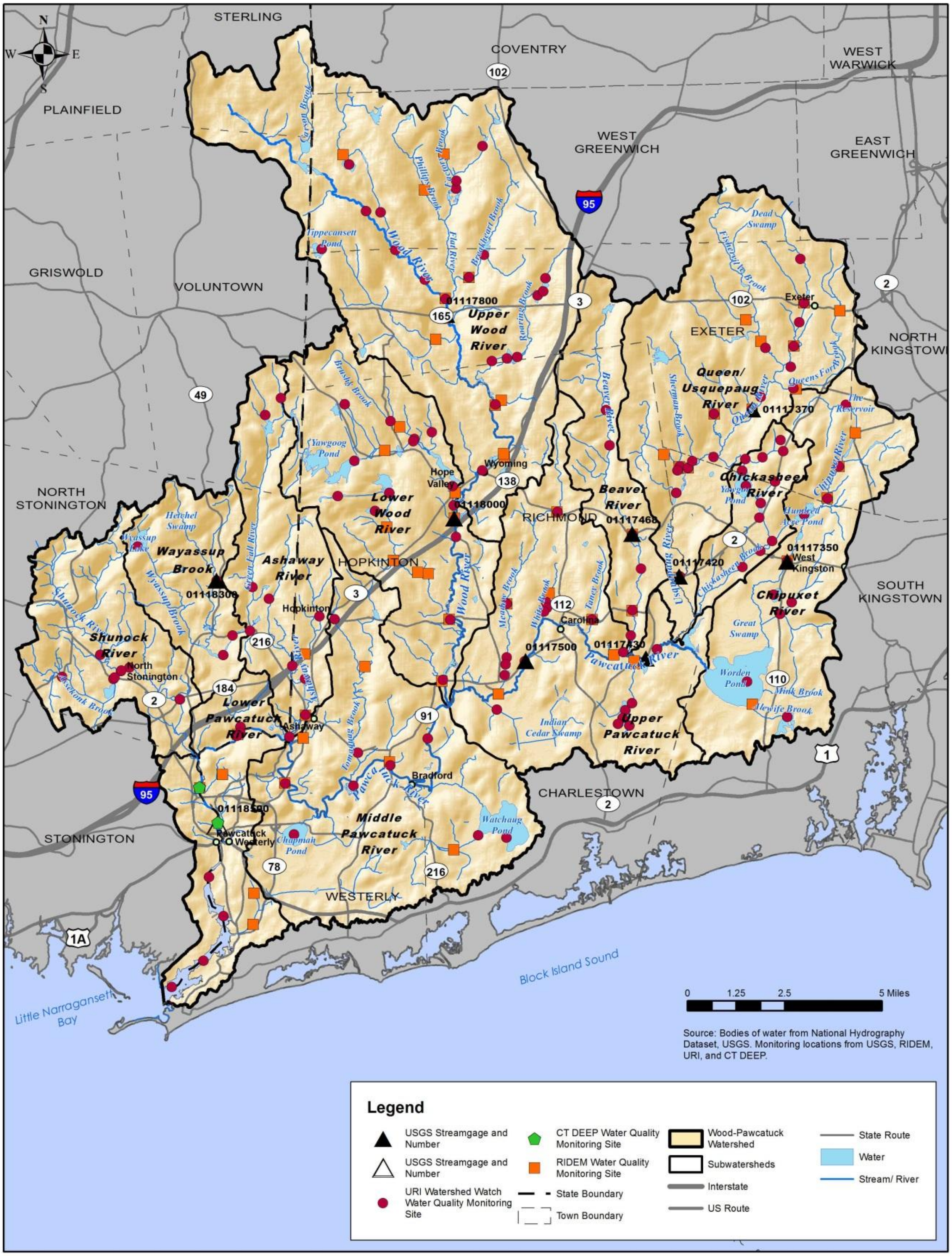

Figure 7-2. Water quality monitoring locations in the Wood-Pawcatuck watershed.

Under the CWA, each state is responsible for collecting and interpreting physical, chemical and biological data for state waters in order to support designated use assessments. Every two years states are required to report to the USEPA on the quality of their surface waters and to provide a list of those waters that do not meet water quality standards (RIDEM, 2015; CTDEEP, 2014). Through this assessment and listing process, waterbodies are placed in one of the following five assessment categories:

1. Category 1: Waters are considered to be "fully supporting" all designated uses.

2. Category 2: Some designated uses are "fully supporting," but more data are needed to assess other uses.

3. Category 3: More monitoring is needed to assess any designated use; associated waters are considered to have insufficient data or no data to be assessed.

4. Category 4: Impaired or threatened for one or more designated uses but does not require development of a TMDL because:

    - A: TMDL has been completed.

    - B: Other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future.

    - C: Impairment is not caused by a pollutant.

5. Category 5: Impaired or threatened for one or more designated uses by a pollutant(s), and requires a Total Maximum Daily Load (TMDL). Category 5 waters constitute the "303d list of impaired waters."

Water Quality Impairments

Figure 7-3 is a map of the impaired waters in the Wood-Pawcatuck watershed, according to the latest integrated water quality reports for Rhode Island and Connecticut (RIDEM, 2015; CTDEEP, 2014). Appendix B contains tabular summaries of the impaired waterbodies in the watershed, including impaired designated uses and suspected causes and sources of the impairments.

Most of the listed inland rivers and streams are impaired for recreation or fish and wildlife habitat, while the tidal portion of the Pawcatuck River is not supporting for contact recreation, shellfish and aquatic life. Stormwater runoff and nonpoint source pollution are the primary causes of many of these impairments.

Overall, there are 32 stream segments listed as impaired, either with or without a TMDL, covering over 156 miles of streams in the Rhode Island portion of the watershed and 7 additional segments listed as impaired for at least one designated use covering another 12 miles of streams in Connecticut. Twenty three ponds are listed as impaired for at least one designated use. One pond is listed as impaired in Connecticut, for both recreation and fish consumption. The Pawcatuck River estuary is broken into five segments, three in Rhode Island and two in Connecticut. All but one of the Connecticut segments is listed for failing to meet its designated uses for at least one pollutant; insufficient data exists for one unlisted section of the estuary.

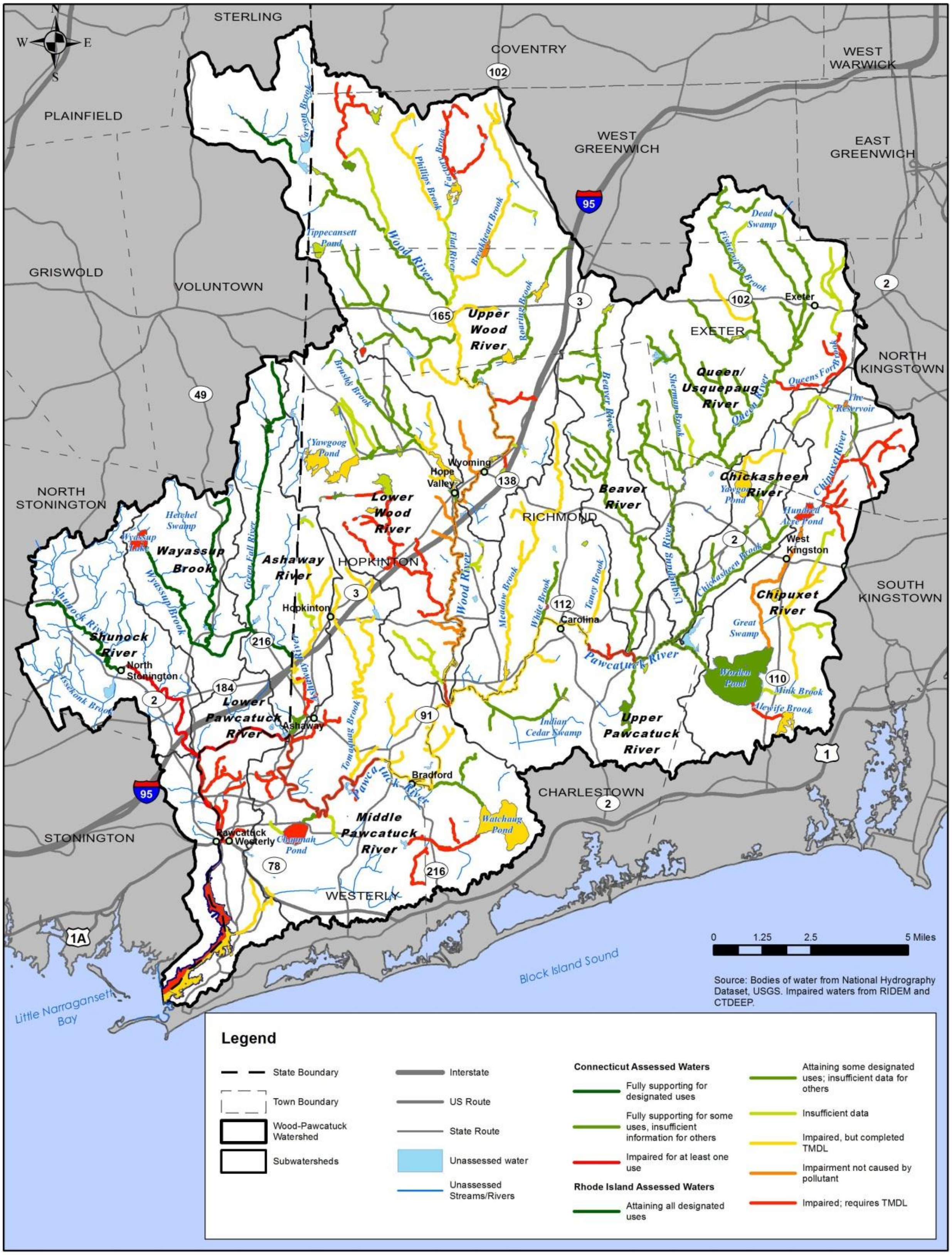

Figure 7-3. Impaired waterbodies in the Wood-Pawcatuck watershed.

Pathogens are the most common pollutant contributing to impairments in the Wood-Pawcatuck watershed. Additional pollutants contributing to impairments include nutrients (specifically phosphorus), non-native aquatic plants, and heavy metals such as cadmium and mercury. The State of Rhode Island uses fecal coliform and enterococci as indicator organisms of potential pathogen contamination. Fecal coliform is used to determine risk for shellfish consumption, while enterococci is used to determine risk associated with primary and secondary contact recreation activities in the state's fresh and salt waters. The State of Connecticut uses the indicator organism *E. coli* rather than enterococcus for freshwater systems.

A TMDL is a pollution budget that specifies how much of a specific pollutant that a waterbody can receive without exceeding water quality standards. The TMDL process maps a course for states, municipalities, private landowners, and other stakeholders to follow to ultimately restore impaired waters. The following TMDLs have been developed and approved for impaired waterbodies in the Wood-Pawcatuck watershed:

- Rhode Island Statewide TMDL for Bacteria Impaired Waters (RIDEM, 2011): The State of Rhode Island has a TMDL addressing bacterial pollution across the state, including many rivers and streams in the Wood-Pawcatuck watershed. In 2014, the TMDL was updated to include 5 additional impaired stream segments in the Wood-Pawcatuck (RIDEM, 2014).

- Rhode Island Pawcatuck River and Little Narragansett Bay Waters Bacteria TMDL (RIDEM, 2010): In 2010, RIDEM developed a TMDL for the bacteria-impaired waters of the estuarine portion of the Pawcatuck River and Little Narragansett Bay.

- Total Phosphorus TMDL for Chickasheen Brook, Barber Pond, and Yawgoo Pond (RIDEM, 2004): RIDEM developed a TMDL for the nutrient-related impairments in Chickasheen Brook, Barber Pond, and Yawgoo Pond.

- Connecticut Statewide Bacteria TMDL (CTDEEP, 2012): Connecticut also has a statewide bacteria TMDL, which includes the impaired segments of the Shunock and Pawcatuck Rivers.

- Connecticut Pawcatuck River Watershed Bacteria TMDL (CTDEEP, 2014): In 2014, CTDEEP developed a bacteria TMDL specifically for the Connecticut portion of the Pawcatuck River, which builds on information contained in the 2012 statewide bacterial TMDL.

The above TMDL documents address in detail the sources and causes of the impairments, required pollutant load reductions for these waterbodies to meet water quality standards and support certain uses, and recommended management actions to help achieve the necessary load reductions.

7.2 Groundwater

As described in Section 2.2, significant high-quality groundwater resources underlie large portions of the Wood-Pawcatuck watershed. Groundwater resources in the Wood-Pawcatuck are designated by EPA as a Sole Source Aquifer, serving as the sole source of drinking water for more than 60,000 residents in the watershed. The vast majority of the groundwater in the watershed is classified as suitable for public or private drinking water supply (Class GAA or GA).

8 References

Armstrong, D. S., & Parker, G.W. (2003). *Assessment of Habitat and Streamflow Requirements for Habitat Protection, Usquepaug–Queen River, Rhode Island, 1999–2000.* U.S. Geological Survey.

Arnold, C. J. (1996). Impervious Surface Coverage: the Emergence of a Key Environmental Indicator. *Journal of the American Planning Association*, Vol. 62, No. 2.

Audubon Society of Rhode Island. (n.d.). *Chipuxet River in Danger*. Retrieved September 30, 2016, from http://www.asri.org/our-major-projects/chipuxet-river-in-danger.html

Bent, G., Zarriello, P., Granato, G., Masterson, J., Walter, D., Waite, A., et al. (2011). *Simulated Effects of Water Withdrawals and Land-Use Changes on the Streamflows and Groundwater Levels in the Pawcatuck River Basin, Southwestern Rhode Island and Southestern Connecticut.* U.S. Department of Agriculture, Natural Resources Conservation Service.

Booth, D. a. (1993). Consequences of Urbanization on Aquatic Ecosystems - Measured Effects, Degradation Thresholds and Corrective Strategies. *Watershed 93' Conference.* Alexandria, VA.

Booth, D., Hartlet, D., & Jackson, R. (2002). Forest Cover, Impervious-Surface Area, and the Mitigation of Stormwater Impacts. *JAWRA Journal of the American Water Resources Association, 38*(3), 835-845.

Brabec, E., Schulte, S., & Richards, P.L. (2002). Impervious Surfaces and Water Quality: A Review of Current Literature and Its Implications for Watershed Planning. *Journal of Planning Literature, 16*(499).

Breault, R., Zarriello, P., Bent, G., Masterson, J., Granato, G., Scherer, J., et al. (2009). *Effects of Water-Management Stratedies on Water Resources in the Pawcatuck River Basin, Southwestern Rhode Island and Southeastern Connecticut.* United States Geological Survey (USGS).

Center for Watershed Protection. (2003). *Watershed Protection Research Monograph No. 1: Impacts of Impervious Cover on Aquatic Systems.* Ellicott City, MD: Center for Watershed Protection.

Community Rating System (CRS). (2016, September 27). Retrieved October 10, 2016, from National Flood Insurance Program - FloodSmart.gov: https://www.floodsmart.gov/floodsmart/pages/crs/community_rating_system.jsp

Connecticut Economic Resource Center, I. (2014c). *Sterling.* Retrieved November 2015, from Connecticut Economic Resource Center Town Profiles: https://www.cerc.com/TownProfiles/

Connecticut Economic Resource Center, I. (2014d). *Voluntown.* Retrieved November 2015, from Connecticut Economic Resource Center Town Profiles: https://www.cerc.com/TownProfiles/

Connecticut Economic Resource Center, Inc. (2014a). *North Stonington.* Retrieved November 2015, from Connecticut Economic Resource Center Town Profiles: https://www.cerc.com/TownProfiles/

Connecticut Economic Resource Center, Inc. (2014b). *Stonington.* Retrieved November 2015, from Connecticut Economic Resource Center Town Profiles: https://www.cerc.com/TownProfiles/

Coonecticut Economic Resource Center, I. (2014d). *Voluntown.* Retrieved November 2015, from Connecticut Economic Resource Center Town Profiles: https://www.cerc.com/TownProfiles/

CTDEEP. (2012). *Connecticut Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters.*

CTDEEP. (2014). *Connecticut Nonpoint Source Management Program Plan.* Connecticut Department of Energy and Environmental Protection.

CTDEEP. (2014). *Connecticut Pawcatuck River Bacteria TMDL.* Hartford, CT: Connecticut Department of Energy and Environmental Protection.

CTDEEP. (2014, October). *State of Connecticut Integrated Water Quality Report.* Retrieved from http://www.ct.gov/deep/lib/deep/water/water_quality_management/305b/2014_iwqr_305b_303d_final.pdf

Dillingham, T., Abrams, R., Dasbonnet, A., & Willis, J. (1993). *The Pawcatuck River Estuary and Little Narragansett Bay: An Interstate Management Plan.* Rhode Island Coastal Resources Managemetn Council and Connecticut Department of Environmental Protection Office of Long Island Sound Programs.

Erkan, D. (2002). *Strategic Plan for the Restoration of anadromous Fishes to Rhode Island Coastal Streams.* Providence, RI: Rhode Island Department of Environmental Management, Division of Fish and Wildlife.

Federal Register. (1988). *Sole source stratified-drift area designation for the Pawcatuck Basin stratified-drift area system, Rhode Island and Connecticut.* Feneral Register v. 53, no. 93.

FEMA. (Revised 2013). *Flood Insurance Study, Washington County, Rhode Island.* Federal Emergency Management Agency.

Field, J. (2015). *Fluvial Geomorphic Assessment and River Corridor Planning in the Wood-Pawcatuck Watershed, RI and CT.*

Field, J. (2016). *River Corridor Plan for the Wood-Pawcatuck Watershed, RI and CT.*

Fuss & O'Neill. (2016a). *Watershed-Scale Wetlands Assessment, Wood-Pawcatuck Flood Resiliency Watershed Management Plan.*

Fuss & O'Neill. (2016b). *Dams, Bridges and Culverts Assessment Technical Memorandum.*

Fuss & O'Neill. (2016c). *Green Infrastructure Assessment, Wood-Pawcatuck Watershed Flood Resiliency Management Plan.*

Fuss & O'Neill. (2016d). *Land Use Regulatory Review, Wood-Pawcatuck Watershed Flood Resiliency Management Plan.*

Gephard, S. (2015, December 23). Supervising Fisheries Biologist, Diadromous Fisheries and Habitat Conservation and Enhancement Programs. *Personal communication.* Connecticut Department of Energy and Environmental Protection.

Hirshman, D. C. (2008). *Technical Memorandum: The Runoff Reduction Method.* Center for Watershed Protection.

Homer, C., Dewitz, J., Yang, L., Danielson, P., Xian, G., Coulston, J., et al. (2015). Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing, v. 81, no. 5,*, 345-354.

Hopkinton Hazard Mitigation Committee. (2011). *Town of Hopkinton, Rhode Island Hazard Mitigation Plan.*

Lehner, P., Aponte Clark, G., Cameron, D., & Frank, A. (1999). *Stormwater Strategies: Community Responses to Runoff Pollution.* Natural Resources Defense Council.

Masterson, J., Sorenson, J., Stone, J., Moran, S., & Hougham, A. (2007). *Hydrogeology and Simulated Ground-Water Flow in the Salt Pond Region of Southern Rhode Island.* United States Geological Survey.

Melillo, J., Richmond, T.C., & Yohe, G.W. (n.d.). *2014: Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program.

Miller, N., & Golet, F. (2000). *Development of a Statewide Freshwater Wetland Restoration Strategy Phase 1: Site Identification and Prioritization Methods.* University of Rhode Island Departmetn fo Natural Resources for RIDEM Office of Water Resources.

Monroy, E. (2016). *Summary of Existing Efforts to address Stream Continuity in the Narragansett Bay Watershed.* Providence, Rhode Island: Narragansett Bay Estuary Program.

Narragansett Bay Estuary Program. (2016). *The State of Our Watershed Technical Report: Narragansett Bay Estuary Program 2017, Final Draft.* Providence, RI: Narragansett Bay Estuary Program.

National Park Service. (2013). *Wild and Scenic River Reconnaissance Survey of the Wood-Pawcatuck Watershed.* Department of the Interior, National Park Service Northeast Region.

Natural Resources Conservation Service. (2009). Part 630 Hydrology. In *National Engineering Handbook* (p. Chapter 7). United States Department of Agriculture, Natural Resources Conservation Service.

Pawcatuck Watershed Partnership. (1999). *The Pawcatuck Watershed Report.* United States Environmental Protection Agency, Region 1.

Rhode Island Statewide Planning Program. (2013). *Technical Paper 162: Rhode Island Population Projections 2010-2040.* Rhode Island Department of Administration, Division of Planning.

Richardson, C. (1985). Mechanisms Controlling Phosphorus Retention Capacity in Freshwater Wetlands. *Science, vol. 228*, 1424-1426.

RIDEM. (2004). *Total Phosphorus TMDL for Chickasheen Brook, Barber Pond, and Yawgoo Pond, Rhode Island.* Providence, RI: Rhode Island Department of Environmental Management.

RIDEM. (2009). Water Quality Regulations. Rhode Island Department of Environmental Management, Office of Water Resources.

RIDEM. (2010). *Final Pawcatuck River and Little Narragansett Bay Waters Bacteria TMDL.* Providence, RI: Rhode Island Department of Environmental Management.

RIDEM. (2011). *Rhode Island Statewide TMDL for Bacteria Impaired Waters.*

RIDEM. (2014). *Summary of Rhode Island Municipal Onsite Wastewater Programs.* Rhode Island Department of Environmental Management.

RIDEM. (2014). *Updates to the Rhode Island Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters.* Providence, RI: Rhode Island Department of Environmental Management.

RIDEM. (2015, May). *State of Rhode Island Integrated Water Quality Report.* Retrieved from http://www.dem.ri.gov/programs/benviron/water/quality/pdf/iwqmon14.pdf

RIEMA. (2011). *Rhode Island State Hazard Mitigation Plan.* Rhode Island Emergency Management Agency.

RIEMA. (2014). *Rhode Island Hazard Mitigation Plan - 2014 Update.* Rhode Island Emergency Management Agency.

RIEMA. (2016). *Flood Insurance - Rhode Island Community Rating System*. Retrieved October 10, 2016, from State of Rhode Island Emergency Management Agency: http://www.riema.ri.gov/resources/citizens/mitigation/insurance.php

Schafer, J. (1965). *Surficial geology of the Watch Hill quadrangle, Rhode Island-Connecticut, Geologic Quadrangle Map GQ-410, 1pl., scale 1:24,000.* United States Geological Survey.

Schueler, T. (1994). The Importance of Imperviousness. *Watershed Protection Techniques, 1*(3), 100-111.

Schueler, T. (1995). *Site Planning for Urban Stream Protection.* Washington, DC: Metropolitan Washington Council of Governments.

Schueler, T. K. (1992). *A current assessment of urban best management practices: techniques for reducing non-point source pollution in the coastal zone.* Washington, DC: Metropilitan Washington Council of Governments.

Shaver, E. a. (1996). Technical Note 72: Habitat and Biological Monitoring Reveals Headwater Stream Impairment in the Deleware Peidmont. *Watershed Protection Techniques*, pp. Vol. 2, No. 2.

Sojkowski, B., Morales, J., & Orvis, C. (2014). *Evaluation of Fish Passage Efficiency for Three Fish Passage Ways on the Pawcatuck River (White Rock Bypass Channel, Potter Hill, and Bradford Denil Fishways).* U.S. Fish and Wildlife Service.

Sweeney, B., & Newbold, J. (2014). Streamside Forest Buffer WIdth Needed to Protect Stream Water Quality, Habitat, and Organisms: A Literature Review. *Journal of the America Water Resources ASsociation (JAWRA) 50(3):*, 560-584.

Town of Charlestown Natural Hazard Mitigation Committee. (2016). *Town of Charlestown, Rhode Island Natural Hazard Mitigation Plan.*

U.S. Fish and Wildlife Service. (1991). *Northeast coastal areas study: Significant coastal habitats of Southern New England and portions of Long Island Sound, New York.* Charlestown, Rhode Island: Southern New England-Long Island Sound Coastal Estuary Office.

University of Connecticut Center for Land Use Education and Research (CLEAR). (2010). *Connecticut's Changing Landscape - Statewide Land Cover.*

URI Climate Change Collaborative. (2011). *Climate Change in Rhode Island: What's Happenign Now & What You Can Do.*

USEPA. (2014). *Planning for Flood Recovery and Long-Term Resilience in Vermont: Smart Growth Approaches for Disaster-Resilient Communities, EPA 231-R-14-003.* U.S. Environmental Protection Agency.

Wood-Pawcatuck Watershed Association. (2004a). *Assessing Habitat Requirements for Brook Trout in Low Order Streams.* Hope Valley, RI: Wood-Pawcatuck Watershed Association.

Wood-Pawcatuck Watershed Association. (2004b). *Maximum Stream Temperature Estimation from Ait Temperature Data and its Relationship to Brook Trout Habitat Requirements in RI.* Hope Valley, RI: Wood-Pawcatuck Watershed Association.

Wood-Pawcatuck Watershed Association. (2005). Atlantic Salmon in the Wood-Pawcatuck Watershed - Fact or Fantasy? *Watershed, 22*(1).

Wood-Pawcatuck Watershed Association. (2005). *Small Dams and Habitat Quality in Low Order Streams.* Hope Valley, RI: Wood-Pawcatuck Watershed Association.

Wood-Pawcatuck Watershed Association. (2015). *Assessing the Wood-Pawcatuck Watershed Association's Water Quality Monitoring Program.*

Xian, G., Homer, C., Dewitz, J., Fry, J., Hossain, N., & Wickham, J. (2011). The change of impervious surface area between 2001 and 2006 in the conterminous United States. *Photogrammetric Engineering and Remote Sensing, 77*(8), 758-762.

Zarriello, P., Ahearn, E., & Levin, S. (2012). *Magnitude of flood flows for selected annual exceedance probabilities in Rhode Island through 2010: U.S. Geological Survey Scientific Investigations Report 2012-5109.*

Appendix A

Documented Areas of Flooding in the Wood-Pawcatuck Watershed

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	North Stonington	Shunock River	Main Street Bridge between Wyassup Road and Avery Lane	North Stonington HMP Annex Update, 2013	Old Town Hall Bridge closed after flooding. FEMA grant funded reconstruction of the structure (scheduled for completion September 2012). New structure expected to alleviate flooding in Village center and withstand 0.5% flood event.	Damage to Old Town Hall bridge, Watermark Café, Village Hardware Store in 2010 flood
CT	North Stonington	Pendelton Hill Brook	Grindstone Hill Road	North Stonington HMP Annex Update, 2013		Washed out in 2010 storm; required repair.
CT	North Stonington	Unnamed Stream	Loin Hill Road	North Stonington HMP Annex Update, 2013		Washed out in 2010 storm; required repair.
CT	North Stonington	Glade Brook	Pine Woods Road	North Stonington HMP Annex Update, 2013		Washed out in 2010 storm; required repair.
CT	North Stonington	Pawcatuck River	Boom Bridge	North Stonington HMP Annex Update, 2013	Closed since 2008; Design, engineering and permitting occuring in 2012 to rehabilitate bridge (O?)	
CT	North Stonington	Assekonk Swamp	Old Colony Road, from Kingswood Drive to Raven Wood Road, Kingswood Meadowwood development	North Stonington HMP Annex Update, 2013	Basement flooding mitigated by 950 ft of storm drainage after 2010 floods. (C)	Repetitive loss of properties in this area
CT	North Stonington	Assekonk Brook	Jeremy Hill Road	North Stonington HMP Annex Update, 2013		

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	North Stonington	Assekonk Brook	Mystic Road	North Stonington HMP Annex Update, 2013		
CT	North Stonington	Assekonk Brook	Norwich-Westerly Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Glade Brook	East Clarks Falls Road	North Stonington HMP Annex Update, 2013		Flooded in 2010. Structures affected by overbank flooding.
CT	North Stonington	Green Fall River	Putker Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Pendleton Hill Brook	Pendleton Hill Road	North Stonington HMP Annex Update, 2013	Recommended culvert replacements along Pendelton Hill Road. However, this is a State Road, and CTDOT must perform upgrades. (R)	Flooded in 2010; floods annually
CT	North Stonington	Pendleton Hill Brook	Clarks Falls Road	North Stonington HMP Annex Update, 2013		
CT	North Stonington	Shunock River	Norwich-Westerly Road, near Ryder Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Babcock Brook Tributary	Babcock Road	North Stonington HMP Annex Update, 2013		Flooded in 2010

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	North Stonington	Unnamed Stream	East Clarks Falls Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Shunock Tributary	Reutemann Road at Wyassup Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Shunock Tributary	Reutemann Road west of Bergius Lane	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Wyassup Brook	Grindstone Hill Road	North Stonington HMP Annex Update, 2013	Culvert repalcement (R)	Flooded in 2010. Structures affected by overbank flooding, though not within 1% floodplain.
CT	North Stonington	Wyassup Brook	Pendleton Hill Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Wyassup Brook	Wyassup Road	North Stonington HMP Annex Update, 2013		Flooded in 2010
CT	North Stonington	Yawbucs Brook	Yawbux Valley Road	North Stonington HMP Annex Update, 2013		Structures affected by overbank flooding
CT	North Stonington	Yawbucs Brook	Norwich-Westerly Road	North Stonington HMP Annex Update, 2013		

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	North Stonington	Shunock River	Nearby structures in North Stonington Village	North Stonington HMP Annex Update, 2013		Structures affeced by overbank flooding.
CT	North Stonington/ Westerly	Pawcatuck River		New London County FIS, 2013		USGS historic records indicate flooding is not a major problem along the Pawcatuck River, due to wetlands, which attenuate flooding.
CT	North Stonington	Pawcatuck and tributaries		New London County FIS, 2013		Existing dams are unregulated old mill dams. However, runoff is attenuated by wetland, ponds, and low graidient streams.
CT	Town of Stonington	Pawcatuck River	Structures on Liberty Street	Town of Stonington Annex HMP Update, 2005	The Pawcatuck Hurricane Flood Protection Project, completed in 1963, begins about 0.7 miles south of the U.S. Route 1 bridge and extends about 0.4 miles northward along the west bank of the Pawcatuck River, before turning westward to tie into the railroad embankment west of Mechanic Street.	During the 1938 and 1954 hurricanes, two industrial plants were severely damaged along the Pawcatuck River. As a result of this damage, the Pawcatuck Hurricane Flood Protection Project now protects an industrial area of 31 acres. The protection consists of 1,915 feet of earth dike, 940 feet of concrete wall, two vehicular structures, and a pumping station.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	Town of Stonington	Pawcatuck River	Structures on Route 1	Town of Stonington Annex HMP Update, 2005	The Pawcatuck Hurricane Flood Protection Project, completed in 1963, begins about 0.7 miles south of the U.S. Route 1 bridge and extends about 0.4 miles northward along the west bank of the Pawcatuck River, before turning westward to tie into the railroad embankment west of Mechanic Street.	During the 1938 and 1954 hurricanes, two industrial plants were severely damaged along the Pawcatuck River. As a result of this damage, the Pawcatuck Hurricane Flood Protection Project now protects an industrial area of 31 acres. The protection consists of 1,915 feet of earth dike, 940 feet of concrete wall, two vehicular structures, and a pumping station.
CT	Town of Stonington	Pawcatuck River	Structures on West Broad Street	Town of Stonington Annex HMP Update, 2005	The Pawcatuck Hurricane Flood Protection Project, completed in 1963, begins about 0.7 miles south of the U.S. Route 1 bridge and extends about 0.4 miles northward along the west bank of the Pawcatuck River, before turning westward to tie into the railroad embankment west of Mechanic Street.	During the 1938 and 1954 hurricanes, two industrial plants were severely damaged along the Pawcatuck River. As a result of this damage, the Pawcatuck Hurricane Flood Protection Project now protects an industrial area of 31 acres. The protection consists of 1,915 feet of earth dike, 940 feet of concrete wall, two vehicular structures, and a pumping station.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	Town of Stonington	Pawcatuck River	Structures on Mechanic Street	Town of Stonington Annex HMP Update, 2005	The Pawcatuck Hurricane Flood Protection Project, completed in 1963, begins about 0.7 miles south of the U.S. Route 1 bridge and extends about 0.4 miles northward along the west bank of the Pawcatuck River, before turning westward to tie into the railroad embankment west of Mechanic Street.	During the 1938 and 1954 hurricanes, two industrial plants were severely damaged along the Pawcatuck River. As a result of this damage, the Pawcatuck Hurricane Flood Protection Project now protects an industrial area of 31 acres. The protection consists of 1,915 feet of earth dike, 940 feet of concrete wall, two vehicular structures, and a pumping station.
CT	Town of Stonington	Pawcatuck River	Structures on Palmer Road	Town of Stonington Annex HMP Update, 2005		
CT	Town of Stonington	Pawcatuck River	Structures on Mary Hall Road	Town of Stonington Annex HMP Update, 2005		
CT	Town of Stonington	Pawcatuck River	Structures on River Road	Town of Stonington Annex HMP Update, 2005		
CT	Town of Stonington	Little Naragansett Bay/ Pawcatuck River	Structures on Riverside Drive	Town of Stonington Annex HMP Update, 2005		
CT	Town of Stonington	Pawcatuck River	Route 78	Town of Stonington Annex HMP Update, 2005		

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
CT	Town of Stonington	Little Naragansett Bay/ Pawcatuck River	Osbrook Point Road	Town of Stonington Annex HMP Update, 2005		
RI	Town of Hopkinton	Wood River	Dow Field, Main Street	Town of Hopkinton HMP, 2012		Flooded in April 2004
RI	Hopkinton	Pawcatuck River	French Village, Main Street	Town of Hopkinton HMP, 2012		Flooded in March 2010. River breached wall in neighborhood, stopped just short of entering residences.
RI	Hopkinton	Wood River, Pawcatuck River	Woodville Road Bridge	Town of Hopkinton HMP, 2012		Flooded in March 2010. Damaged, and remains closed.
RI	Hopkinton	Ashaway River	Near Wellstown Road	Town of Hopkinton HMP, 2012		April 2004 fire crews were called when floods carried propane tanks into the river
RI	Hopkinton	Ashaway River/ Pawcatuck River	Main Street (Rte 3) (Ashaway)	Town of Hopkinton HMP, 2012		Flooded in 2010. Closed for a week and a half. Floodwaters crossed and destroyed road near Reynolds Farm. Flooded overbank from Westerly Line to Lucky House Restaurant (0.25 miles away). Underwater from Richmond Town line to Fairview Avenue
RI	Hopkinton	Ashaway River/ Pawcatuck River	Laurel Street	Town of Hopkinton HMP, 2012		Flooded in 2010; under 6 ft of water. Residents evacuated.
RI	Hopkinton	Pawcatuck River	Maxson Street	Town of Hopkinton HMP, 2012		Flooded in 2010; under 6 ft of water. Residents evacuated.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Hopkinton	Ashaway River/ Pawcatuck River	Clay Street	Town of Hopkinton HMP, 2012		Flooded in 2010; under 6 ft of water. Residents evacuated.
RI	Hopkinton	Ashaway River/ Pawcatuck River	Ashaway Line and Twine Building, Laurel Street	Town of Hopkinton HMP, 2012		Flooded in 2010.
RI	Hopkinton	Pawcatuck River	Burdickville Road, near town line	Town of Hopkinton HMP, 2012		Flooded in 2010; destroyed roadway, relocated outbuildings near bridge.
RI	Hopkinton	Brushy Brook	Village of Hope Valley at Main Street and Spring Street	Town of Hopkinton HMP, 2012		Flooded in 2010; several feet of running water. Damaged all businesses in area. Significant damage to Hope Valley-Wyoming Fire District Building and apparatus apron.
RI	Hopkinton	Locustville Pond and Wood River	Fairview Avenue	Town of Hopkinton HMP, 2012		Limit of Pawcatuck river flooding, in 2010.
RI	Hopkinton	Wood River	Mechanic Street	Town of Hopkinton HMP, 2012		Flooded, especially near stone dam and mill.
RI	Hopkinton	Blue Pond Dam failure	Marshall Driftway, surrounding area	Town of Hopkinton HMP, 2012		2010: 700 ft washed out, stranding families for 6 days due to dam at Blue Pond failing and emptying pond. Large portion of dam retaining wall missing.
RI	South Kingstown	California Jim's Pond/Peacedale Reservoir Dam failure	Surrounding area,	Town of Hopkinton HMP, 2012		Breached in 2010.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Hopkinton	Blue Pond Dam failure	Canonchet Road, surrounding area	Town of Hopkinton HMP, 2012		2010 Dam breach; damage to residential yards, fences, culverts. Large portion of dam retaining wall missing.
RI	Hopkinton	Alton Pond Dam/Blue Pond Dam failures	Roads between ponds (2.25 miles between)	Town of Hopkinton HMP, 2012		According to innundation maps, damage from Blue Pond could reach Alton Pond Dam (2.25 miles away). Damage to roads and flooding was experienced along innundation area in 2010.
RI	Hopkinton	Alton Pond Dam failure	Road surface at dam	Town of Hopkinton HMP, 2012		2010: Dam overtopped, caused damage to road surface and some erosion at sides. Dam not repaired.
RI	Hopkinton	Alton Pond Dam failure	Burdickville Road Bridge and road surface	Town of Hopkinton HMP, 2012		2010: Damage due to dam failure. Road surface repaired. Dam not repaired.
RI	Hopkinton	Alton Pond Dam failure	Outbuildings on Burdickville Road	Town of Hopkinton HMP, 2012		2010: Damage due to dam failure. Dam not repaired.
RI	Hopkinton	Ashaway River, drainage	Eccelston Plat, Lynn Lane water supply	Town of Hopkinton HMP, 2012		Identified as vulnarable to flood
RI	Hopkinton	Ashaway River, Pawcatuck River	High Street (Rte 216)	Town of Hopkinton HMP, 2012		Identified as vulnarable to flood
RI	Hopkinton	Tomaquag Brook	Ashaway Road (Rte 216)	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Moscow Brook and unnamed	Spring Street (Rte 138)	Town of Hopkinton HMP,		Identified as vulnerable to flood

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
		pond		2012		
RI	Hopkinton	Tomaquag Brook	Bridge: Main St Over Rt 95 (exit 1)	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Pawcatuck River	Bridge: Main St, Meeting House Bridge	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Cononchet Brook	Bridge: Woodville Alton (Rte 95, exit 2)	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Pawcatuck, Mile Brook	Bridge: Laurel St at Potter Hill	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Tomaquag Brook Tributary	Bridge: Collins Rd	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Tomaquag Brook	Bridge: Chase Hill Rd, near Ashaway Rd.	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Unnamed Stream near Woodville Pond	Bridge: Woodville Alton Rd at Golf Course	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Unnamed Pawcatuck Tributary	Bridge: Burdickville Rd.	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Ashaway River	Bridge: Wellstown Rd.	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Hopkinton	Ashaway River	Bridge: High Street	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Tomaquag Brook	Businesses, structures along Main St, including "Extremely Hazardous Substance Building"	Town of Hopkinton HMP, 2012		Many flooded in 2010. In general, identified as vulnerable to flood.
RI	Hopkinton	Ashaway River	Structures on Gray Lane	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Pawcatuck River	Structures on Chase Hill Road	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Ashaway River	Structures on High Street	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Wood River	Structures on Skunk Hill Road	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton		Woodville Alton Boat Ramp	Town of Hopkinton HMP, 2012		Identified as vulnerable to flood
RI	Hopkinton	Bushy Brook, Wood River	Hope Valley-Wyoming Fire District Headquarters	Town of Hopkinton HMP, 2012		Sustained flood damage in 2010. Identified as vulnerable to flood.
RI	Hopkinton	Ashaway River/ Pawcatuck River	Line & Twine Lower, dry hydrant	Town of Hopkinton HMP, 2012		Identified as vulnerable to impairment in flood

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Hopkinton	Drainage-Related	Eccleston Plat, South Drive section	Town of Hopkinton HMP, 2012	Storm runoff system to be constructed to alleviate flooding in neighborhood. Ranked No. 1 priority for all Hazard Mitigation Projects (O)	Susceptible to significant flooding during heavy rains. Some homeowners have attempted mitigation measures on their own property. South Drive closes, and remains closed for up to a week.
RI	Hopkinton	Drainage-Related	Egypt Street	Town of Hopkinton HMP, 2012	Replace stone culvert with box culvert to prevent impassability during future storms. Ranked high (5th) in priorities for all Hazard Mitigation Projects (R)	
RI	Hopkinton	Drainage-Related	West end of Church Street	Town of Hopkinton HMP, 2012	Outline project to alleviate flooding. Ranked high (9th) in priorities for all Hazard Mitigation Projects (R)	Road floods several times a year, occasionally impassable. Road conditions have deteriorated due to flooding.
RI	Hopkinton	Streams within Hopkinton		Washington County FIS, 2013	No building below 2% annual flood elevation. (C)	No flood control structures. Existing dams are unregulated, old mill dams. Wetlands, ponds, and low-gradient streams aid moderation of flooding.
RI	North Kingstown	Streams within North Kingstown		Washington County FIS, 2013	Zoning laws to conform with FEMA requirements protecting new construction in a 1% annual flood. (C)	
RI	North Kingstown	Storm runoff		Washington County FIS, 2013	Management provides some control of storm runoff in developed areas (C)	
RI	South Kingstown	Streams within South Kingstown		Washington County FIS, 2013		No flood control structures affecting streamflow.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Westerly	Coastal flooding		Washington County FIS, 2013	Barrier beaches, sand fill, and sea walls. Protective ordinances for barrier beaches. All barrier beaches except Atlantic Beach zoned flood prone residential areas, with strict development controls.	
RI	Westerly	Pawcatuck River	North End Neighborhood	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Bowling Lane (Bradford)	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Bradford Dye Associates, low-lying areas on State Route.	Town of Westerly HMP, 2012. Washington County FIS, 2013	Dam proposed for removal.	Flooded in March 2010
RI	Westerly	Pawcatuck River	Canal Street	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Chapman Pond Area	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Newton Marsh Area	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Aguntaug Swamp Area	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Town of Westerly Animal Shelter	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Town of Westerly DPW	Town of Westerly HMP, 2012		Flooded in March 2010

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Westerly	Pawcatuck River	Town of Westerly Transfer Station	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	Route 91 between Westerly & Bradford neighborhoods	Town of Westerly HMP, 2012		Flooded in March 2010
RI	Westerly	Pawcatuck River	National Grid Substation, Canal Street	Town of Westerly HMP, 2012		Out of service because of flood in 2010, disabling power to area and Industrial Drive in North End. Due in part to Blue Pond Dam failure in Hopkinton
RI	Westerly	Pawcatuck River	Downtown Westerly	Town of Westerly HMP, 2012		Identified as subject to riverine flooding
RI	Westerly	Pawcatuck River	White Rock	Town of Westerly HMP, 2012		Identified as subject to riverine flooding
RI	Westerly	Pawcatuck River	Bradford	Town of Westerly HMP, 2012		Identified as subject to riverine flooding
RI	Westerly	Mastuxet Brook, Pawcatuck River	Mastuxet Brook Area	Town of Westerly HMP, 2012		Identified as subject to riverine flooding
RI	Westerly	Pawcatuck River	Bradford Pond Dam	Town of Westerly HMP, 2012		Identified as dam of concern across Pawcatuck River (low hazard)
RI	Westerly	Pawcatuck River	Potter Hill Dam	Town of Westerly HMP, 2012	Proposed for removal, dry reservoir (R)	Identified as dam of concern across Pawcatuck River (low hazard)
RI	Westerly		White Rock Dam	Town of Westerly HMP, 2012		Identified as dam of concern across Pawcatuck River (low hazard)

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Westerly	Aguntaug Brook, McGowan Brook, Pawcatuck River	Bridges along Route 91	Town of Westerly HMP, 2012		Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	Railroad bridges in Bradford and near Stonington Town line	Town of Westerly HMP, 2012		Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	Bridge at Boom Bridge Road	Town of Westerly HMP, 2012		Identified as vulnerable to Flood; may act as a weir in times of high flooding. Closed after an event in July 2009.
RI	Westerly	Pawcatuck	Bridge at Potter Hill Road	Town of Westerly HMP, 2012	Recently replaced (C)	Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	Route 3 bridge near Hopkinton town line	Town of Westerly HMP, 2012		Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	White Rock Road Bridge near Stonington Town Line	Town of Westerly HMP, 2012	Recently replaced (C)	Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	Downtown Historic District	Town of Westerly HMP, 2012		Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	Watch Hill Road Historic District	Town of Westerly HMP, 2012		Identified as vulnerable to Flood
RI	Westerly	Pawcatuck	West Broad Street Bridge	Town of Westerly HMP, 2012		Identified as vulnerable to Flood; may act as a weir in times of high flooding.
RI	Westerly	Pawcatuck	Crandall Swamp/ Aguntaug Swamp	Town of Westerly HMP, 2013		Identified as a flood control area
RI	South Kingstown	Worden Pond	Worden Pond Docks	Town of South Kingstown HMP, 2006		Docks vulnerable to floods

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	South Kingstown	Worden Pond	Worden's Pond Road	Town of South Kingstown HMP, 2006		NFIP insured properties. Road providing access/ egress to residential area within 100 yr floodplain.
RI	South Kingstown	White Horn Brook	Curtis Corner Road (Rockwood lane to Kogoli Way)	Town of South Kingstown HMP, 2006		Road providing access/egress to residential area within 100 yr floodplain.
RI	South Kingstown	Worden Pond, Mink Brook	Ministerial Road	Town of South Kingstown HMP, 2006		Road providing access/egress to residential area within 100 yr floodplain.
RI	South Kingstown	Usquepaug River	Three dams along Usquepaug River	Town of South Kingstown HMP, 2006		Vulnerability unknown; detailed inspections needed.
CT	Voluntown	Drainage-Related	Route 49	Town of Voluntown HMP, 2013	CT DOT installed a catch basin on Route 49 to eliminate chronic ponding (C)	
CT	Voluntown		Route 138	Town of Voluntown HMP, 2013		Identified as vulnerable to extreme flood
CT	Voluntown		Route 165	Town of Voluntown HMP, 2013		Identified as vulnerable to extreme flood
CT	Voluntown	Wood River	Williams Road, Brown Road	Town of Voluntown HMP, 2013		Identified as vulnerable to extreme flood
CT	Voluntown	Green Fall River, Peg Mill Brook	Green Fall Road	Town of Voluntown HMP, 2013		Identified as vulnerable to extreme flood
CT	Voluntown		Townwide	Town of Voluntown HMP, 2013	Town succeeded in alleviating drainage issues as outlined in last HMP; currently no issues within the	

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
					town	
CT	Voluntown	Bailey Pond & Wood River	Bailey Pond Road	Town of Voluntown HMP, 2013		In 1% annual flood zone; main entrance/egress to area around Bailey Pond. Vulnerable in severe storms.
RI	Hopkinton	Drainage-Related	Crandall Field	Town of Hopkinton Comprehensive Plan, 2011.	Identified for improvement in Comprehensive Plan (R)	Poor drainage of fields restricts use in spring and fall.
RI	Charlestown	Drainage-Related	Parking lot near Michel Pond	Washington County FIS, 2013		
RI	Charlestown	Pawcatuck River	Marshes	Washington County FIS, 2013		
RI	Exeter	Queens Fort Brook	South County Trail Bridge	Washington County FIS, 2013		Identified as flood-prone area; no extensive flooding documented.
RI	Exeter	Queens Fort Brook	Joseph H. Ladd School entrances	Washington County FIS, 2013		Identified as flood-prone area; no extensive flooding documented.
RI	Exeter	Queens Fort Brook	Confluence at Queen River	Washington County FIS, 2013		Identified as flood-prone area; no extensive flooding documented.
RI	Exeter	Chipuxet River	Upstream of Yawgoo Valley Road	Washington County FIS, 2013		Identified as flood-prone area; no extensive flooding documented.
RI	Exeter	Chipuxet River	Wolf Rock Road	Washington County FIS, 2013		Identified as flood-prone area; no extensive flooding documented.
RI	Exeter	Queen River	Mail Road	Washington County FIS, 2013		Floods when rainfall amounts reach 4 inches. Results in road closures.

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Exeter	Roaring Brook	Summit Road	Washington County FIS, 2013		Floods when rainfall amounts reach 2.5 inches. Results in road closures.
RI	Richmond	Richmond Streams		Washington County FIS, 2013		No floodplain zoning law (flood overlay zoning district)
RI	Exeter		Ladd property/ Job Corps Academy	Exeter HMP, 2005		Known flooding
RI	Exeter	Boon Lake	Boon Lake Dam	Exeter HMP, 2005		Low hazard dam. No history of issues.
RI	Exeter	Dorset Mill Pond	Dorset Mill Pond Dam	Exeter HMP, 2005		Low hazard dam. No history of issues.
RI	Exeter	Boon Lake	East Shore Road	Exeter HMP, 2005		Vulnerable to flooding in event of dam failure
RI	Exeter	Boon Lake	West Shore Road	Exeter HMP, 2005		Vulnerable to flooding in event of dam failure
RI	Charlestown	Pawcatuck River	Driftwood Drive	Charlestown HMP, 2005; Charlestown HMP (Draft), 2015		Flashflood, April 1, 1993. Pawcatuck River Flooding onto Driftwood Drive
RI	Charlestown	Drainage-Related	Various	Charlestown HMP, 2005; Charlestown HMP (Draft), 2015		Flooding in poor drainage areas--February 18, 1998; March 8, 1998; March 29, 2003.
RI	Charlestown	Various streams	Various	Charlestown HMP, 2005; Charlestown HMP (Draft), 2015		June 13, 1998, 6"-8" rain event. Numerous small streams flooded their banks.
RI	Charlestown	Pasquiset Brook, Pawcatuck River	Sherman Ave	Charlestown HMP, 2005		Identified as road subject to flooding and washout

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Charlestown	Pasquiset Brook, Unnamed Marsh	Old Coach Road	Charlestown HMP, 2005		Identified as road subject to flooding and washout
RI	Charlestown	Pasquiset Brook, Pawcatuck River	Kenyon Industries, Sherman Ave	Charlestown HMP, 2005. Local knowledge.	Dam just rebuilt as rock ramp fishway	Identified as industrial in a floodplain. Low lying developed property, routinely flooded
RI	Charlestown	Various streams & ponds	Cottages in 25-year floodplain (various areas)	Charlestown HMP, 2005	Enforce floodplain regulations & reduce number of marginal locations. Create GIS database specific to Charlestown of hazard prone structures and risk areas. (R)	Older lots do not conform to current zoning for 2- or 3- acre lots and/or 50-ft setback from water resource areas.
RI	Charlestown	Pawcatuck River	Kings Factory Road stream crossing	Charlestown HMP, 1997		Identified as an area subject to flooding
RI	Charlestown	Unnamed Stream	Narragansett Trail stream crossing	Charlestown HMP, 1997		
RI	Richmond	Wood River	Valley Lodge Estates on Wood River Drive	Henry Oppenheimer, 5/21/15 Steering Committee Meeting		Subject to regular periodic flooding
RI	Richmond	Wood River	Charbert Office, 299 Church St	Henry Oppenheimer, 5/21/15 Steering Committee Meeting		Known flood area
RI	Westerly	McGowan Brook	Route 91 Westerly	Local knowledge		Culvert subject to beaver blockages, beaver blockages also reported at downstream Amtrak culvert. Severe flooding in 2010 isolated the high land area to west for several days (additional inundation further to west by

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
						Chapman Pond).
RI	Westerly	Pawcatuck River	Westerly Urban District	Local knowledge		Most flooding upstream of downtown
RI	Westerly	Pawcatuck River	Low-lying Areas on State Route/ Main Street	Local knowledge		
RI			Alton Pond, on Rt 91	Local knowledge		Dam below Route 91,confluence of Wood and Pawcatuck Rivers
RI	Richmond	Beaver River	Rt 112	Local knowledge		Low point in road, adjacent residences
RI	Charlestown	Pawcatuck River	Biscuit City Road Bridge	Local knowledge		Some residences affected
RI	Richmond	Beaver River	Beaver River Crossing at Shannock Hill Road	Local knowledge		Undersized culvert and low-lying roads.
RI	Richmond	Beaver River	Flooding on Hillsdale Road	Local knowledge		This is "Decoppett", other locations as well
RI	Richmond	Wyoming Pond	Wyoming Dam	Local knowledge		Developed areas affected by flooding.
RI	Richmond	Wood River	WPWA Office	Local knowledge		Basement flooded.
RI	Hopkinton	Wood River	Developed properties on Wood River	Local knowledge		
RI	Hopkinton	Wood River	Developed properties by Woodville Dam	Local knowledge		

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Charlestown	Pawcatuck River	Some developed properties in low-lying areas on Rt 91	Local knowledge		
RI	Hopkinton	Wood River	Electrical Substation at Dow Field	Local knowledge		
RI	Richmond	Meadow Brook Pond	Meadow Brook Pond flooding onto Rt 91	Local knowledge		
RI	Richmond	Meadow Brook	Kenyon Mill Road	Local knowledge		Known flood area
RI	Charlestown	Various streams	Various Roads	Charlestown HMP, 2015		Heavy rain caused road closures due to flooding; October 15, 2005. 2.5-4.5"
RI	Charlestown	Various streams	Urban and stream flooding	Charlestown HMP, 2015		Rainfall produced significant urban flooding and minor flooding of streams; October 28, 2006. 2-4".
RI	Charlestown	Various streams	Widespread urban and stream flooding	Charlestown HMP, 2015		Snow changing to heavy rain caused widespread flooding; March 2, 2007. 2-3".
RI	Charlestown	Various streams	Various locations	Charlestown HMP, 2015		Heavy rain and snowmelt caused river flooding; March 8, 2008. 2-3"
RI	Charlestown	Various streams & drainage related	Various locations	Charlestown HMP, 2015		Heavy rain caused flooding of small streams, urban, and poor drainage areas; March 14, 2010. 3-6".
RI	Charlestown	Pawcatuck River	Route 91	Charlestown HMP, 2015		Route 91 closed due to flooding when the Pawcatuck River set a record of approx. 15.5 ft; March 29, 2010. 5-10".

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Charlestown	Pawcatuck River	Shannock Road	Charlestown HMP, 2015		Shannock Road closed due to flooding when the Pawcatuck River set a record of approx. 15.5 ft; March 29, 2010. 5-10".
RI	Charlestown	Pawcatuck River	Nearby roads and properties	Charlestown HMP, 2015		Numerous roads closed and basements flooded; March 29, 2010. 5-10".
RI	Charlestown	Various streams/brooks	Various roads which cross streams/brooks	Charlestown HMP, 2015		
RI	Charlestown	Pawcatuck River	Dam: Lower Falls	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Pawcatuck River	Dam: Horseshoe Falls	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Burlingame Reservoir	Dam: Burlingame Reservation	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Carolina Pond	Dam: Carolina Pond	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Clausen Farm Pond	Dam: Clausen Farm Pond	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Cedar Swamp Brook	Dam: Gobeille Pond	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Saw Mill Pond	Dam: Indian Cedar Swamp/ Wanansequot	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	McLeod Farm Pond	Dam: McLeod Farm Pond	Charlestown HMP, 2015		Identified as vulnerable to heavy rains
RI	Charlestown	Olaf Farm Pond	Dam: Olaf Farm Pond	Charlestown HMP, 2015		Identified as vulnerable to heavy rains

Table A-1. Documented areas of flooding in the Wood-Pawcatuck watershed.

State	Town	Flooding Source	Location/Area of Flooding	Information Source	Recommended (R), Ongoing (O), or Completed (C) projects	Notes
RI	Charlestown	Pawcatuck River	Shannock Road Utilities Electrical Substation	Charlestown HMP, 2015		Identified as vulnerable to heavy rains/flood

Appendix B

Water Quality Impairments in the Wood-Pawcatuck Watershed

FUSS & O'NEILL

Table B-1. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Rivers and Streams (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Alewife Brook (South Kingstown)	RI0008039R-01	1.1	B	5	Fish and Wildlife Habitat	Copper Iron Lead
Ashaway River (Ashaway River headwaters including tributaries, south to the Ashaway Road highway bridge. Hopkinton)	RI0008039R-02A	1.8	A	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Cadmium Enterococcus
Chipuxet River (Chipuxet River and tributaries from outlet of Yawgoo Mill Pond to the entrance of Hundred Acre Pond. Exeter, South Kingstown)	RI0008039R-06B	8.2	A	5	Fish and Wildlife Habitat	Cadmium Copper Iron
Mile Brook (Hopkinton)	RI0008039R-14	2.0	B	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Iron Enterococcus
Pawcatuck River (Pawcatuck River and tributaries from the dam at Kenyon to the beginning of the Carolina Mill Pond in Carolina. Richmond, Charlestown)	RI0008039R-18B	2.16	B1	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Whole Effluent Toxicity (WET) Enterococcus
Pawcatuck River (Pawcatuck River and tributaries from the Bradford Dyeing Associates WWTF discharge point to the Route 3 bridge crossing. Hopkinton, Westerly)	RI0008039R-18D	5.5	B1	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Benthic-Macroinvertebrate Bioassessments Enterococcus

Table B-1. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Rivers and Streams (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Pawcatuck River (Pawcatuck River and tributaries from the Route 3 bridge crossing to the Route 1 highway bridge at the junction of Main Street and Broad Street in Westerly. Westerly)	RI0008039R-18E	13.8	B	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Iron Lead Non-Native Aquatic Plants Enterococcus
Perry Healy Brook (Perry Healy Brook and tributaries. Westerly, Charlestown)	RI0008039R-19	4.8	B	5	Fish and Wildlife Habitat	Copper Lead
Queens Fort Brook (Queens Fort Brook and tributaries from 3/4 mile south of Victory Highway (Route 102) to the confluence with the Queens River. Exeter)	RI0008039R-31B	4.2	B	5	Fish and Wildlife Habitat	Iron Lead Turbidity
Canonchet Brook (Canonchet Brook headwaters including tributaries, excluding all ponds, to Route 3 in Hopkinton. Hopkinton)	RI0008040R-04A	5.3	B	5	Fish and Wildlife Habitat	Copper Iron
Canonchet Brook (Canonchet Brook and tributaries from Route 3 in Hopkinton to the confluence with the Wood River. Hopkinton)	RI0008040R-04B	4.6	B	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Cadmium Copper Lead Enterococcus
Coney Brook (Coney Brook and tributaries. West Greenwich)	RI0008040R-05	3.9	A	5	Fish and Wildlife Habitat	Copper
Wood River (Wood River and tributaries from the Alton Pond dam to the confluence with the Pawcatuck River. Richmond, Hopkinton, Charlestown)	RI0008040R-16D	0.7	B	5	Fish and Wildlife Habitat	Ambient Bioassays--Chronic Aquatic Toxicity Benthic-Macroinvertebrate Bioassessments Copper

Table B-1. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Rivers and Streams (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Canob Brook (Richmond)	RI0008040R-23	0.3	B	5	Fish and Wildlife Habitat	Iron
Chickasheen Brook (Chickasheen Brook headwaters to Yawgoo Pond. Exeter)	RI0008039R-05A	1.6	A	4A	Primary, Secondary Recreation	Fecal Coliform, Enterococcus
Mastuxet Brook (Mastuxet Brook and tributaries. Westerly)	RI0008039R-11	2.6	B	4A	Primary, Secondary Recreation	Fecal Coliform, Enterococcus
Meadow Brook (Meadow Brook and tributaries from the headwaters to the confluence with the Pawcatuck River. Richmond)	RI0008039R-13	10.0	A	4A	Primary, Secondary Recreation	Enterococcus
Pawcatuck River (Pawcatuck River and tributaries from the entrance to the Carolina Mill Pond to the Bradford Dyeing Associates WWTF discharge point. Richmond, Charlestown, Hopkinton, Westerly)	RI0008039R-18C	14.2	B	4A	Primary, Secondary Recreation	Enterococcus
Taney Brook (Richmond)	RI0008039R-23	1.7	B	4A	Primary, Secondary Recreation	Enterococcus
Tomaquag Brook (Tomaquag Brook and tributaries. Hopkinton)	RI0008039R-24	13.6	A	4A	Primary, Secondary Recreation	Enterococcus
White Horn Brook (White Horn Brook and tributaries from Route 138 to the wetlands associated with and due east of, Worden Pond. South Kingstown)	RI0008039R-27B	4.7	B	4A	Primary, Secondary Recreation	Enterococcus
Dutemple Brook (Exeter)	RI0008039R-30	1.8	A	4A	Primary, Secondary Recreation	Enterococcus

FUSS & O'NEILL

Table B-1. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Rivers and Streams (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Parmenter Brook (Parmenter Brook and tributaries. Hopkinton)	RI0008039R-37	5.0	A	4A	Primary, Secondary Recreation	Enterococcus
Spring Brook (Spring Brook and Tributaries. Westerly)	RI0008039R-41	2.4	B	4A	Primary, Secondary Recreation	Enterococcus
Acid Factory Brook (Acid Factory Brook and tributaries. West Greenwich)	RI0008040R-01	4.3	A	4A	Primary, Secondary Recreation	Enterococcus
Breakheart Brook (Breakheart Brook and tributaries. West Greenwich, Exeter)	RI0008040R-02	5.9	A	4A	Primary, Secondary Recreation	Enterococcus
Brushy Brook (Brushy Brook and tributaries from Sawmill Road to the entrance of Locustville Pond. Hopkinton)	RI0008040R-03B	2.6	B	4A	Primary, Secondary Recreation	Enterococcus
Phillips Brook (Brushy Brook and tributaries from Sawmill Road to the entrance of Locustville Pond. Hopkinton)	RI0008040R-14	4.0	A	4A	Primary, Secondary Recreation	Enterococcus
Wood River (Wood River and tributaries from the headwaters starting at confluence of Flat and Falls Rivers, to the confluence with Roaring Brook. Exeter, Hopkinton, Richmond.)	RI0008040R-16A	6.5	A	4A	Primary, Secondary Recreation	Enterococcus
Baker Brook (Richmond)	RI0008040R-18	1.4	B	4A	Primary, Secondary Recreation	Enterococcus
Chipuxet River (Chipuxet River from outlet of Hundred Acre Pond to the entrance into Worden Pond, excluding Thirty Acre Pond. South Kingstown)	RI0008039R-06C	3.9	B	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants

Table B-1. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Rivers and Streams (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Wood River (Wood River from confluence with Roaring Brook to the inlet of Wyoming Pond. Richmond, Hopkinton)	RI0008040R-16B	2.6	B	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants
Wood River (Wood River and tributaries from the outlet of Wyoming Pond to the inlet of Alton Pond. Richmond, Hopkinton)	RI0008040R-16C	11.9	B	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants

Table B-2. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Pawcatuck River Estuary (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Tidal Pawcatuck River (Tidal Pawcatuck River from Pawcatuck Rock to a line from Rhodes Point, RI to Pawcatuck Point, CT. Westerly)	RI0008038E-01B	0.7	SB	4A	Primary, Secondary Recreation Shellfish Consumption	Fecal Coliform
Little Narragansett Bay (Waters of Little Narragansett Bay within the State of Rhode Island which are north and east of Sandy Point to the state line; and northeast of a line from the Rhode Island Department of Environmental Management pole (Latitude 41° 19' 17" North, Longitude -71° 52' 47" West) near the southeastern extremity of Sandy Point to a Rhode Island Department of Environmental Management pole (Latitude 41° 18' 37" North, Longitude -71° 52' 39" West) on the northern shoreline of Napatree Point; and north of a line from the northernmost extension of land that forms Napatree Point to the westernmost point of land on the south side of the mouth of Fosters Cove; and west of a line extending from Pawcatuck Point in Connecticut to Rhodes Point in Rhode Island. Westerly)	RI0008038E-02A	0.8	SA	4A	Shellfish Consumption	Fecal Coliform
Little Narragansett Bay (Little Narragansett Bay including Watch Hill Cove and the waters of "The Kitchen", southeast of a line from the northernmost extension of land that forms Napatree Point to the westernmost point of land on the south side of the mouth of Fosters Cove. Westerly)	RI0008038E-02B	0.3	SA{b}	4A	Shellfish Consumption	Fecal Coliform
Tidal Pawcatuck River (Tidal Pawcatuck River from Route 1 highway bridge to Pawcatuck Rock. Westerly)	RI0008038E-01A	0.32	SB1	5	Fish and Wildlife Habitat Primary, Secondary Recreation	Oxygen, Dissolved Fecal Coliform

Table B-3. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Lakes and Ponds (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (acres)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Chapman Pond (Westerly)	RI0008039L-01	172.8	B	5	Fish and Wildlife Habitat	Eurasian Water Milfoil Lead Non-Native Aquatic Plants
Hundred Acre Pond (South Kingstown)	RI0008039L-13	84.2	B	5	Fish and Wildlife Habitat Fish Consumption	Non-Native Aquatic Plants Oxygen, Dissolved Mercury in Fish Tissue
White Brook Pond (Richmond)	RI0008039L-26	6.4	B	5	Fish and Wildlife Habitat	Phosphorus (Total)
Deep Pond (Exeter)	RI0008040L-12	17.4	A	5	Fish and Wildlife Habitat	Oxygen, Dissolved Phosphorus (Total)
Watchaug Pond (Charlestown)	RI0008039L-02	567.9	B	4A	Fish Consumption	Mercury
Meadowbrook Pond (Sandy Pond) (Richmond)	RI0008039L-05	23.1	A	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Tucker Pond (South Kingstown)	RI0008039L-08	93.0	B	4A	Fish Consumption	Mercury in Fish Tissue
Larkin Pond (South Kingstown)	RI0008039L-11	41.7	B	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Barber Pond (South Kingstown)	RI0008039L-14	28.2	B	4A	Fish and Wildlife Habitat Fish Consumption	Oxygen, Dissolved Non-Native Aquatic Plants
Yawgoo Pond (Exeter, South Kingstown)	RI0008039L-15	143.4	A	4A	Fish and Wildlife Habitat Fish Consumption	Phophorus (Total) Oxygen, Dissolved Excess Algal Growth Mercury in Fish Tissue

Table B-3. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Lakes and Ponds (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (acres)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Alton Pond (Hopkinton)	RI0008040L-01	44.2	B	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Ashville Pond (Hopkinton)	RI0008040L-04	25.7	B	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Wincheck Pond (Hopkinton)	RI0008040L-06	145.7	B	4A	Fish Consumption	Mercury in Fish Tissue
Yawgoog Pond (Hopkinton)	RI0008040L-07	160.7	AA	4A	Fish Consumption	Mercury in Fish Tissue
Locustville Pond (Hopkinton)	RI0008040L-10	82.3	B	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Wyoming Pond (Hopkinton)	RI0008040L-11	34.1	B	4A	Fish and Wildlife Habitat Fish Consumption	Non-native Aquatic Plants Mercury in Fish Tissue
Browning Mill Pond (Arcadia Pond) (Exeter, Richmond)	RI0008040L-13	50.0	B	4A	Fish Consumption	Mercury in Fish Tissue
Boone Lake (Exeter)	RI0008040L-14	45.6	B	4A	Fish Consumption	Mercury in Fish Tissue
Eisenhower Lake (West Greenwich)	RI0008040L-16	55.3	A	4A	Fish Consumption	Mercury in Fish Tissue
Thirty Acre Pond (South Kingstown)	RI0008039L-12	15.2	B	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants
The Reservoir (Exeter)	RI0008039L-21	21.5	A	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants

Table B-3. Water Quality Impairments, Wood-Pawcatuck Watershed – RI Lakes and Ponds (2014 IWQR, May 2015)

Name (Location)	Water Body ID	Length of Segment (acres)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Carolina Trout Pond (Richmond)	RI0008040L-02	3.3	A	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants
Breakheart Pond (West Greenwich, Exeter)	RI0008040L-15	43.8	A	4C	Fish and Wildlife Habitat	Non-Native Aquatic Plants

Table B-4. Water Quality Impairments, Wood-Pawcatuck Watershed – CT Rivers and Streams (2014 IWQR, October 2014)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Pawcatuck River (Head of tide at Route 1 crossing Stonington to Pawcatuck-Westerly RI, US along CT/RI boarder until river enters RI, lower portion North Stonington.)	CT1000-00_01	5.38	B	5	Recreation	*E.coli*
Unnamed Tributary Pawcatuck River (Mouth at confluence Pawcatuck River, US to Lewis Pond OUTLET, just US of Boom Bridge Road crossing, North Stonington. Statewide bacteria TMDL)	CT1000-01_01	0.14	A	5	Recreation	*E.coli*
Unnamed Tributary Pawcatuck River (Mouth at confluence Pawcatuck River, US to HW at unnamed pond OUTLET just US of Arch Street crossing, Stonington. Statewide bacteria TMDL)	CT1000-05_01	0.55	A	5	Recreation	*E.coli*
Unnamed Tributary Pawcatuck River (Mouth at confluence Pawcatuck River, US to HW, US of Route 2/78 crossing and above Kelly Street and North Road access points, Stonington. Statewide bacteria TMDL)	CT1000-04_01	0.72	A	5	Recreation	*E.coli*
Unnamed Tributary Pawcatuck River (Mouth at confluence Pawcatuck River, just DS of Route 2/78 crossing, US to HW at unnamed pond OUTLET just US of Elm Ridge Road crossing, Stonington)	CT1000-03_01	0.88	A	5	Recreation	*E.coli*

Table B-4. Water Quality Impairments, Wood-Pawcatuck Watershed – CT Rivers and Streams (2014 IWQR, October 2014)

Name (Location)	Water Body ID	Length of Segment (miles)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Unnamed Tributary Pawcatuck River (Mouth at confluence Pawcatuck River (Little Narragansett Bay portion) just DS of Route 49 crossing, US to HW at unnamed pond outlet just US of Route 49 crossing, very close to Town border, Stonington. Statewide bacteria TMDL)	CT1000-00_trib_01	0.18	A	5	Recreation	*E.coli*
Shunock River (Mouth at Pawcatuck River, US to Side Pond dam at outlet of Ripley Parks Pond (just south of Babcock Road), North Stonington Center.)	CT1004-00_01	4.37	A	4A	Recreation	*E.coli*

Table B-5. Water Quality Impairments, Wood-Pawcatuck Watershed – CT Pawcatuck River Estuary (2014 IWQR, October 2014)

Name (Location)	Water Body ID	Length of Segment (sq. mi.)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Inner Pawcatuck River (01) Eastern portion of LIS, Inner Estuary in Pawcatuck River from Stanton Weir Point US to Saltwater limit, parallel to RR and Mechanic Street, Clarks Village, (Stonington)	CT-E1_001-SB	0.103	SB	5	Aquatic Live Recreation Shellfish	Nutrient/Eutrophication Biological Indicators Oxygen, Dissolved

Table B-6. Water Quality Impairments, Wood-Pawcatuck Watershed – CT Lakes and Ponds (2014 IWQR, October 2014)

Name (Location)	Water Body ID	Length of Segment (acres)	Water Quality Rating	Impairment Classification	Impaired Designated use	Cause/Impairment
Wyassup Lake (North Stonington)	CT1001-00-1-L1_01	98.94	A	4C Recreation 5 Fish Consumption	Recreation Fish Consumption	Mercury