TOTAL MAXIMUM DAILY LOAD ANALYSIS FOR THE PAWCATUCK RIVER AND LITTLE NARRAGANSETT BAY WATERS

BACTERIA IMPAIRMENTS

PAWCATUCK RIVER
MASTUXET BROOK

LITTLE NARRAGANSETT BAY
WATCH HILL COVE

WESTERLY, RHODE ISLAND

Final Report
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RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF WATER RESOURCES
235 PROMENADE STREET
PROVIDENCE, RI 02908

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ABSTRACT

This Total Maximum Daily Load (TMDL) addresses elevated fecal coliform concentrations in the estuarine Pawcatuck River and its outlet Little Narragansett Bay, including Watch Hill Cove. These waters are located in southwestern Rhode Island and form the boundary between Westerly, Rhode Island and Stonington, Connecticut. The TMDL also addresses elevated fecal coliform and enterococci impairments to Mastuxet Brook, a tributary stream that discharges to estuarine Pawcatuck River, located entirely in Westerly. The estuarine Pawcatuck River and Little Narragansett Bay are included on Rhode Island's 2008 303(d) List of Impaired Waters. Mastuxet Brook will be added in 2010. These waters do not support their designated uses associated with the fecal coliform and/or enterococci, which include primary recreation for all waters and shellfish harvesting for those waters classified as SA.

This TMDL aims to restore water quality by identifying necessary fecal coliform and/or enterococci reductions, locating pollution sources, and outlining an implementation strategy to abate fecal coliform/enterococci sources such that water quality standards can ultimately be attained during all weather conditions.

All stations in the Pawcatuck River estuary violate the geometric mean and 90th percentile criteria during both dry and wet weather with significant impairments occurring in wet weather. The freshwater Pawcatuck River is a bacteria source to the estuarine Pawcatuck River, especially in wet weather, but there also exist many significant dry and wet weather bacteria sources that discharge directly to estuarine Pawcatuck River. As expected by the increased flushing and its distance from actual and potential bacteria sources, water quality improves in Little Narragansett Bay. In Little Narragansett Bay and Watch Hill Cove, there are stations, generally those furthest away from the Pawcatuck River, that meet criteria in dry weather. Dry weather violations in Watch Hill Cove indicate the presence of localized sources. Data also indicate that a localized dry weather source exists in Mastuxet Brook. All stations in the study area violate criteria under wet weather conditions. Required percent reductions range from 77.1% to 100% throughout the impaired segments.

Recommended implementation activities for the study area focus on stormwater, wastewater, and waterfowl management. Achieving water quality standards will also require that both the amount of stormwater and the bacteria concentrations in that stormwater reaching the river be reduced. To reduce runoff volumes and treat stormwater, use of infiltration basins or similar structures is recommended. A targeted approach to construction of stormwater retrofit best management practices (BMPs) in state and municipally owned stormwater drainage networks are recommended. Priority areas for BMP construction include the downtown Westerly area and the Mastuxet Brook area. Ongoing efforts to ensure proper operation and maintenance of onsite wastewater disposal systems and to correct illicit discharges should continue. Waterfowl management, including elimination of human feeding should be undertaken where appropriate. This TMDL also recommends pollution prevention efforts to encourage residents to pick up after their pets and to ensure that boats comply with the *No Discharge* requirements of Rhode Island marine waters. Rhode Island will also continue to work with Connecticut to identify and correct bacteria sources along the Connecticut shoreline.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and Environmental Protection Agency's (EPA) implementing regulations in 40 CFR§130 direct each state to develop Total Maximum Daily Load (TMDL) plans for waterbodies that are not meeting their water quality standards. The primary pollutants of concern for Little Narragansett Bay Waters on the 2008 303(d) List of Impaired Waters are pathogens and low dissolved oxygen (RIDEM, 2008b). This TMDL addresses elevated fecal coliform and enterococci concentrations, which are used as indicators of potential pathogen contamination. The goal of a TMDL is to set pollutant reductions needed to attain water quality standards throughout the study area.

1.1 Study Area

The study area consists of Rhode Island's saltwater portion of the Pawcatuck River[1] and its outlet, Little Narragansett Bay. The study area also includes Mastuxet Brook, a freshwater tributary to the Pawcatuck River that was found to be impaired during this study.

The tidal portion of the Pawcatuck River forms the boundary between Rhode Island (RI) and Connecticut (CT). It is eight kilometers (km) long starting south of the Route 1 Bridge in Westerly and ending at Pawcatuck Point, where it flows into Little Narragansett Bay. The tidal Pawcatuck River is bounded by Stonington, CT on the west and Westerly, RI on the east. Stonington, Westerly, the Napatree Point barrier beach, the open waters of the Atlantic Ocean, and Sandy Point bound Little Narragansett Bay. Mastuxet Brook discharges to Mastuxet Cove, which is located downstream of Pawcatuck Rock in the lower Pawcatuck River. This TMDL addresses bacteria impairments in the Rhode Island portion of the Pawcatuck River estuary and Little Narragansett Bay *only*. It does include recommendations for mitigation of identified sources along both the Rhode Island and Connecticut shorelines. The study area is shown in Figure 1.1.

Table 1.1 contains a list of the bacteria-impaired waters for the study area along with their water quality classifications (RIDEM, 2008b). Mastuxet Brook is not included in the current 303(d) List. It will be added to the appropriate category in the state's Integrated Report during the 2010 assessment.

[1]In this report, the freshwater reaches of the Pawcatuck River will be referred to as the freshwater Pawcatuck River.

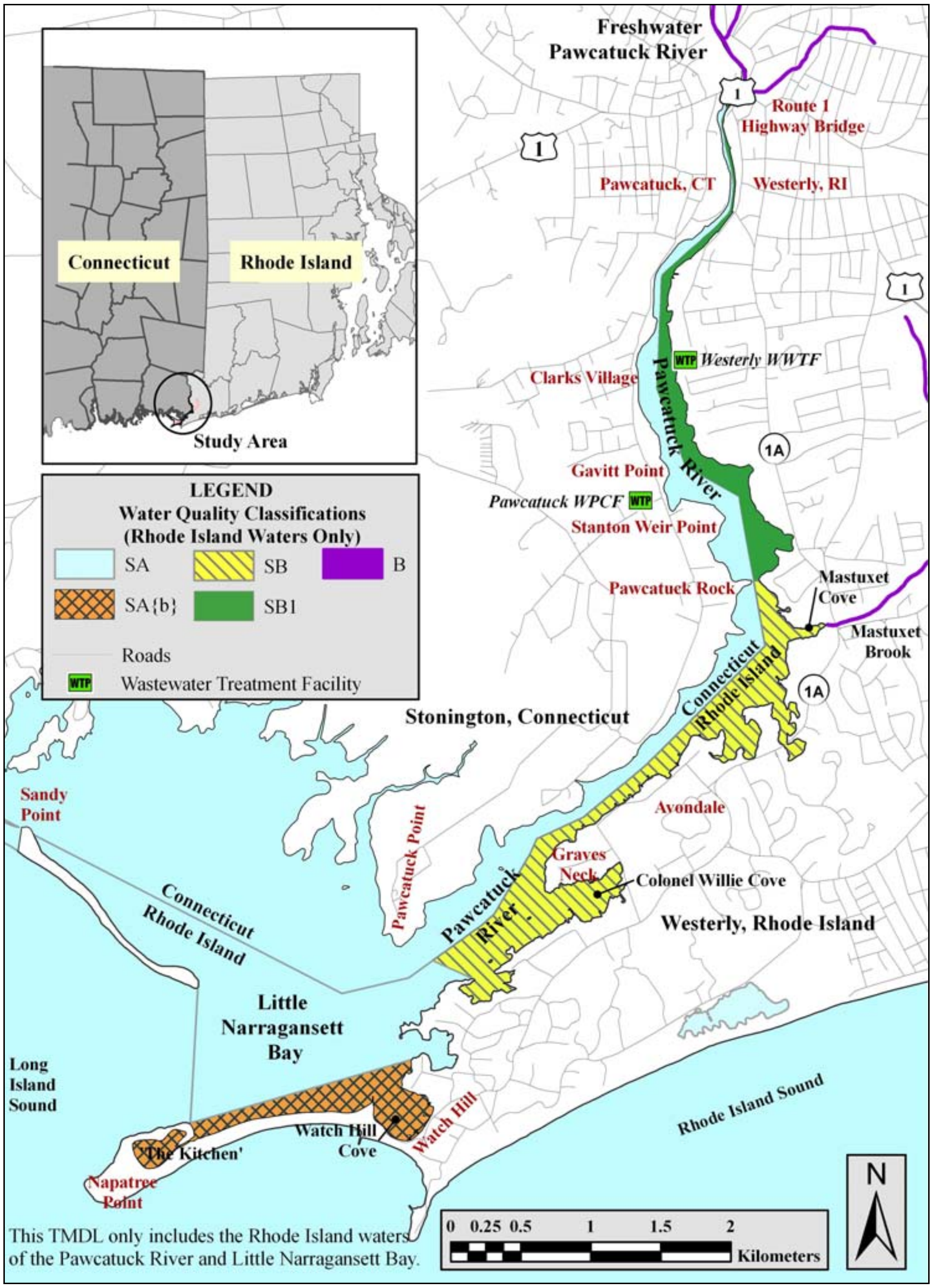

Figure 1.1 Pawcatuck River and Little Narragansett Bay Waters.

Table 1.1 Study Area Impaired Waters and Water Quality Classifications (RIDEM, 2008b).

Waterbody ID	Waterbody Description	Water Quality Classification	Size	303(d) Pathogen Impairment
RI0008039R-11	Mastuxet Brook[1]	B	4.2 km 2.641 mi	Enterococci Fecal Coliform
RI0008038E-01A	Tidal Pawcatuck River: Route 1 highway bridge to Pawcatuck Rock	SB1	0.8316 km^2 0.3211 mi^2	Fecal Coliform
RI0008038E-01B	Tidal Pawcatuck River: Pawcatuck Rock to Pawcatuck Point	SB	1.7814 km^2 0.6889 mi^2	Fecal Coliform
RI0008038E-02A	Little Narragansett Bay	SA	2.0442 km^2 0.7893 mi^2	Fecal Coliform
RI0008038E-02B	Little Narragansett Bay: Watch Hill Cove and area north of Napatree	SA{b}	0.7980 km^2 0.3081 mi^2	Fecal Coliform

[1]Mastuxet Brook will be added to Rhode Island's 303(d) List for both enterococci and fecal coliform impairments.

1.2 Pollutant of Concern

Rhode Island's entire tidal Pawcatuck River and Little Narragansett Bay are identified as impaired for fecal coliform, a parameter used by Rhode Island as an indicator of potential pathogen contamination. In Rhode Island's 2010 Integrated Report, Mastuxet Brook will be identified as impaired for both fecal coliform and enterococci.

1.3 TMDL Schedule

On the 2008 303(d) List of Impaired Waters, Rhode Island scheduled the Pawcatuck River and Little Narragansett Bay for TMDL development in 2010.

1.4 Applicable Water Quality Standards

Designated uses and water quality standards vary depending on the water quality classification of a waterbody. Both are described in the State of Rhode Island's Water Quality Regulations (2009d). The tidal Pawcatuck River and Little Narragansett Bay are composed of four water quality classifications, Class SA, Class SA{b}, Class SB, and Class SB1. Mastuxet Brook, a freshwater waterbody, has been assigned a water quality classification of B. Standards comply with the requirements of the federal Clean Water Act of 1972, Rhode Island General Laws (Chapter 46-12).

Designated Uses

Section 8.B(2) of the Water Quality Regulations (2009d) describes the water use classification of Class SA, SA{b}, SB, SB1, and B waters. It is important to note the differing waterbody classes because the waterbody classifications are developed to be protective of varying *designated* uses, including shellfish harvesting and primary and secondary recreational activities. All water quality classifications and locations are shown in Figure 1.1.

> Class SA waters are designated for shellfish harvesting for direct human consumption; primary and secondary contact recreational activities, and fish and wildlife habitat.

Class SA{b} waters are designated for shellfish harvesting for direct human consumption; primary and secondary contact recreational activities, and fish and wildlife habitat. These waters are in the vicinity of marinas and/or mooring fields and therefore seasonal shellfish harvesting closures will likely be required. Class SA criteria must be attained at all times.

Class SB waters are designated for primary and secondary contact recreational activities; shellfish harvesting for controlled relay and depuration; and fish and wildlife habitat.

Class SB1 waters are designated for primary and secondary contact recreation and fish and wildlife habitat. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges. Class SB criteria must be attained at all times.

Class B waters are designated for primary and secondary contact recreational activities and fish and wildlife habitat.

Numeric Water Quality Criteria

The Water Quality Regulations contain the following numeric water quality criteria for fecal coliform concentrations.

Class SA and Class SA{b} fecal coliform concentrations are not to exceed a geometric mean MPN value of 14 and not more than 10% of the samples shall exceed an MPN value of 49 for a 3-tube decimal dilution. RIDEM evaluates compliance with these criteria using the Approved Status Classification in accordance with Rhode Island's Shellfish Growing Area Monitoring Program as approved by the United States Food and Drug Administration (FDA).

Class SB and SB1 fecal coliform concentrations are not to exceed a geometric mean MPN value of 50 and not more than 10% of the samples shall exceed an MPN value of 400. This fecal coliform standard is applied only when adequate enterococci data are not available to assess for primary contact recreational/swimming uses in seawaters.

Class B fecal coliform concentrations are not to exceed a geometric mean MPN value of 200 and not more than 10% of the samples shall exceed an MPN value of 400. This fecal coliform standard is applied only when adequate enterococci data are not available.

The Water Quality Regulations contain the following numeric water quality criteria for enterococci concentrations.

Saltwater enterococci (Class SA, SA{b}, SB, SB1) concentrations at non-designated bathing beaches are not to exceed a geometric mean value of 35 colonies per 100 mL.

Freshwater (Class B) enterococci concentrations at non-designated bathing beaches are not to exceed a geometric mean value of 54 colonies per 100 mL.

Other Applicable Standards

The closure of shellfish areas to harvesting is not solely based on the ambient water quality data. In accordance with the National Shellfish Sanitation Program (NSSP), a shellfish growing area shall be classified as Prohibited if no current sanitary survey has been performed or if a sanitary survey or other monitoring program data indicates that fecal coliform material may reach the area in excessive concentrations. If it has been determined that there is a good potential for harvested shellfish to be contaminated due to the nature of an upland source, then the affected growing area is closed (NSSP, 1997, 2007).

Antidegradation Policy

Rhode Island's antidegradation policy requires that, at a minimum, the water quality necessary to support existing uses be maintained (see Rule 18, Tier 1 in the State of Rhode Island's Water Quality Regulations). If water quality for a particular parameter is of a higher level than necessary to support an existing use (i.e. bacterial levels are below Class SA or SB standards), that improved level of quality should be maintained and protected (see Rule 18, Tier 2 in the State of Rhode Island's Water Quality Regulations). Because water quality violates standards in several locations, Tier 2 does not apply.

Numeric Water Quality Target

The numeric water quality targets are set at the applicable water quality criteria or standard for each portion of the Pawcatuck River and Little Narragansett Bay. Numeric targets must ensure that water quality criteria are met in all adjacent waters, including waters that belong to an adjacent state. In some areas, a waterbody segment with higher allowable fecal coliform bacteria limits discharges to a waterbody with more stringent criteria; for example, where Mastuxet Brook, a Class B water, flows into lower Pawcatuck River, a Class SB water. In these places, the numeric water quality target must be set to the more strict criteria of the two standards at the point of discharge. These targets incorporate an implicit margin of safety (MOS) through conservative assumptions that ensure that the water quality standards are met.

The numeric water quality targets are set to the applicable fecal coliform or enterococci concentrations necessary to restore the designated uses to the waterbodies. For example, in SA waters, targets are set to what is necessary to reopen the shellfish waters during all weather conditions, in accordance with Rhode Island's Shellfish Program approved by the United States Food and Drug Administration (FDA).

1.5 Connecticut Water Quality Summary

The boundary between Rhode Island and Connecticut runs through the estuarine Pawcatuck River with Stonington, CT located along the western Pawcatuck River shoreline and Westerly, RI located on the eastern shoreline. Given that the two states share these waters, an effective TMDL must take into consideration similarities and potential conflicts in each State's waterbody classifications, designated uses, and impairments. While this TMDL is being developed for *Rhode Island waters only*, it sets targets that are protective of adjacent Connecticut waters, and examines and makes recommendations concerning actual and potential bacteria sources in both states along the entire River.

As shown in Figure 1.2, there are four Connecticut waterbody segments that are directly adjacent to Rhode Island waters in this study area. Two Connecticut waterbody segments are in the Pawcatuck River, and two are directly adjacent to the Rhode Island waters of Little Narragansett Bay. The uppermost estuarine Pawcatuck River segment in Connecticut extends from Clarks Village to Stanton Weir Point and the lower segment's boundaries are Stanton Weir Point and Pawcatuck Point. While Rhode Island also splits the Pawcatuck River into two segments, there are differences in how the two states divide the River for assessment purposes. In Rhode Island, the uppermost segment directly abuts the freshwater Pawcatuck River and extends to Pawcatuck Rock, which is just over 0.5 kilometers downstream of Stanton Weir Point, the segment boundary used by Connecticut. In both states, the upper segment of the Pawcatuck River includes or is directly adjacent to outfalls at the Westerly WWTF and the Pawcatuck WPCF. The lower RI segment extends from Pawcatuck Rock to Pawcatuck Point, the same segment boundary used by Connecticut.

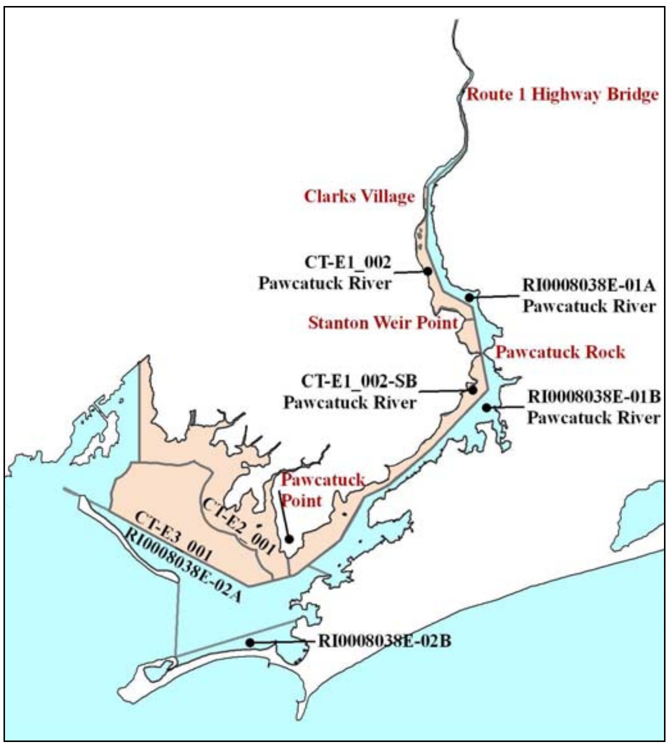

Figure 1.2 Connecticut Waters.

All waterbodies in both states are designated for primary and secondary contact recreation with both states using enterococci as their primary bacteria indicator for recreational uses. In 2008, Connecticut did not have sufficient enterococci data to assess these segments for recreational use.[2] Connecticut's upper Pawcatuck River segment was found to be impaired for fecal coliform because in Connecticut, waters classified as prohibited for shellfish harvesting do not meet their designated use. In its lower segment of the Pawcatuck River, Connecticut only allows commercial shellfish harvesting and requires that shellfish undergo depuration or cleansing prior

[2] Rhode Island listed its Pawcatuck River segments as impaired for recreational uses because, in Rhode Island, fecal coliform can be used to assess for recreational use when there is not adequate enterococci data.

to consumption. Both Rhode Island and Connecticut list their portions of Little Narragansett Bay as impaired for direct harvesting of shellfish for fecal coliform (CTDEP, 2008; Stonington, 2005).

Table 1.2 contains information concerning the Connecticut waterbodies that are adjacent to Rhode Island waterbodies.

Table 1.2 Connecticut Impaired Waters and Water Quality Classifications (CTDEP, 2008).

Waterbody ID	Waterbody Description	Water Quality Classification	Size	303(d) Pathogen Impairments[1]
CT-E1_001-SB[2]	Tidal Pawcatuck River: Clarks Village to Stanton Weir Point	SB	0.267 km^2 0.103 mi^2	Fecal Coliform
CT-E1_002-SB	Tidal Pawcatuck River: Stanton Weir Point to Pawcatuck Point	SB	0.80 km^2 0.31mi^2	None
CT-E2_001	LIS EB Shore - Wequetequock Cove, Stonington, includes areas of Little Narragansett Bay	SA	1.61 km^2 0.62 mi^2	Fecal Coliform
CT-E3_001	LIS EB Midshore – Stonington, includes areas of Little Narragansett Bay	SA	1.53 km^2 0.59 mi^2	Fecal Coliform

[1]In 2008, Connecticut did not have sufficient enterococci data to assess these segments for recreational use. In contrast to Rhode Island, where fecal coliform can be used to assess for recreational use when there is not adequate enterococci data, Connecticut only allows enterococci to be used for recreational use assessments.
[2]There is no assessment unit for the estuarine Pawcatuck River between the freshwater Pawcatuck River and Clarks Village.

The Connecticut Water Quality Regulations (2002) contain numeric water quality criteria for fecal coliform concentrations. In Class SA waters, which are designated for the direct consumption of shellfish, fecal coliform concentrations shall be less than a geometric mean value of 14/100 mL and 90% of the samples shall be less than 43/100 mL. The geometric mean criterions are the same in both Rhode Island and Connecticut, while the variability criterion differ. FDA regulations, of which both criteria are derived, prescribe different variability criteria depending on the analytic test being used. Rhode Island uses a three-tube MPN test, while Connecticut's criteria indicate the use of the five-tube MPN test (NSSP, 1997, 2007). Therefore the two variability criteria are comparable even though they are numerically different.

In Connecticut's Class SB waters, which are designated for commercial shellfish harvesting, fecal coliform concentrations shall be less than a geometric mean value of 88/100 mL and 90% of the samples shall be less than 260/100 mL. Rhode Island does not have a commercial shellfish harvesting designated use, but its fecal coliform geometric mean criterion for Class SB waters is protective of Connecticut waters, while its variability criterion is not protective. For purpose of setting TMDL reductions protective of both states' criteria (Section 4.3), the numeric target for variability in Class SB waters will be not more than 10% of samples to exceed 300/100 mL (the three-tube MPN value comparable to 260 for the five-tube MPN analytic test) (NSSP, 1997, 2007).

2.0 DESCRIPTION OF STUDY AREA

The tidal Pawcatuck River is influenced by water flowing into its northern reaches from the freshwater Pawcatuck River. The Rhode Island drainage area includes large portions of the towns of Westerly, Hopkinton, Charlestown, Richmond, South Kingstown, Exeter, West Greenwich, and a small portion of Coventry and East Greenwich. On the Connecticut side, portions of Sterling, Voluntown, North Stonington, and Stonington drain into the Pawcatuck River watershed.

2.1 Background Information

The freshwater and estuarine Pawcatuck River is 50 km long, flowing from its origin at the outlet of Worden's Pond in South Kingston, Rhode Island, to the inlet of Little Narragansett Bay in Westerly, Rhode Island. Its drainage basin is 782 square kilometers (km^2) that includes 634 km^2 in Rhode Island and 148 km^2 in Connecticut (RIDOA, 2007). The tea-color of the Pawcatuck River is from tannins and humics, which result when leaves and other organics from the watershed decompose (Dillingham et. al., 1993). Small towns and rural communities characterize most of the watershed. The lower freshwater and estuarine sub-watersheds include the urbanized areas of the Towns of Westerly, Rhode Island and Stonington, Connecticut.

The Pawcatuck River and the Wequetequock Cove sub-watersheds both drain into Little Narragansett Bay. The Wequetequock Cove sub-watershed is 35.50 km^2 and is located entirely in Connecticut. At 19.69 km^2, the Pawcatuck River estuarine sub-watershed is smaller than the Wequetuock Cove sub-watershed and it is more urbanized and more closely borders the estuarine portion of the Pawcatuck River. Data support that the impact of Wequetequock Cove on bacteria levels in Little Narragansett Bay is minimal (RIDEM, 2006b; Desbonnet, 1991). It will not be included in this report.

Little Narragansett Bay has a surface area of approximately 3.2 km^2 with an average depth of 2 meters. It is protected from the open ocean by Napatree Point on the south and Sandy Point on the west. Little Narragansett Bay is an important area for migratory bird and a good habitat for juvenile fish and crustaceans (Dillingham et. al., 1993).

Flushing

The freshwater reach of the Pawcatuck River is the main source of freshwater to the tidal portion of the river. The large volume of freshwater that enters the estuary causes a stratified condition within the tidal Pawcatuck River when an influx of denser saltwater from Little Narragansett Bay mixes with freshwater from the upper estuary. Estimates of the flushing time of the freshwater layer of the Pawcatuck River estuary is approximately 1 to 3 days, depending on freshwater input and 2 to 8 days for the saltwater bottom layer, also depending on freshwater input and tidal height (Dillingham et. al., 1993).

Navigation

There is a federal navigation channel that exists along most of the tidal portion of the Pawcatuck River. The channel depths and widths are sufficient to support navigation, but vary greatly outside of the marked channel. Many of the coves located along the central and southern section of the Pawcatuck River estuary have either shallow water depths or rocky exposures or both. Shoals occur in the upper river, near coves, at narrow river passages and at deteriorated structures (Willis, 1991). A 1985 Condition Survey by the Army Corps of Engineers (ACOE) indicated that Sandy Point has shifted into and through the federal channel as it enters Little Narragansett Bay. Due to the dynamic nature of the Sandy Point and Napatree Point barrier systems, new areas will shoal each year or become actual islands.

Boating

The tidal Pawcatuck River is a significant recreational boating center in Rhode Island. In 1989, it was estimated that there were 1493 slips and mooring within the sixteen marinas in the Pawcatuck River. An additional 88 private moorings existed. In Watch Hill Cove, there were two marinas with 47 slips and moorings and 100 additional private moorings (Dillingham et. al., 1993). Little Narragansett Bay is also a popular place for recreational anchoring along the back of the Napatree Beach; the area is well protected from any swell and provides a natural navigation channel for boats to the shoreline.

2.2 Watershed Land Use

The Pawcatuck River freshwater and estuarine basin drains an area of 782 square kilometers (km^2) that includes 634 km^2 in Rhode Island and 148 km^2 in Connecticut (RIDOA, 2007). Small towns and rural communities characterize the watershed, with the exceptions of the urbanized areas in Westerly and in Pawcatuck Village in Stonington. Analyzing the amount of land in various land use categories shows the contrast between the forested areas of the freshwater Pawcatuck River watershed and the developed areas of the estuarine Pawcatuck River watershed.

Land use for Rhode Island and Connecticut was calculated separately for Rhode Island and Connecticut because different land use files were used for each state. Land use for the Rhode Island portions of the watershed was calculated using a statewide digital land cover / land use GIS layer that was based on imagery captured in 2003 and 2004 (RIDOA, 2007), while land use for the Connecticut portions of the watershed was calculated using a data file downloaded from the University of Connecticut's Map and Geographic Information Center (MAGIC)[3]. The entire Pawcatuck watershed was split into three sub-watersheds in each state. The freshwater Pawcatuck River, which contained the majority of the freshwater Pawcatuck River, was the largest of these sub-watersheds. It did not include the watershed for the lower freshwater Pawcatuck River because the sub-watershed GIS file included the about five miles of the lower freshwater Pawcatuck River as part of the estuarine sub-watershed. The land use information for the Wood River was calculated separately from the freshwater Pawcatuck River as well. Due to differences in how each state denotes boundaries in their GIS files, the Connecticut estuarine Pawcatuck River sub-watershed includes the surface of the estuarine Pawcatuck River, while the Rhode Island sub-watershed does not.

[3] It is believed that the land use information was generated in the early to mid 1990s.

Table 2.1 describes the land uses within the Rhode Island and Connecticut sub-watersheds. Characteristics and land uses within these sub-watersheds vary. Land use is given both by total area in km^2 and by percentage. Sub-watershed boundaries are shown in Figure 2.1. The Little Narragansett Bay sub-watershed, which includes the Watch Hill Cove area, is not included in this discussion because Rhode Island GIS files group the Watch Hill Cove area with its south coastal watersheds, which includes the entire southern shoreline of Rhode Island. The sections following Table 2.1 and Figure 2.1 detail land use and other information about these sub-watersheds.

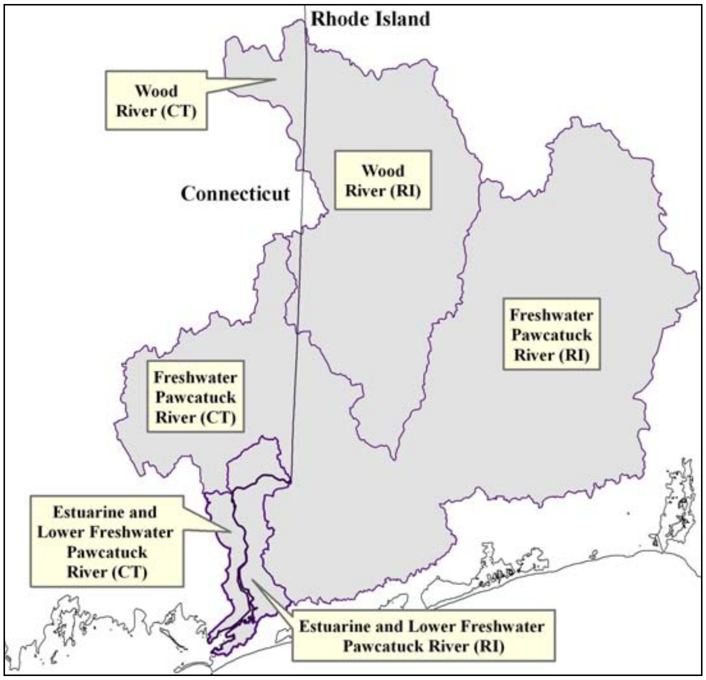

Figure 2.1 Pawcatuck River Sub-Watersheds.

Table 2.1 Sub-watershed Land Use by Area (km^2)[1] and Percentage (RIDOA, 2007)[2].

	Estuarine and Lower Freshwater Pawcatuck River[2]		Freshwater Pawcatuck River[2]		Wood River	
	RI	**CT**	**RI**	**CT**	**RI**	**CT**
Medium to High Density Residential	4.92 25.12%		4.96 1.22%		1.04 0.51%	
Low to Medium Density Residential	3.05 15.58%	4.84 25.15%	29.81 7.30%	1.56 1.52%	9.25 4.49%	0.26 1%
Commercial and Industrial	1.92 9.81%		9.34 2.29%		3.39 1.65%	
Roads, Airports, Utilities, etc.	0.92 4.72%	1.36 7.04%	2.70 0.66%	3.17 3.09%	1.32 0.64%	0.46 1.76%
Recreation and Cemeteries	0.95 4.83%	NA[4]	5.17 1.27%	NA[4]	1.36 0.66%	NA[4]
Agriculture	0.68 3.48%	2.17 11.30%	32.42 7.94%	7.75 7.56%	7.17 3.48%	1.57 5.98%
Forests	6.81 34.78%	8.73 45.38%	303.56 74.38%	83.36 81.34%	174.14 84.56%	21.30 81.02%
Water, Wetlands, Sandy Areas	0.33 1.68%	2.14 11.13%	20.17 4.94%	6.65 6.49%	8.25 4.01%	2.69 10.24%
Total Area (km^2)	**19.56 km^2**	**19.24 km^2**	**408.14 km^2**	**102.49 km^2**	**205.93 km^2**	**26.39 km^2**

[1]The conversion from km^2 to acres is 1 km^2 is 247 acres.
[2]Caution should be used when directly comparing between land use categories in Rhode Island versus Connecticut because different land use files were used.
[3]The boundary between the Freshwater Pawcatuck River and the Estuarine and Lower Freshwater Pawcatuck River sub-watersheds is located where the freshwater Pawcatuck River becomes the Rhode Island / Connecticut Stateline.
[4]The Connecticut land use file did not separate out developed recreation and cemeteries as a category. These land uses are probably included under the developed land or agriculture categories.

Freshwater Pawcatuck River

The headwaters of the Pawcatuck River are located in South Kingstown at Worden Pond. The river primarily flows from east to west, picking up water from several rivers. The principle tributaries to the river are Shunock River, Ashaway River, Tomauqag Brook, Wood River, Meadow Brook, Beaver River, Queen/Usquepaug River, and Chipuxet River.

The predominate land use in the freshwater Pawcatuck River and the Wood River sub-watersheds in both Rhode Island and Connecticut is forested land. Forested land accounts for about three-quarters of all land in these areas. The next highest land use categories are agriculture and medium to low density residential. Each uses about eight percent of the land in the freshwater Pawcatuck River. Within the freshwater Pawcatuck River watershed, the Queen and Chipuxet sub-watersheds have the most agricultural uses by land area. The medium to low-density residential land use reflects the rural nature of the watershed. Development has increased in the entire Pawcatuck River watershed with the largest growth from natural to developed land occurring in the headwaters and the tidal watershed (Jordan, 2008a, 2008b). The Wood River has the least amount of developed land.

Estuarine Pawcatuck River and Lower Freshwater Pawcatuck River

The estuarine Pawcatuck River watershed is much smaller and more developed than that of the freshwater Pawcatuck River. While the watershed values presented in Table 2.1 include the watershed for approximately five miles of the lower freshwater Pawcatuck River, this TMDL study area only includes the estuarine portions of the Pawcatuck River. The estuarine portion of the Pawcatuck River is approximately 8 kilometers long and considered to begin at the Route 1 highway bridge, at the junction of Main Street and Broad Street in Westerly, RI (RIDEM, 2009d).

In Rhode Island, the various developed land use categories are present on over half of the land in this segment. In this lower freshwater and estuarine segment of the Pawcatuck River, forested land only accounted for 35 percent of the land, less than half the percentage that was found in the rest of the watershed. The land use trends were similar for the Connecticut half of this sub-watershed. There does appear to be less developed land on the Connecticut side of the sub-watershed than on the Rhode Island side. This could be due to the differing methodologies and/or different time periods captured. As mentioned above, development has increased in this watershed with the largest growth from natural to developed land occurring in the tidal areas and headwaters of the entire Pawcatuck River watershed (Jordan, 2008a, 2008b).

Though densely populated year-round, the summertime shows an increase in the number of people staying and visiting the Westerly and Stonington area. Summer months see a population swell as summer houses not occupied during the winter months are opened for the summer. The beaches in the area are also popular day trip destinations for people from around the bi-state region. Summer months also see a substantial increase in boat traffic to the area.

2.3 Water Quality History

Historical Shellfish maps are available for Rhode Island between 1942 and the present. A review of these maps reveals that as early as 1942, the Rhode Island Department of Health prohibited shellfish harvesting for the Pawcatuck River from Pawcatuck Rock to the opening to Little Narragansett Bay. The upper portion of the river, upstream of Pawcatuck Rock, was not shown in the closure maps because it was classified as Class SC waters and shellfish harvesting was prohibited in all Class SC waters. The entire Rhode Island portion of the tidal Pawcatuck River is currently closed to shellfish harvesting.

Going back to at least 1942, Little Narragansett Bay fluctuated between being permanently closed to shellfish harvesting and having a portion closed only during summer months. Generally, a wedge of ocean abutting Napatree Point was open for seasonal shellfish harvesting during the fall, winter, and spring while the remainder of Little Narragansett Bay was closed to shellfish harvesting. From 1985 through 1990, the northern half of the bay was closed to shellfish harvesting while the southern half was seasonally open. In 1991, the entire bay was permanently closed to shellfish harvesting in all Rhode Island waters and remains so to the present (RIDEM, 2002). Historical data is available from 1984 through the present. Data collection has shown that water quality has remained about the same throughout the past 25 years. The Pawcatuck River and Little Narragansett Bay are part of the Rhode Island Shellfish Program's Growing Area 12 and are sampled at fifteen locations when the monitoring schedule allows for sampling in closed areas.

2.4 Supporting Documentation

Recent water quality studies are presented in Table 2.2. These references were used to characterize present water quality conditions and to identify water quality trends.

Table 2.2 Supporting Documentation.

Primary Organization	Title	Date of Report	Approximate Date of Study
Connecticut Department of Agriculture / Bureau of Aquaculture	Shellfish Surface Water Monitoring Program	Ongoing	Ongoing
Rhode Island Department of Environment Management, Office of Water Resources	Summer 2006 Sampling Results: Pawcatuck River and Little Narragansett Bay Study	2006	Summer 2006
Rhode Island Department of Environment Management, Office of Water Resources	Shellfish Surface Water Monitoring Program	Ongoing	Ongoing
Rhode Island Department of Environment Management, Office of Water Resources	Rotating Basin Ambient River Monitoring	2008	2006-2007
Save the Bay	Baykeeper Monitoring	Ongoing	2007 - present

3.0 PRESENT CONDITION OF THE WATERBODY

The current water quality conditions for the Pawcatuck River, Little Narragansett Bay, and Mastuxet Brook are detailed in the following sections. Data collected at stations within the Pawcatuck River and Little Narragansett Bay are discussed in the first section. Other sections detail current water quality conditions in Mastuxet Brook, a freshwater tributary to the estuarine Pawcatuck River, from direct stormwater discharges, in the effluent from the Westerly, Rhode Island Wastewater Treatment Facility and the Pawcatuck, Connecticut Water Pollution Control Facility, and from other sources, including wildlife and boats.

The impacts of elevated bacteria concentrations in Little Narragansett Bay can be seen in closures of the shellfish harvesting grounds. Harvesting shellfish is prohibited at all times in Little Narragansett Bay and Watch Hill Cove.

3.1 Instream Water Quality – Pawcatuck River and Little Narragansett Bay Waters

The Shellfish Growing Area Water Quality Monitoring Program is part of the State of Rhode Island's agreement with the FDA NSSP. NSSP requires Rhode Island to conduct routine bacteriological monitoring and conduct shoreline surveys of the State's waters where shellfish is intended for direct human consumption. Harvesting shellfish is currently prohibited in all the Class SA and SA{b} waters of Little Narragansett Bay within the state of Rhode Island (RIDEM, 2009b).

Sampling by the Rhode Island Shellfish Program has been limited since Little Narragansett Bay was closed for shellfish harvesting in 1991. Beginning in 2002, the RIDEM TMDL and Shellfish Programs began to jointly sample the area using the Shellfish Program's protocol. The locations of the fifteen monitoring stations had previously been approved by the FDA as representative of the waters of the Pawcatuck River, Little Narragansett Bay, and Watch Hill Cove. Figure 3.1 shows these Shellfish Program sampling stations. Four stations are in the Class SA Little Narragansett Bay waters, three stations are in Class SA{b} Watch Hill Cove waters, and eight stations are in the Class SB/SB1 Pawcatuck River waters.

During the summer of 2006, the RIDEM Office of Water Resources organized a multi-agency study of the tidal Pawcatuck River and Little Narragansett Bay which included staff from RIDEM, Connecticut Department of Environmental Protection (CTDEP), Connecticut Department of Agriculture / Bureau of Aquaculture (CT DA/BA), Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA). The goal of this joint agency study was to characterize bacteria sources to the estuarine Pawcatuck River and to gauge their impact on the tidal Pawcatuck River and Little Narragansett Bay. Two days of instream monitoring was also conducted at a subset of Rhode Island and Connecticut Shellfish Programs' sampling stations. FDA analyzed the samples for fecal coliform bacteria using the A-1 Analytic technique.

As a follow-up to the instream monitoring conducted as part of the 2006 Shoreline Survey, additional stations were added to the routine Rhode Island Shellfish Program stations. The additional stations were located in the freshwater Pawcatuck River, between this freshwater station and the northern-most shellfish station, and upstream of Stanton Weir Point. The TMDL Program conducted sampling at these locations in an attempt to further localize and characterize pollutant sources. Also, during a 2008 wet weather event, weather conditions did not allow the area to be sampled by boat. Shore-based stations were added to characterize instream conditions during this event. All of these additional stations are shown in Figure 3.1. Additional information about all the sampling results, including those stations where only one or two samples were taken are detailed in the Shoreline Survey Data Report (RIDEM, 2006c) and the project Final Data Report (RIDEM, 2010).

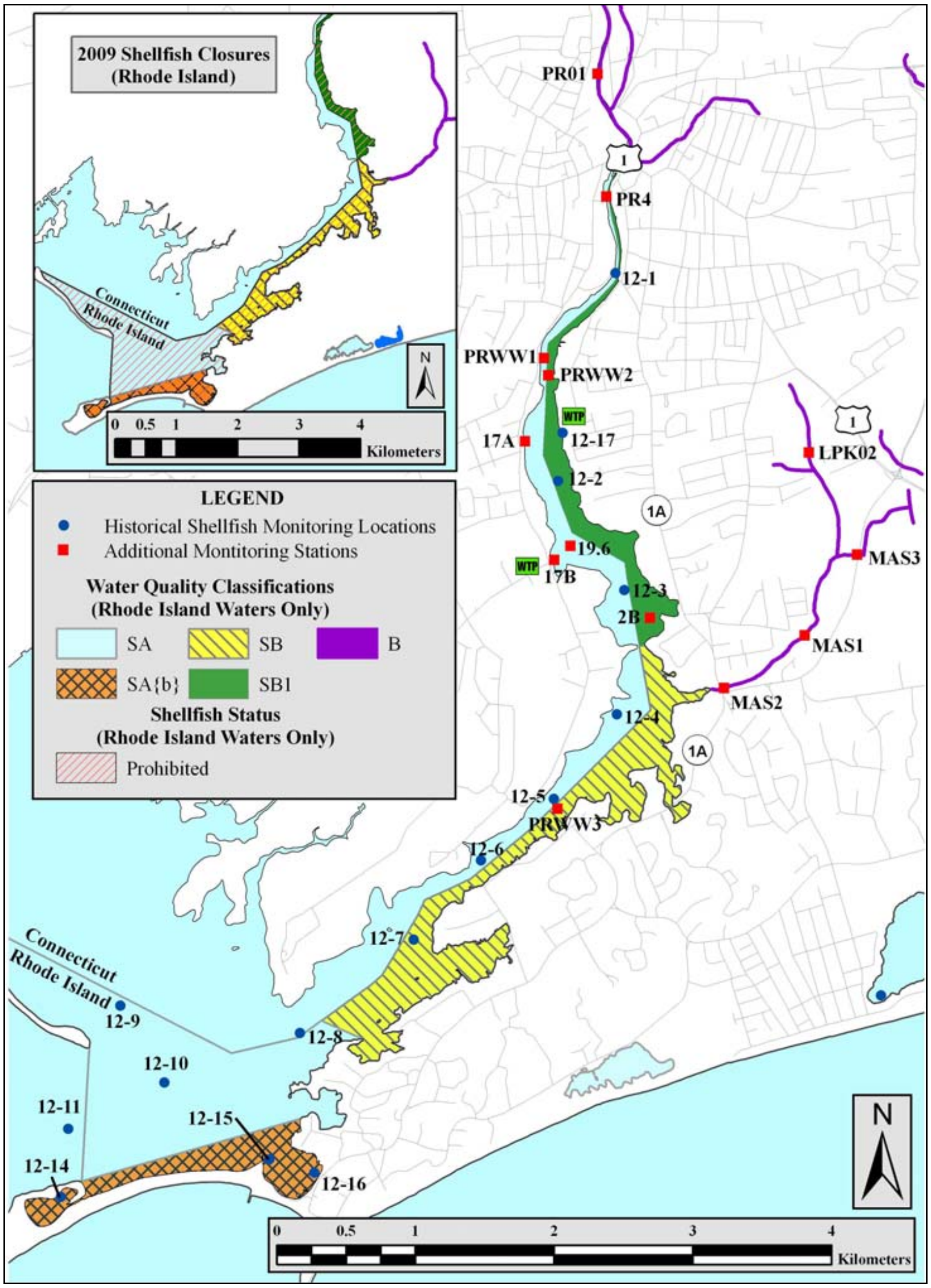

Figure 3.1 Instream Station Locations.

Table 3.1 summarizes water quality data for the Pawcatuck River and Little Narragansett Bay collected between 2002 and 2008. With some exceptions[4], samples were analyzed using the MPN three-tube technique. Wet weather conditions occurred when sampling within five days of receiving 0.5 inches or more of rain in a 24-hour period. Dry weather conditions generally occurred when no more than 0.1 inches of rain fell the in the day proceeding sampling and when there was more than five days since the area experienced 0.5 inches or more of rain. More information about station locations descriptions and individual sample results can be found in Appendix A. Numbers shown in bold in Table 3.1 exceed the applicable criterion. During an intensive wet weather study, multiple samples were taken on one day. One daily value was calculated for each of these three stations by taking the geometric mean of these multiple samples. Table 3.1 also contains data from freshwater Pawcatuck River, which is discussed in the next section.

[4] Samples collected during the 2006 Joint Agency Shoreline Survey and on 09/19/2006 were analyzed using the A1 method. See Appendix A for more detail.

Table 3.1 Pawcatuck River and Little Narragansett Bay Fecal Coliform Data.[1, 2]

Station	Location	Class	Number of Samples		Geometric Mean (MPN/100 ml)			90th Percentile (MPN/100 ml)		
			Dry	Wet	Target	Dry	Wet	Target	Dry	Wet
PR01[3]	Pawcatuck River	B	8	8[4]	200	71	**920[4]**	400	137	**10210[4]**
PR4	Upper Pawcatuck River	SB1	5	8[4]	50	**190**	**1359[4]**	300[5]	**742**	**6310[4]**
12-1			10	6		**152**	**402**		**262**	**1100**
PRWW1			NS	2		NS	**5679**		NS	**7180**
PRWW2			NS	2		NS	**4447**		NS	**4570**
12-17			11	6		**188**	**302**		**460**	**1395**
17A			5	2		**414**	**3198**		**1204**	**9993**
12-2			8	6		**453**	**697**		**1702**	**3050**
17B			5	2		**454**	**5030**		**2120**	**10130**
19.6			7	3		**676**	**2088**		**5360**	**4600**
12-3			11	6		**316**	**711**		**1600**	**6300**
2B			NS	7[4]		NS	**1180[4]**		NS	**6050[4]**
12-4	Lower Pawcatuck River	SB	10	6	50	**119**	**752**	300[5]	**930**	**6700**
12-5			10	5		**112**	**490**		**785**	**1920**
PRWW3			NS	2		NS	**3691**		NS	**13278**
12-6			10	5		**164**	**595**		**627**	**2100**
12-7		SB[6]	10	5	14[6]	**58**	**387**	49[6]	**259**	**3200**
12-8	Little Narragansett Bay	SA	8	4	14	**35**	**237**	49	**177**	**1752**
12-9			8	3		**14.3**	**97**		**102**	**899**
12-10			10	4		11	**142**		48	**798**
12-11			8	3		4	**30**		9	**68**
12-14	Watch Hill Cove	SA{b}	8	3	14	6	**21**	49	23	**194**
12-15			10	4		11	**52**		53	**345**
12-16			10	4		**30**	**103**		**141**	**460**

[1]Samples were taken between July 2002 and September 2008.
[2]Shellfish use support has been evaluated consistent with NSSP protocol.
[3]The freshwater Pawcatuck is only included in this Table as a bacteria source to the estuarine Pawcatuck River. Additional information about the freshwater Pawcatuck River can be found in the Pollutant Source section.
[4]Intensive wet weather surveys (i.e. multiple samples per day) occurred at stations PR01, PR4, and 2B. One daily value was calculated for each station by taking the geometric mean of these multiple samples.
[5]The 90th Percentile Target for Class SB/SB1 waters is set to the FDA MPN three-tube variability criterion for the restricted classification of waters to be protective of Connecticut waters.
[6]This station is on or close to the Class SA line and must meet Class SA standards.

All stations in the Pawcatuck River estuary violate the geometric mean and 90th percentile criteria during both dry and wet weather with significant impairments occurring in wet weather. The freshwater Pawcatuck River is a bacteria source to the estuarine Pawcatuck River, especially in wet weather, but there also exist many significant dry and wet weather bacteria sources that discharge directly to estuarine Pawcatuck River as it travels to Little Narragansett Bay.

As shown in Table 3.1, with three exceptions, there is a trend of decreasing bacteria concentrations at downstream stations within the Pawcatuck River beginning at the freshwater Pawcatuck River. This trend is particularly noticeable under dry weather conditions. These exceptions indicate the presence of localized bacteria sources to the estuarine Pawcatuck River. The first exception is in the vicinity of the downtown areas in Westerly and Stonington (also known as Pawcatuck Village). Downstream of these downtown areas, dry weather bacteria concentrations are greater than those concentrations in the freshwater Pawcatuck River. A second increase in bacteria concentrations occurs in the vicinity of Clarks Village and Gavitt Point, while the third increase is observed at Station 12-6, which is upstream of Graves Neck near Avondale.

As expected by the increased flushing and its distance from actual and potential bacteria sources, water quality improves in Little Narragansett Bay. While stations close to the Pawcatuck River violate water quality standards during both dry and wet weather, the two stations in Little Narragansett Bay furthest away from the Pawcatuck River meet water quality criteria in dry weather and violate criteria in wet weather. In the Watch Hill Cove waterbody segment, the stations at the mouth of Watch Hill Cove and in the area off the tip of Napatree Point often referred to as "The Kitchen", meet criteria in dry weather only, while the station within Watch Hill Cove violates during both dry and wet weather. The dry weather violation at this station near shore station indicates the presence of localized bacteria sources.

The steps that RIDEM has taken to identify and correct bacteria sources in these areas are detailed in the Pollution Source and the Implementation Sections (Sections 3.2 and 5).

3.2 Pollution Sources

As mentioned previously, in 2006 RIDEM organized a multi-agency survey of the study area shoreline to identify and quantify all actual and potential pollution sources, which may directly or indirectly affect this growing area and, as a result, render shellfish harvested from that area as unsafe for human consumption. The study participants documented any evidence of human waste contamination and took water quality samples from all creeks, streams, ground water seeps, and discharging pipes and/or culverts. The study results were used when developing a monitoring plan to complete the TMDL study. All collected data has been analyzed and used to evaluate water quality conditions in this watershed and to aid in source identification and prioritization for abatement, as discussed in the following section and in the Implementation Section of this report.

Freshwater Pawcatuck River

The freshwater Pawcatuck River was sampled at Stillmanville Avenue, 0.75 kilometers upstream of the estuarine Pawcatuck River. This station provides a good representation of the bacteria inputs from the freshwater Pawcatuck River to the estuarine Pawcatuck River. It was located in the vicinity of a United States Geologic Survey (USGS) flow-gaging station. Bacteria sample results from the freshwater Pawcatuck River can be found in Table 3.1 and Appendix A.

The dry weather data from the freshwater Pawcatuck River indicate that the freshwater Pawcatuck River is not a significant dry weather bacteria source to the estuarine Pawcatuck River. Bacteria concentrations are much lower in the freshwater Pawcatuck River than at the station furthest upstream in estuarine Pawcatuck River (PR4). More detail about actual and potential sources that discharge to this upper section of the River are detailed below.

Under wet weather conditions, the freshwater Pawcatuck River is a significant bacteria source to the estuarine Pawcatuck River. Given the high bacteria concentrations and flow, the bacteria load entering from the freshwater Pawcatuck River is significant. It is important to note, however, that even with this high load entering the estuarine Pawcatuck River and creating an elevated upstream condition, the impacts of localized wet weather sources between the freshwater Pawcatuck River and the upstream station in the estuarine Pawcatuck River (PR4) as well as at other points downstream are evident.

Mastuxet Brook

Mastuxet Brook is a freshwater stream that discharges to Mastuxet Cove in the lower Pawcatuck River. Pre-storm fecal coliform samples taken at two locations before a 2008 wet weather event indicated that the stream might have dry weather fecal coliform impairments. In addition, the RIDEM Ambient Monitoring Program dry weather enterococci data collected in 2006 and 2007, also revealed an impairment. Additional dry weather fecal coliform sampling was completed in 2009 to characterize water quality conditions along the stream and to investigate potential bacteria sources. Based on the sample results and field investigations, there appears to be a dry weather bacteria source between Whipple Avenue (LPK02) and Rotary Park on Airport Road (MAS1). A tributary that begins on Westerly airport property (MAS3) was also sampled under dry weather conditions in 2009 and was found to meet water quality standards.

Wet weather bacteria concentrations in Mastuxet Brook are consistent with levels seen in other urbanized areas. It appears that the dry weather source upstream of MAS1 may also contribute to wet weather concentrations at this station. Four of the five wet weather samples were taken on the same day.

Table 3.2 summarizes the fecal coliform data and Table 3.3 summarizes the dry weather enterococci data from Mastuxet Brook. Station Locations are shown in Figure 3.1. Numbers shown in bold exceed the applicable criterion. Appendix B lists all the data used in these tables and details station location information. During the intensive wet weather study, multiple samples were taken on one day. One daily value was calculated for each station by taking the geometric mean of these multiple samples.

Table 3.2 Mastuxet Brook Fecal Coliform Data.

Station	Location	Class	Number of Samples		Geometric Mean (MPN/100 ml)			90th Percentile (MPN/100 ml)		
			Dry	Wet[1]	Target	Dry	Wet[1]	Target	Dry	Wet[1]
LPK02	Mastuxet Brook	B	3	NS	200	48	NS	400	105	NS
MAS1	Mastuxet Brook		4	2[3]		**592**	**50288**[1]		**1380**	**208005**[1]
MAS2[2]	Mastuxet Brook		4	2[3]	50	**70**	**11496**[1]		**538**	**47828**[1]
MAS3	Airport Tributary		3	NS	200	29	NS		93	NS

[1]All samples come from one rain event where four of five wet weather samples were taken on one day. One daily value was calculated for each station by taking the geometric mean of these multiple samples.
[2]This station is on or close to the Class SB line and must meet Class SB standards.

Table 3.3 Mastuxet Brook Enterococci Data.

Station	Location	Class	Number of Samples		Geometric Mean (MPN/100 ml)		
			Dry	Wet	Target	Dry	Wet
LPK02	Mastuxet Brook	B	5	NS	54	**76**	NS
MAS1	Mastuxet Brook		5	NS		**194**	NS

Direct Stormwater Discharge and other Sources

During the 2006 joint Agency Shoreline Survey, special attention was given to all types of pipes, drainage ditches, culverts, and streams in order to classify them as a direct (discharges directly to the river), indirect (does not discharge directly to the river but may contribute to pollution in the river), actual (discharging at the time of the survey), or potential (not actively discharging at the time of the survey but considered a possible source of pollution).

Over the course of this study, thirty-nine actual and potential pollution sources were identified by RIDEM along the Rhode Island shoreline and twenty-two actual and potential pollution sources were identified along the Connecticut shoreline. In 2006, dry weather samples were taken at seven Rhode Island and four Connecticut sources. In 2007, RIDEM discovered two sources that had not been identified during the shoreline survey. These two sources had dry weather flow and were sampled. No outfalls along Mastuxet Brook have been identified by RIDEM. Westerly and RIDOT have also identified stormwater outfalls and structures. Appendix C contains tabular information about all the known outfalls that have been identified by RIDEM, Westerly, and RIDOT.

RIDEM selected a subset of the previously identified actual and potential sources to be sampled during the wet weather event. Intensive sampling during this wet weather event resulted in up to four samples being taken in one day at each sampled source. Sources were chosen based on flow, size of outfall, dry weather fecal coliform concentration, existing land use, and accessibility. The intent of sampling a subset of sources was to identify the major sources of fecal coliform and to assess the bacterial loading associated with different land uses. Accessibility during the wet weather study was influenced by the tidal condition. Several samples were collected in the outfall plume. This information is clearly stated in the Sampling Reports that are located in Attachment A of the Pawcatuck River Estuary Final Data Report.

Table 3.4 includes the geometric mean and maximum sample value for all dry and wet weather fecal coliform samples taken at source stations in Rhode Island and Connecticut throughout this study. Most of these outfalls were also sampled for male-specific bacteriophage (coliphage), an enteric virus that is present in high densities in treated and untreated human wastes, generally in greater densities than in animal wastes. RIDEM uses coliphage as a tool that can help determine whether elevated bacteria concentrations are the result of human sources (RIDEM, 2010). During the 2008 wet weather study all sampled outfalls had at least one elevated coliphage sample. Sample locations are shown in Figure 3.2. Appendix C lists all known direct stormwater discharges organized by state and identifying organization. Fecal coliform and coliphage results are listed in Appendix D.

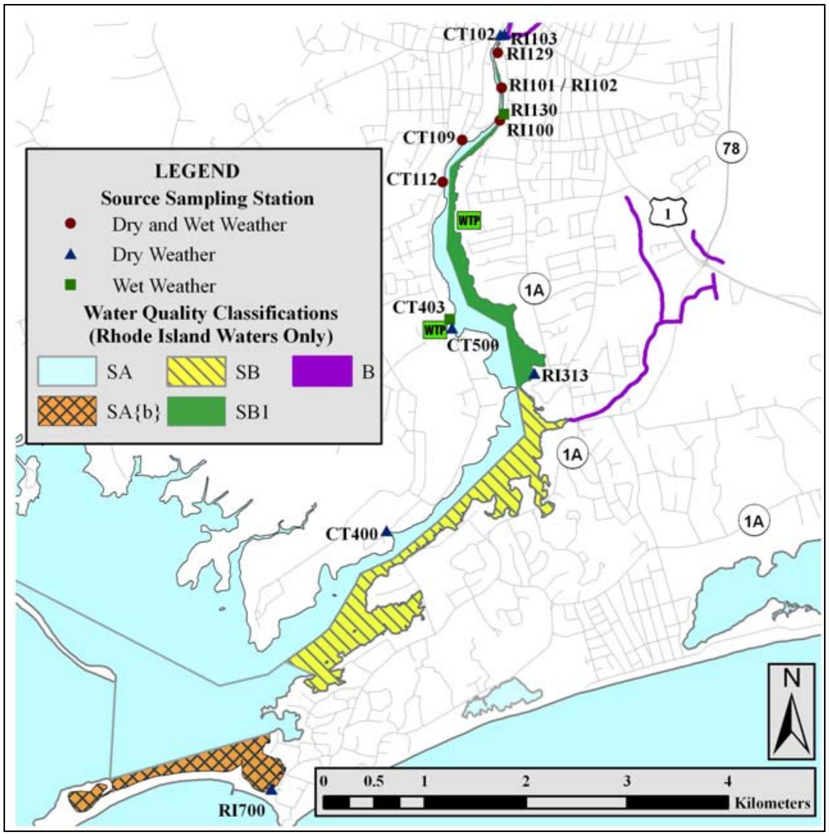

Figure 3.2 Sampled Stormwater Locations.

Table 3.4 Direct Stormwater Discharges Fecal Coliform Data.

Station	Location	Number of Samples		Geometric Mean (MPN/100 mL)		Maximum Value (MPN/100 mL)		Elevated Coliphage[1]
		Dry	Wet[2]	Dry	Wet[2]	Dry	Wet[2]	Wet[2]
Connecticut Sources								
CT102	Within 20 feet of Broad Street Bridge	2	NS	884	NS	1700	NS	NS
CT109	Mechanic Street and Prospect Street	1	5	79	8187	79	93000	*YES*
CT112	Across from 191 Mechanic Street	2	5	256	5077	540	15000	*YES*
CT400	Riverside Drive	1	NS	220	NS	220	NS	NS
CT403	Mary Hall Road and Green Haven Road	NS	1	NS	9300	NS	9300	NS
CT500	River Road next to Pump Station	1	NS	15	NS	15	NS	NS
Rhode Island Sources								
RI103	Under Broad Street Bridge	2	NS	2939	NS	5400	NS	NS
RI129	Commerce Street (RIDOT Outfall 5)	1	1	2.9	9300	3	9300	*YES*
RI101	137 Main Street	3	5	2764	12769	5400	46000	*YES*
RI102	137 Main Street	2	NS	3955	NS	9200	NS	NS
RI130	181 Main Street (RIDOT Outfall 9)	NS	4	NS	24689	NS	150000	*YES*
RI100	Margin Street	2	3	3837	8029	9200	15000	*YES*
RI313	Westerly Yacht Club	1	NS	33	NS	33	NS	NS
RI700	Watch Hill Cove	1	NS	17	NS	17	NS	NS

[1]During the wet weather study, at least one coliphage result was greater than 50 plaque-forming units per 100 ml (pfu/100 mL). See Appendix D for full results.
[2]All samples come from one rain event where multiple (up to four) samples were taken on one day.

As shown in Table 3.4, the bacteria results from direct stormwater discharges sampled under dry weather conditions show several pipes with dry weather problems. In Rhode Island, outfalls RI101 and RI102 are one source that discharge through a double pipe. These outfalls had elevated dry weather bacteria and coliphage concentrations and were forwarded to the Office of Compliance and Inspection at RIDEM for further investigation. The investigation into this source has involved tracing the storm drain network and taking bacteria samples. The primary storm drain network runs along School Street in Westerly. One RIDEM fecal coliform sample from the intersection of Elm Street and School Street was 240,000 MPN/100 mL. Other samples upstream of this location were 93,000 MPN/100 mL. These results indicate multiple sources along this storm drain network. RIDEM forwarded these locations to the Town of Westerly for further investigation. While investigating, town personnel saw signs of sewage discharge in the storm drain system. In July 2009, the town dye tested six locations on George Street that had previously been determined to have both sewer and underdrain connections. Five of the six were found to be leaking from the sewer lateral into the underdrain. Four of these locations have been sealed and need to be dye tested again. The last connection was excavated and found to be attached directly to the stormwater underdrain. It too has been fixed. Westerly has also fixed a broken sewer lateral on Main Street in the vicinity of Cross Street that may have been impacting the downtown area. Two other Rhode Island sources (RI100 and RI103) had high dry weather bacteria counts that will be forwarded to the town and to the Rhode Island Department of Transportation (RIDOT) to investigate as part of their illicit discharge and detection requirements under the RIPDES Phase II program. These sources, located in downtown Westerly, discharge to an area of the Pawcatuck River that has been identified as having localized dry weather bacteria sources.

In Connecticut, a pipe that drains parts of River Road in the vicinity of Hoxsie Farm (CT402A) should be investigated. This pipe was identified during a September 14, 2006 field visit to Hoxsie Farm. The owner of the farm mentioned that discharge from the pipe is often oily and soapy. The pipe travels east from River Road along the southern boundary of Hoxsie Farm and discharges to a pasture and then into the Pawcatuck River (CTDEP, 2006a). Additional outfalls in Connecticut that should be investigated due to their proximity to areas in the Pawcatuck River where there are localized bacteria sources include CT102 and CT400. CT102, located in downtown Pawcatuck, had high dry weather fecal coliform concentrations. CT400 is located in the lower Pawcatuck River, upstream of Graves Neck, near Station 12-6. In a September 2006 conference call following the 2006 Shoreline Survey, CTDEP reported that they had asked their municipal facilities staff to conduct initial assessments on these outfalls.

The wet weather results shown in Table 3.4 confirm that while the freshwater Pawcatuck River is the largest bacteria source in terms of load, there are significant stormwater bacteria sources that discharge directly to the estuarine Pawcatuck River. Consistent with stormwater from urban areas, bacteria concentrations from all sampled sources were in the thousands and tens of thousands. Source RI101 discharged high levels of bacteria and coliphage before, during, and immediately after the storm event. This source is discussed above. The second largest stormwater source for bacteria and coliphage sampled along the Rhode Island shoreline appears to be RI130, which is also known as RIDOT Outfall 9. It drains a portion of Main Street north of the outfall location at 181 Main Street. Among the Connecticut sources, CT109 stands out for its coliphage results, the lowest of which was reported as >425 pfu/100 mL.

RIPDES (Rhode Island Pollutant Discharge Elimination System) Sources

The Rhode Island Pollution Discharge Elimination System Program (RIPDES) is responsible for permitting industrial and municipal waste discharges to all Rhode Island waters. The Westerly WWTF, RIPDES permit number RI0100064, discharges municipal waste to the Pawcatuck River. The observed average discharge and fecal coliform concentrations at the WWTF for 2008 and 2009 are listed in Table 3.5.

Table 3.5 Westerly WWTF Discharge and Fecal Coliform Data.

Point Source	Observed Discharge[1] (MGD)	Observed Concentration[1] (MPN/100 ml)
Westerly WWTF	2.533	3.06

[1]Discharge is the average of all daily 2008-2009 flows. Concentration is the geometric mean of 261 samples collected from 2008-2009. Samples were analyzed using the A-1 Analytic Technique.

Connecticut NPDES (National Pollutant Discharge Elimination System) Sources

The Pawcatuck WPCF in Stonington, NPDES permit number CT0101290, discharges to the Pawcatuck River. It is located downstream of the Westerly WTTF. Information about the plant's discharge was obtained from EPA's Integrated Compliance Information System database. The discharge and fecal coliform concentrations at the WWTF for 2005 and 2006 are listed in Table 3.6.

Table 3.6 Pawcatuck (Stonington) WPCF Discharge and Fecal Coliform Data.

Point Source	Observed Discharge[1] (MGD)	Observed Concentration[1] (MPN/100 ml)
Pawcatuck (Stonington) WPCF	0.58	1.52

[1]Discharge is the average of the 2005 and 2006 average monthly flows. Concentration is the geometric mean of the 30-day geometric means for samples collected from 2005-2006.

Wastewater Disposal

Sources of domestic wastes that may convey fecal coliform bacteria to the Pawcatuck River and Little Narragansett Bay include dry wells, cesspools, and onsite wastewater treatment systems (OWTS). The method of transport of effluent is normally through the groundwater, either to the river itself or to a tributary that ultimately drains to the study area. Although less common, failure of on-site systems can also result in fecal coliform bacteria to be transported via surface seepage, storm drain networks or by illegal pipes. As discussed in the Direct Stormwater Discharge section, leaking sewer lines can also contribute human wastewater to the study area.

Westerly estimates that approximately 45 to 50% of its residents (about 11,000 people) are serviced by existing sewer lines. Sewer lines are available throughout much of the upper estuarine Pawcatuck River watershed, while the residential areas served by OWTS in the study area are mostly located in southwestern Westerly. This area includes Avondale and Watch Hill, which drain to the lower estuarine Pawcatuck River and Little Narragansett Bay shorelines (Beta, 2008).

Beta Engineering, Inc., a consultant for the Town of Westerly, analyzed wastewater problems related to onsite systems in its 1999 Revision of the Westerly Wastewater Facilities Plan. Beta used OWTS repair applications submitted to RIDEM because repair applications "represent 'failures' of existing systems" that could be used to establish how frequently OWTS fail (Beta, 1999). In its 2008 Revision of the Westerly On-Site Wastewater Management Plan, Beta analyzed repair applications submitted between 1997 and 2008. Approximately 10% of the submitted repair applications were reviewed in an attempt to determine if there were common 'failure' characteristics for each of seven sub-areas (Beta, 2008).

Beta analyzed wastewater needs for seven areas in Westerly using the existing Fire Districts as boundaries. Fire Districts containing the study area watershed include parts of both the Westerly Fire District and the Watch Hill Fire District. The Westerly Fire District includes the downtown area. Excluding Avondale, sewer connections are available to most of the homes in this Fire District that are also in the estuarine Pawcatuck River watershed. Beta estimated that 1700 of 6900 homes in the entire Westerly Fire District use OWTS. Ninety-two repair applications (representing 5% of the systems) were received during the study period. The Watch Hill Fire District discharges to the lower Pawcatuck River and Little Narragansett Bay. No sewers are available in this area. There were 35 repair applications for the 580 homes in this area, representing a repair rate of 6%. Town-wide, nine sub-areas with constraints related to the use of onsite wastewater disposal were identified. Two of these, Avondale and Bay Street, a commercial district near Watch Hill Cove, are located in the estuarine Pawcatuck River watershed (Beta, 2008).

RIDEM mapped OWTS failures in Westerly between 1980 and 2007. Failures were determined by the issuance of Notice of Intent to Violate (NOI) and Notice of Violation (NOV) letters sent to property owners by the RIDEM Office of Compliance and Inspection. Two failures from the mid-1990s were in Avondale. About five other failures were located in the Mastuxet Brook and estuarine Pawcatuck River watersheds.

In Stonington, while sewer lines service most of the urbanized areas of Pawcatuck and Clarks Village, it appears that there are several neighborhoods within these areas that do not have sewers. In its Wastewater Facilities Plan, Stonington identified 18 areas in town with wastewater needs. Seven of the nine areas in the Pawcatuck WPCF district had critical or high need. Areas closest to the Pawcatuck River included some of the 143 houses in the Greenhaven Road area and 34 houses in the Meadow Road area, which also includes a small section of River Road (Stonington, 2007). Both of these areas are located along the lower Pawcatuck River.

Other Bacteria Sources - Animals

Other bacteria sources to the study area include waterfowl, wildlife, and domestic pets. Waterfowl are known to gather along the Pawcatuck River.

Waterfowl

The RIDEM Division of Fish and Wildlife conducts an annual aerial waterfowl survey of the coastal areas of the state to derive regional totals, which are combined with information from other states and provinces to obtain wintering population estimates for waterfowl species. Although the survey design is focused at a large scale, the site specific data imply that the most common wintering waterfowl found utilizing the Pawcatuck River and Little Narragansett Bay include American black duck, bufflehead, Canada geese, common goldeneye, mallard, red-breasted merganser, and mute swans. Of those commonly found species mute swans and Canada geese are by far the most abundant averaging 105 and 87 individuals respectively each winter for the past 10 years. Geese and swans are located primarily in the section of the river south of the River Bend Cemetery and north of Colonel Willie Cove and attracted by adequate habitat and artificial feeding on the Connecticut side of the river. Summer population levels of many of these birds are nonexistent because they are boreal breeders; however, swan numbers remain relatively high because of their resident status. Although, the arctic breeding subspecies of Canada geese are not present during the summer resident populations of geese are present (Osenkowski, 2009).

Consistent with the RIDEM Fish and Wildlife observations, there have been three areas where waterfowl have been observed to gather during the summer months along the Pawcatuck River. The first area where waterfowl have been observed is upstream of Gavitt Point, opposite the Westerly WWTF outfall. Numerous waterfowl have been seen in this area on a sandbar that is exposed at low tide. RIDEM sampling seems to indicate that while the waterfowl most likely contribute bacteria to the Pawcatuck River in the vicinity of Gavitt Point, they do not appear to be the major contributing source causing the increased bacteria concentrations downstream as further described in Section 5.9 and Appendix G.

The next area where waterfowl gather was identified by CTDEP as source CT402 during the 2006 Shoreline Survey. Source CT402, located just downstream of Stanton Weir Point, is a gathering spot for cows and geese at Hoxsie Farm. Hoxsie Farm is discussed in the next section.

Also during the 2006 Shoreline Survey, CTDEP identified waterfowl congregating upstream of Graves Neck, near Station 12-6 in the lower Pawcatuck River as a potential bacteria source. The waterfowl were identified as source CT400A. Shellfish meat analysis during this study indicated the possibility of a persistent localized bacteria source. Analysis of Shellfish Program data collected at stations in this area seems to reveal an increase of bacteria near these waterfowl. During a field visit on August 30, 2007, RIDEM observed at least two-dozen swans and two-dozen ducks at this location (RIDEM, 2010). It is believed that there is an artificial feeding source at this location. This location is also one of the areas in the Pawcatuck River where localized bacteria sources seem to be causing increases in instream bacteria concentrations.

Farms

There are two farms that abut the waterbodies covered by this TMDL. One is located in Rhode Island along Mastuxet Brook and the other is located in Connecticut along the lower Pawcatuck River.

Silver Farm is located between Whipple Avenue and Rotary Park on Mastuxet Brook, where sampling data indicates that there is a bacteria source. It is a permanently protected farmland by the state via the Agricultural Land Preservation Commission. The RIDEM Division Agriculture believes that this farm is now largely hayfield and/or pasture. Silver Farm is a former dairy farm, but is not currently intensively used. It may contain a limited number of young livestock. RIDEM will conduct a visit with USDA/NRCS. There is a pond on the property that appears to have a hydrologic connection to the stream, which could contribute to bacterial elevations if frequented by waterfowl, deer, and cattle, if they have access. There also appears to be a crossing that connects pastures on either side of the farm. The stream has a wooded buffer as it crosses through the farm property.

Hoxsie Farm is located on the Connecticut shoreline between Stanton Weir Point and station 12-4 in the Pawcatuck River. During the 2006 Joint Agency Shoreline survey, cows were observed along the shoreline with unobstructed access to the River. CTDEP visited the farm in September 2006 and found the farm and its pastures to be well managed. Seven beef cows were located in a pastured area with more than 1000 feet of direct access to the Pawcatuck River. The animals slept and fed in a partially covered heavy use area more than 100 feet from the River. Manure was cleaned from this area weekly and moved to a high and dry area where it was stockpiled and passively composted before being applied to rented fields off the farm. NRCS assistance was recommended for roofing the heavy use area and for fencing cows out of the tidal wetlands to create a buffer along the Pawcatuck River (CTDEP, 2006a). Since the 2006 visit, chicken have replaced the cows at Hoxsie Farm (CT DA/BA personal communication, 2010).

Pets and Wildlife

Given that residential areas drain to the Pawcatuck River and Little Narragansett Bay, pet waste is expected to be a significant source of bacteria carried in stormwater. One gram of dog waste contains 23 million fecal coliform bacteria, almost twice as much as human waste (Pacific Shellfish Institute). MADEP estimates that there is approximately one dog per 10 people producing an estimated one-half pound of feces per dog per day (MADEP et. al., 2009). Using the 2000 census data, a population estimate of 17,860 was calculated for the estuarine and lower freshwater Pawcatuck River watershed (see Figure 2.1). This translates to an estimated 1786 dogs in the watershed producing 893 pounds of feces per day. During rainstorms, pet waste washes from yards, sidewalks, and other areas were pets are walked into nearby waterways.

Additionally, almost 600 km^2 of forests and brushlands are present in the watershed. This undeveloped land is home to wildlife, which is also expected to be a source of bacteria to the study area, especially where drainage structures intercept runoff from these areas and provide direct delivery to the pond.

Other Bacteria Sources - Boats

On August 18, 1998 EPA designated Rhode Island’s marine waters as a *Federal No Discharge Area*. EPA designated marine waters in Stonington, Connecticut as *No Discharge* on August 22, 2003 (USEPA, 2003). Boats with installed toilets must have an operable Coast Guard approved marine sanitation device (MSD) designed to hold sewage for pump-out or for discharge in the ocean beyond the three-mile limit. RIDEM oversees the operation and maintenance of the pump-out infrastructure by participating in the Clean Vessel Act (CVA) program, which provides money for the construction, repair, and replacement of pump-out facilities and, by coordinating outreach and education programs. There are three stationary pump-out facilities and two mobile pump-out facilities servicing the Pawcatuck River and Little Narragansett Bay in Rhode Island and Connecticut. Two of the stationary facilities are in Rhode Island at the Westerly Yacht Club and Avondale Marina and one is in Connecticut at Norwest Marine (CTDEP, 2009; RIDEM, 2008). The mobile pump-out facilities were purchased by the Town of Westerly using Rhode Island CVA grant funds and are operated with funds from the CTDEP.

A 1991 EPA Region 1 guidance document recommended that one pump-out facility per 300 to 600 boats with holding tanks (type III MSDs) was needed to meet demand for pump-out services in most harbor areas (USEPA, 1991a). Using the 1989 count of 1750 boat slips and moorings in the Pawcatuck River and Watch Hill Cove, a conservative estimate of the ratio of pump-out facilities per boat would be 1:350, which meets EPA guidance. This is a conservative estimate because not all of the 1750 boats have MSDs.

During the 2006 Joint Agency Shoreline Survey, CTDEP identified a houseboat on Mechanic Street (CT405) as a potential bacteria source. CT DA/BA reports that the houseboat does not contain a bathroom and its occupants use onshore facilities (personal communication, 2010).

3.3 Natural Background Conditions

Natural background concentrations are those that would exist in the area in the absence of human-induced sources. The natural background concentrations could not be resolved independently for this TMDL.

3.4 Other Monitoring Data

During the course of this study, RIDEM reviewed bacteria data collected by other organizations.

Save the Bay

In July 2006, RIDEM promulgated amendments to its water quality regulations that began a transition from fecal coliform to enterococci as the criteria to use for primary contact recreation. EPA had determined that enterococci are a better indicator of the safety of waters for primary contact recreation than fecal coliform. The regulations allow for the continued use of the fecal coliform standard when enterococci data is not available.

RIDEM has evaluated the Pawcatuck River and Little Narragansett Bay for enterococci using data collected by Save the Bay in 2008 and 2009. Save the Bay conducts its monitoring in conjunction with the University of Rhode Island’s Watershed Watch Program. Watershed Watch is a statewide volunteer monitoring program that provides training, equipment, supplies, and analytical services. The program meets strict quality assurance and quality control guidelines in the field and in our state-certified laboratory, which allows its data to be used by RIDEM when assessing water quality conditions in monitored waters. Save the Bay conducts weekly measurements at six stations in this project area. Monthly enterococci samples are also collected.

An evaluation of the Save the Bay enterococci data shows that all stations meet the enterococci recreational standard. The fecal coliform and enterococci data for Little Narragansett Bay and Watch Hill Cove are consistent in that both meet their recreational criteria. They are not consistent for stations in the Pawcatuck River. This may be because the enterococci data was generally collected under dry weather conditions over the last two years, while the RIDEM fecal coliform data was collected over a longer time period under a variety of environmental conditions. At this time, RIDEM believes that it is appropriate to continue to list the Pawcatuck River as impaired for recreational uses based on the fecal coliform data. RIDEM will use the enterococci data to evaluate for recreational uses as additional enterococci data is collected and bacteria sources are eliminated. Save the Bay sampling results can be found in Appendix E.

Connecticut Shellfish Data

The Connecticut Shellfish Program of the Department of Agriculture (Bureau of Aquaculture & Laboratory Services) conducts shellfish monitoring in Connecticut Waters. RIDEM reviewed data from three locations in the tidal Pawcatuck River and one location in Little Narragansett Bay. Data were available from 1990 through 2004. The data is presented in Appendix F.

3.5 Water Quality Impairments

Consistent with the current prohibited shellfish harvesting restrictions established by Rhode Island's Shellfish Program, data analyses for this TMDL found every segment of the Pawcatuck River and Little Narragansett Bay waters to violate one or both parts of the fecal coliform standard during dry and/or wet weather. Table 3.1 shows that the highest bacteria concentrations can be seen in the upper Pawcatuck River that the lowest concentrations are in the parts of Little Narragansett Bay and Watch Hill Cove, furthest away from the upper Pawcatuck River. Wet weather bacteria concentrations are much higher than dry weather concentrations. This same trend occurs in Mastuxet Brook as shown in Table 3.2. There also appears to be a dry weather bacteria source in Mastuxet Brook.

4.0 TMDL ANALYSIS

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The TMDL is often defined as the sum of loads allocated to point sources (i.e. waste load allocation, WLA), loads allotted to nonpoint sources, including natural background sources (i.e. load allocation, LA), and a margin of safety (MOS). The loadings are required to be expressed as mass per time, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]).

4.1 Establishing the Numeric Water Quality Target

Margin of Safety

The TMDL must contain a margin of safety to account for uncertainty in the analysis. The use of an explicit margin of safety provides a conservative estimate of reductions needed. An explicit margin of safety equal to an additional five percent of the calculated percent reduction was assumed to conservatively account for possible uncertainties in the analysis. Examination of Table 4.3 reveals that with this margin of safety applied, Mastuxet Brook, waterbody ID RI0008039R-11, would need over 100% reduction in fecal coliform bacteria concentrations to meet water quality criteria and support designated uses. However, RIDEM believes that pollution reductions between 90 to 100 percent should be adequate to achieve water quality standards; RIDEM will conduct follow-up monitoring to assess compliance with water quality standards

Seasonal Variation/Critical Conditions

The data used to develop this TMDL were collected between May and September during all tidal cycles and weather conditions. Critical conditions in the Pawcatuck watershed occur after wet weather events. Samples collected in the days immediately following larger storms are expected to result in higher bacteria concentrations. The wet weather data set for some stations includes up to five samples taken within two days of storm events where more than 1 inch of rain fell on the watershed. Additionally, these stations were located close to known wet weather bacteria sources. Appendix A and Appendix B includes information about the weather and tidal conditions, when relevant, on each sampling day.

While the TMDL contains no samples collected between October and April, an analysis of data collected between 1989 and 2003 revealed that in most cases bacteria concentrations are higher in the summer than the winter. This trend held for dry weather in both the Pawcatuck River and Little Narragansett Bay and for wet weather in the Pawcatuck River. Little Narragansett Bay winter wet weather bacteria concentrations were higher than the summer samples (RIDEM, 2006b). A reassessment of the geometric mean and 90th percentile values of this historical dataset as compared with the TMDL dataset found the two datasets to be comparable. Therefore RIDEM believes that the data used for the TMDL calculations in Little Narragansett Bay are protective of the winter months. RIDEM believes the allocations and reductions in this TMDL plan are protective because data from critical conditions is adequately represented.

Numeric Water Quality Targets

The numeric water quality targets will be set to the applicable water quality criteria or standard for each segment of the Pawcatuck River and Little Narragansett Bay. Segment boundaries and water quality standards are described in Section 1.1. In some areas, a waterbody segment with higher allowable limits of fecal coliform bacteria discharges to or is adjacent to a waterbody with more stringent criteria. In these places, the numeric water quality target must be the more strict criteria at the station nearest the boundary with the higher water quality standard. Targets are set such that the study area can meet designated uses.

4.2 Establishing the Allowable Loading (TMDL)

While TMDL allocations are often expressed on a mass-loading basis (e.g. kilograms per day), EPA recommends establishing a concentration-based TMDL for pollutants that are not readily controllable on a mass basis (USEPA, 2001). Since the mass or total number of indicator bacteria, such as fecal coliform or enterococci, is not significant with respect to public health risk and protection of beneficial uses, concentration, the number of organisms in a given volume of water, is a more technically relevant criterion for assessing the relative impact of pollution sources, the quality of the shellfish harvesting area, and the public-health risk.

In this TMDL, the allowable load or loading capacity is expressed as concentrations set equal to the applicable water quality standard. Concentration is considered to apply daily because daily values are used to calculate the geometric means and percent variability. The allowable daily load is the criterion concentration multiplied by the flow in the receiving water. For the purposes of implementation and the reasons expressed below, it is recommended that the concentration and percent reduction bacteria TMDL targets be used.

- Expressing bacteria TMDL reductions in terms of concentration provides a direct link between existing water quality and the numeric water quality criteria.
- Using concentration to set TMDL reductions is more relevant and consistent with water quality standards, which apply for a range of flow and environmental conditions.
- Expressing bacteria TMDL reductions as daily loads can be more confusing to the public and can be more difficult to interpret since they are dependent on flow conditions.

Extensive field surveys, water quality monitoring, and a review of aerial and topographic maps were used to establish the link between pollutant sources and instream concentrations. As a first step in determining allowable loads and percent reductions, RIDEM separated the surface waters in the study area into segments based on waterbody identification numbers. Table 4.1 lists the stations grouped in each segment. Figure 3.1 shows the locations of the shellfish program and other stations. Station data and descriptions may be found in Appendices A and B.

Table 4.1 Stations within each Waterbody Segment.

Waterbody ID	Waterbody Description	Station Used to Characterize Water Quality Conditions
RI0008039R-11	Mastuxet Brook	LPK02, MAS1, MAS2, MAS3
RI0008038E-01A	Tidal Pawcatuck River: Route 1 Bridge to Pawcatuck Rock	PR4, 12-1, 12-17, 17A, 12-2, 17B, 19.6, 12-3
RI0008038E-01B	Tidal Pawcatuck River: Pawcatuck Rock to Pawcatuck Point	12-4, 12-5, 12-6, 12-7
RI0008038E-02A	Little Narragansett Bay	12-8, 12-9, 12-10, 12-11
RI0008038E-02B	Watch Hill Cove and area north of Napatree	12-14, 12-15, 12-16

The reduction goal for each segment was determined by comparing current fecal coliform and/or enterococci concentrations to the applicable water quality targets (e.g. geometric mean and 90th percentile values). The percent reductions required to reach each portion of the target were then calculated. The higher percent reduction resulting from evaluation of the data against both the geometric mean and 90th percentile criteria was used to set each segment's necessary coliform reduction. Since enterococci only have a geometric mean criterion, the reductions for enterococci were based on the station with highest geometric mean reduction. The geometric mean values were calculated using the GEOMEAN function in Microsoft Excel while 90th percentile values were calculated using the PERCENTILE function.

4.3 Required Reductions

Wasteload / Load Allocations

EPA guidance requires that load allocations be assigned to either point (wasteload) or nonpoint (load) sources. As is the case for most bacteria impairments, insufficient data existed to accurately differentiate between point (stormwater discharges regulated under RIPDES stormwater permitting program) and nonpoint sources of bacteria. Therefore, as recommended by EPA Region 1, all bacteria source reductions for this TMDL are combined into the wasteload allocation with the allocations for the two wastewater treatment facilities set to their permitted discharge limits as discussed in a following section. However, in implementing this TMDL both point and nonpoint controls will be necessary to meet the plan's water quality targets. To guide TMDL implementation, RIDEM evaluated the Pawcatuck River watershed land use and pollution source data.

Instream Reductions

The required fecal coliform reductions for the Pawcatuck River and Little Narragansett Bay, including Watch Hill Cove are presented in Table 4.2. The required fecal coliform reductions for Mastuxet Brook are in Table 4.3. The reductions are calculated from observed concentrations at instream shellfish and TMDL monitoring stations. These values were then compared to the applicable portion of the water quality standard. The station having the largest violation relative to the state's fecal coliform standard was used to calculate the percent reduction for the segment containing that station and is shown in bold in the tables. The required reduction for each segment is the higher of the two reductions (geometric mean versus 90th percentile value). The geometric mean and 90th percentile values were calculated by combining the dry and wet weather data presented in Appendix A and Appendix B. While data collected at stations PRWW1, PRWW2, PRWW3, and 2B are included in Table 3.1 and Appendix A, they are not included in TMDL reductions because only wet weather samples were taken at these stations. RIDEM believes that adequate data exists from nearby stations to accurately characterize water quality conditions in the waterbody segments. All segments violate water quality standards.

Table 4.2 Pawcatuck River and Little Narragansett Bay Fecal Coliform TMDL Reductions[1]

Station	Segment ID Location	Class	No. Samples	Geometric Mean Target	Geometric Mean Observed	90th Percentile Target	90th Percentile Observed	Percent Reduction[2]
PR4	**RI0008038E-01A Pawcatuck River**	**SB1**	13	50	**638**	300[3]	**4156**	**94.9** (99.9)
12-1			16		**219**		**780**	
12-17			17		**222**		**956**	
17A			7		**743**		**5420**	
12-2			14		**545**		**3670**	
17B			7		**903**		**5840***	
19.6			10		**948**		**5240**	
12-3			17		**421**		**2800**	
12-4	**RI0008038E-01B Pawcatuck River**	**SB**	16	50	**238**	300[3]	**1950**	**95.3** (100)
12-5			15		**183**		**1160**	
12-6			15		**252**		**2040**	
12-7[2]		**SB[4]**	15	14	**110**	49	**1032***	
12-8	**RI0008038E-02A Little Narragansett Bay**	**SA**	12	14	**66**	49	**240***	**79.6** (84.6)
12-9			11		**24**		**240***	
12-10			14		**23**		**93**	
12-11			11		7		39	
12-14	**RI0008038E-02B Watch Hill Cove**	**SA{b}**	11	14	9	49	43	**87.6** (92.6)
12-15			14		**17**		**196**	
12-16			14		**43**		**394***	

[1] Results denoted with a * show that data for that station was used to set the reduction for the segment.
[2] The actual percent reduction is shown in bold. The value in parentheses includes an explicit 5% margin of safety.
[3] The 90th Percentile Target for Class SB/SB1 waters is set to the FDA MPN three-tube variability criterion for the restricted classification of waters to be protective of Connecticut waters.
[4] This station is located on the Class SA line and needs to meet Class SA standards.

Table 4.3 Mastuxet Brook Fecal Coliform TMDL Reductions[1]

Station	Segment ID Location	Class	No. Samples	Geometric Mean Target	Geometric Mean Observed	90th Percentile Target	90th Percentile Observed	Percent Reduction[3]
LPK02	**RI0008039R-11 Mastuxet Brook and Tributaries**	**B**	3	200	48	400	105	**97.6** (100)
MAS1			6		**1772**		**16995***	
MAS2[2]		**B[2]**	6	50	**262**		**3893**	
MAS3		**B**	3	200	29		93	

[1] Results denoted with a * show that data for that station was used to set the reduction for the segment.
[2] This station is located near the Class SB line and needs to meet Class SB standards.
[3] The actual percent reduction is shown in bold. The value in parentheses includes an explicit 5% margin of safety.

The required enterococci reductions Mastuxet Brook are presented in Table 4.4 below. The reductions are calculated from observed concentrations at RIDEM Ambient Monitoring Program stations.

Table 4.4 Mastuxet Brook Enterococci TMDL Reductions[1]

Station	Segment ID Location	Class	No. Samples	Geometric Mean		Percent Reduction[2]
				Target	Observed	
LPK02	**RI0008039R-11**	**B**	5	54	**76**	**72.1**
MAS1	**Mastuxet Brook**		5		**194***	(77.1)

[1] Results denoted with a * show that data for that station was used to set the reduction for the segment.
[2] The actual percent reduction is shown in bold. The value in parentheses includes an explicit 5% margin of safety.

RIPDES (Rhode Island Pollutant Discharge Elimination System) Sources

The allocations for the Westerly WWTF are the same in dry and wet weather and, consistent with EPA policy, are set to meet the bacteria standards at the point of discharge. Since Rhode Island has adopted recreational enterococci criteria, RIPDES is expected to issue the Westerly WWTF a permit limit consistent with water quality regulations (2009d) and this wasteload allocation. The Class SB/SB1 enterococci criterion is a geometric mean concentration of 35 colonies per 100 mL.

Table 4.5 shows the current fecal coliform permit limits, geometric mean, and average discharge for 2008 and 2009 at the Westerly WWTF. While the re-issued permit will not include limits for fecal coliform, the plant will be required to continue its monitoring of fecal coliform. Die dilution studies indicate that effluent from the Westerly WWTF is diluted to a sufficient degree that its contribution to fecal coliform concentrations in Little Narragansett Bay may be neglected.

Table 4.5 Current Westerly WWTF Permit Limits.

Point Source	Permitted Discharge[1] (MGD)	Permitted Concentration[1] (MPN/100 ml)	Observed Discharge[2] (MGD)	Observed Concentration[2] (MPN/100 ml)
Westerly WWTF	3.3	200	2.533	3.06

[1]The permitted discharge and concentration values are the average monthly limits.
[2]Discharge is the average of all daily 2008-2009 flows. Concentration is the geometric mean of 315 samples from 2008-2009. Samples were analyzed using the A-1 Analytic Technique.

NPDES (National Pollutant Discharge Elimination System) Sources

The Pawcatuck WPCF outfall is located in waters that are directly adjacent to Rhode Island waters, about one kilometer downstream of the Westerly WWTF. Its permit limits for average monthly discharge and average monthly fecal coliform concentration are 1.3 MGD and 200 MPN/100 mL, respectively (CTDEP, 2005). As shown in Table 3.6, its observed discharge and bacteria concentrations in 2005 and 2006 were 0.58 MGD and 1.52 MPN/100 mL, respectively.

RIDEM used GIS and Westerly WWTF dilution study (1991) to determine that the Pawcatuck WPCF would not result in an exceedance of the Rhode Island water quality standard for fecal coliform at the Stateline. It should also have very little impact on fecal coliform concentrations in Little Narragansett Bay. Based on aerial photographs and USGS topographical maps, the Pawcatuck WPCF outfall was estimated to be 450 feet from the Rhode Island Stateline. Since the Westerly WWTF and the Pawcatuck WPCF discharge in the same area of the Pawcatuck River, the Westerly dilution zone was applied to the Pawcatuck WPCF outfall. Neither the chronic and acute dilution zone would extend into Rhode Island waters. This analysis was conservative because the Pawcatuck WPCF's permitted discharge is 40% of the Westerly

WWTF's permitted discharge and the Pawcatuck WPCF outfall location should have higher flushing.

Similar to the Westerly WWTF, re-issuance of the Pawcatuck WPCF permit should establish permit limits consistent with EPA policy regarding meeting applicable bacteria standards at the point of discharge.

4.4 Strengths and Weaknesses in the Analytical Approach

Strengths

- The TMDL incorporates the findings of several studies and utilizes data collected over several years. In addition, extensive knowledge of land use and potential bacteria sources in the watershed was available.
- The area has been sampled by a number of programs in recent years.
- The TMDL endpoints presented in the load allocation sections allow water quality standards to be met at all times.
- The phased approach allows an emphasis on mitigation strategies rather than on modeling and more complex monitoring issues to keep the focus on abating sources.

Weaknesses

- The relative significance of identified outfalls during wet weather is not fully known because shoreline surveys were completed during dry weather.
- Studies were not conducted to identify specific forms of fecal contamination from wildlife and/or humans. It is difficult to separate pollution caused by human sources, such as failed OWTS systems from natural causes.

4.5 Reasonable Assurance

EPA guidance calls for reasonable assurance when a TMDL is developed for waters impaired by both point and nonpoint sources. If a point source is given a less stringent wasteload (i.e. point source) allocation based on an assumption that nonpoint source load reductions will occur, there must be reasonable assurance that the nonpoint source reductions will occur before the TMDL can be approved. EPA uses this information to determine whether the load and wasteload allocations will achieve water quality standards.

In this case, reasonable assurance is ***not*** required because point sources are ***not*** given less stringent wasteload allocations. As mentioned previously in Section 4.3 and as recommended by EPA Region 1, all bacteria sources are combined into the wasteload (i.e. point source) allocation.

5.0 IMPLEMENTATION

Actual and potential bacteria sources exist in both the Rhode Island and Connecticut portions of the Pawcatuck River watershed. The following sections describe implementation activities and next steps that should be taken towards the goal of restoring water quality to this area. Recommendations and requirements, where appropriate, are prescribed for bacteria sources in both Rhode Island and Connecticut. Implementation activities focus on stormwater, wastewater, and animal management.

Mitigation activities for bacteria sources that impact the estuarine Pawcatuck River under dry weather conditions should focus on those areas of the Pawcatuck River and Watch Hill Cove where sampling data indicates the presence of localized sources. Localized sources are believed to impact the areas of the Pawcatuck River that travel through downtown Westerly and Pawcatuck, in the vicinity of Gavitt Point, and upstream of Graves Neck near Avondale (Station 12-6). Data also indicate the presence of localized sources to Watch Hill Cove.

The large amount of impervious area within the immediate watershed increases the amount of runoff and bacteria that enter the waterways during and immediately after wet weather events. As the amount of impervious area in a watershed increases, the peak runoff rates and runoff volumes generated by a storm increase because developed lands have lost much or all of their natural capacity to delay, store, and infiltrate water. As a result, bacteria from streets, lawns, wildlife, and domestic pets quickly wash off during storm events and discharge into the nearby waterbodies. Achieving standards requires that both the *quantity* of stormwater and the bacteria concentrations in that stormwater reaching the Pawcatuck River be reduced. Mitigation activities for stormwater should focus on urbanized stormwater runoff from downtown Westerly and Pawcatuck and from areas that discharge to Mastuxet Brook. The freshwater Pawcatuck River is also a very large wet weather bacteria source to this system. Future steps needed for the freshwater Pawcatuck River are discussed in Section 5.10.

Wastewater management activities include adopting wastewater management ordinances in areas without sewers to ensure that septic systems are properly maintained and operated, maintaining sewage collection and treatment systems to avoid sewage overflows, and ensuring that boaters fully utilize pump-out facilities. Other recommendations include minimizing fecal contamination from domestic animals, farm animals, waterfowl, and wildlife.

5.1 RIPDES Phase II Stormwater Program

Stormwater runoff is most often carried to waterways by publicly owned drainage networks. Historically, these storm drain networks were designed to carry stormwater away from developed land as quickly as possible to prevent flooding with little to no treatment of pollutants. In 1999, EPA finalized its Stormwater Phase II rule, which required the operators of small municipal separate storm sewer systems (MS4s) to obtain permits and to implement a stormwater management program as a means to control polluted discharges. In Rhode Island, the RIDEM RIPDES Program administers the Phase II program using a General Permit that was established in 2003 (RIDEM, 2003a). The Town of Westerly and the Rhode Island Department of Transportation (RIDOT) are regulated under the Phase II program.

Stormwater Management Programs – SWMPPs and Six Minimum Measures

The Phase II Program requires MS4 operators to develop a stormwater management program that is based on six minimum measures. Operators develop Stormwater Management Program Plans (SWMPPs) that detail how their stormwater management programs comply with the Phase II regulations. SWMPPs describe BMPs for the six minimum measures, including measurable goals and schedules. The implementation schedules include interim milestones, frequency of activities, and result reporting. Plans also include any additional requirements that are mandated for stormwater that discharges to impaired waters.

The six minimum measures are listed below.

- A public education and outreach program to inform the public about the impacts of stormwater on surface water bodies.
- A public involvement/participation program.
- An illicit discharge detection and elimination program.
- A construction site stormwater runoff control program for sites disturbing 1 or more acres.
- A post construction stormwater runoff control program for new development and redevelopment sites disturbing 1 or more acres.
- A municipal pollution prevention/good housekeeping operation and maintenance program.

In general, municipalities and RIDOT were automatically designated as part of the Phase II program if they were located either completely or partially within census-designated urbanized or densely populated area. Westerly and RIDOT operate MS4s that discharge to the surface waters of the Pawcatuck River and its tributaries inside and outside of a densely populated area (RIDEM, 2003a). Densely populated areas have a population density greater than 1000 people per square mile and a total population greater than 10,000 people. In Westerly, the downtown area is part of the densely populated area, while MS4s that drain the Avondale and Watch Hill areas are not. The boundary for the densely populated area follows Route 1A as it changes from Watch Hill Road to Shore Road. Westerly and RIDOT have obtained coverage under the RIPDES General Permit and have developed and submitted the required Stormwater Management Program Plans (SWMPPs) for those areas of the study that are located within the densely populated area.

Required SWMPP Amendments to TMDL Provisions

In Rhode Island, Part IV.D of the Phase II General Permit requires MS4 operators to address TMDL provisions in their SWMPP if the approved TMDL identifies stormwater discharges that directly or indirectly contain the pollutant(s) of concern (Part II.C3). Operators must comply with Phase II TMDL requirements if they contribute stormwater to identified outfalls, even if they do not own the outfall. Operators must identify amendments needed to their current SWMPP to comply with TMDL requirements. Operators must also address any previously non-regulated areas that are brought into the Phase II program as part of a TMDL. To avoid confusion and to better track progress, the SWMPP amendments should be addressed in a separate TMDL Implementation Plan (TMDL IP). Upon approval of this TMDL, Westerly and RIDOT should make their revisions in a TMDL IP. The 2003 RIPDES General Permit requires that the revisions (i.e. TMDL IP) be submitted within one hundred and eighty (180) days of the date of written notice from RIDEM as described in more detail below (RIDEM, 2003a).

TMDL Implementation Plan Requirements

The TMDL IP must address all parts of the watershed that discharge to the impaired water and all impacts identified in the TMDL, including those areas that are brought into the Phase II program as part of a TMDL. MS4 operators must provide measurable goals for the development and/or implementation of the amendments to the six minimum measures and for additional structural and non-structural BMPs that will be necessary to address the stormwater impacts identified in this TMDL.

TMDL IP requirements include an implementation schedule, which must contain all major milestone deadlines, including start and finish calendar dates, estimated costs, proposed or actual funding sources, and anticipated improvement(s) to water quality. As mentioned previously, these requirements apply to any operators of MS4s contributing stormwater to specifically identified outfalls, regardless of outfall ownership.

The TMDL IP must specifically address the following requirements that are described in Part IV.D of the RIPDES Stormwater General Permit (RIDEM, 2003a).

1. Determine the land areas contributing to the discharges identified in TMDL using sub-watershed boundaries as determined from USGS topographic maps or other appropriate means.
2. Address all contributing areas and the impacts identified by the Department.
3. Assess the six minimum control measure BMPs and additional controls currently being implemented or that will be implemented to address the TMDL provisions and pollutants of concern and describe the rationale for the selection of controls including the location of the discharge(s), receiving waters, water quality classification, shellfish growing waters, and other relevant information.
4. Identify and provide tabular description of the discharges identified in the TMDL including:
    a. Location of discharge (latitude/longitude and street or other landmark.
    b. Size and type of conveyance (e.g. 15” diameter concrete pipe).
    c. Existing discharge data (flow data and water quality monitoring data).
    d. Impairment of concern and any suspected sources(s).
    e. Interconnections with other MS4s within the system.
    f. TMDL provisions specific to the discharge.
    g. Any additional outfall/drainage specific BMP(s) that have or will be implemented to address TMDL provisions.
    h. Schedule for construction of structural BMPs including those for which a Scope of Work is to be prepared, as described below.
5. If the TMDL does not recommend structural BMPs, the TMDL IP must evaluate whether the six minimum measures alone (including any revisions to ordinances) are sufficient to meet the TMDL plans specified pollutant reduction targets. The TMDL IP should describe the rationale used to select BMPs.
6. If the TMDL determines structural BMPs are necessary, the TMDL IP must describe the tasks necessary to design and construct BMPs that reduce the pollutant of concern and

stormwater volumes to the *maximum extent feasible*. The TMDL IP must describe the process and the rationale that will be used to select structural BMPs (or LID retrofits) and measurable goals to ensure that the TMDL provisions will be met. In a phased approach, operators must identify any additional outfalls not identified in the TMDL that contribute the greatest pollutant load and prioritize these for BMP construction. Referred to as a Scope of Work in the current permit, this structural BMP component of the TMDL IP must also include a schedule and cost estimates for the completion of the following tasks:

   a. Prioritization of outfalls/drainage systems where BMPs are necessary. If not specified in TMDL, priority can be assessed using relative contribution of the pollutant of concern, percent effective impervious area, or pollutant loads as drainage area, pipe size, land use, etc. A targeted approach to construct stormwater retrofit BMPs at state and locally owned stormwater outfalls is recommended.
   b. Delineation of the drainage or catchment area.
   c. Determination of interconnections within the system and the approximate percentage of contributing area served by each operator's drainage system, as well as a description of efforts to cooperate with owners of the interconnected system.
   d. Completion of catchment area feasibility analyses to determine drainage flow patterns (surface runoff and pipe connectivity), groundwater recharge potentials(s), upland and end-of-pipe locations suitable for siting BMPs throughout the catchment area, appropriate structural BMPs that address bacteria, any environmental (severe slopes, soils, infiltration rates, depth to groundwater, wetlands or other sensitive resources, bedrock) and other siting (e.g. utilities, water supply wells, etc.) constraints, permitting requirements or restrictions, potential costs, preliminary and final engineering requirements.
   e. Design and construction of structural BMPs.
   f. Identification and assessment of all remaining discharges not identified in the TMDL owned by the operator contributing to the impaired waters addressed by the TMDL taking into consideration the factors addressed in paragraph iv above.

7. If the TMDL determines structural BMPs are necessary, but has not identified or prioritized outfalls/drainage systems for BMP construction, the TMDL IP must first identify and assess outfalls owned by the operator discharging directly to the impaired water or indirectly within 1 mile of the impaired water. The operator must then complete all tasks described in section f above.

5.2 MS4-Specific Requirements to Comply with RIPDES Phase II

The General Permit and Section 5.1 of this document contain the MS4 operator requirements needed to comply with the Phase II requirements for waters with a TMDL. The following sections contain the steps that Westerly and RIDOT must take to comply with RIPDES Phase II requirements as a result of this TMDL for the Pawcatuck River and Mastuxet Brook.

It is common for state-owned and municipal-owned storm drains to interconnect. RIDEM encourages cooperation between MS4 operators when developing and implementing the six minimum measures and in determining suitable locations for the construction of Best Management Practices. Communities affected by the Phase II program are encouraged to cooperate on any portion of, or an entire minimum measure when developing and implementing their stormwater programs.

Expansion of the MS4-Regulated Areas

As mentioned previously, the Avondale and Watch Hill Cove areas of the Pawcatuck River watershed were not automatically regulated as part of the Phase II program because they were located outside of the densely populated area. The RIPDES Regulations (Rule 31(a)(1)(vii)) allow RIDEM to also designate discharges within a geographic area that contribute to a water quality violation (RIDEM, 2003b). Since stormwater contributes to the impairment of receiving waters in these areas, Westerly and RIDOT will now be required to include the areas of Avondale and Watch Hill Cove in its Phase II program.

Westerly and RIDOT should include all relevant information regarding the Avondale and Watch Hill Cove areas in its TMDL IP. Specifically, Westerly and RIDOT need to document that the six minimum measures now apply to these areas in town. RIDEM identified many actual and potential bacteria sources along the Pawcatuck River and Watch Hill Cove. Information about these sources can be found in Appendix C. The TMDL IP should document whether each of these sources is or is not part of a MS4. Westerly and RIDOT should also identify any other outfall, channel, etc. that is a regulated discharge under the Phase II program.

As detailed in Part IV.D of the General Permit (RIDEM, 2003a), Westerly and RIDOT must evaluate whether the six minimum measures (including any revisions to ordinances) are sufficient to meet this TMDL plan’s bacteria reduction targets for the Watch Hill Cove and Avondale areas.

Modifications to Six Minimum Measures

MS4 operators must assess the six minimum control measure BMPs included in their SWMPPs for compliance with this TMDL plan’s provisions and provide measurable goals in the TMDL IP for any needed amendments. The operator must also describe the rationale for the selection of controls including the location of the discharge(s), receiving waters, water quality classification, shellfish growing waters, and other relevant information (General Permit Part IV.D.3.c). The following sections outline activities that Westerly and RIDOT either should or must implement and/or consider when modifying their six minimum measures. Westerly needs to include Avondale and Watch Hill Cove in all minimum measure implementation.

Public Education/Public Involvement

The public education program must focus on both water quality and water quantity concerns associated with stormwater discharges within the watershed. Public education material should target the particular audience being addressed, while public involvement programs should actively involve the community in addressing stormwater concerns.

An educational campaign targeted to residential land uses should include activities that residents can take to minimize water quality and water quantity impacts. Measures that can reduce bacteria contamination include proper septic system maintenance, eliminating any wastewater connections to the storm drain network, proper disposal of pet waste, proper storage and disposal of garbage, and, as discussed in Section 5.8 below, not feeding waterfowl. Measures that can reduce the quantity of water that runs off during a wet weather event include decreasing effective impervious area and by providing on-site attenuation of runoff. Roof runoff can be infiltrated using green roofs, dry wells, or by redirecting roof drains to lawns and forested areas. Reducing land runoff can be accomplished by grading the site to minimize runoff and to promote stormwater attenuation and infiltration, creating rain gardens, and reducing paved areas such as driveways. Driveways can be made of porous materials such as crushed shells, stone, or porous pavement. Buffer strips and swales that add filtering capacity through vegetation can also slow runoff. Waterfront properties as well as those adjacent to hydrologically connected streams and wetland areas should establish and maintain natural buffers, planted with native plants, shrubs and/or trees to minimize impacts of development and restore valuable habitat.

Other audiences include commercial, industrial, and institutional property owners, land developers, and landscapers. In addition to the activities discussed above for residential land use, educational programs for these audiences could discuss BMPs that should be used when redeveloping or re-paving a site to minimize runoff and promote infiltration. Measures such as minimizing road widths, installing porous pavement, infiltrating catch basins, breaking up large tracts/areas of impervious surfaces, sloping surfaces towards vegetated areas, and incorporating buffer strips and swales should be used where possible. Section 5.3 discusses changes to the RI Stormwater Design and Installation Standards Manual (RIDEM and CRMC, 2010) that promote these measures using low impact development (LID) techniques.

The University of Rhode Island Cooperative Extension's Stormwater Phase II Public Outreach and Education Project provides participating MS4s with education and outreach programs that can be used to address TMDL public education recommendations. This project is funded by RIDOT and has many partners, including RIDEM. Westerly is a participating member of this Program. More information may be found on the URI website http://www.ristormwatersolutions.org/.

Illicit Discharge Detection and Elimination

Illicit discharges are any discharge to a MS4 that is not composed entirely of stormwater with some exceptions. Septic system or sewer line wastewater connections to a storm drain result in the untreated discharge of sewage to a waterbody. Sampling storm drains in dry weather can reveal illicit discharges.

As discussed in the pollutant source section, Westerly discovered that five sewer laterals were leaking into the storm drain network when investigating the source of elevated dry weather bacteria concentrations in the School Street storm drain network. The School Street outfalls will be sampled again to confirm that all illicit discharges have been removed. As part of their illicit discharge detection programs, Westerly and RIDOT must give priority to two additional outfalls that have elevated dry weather bacteria concentrations. These outfalls are located under the Broad Street Bridge (RI103) and at Margin Street (RI100). In addition, Westerly and RIDOT should also prioritize their town-wide illicit discharge and elimination programs to those outfalls that discharge into the Pawcatuck River or Mastuxet Brook.

In its Year 5 MS4 Annual Report, Westerly submitted an outfall map and coordinates of identified outfalls, along with an illicit discharge report. The outfall map included very few outfalls that were identified by RIDEM as part of the 2006 Shoreline Survey. While the Year 5 Annual Report mentions that Westerly included four RIDEM-identified outfalls in its illicit discharge program, no further information about the outfalls were submitted. Westerly and RIDOT must review the list of the RIDEM-identified outfalls included in Appendix C and report on which outfalls contain stormwater from the MS4. Outfalls that contain stormwater from the MS4 should be integrated into the MS4 outfall maps and illicit discharge detection program.

Construction/Post Construction

MS4 operators are required to establish post construction stormwater runoff control programs for new land development and redevelopment at sites disturbing *one or more acres*. Untreated stormwater runoff contains high bacteria loads, which contribute significantly to the water quality problems in the Pawcatuck River. Land development and re-development projects must utilize best management practices if the Pawcatuck River and Little Narragansett Bay are to be successfully restored. Consistent with the revised RI Stormwater Design and Installation Manual (RIDEM and CRMC, 2010), local ordinances meant to comply with the post construction minimum measures (General Permit Part IV.B.5.a.2.) must require that applicable development and re-development projects use Low Impact Development (LID) techniques as the primary method of stormwater control to the maximum extent practicable and maintain groundwater recharge to predevelopment levels.

As mentioned previously, examples of acceptable reduction measures include reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, using porous pavement, and installing infiltration catch basins where feasible. Other reduction measures to consider are the establishment of buffer zones, vegetated drainage ways, cluster zoning or low impact development, transfer of development rights, and overlay districts for sensitive areas. Section 5.3 discusses changes to the RI Stormwater Design and Installation Standards Manual (RIDEM and CRMC, 2010) that promote these measures using low impact development (LID) techniques.

To ensure consistency with the goals and recommendations of the TMDL, the TMDL IP must also address any revisions to local ordinances that are needed to ensure that:

- New land development projects employ stormwater controls to prevent any net increase in bacteria pollution to the waterbodies in the Pawcatuck River and Little Narragansett Bay watersheds.
- Redevelopment projects to employ stormwater controls to reduce bacteria pollution to the waterbodies in the Pawcatuck River and Little Narragansett Bay watersheds to the maximum extent feasible.

These runoff control programs also apply to MS4-owned facilities and infrastructure (General Permit Part IV.B.6.a.2 and Part IV.B.6.b.1).

Westerly should also consider expanding these ordinances to include projects that disturb *less than 1 acre*. At a minimum the TMDL IP must assess the impacts of imposing these requirements on lower threshold developments. The TMDL IP should also assess and evaluate various enforceable mechanisms that ensure long-term maintenance of BMPs.

Good Housekeeping/Pollution Prevention
MS4 operators must identify the potential sources of pollution, including specifically the TMDL pollutant of concern (bacteria), which may reasonably be expected to affect the quality of stormwater discharges from their facilities; and describe and ensure implementation of practices, which the permittee will use to reduce bacteria in stormwater discharges from the facility. The SWPPP must address all areas of the facility and describe existing and/or proposed BMPs that will be used and at minimum must include the following:

- Frequent sweeping of roads, parking lots and other impervious areas
- Effective management (storage and disposal) of solid waste and trash
- Regular inspection and cleaning of catch basins and other stormwater BMPs
- Other pollution prevention and stormwater BMPs as appropriate

Structural BMP Requirements

In addition to addressing the Phase II General Permit requirements described above, this TMDL also finds that structural BMPs will be needed to restore water quality to the Pawcatuck River in areas that are located in the densely-populated regions of the study area. As a result, Westerly and RIDOT must comply with the structural BMP requirements of the General Permit. A BMP study must be completed that details the tasks necessary to design and construct BMPs that reduce the pollutant of concern and stormwater volumes to the *maximum extent feasible*. As noted previously, TMDL provisions apply to any MS4 operators contributing stormwater to the identified outfall regardless of outfall ownership. The BMP study should include all the components of Part IV.D.4 (RIDEM, 2003s) that were previously described in Number 6 in the TMDL IP section. It must evaluate the feasibility of distributing infiltration or equivalent BMPs throughout the drainage area of the priority outfalls as an alternative to end of pipe technologies since the amount of land available for BMP construction is limited.

In the Pawcatuck River, all outfalls that discharge road runoff to the River between Stillmanville Avenue and Margin Street (RI100) are considered to be priority outfalls. While outfalls along this stretch of river were identified during the 2006 Shoreline Survey and by Westerly, Westerly and RIDOT should confirm that all outfalls have been identified. Priority should be given to outfalls along this stretch of river that collect stormwater from large catchment areas, including, but not limited to School Street (RI101/102), 181 Main Street (RI130), Commerce Street (RI129), Margin Street (RI100), and under the Broad Street Bridge (RI103). Westerly and RIDOT should consider using the technical scope of work developed by RIDEM when beginning work on its BMP study. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs. Westerly and RIDOT should also conduct a BMP feasibility study for the catchment areas of outfalls that drain to Mastuxet Brook. This area includes outfalls along United States Route 1 and Airport Road.

Table 5.1 DEM-Identified Priority Outfalls for Downtown Westerly[1]

Source ID	Latitude	Longitude	Description / Location
RI103	41.377650	71.831350	30" Box Outfall Under Broad Street Bridge
RI129			36" C. Flared end. Commerce Street (RIDOT Outfall 5)
RI101	41.372883	71.831600	36" C (South-Right). School Street. RI 101 – RI102 are double pipes.
RI102	41.372883	71.831600	36" C (North-Left). School Street. RI 101 – RI102 are double pipes.
RI130	41.37044	71.83139	181 Main Street (RIDOT Outfall 9)
RI100	41.369967	71.831800	48" C Pipe Margin Street (RIDOT Outfall 10)

[1]This is not an inclusive list. See text for further details.

Structural BMP Needs Evaluation

This TMDL prioritizes stormwater retrofit activities in the downtown area and in the Mastuxet Brook area. This prioritization does not preclude the possibility that structural BMPs will be needed in other areas of the watershed. In regards to structural BMPs at areas that discharge outside the prioritized areas, Westerly and RIDOT need to evaluate whether the six minimum measures alone are sufficient to meet the bacteria reduction targets. In addition, this TMDL is requiring Westerly and RIDOT to identify and assess all remaining discharges not identified in the TMDL that discharge directly or indirectly via tributaries or stormwater infrastructure to the impaired water within the area designated by the TMDL (described below) and determine the significance of the discharge as a source of the pollutant of concern. Consideration shall be given to the percent effective impervious area of the catchment area and pollutant loads as indicated by drainage area, pipe size, land use, known hot spots, and/or any sampling data. If these evaluations and measures determine that structural BMPs are needed, then Westerly and RIDOT should include the structural BMP requirements, including a schedule in its TMDL IP. Alternatively if the evaluation determines that no structural BMPs are needed, then the requirements have been satisfied at this time. For the Town of Westerly and RIDOT these requirements apply to areas that discharge outside the downtown and Mastuxet Brook areas, which includes Avondale and Watch Hill Cove.

5.3 LID and Future Development and Redevelopment

The watershed of the Pawcatuck River estuary contains a mix of medium-developed and highly developed areas. When possible, efforts by municipalities, land trusts and others to preserve open space should continue. As land is developed, it is critical that significant natural features be protected to maintain the area's unique characteristics and to prevent further degradation of water quality – as can be achieved through use of conservation development and LID techniques. Redevelopment projects represent opportunities to reduce the water quality impacts from the watershed's urbanized land uses by reducing impervious cover and/or attenuating runoff on-site. As described previously, municipal ordinances must be reviewed and revised to make sure that future development projects do not add to water quality problems and that redevelopment projects reduce contributions to the water quality problems in the Pawcatuck River.

In 2007, Rhode Island adopted the Smart Development for a Cleaner Bay Act (General Laws Chapter 45-61.2), requiring RIDEM and CRMC to update the Rhode Island Stormwater Design and Installations Manual to: maintain groundwater recharge at pre-development levels, maintain post-development peak discharge rates to not exceed pre-development rates, and use low impact development techniques as the primary method of stormwater control to the maximum extent practicable. The draft manual provides twelve minimum standards addressing LID Site Planning and Design Strategies, Groundwater Recharge, Water Quality, Redevelopment Projects, Pollution Prevention, Illicit Discharges, and Stormwater Management System Operation and Maintenance, among other concerns. This revised manual provides appropriate guidance for stormwater management on new development and redevelopment projects and, most importantly, incorporates LID as the "industry standard" for all sites, representing a fundamental shift in how development projects are planned and designed. Rhode Island joins a growing number of states and localities including the Puget Sound area (http://www.psat.wa.gov/Programs/LID.htm) that rely heavily on LID techniques to protect and restore their waters.

A draft of the updated stormwater manual was released for public review and comment in June 2009; in response to comments, RIDEM and CRMC have revised the document and posted the final draft for public review in April 2010. A companion manual on LID site planning and design is also in preparation by RIDEM to provide Rhode Island-specific guidance regarding the site planning, design, and development strategies that communities should adopt to encourage low impact development.

5.4 Stormwater from Industrial Activities

Stormwater discharges from facilities that discharge "stormwater associated with industrial activity" are regulated under the statewide general RIPDES permit prescribed in Chapter 46-12, 42-17.1 and 42-35 of the General Laws of the State of Rhode Island. As mentioned previously, stormwater is a major source contributing to the bacteria and bacteria-related impairments to Pawcatuck River and Little Narragansett Bay. Stormwater from industrial activities may be discharged to these waters directly or via MS4s and may contain bacteria concentrations that contribute to the impairments.

In accordance with Part I.B.3.j of the RIPDES Multi-Sector General Permit (MSGP), permittees are required to demonstrate that the stormwater discharges are consistent with the TMDL once the TMDL has been approved. Permittees will have 90 days from written notification by RIDEM to submit this documentation, including revised Stormwater Pollution Prevention Plans (SWPPPs) to RIDEM. The owner/operators of facilities currently authorized to discharge waters within the study area are listed in the Table 5.2.

Table 5.2 Industrial Stormwater Discharge Facilities.

Facility Name	RIPDES Permit Number	Receiving Water
Frank Hall Boatyard	RIR50Q008	Pawcatuck River
Richards Marine Repair Service	RIR50Q010	Pawcatuck River
Pier 65	RIR50Q018	Pawcatuck River
Westerly State Airport	RIR50S003	Mastuxet Brook

RIDEM is aware that there may be additional facilities that have regulated industrial activities and point source discharges that require authorization under the RIPDES MSGP. RIDEM will continue to work to ensure that all facilities that are required to apply for a multi-sector general permit have done so.

The SWPPP must identify the potential sources of pollution, including specifically the TMDL pollutant of concern (bacteria), which may reasonably be expected to affect the quality of stormwater discharges from the facility; and describe and ensure implementation of practices, which the permittee will use to reduce bacteria in stormwater discharges from the facility. The SWPPP must address all areas of the facility and describe existing and/or proposed BMPs that will be used and at minimum must include the following:

- Frequent sweeping of roads, parking lots and other impervious areas
- Effective management (storage and disposal) of solid waste and trash
- Regular inspection and cleaning of catch basins and other stormwater BMPs
- Other pollution prevention and stormwater BMPs as appropriate

Where structural BMPs are necessary, as stated in Part IV.F.7 of the permit, selection of BMPs should take into consideration:

- The quantity and nature of the pollutants, and their potential to impact the water quality of receiving waters.
- Opportunities to combine the dual purposes of water quality protection and local flood control benefits (including physical impacts of high flows on streams - e.g., bank erosion, impairment of aquatic habitat, etc.).
- Opportunities to offset the impact of impervious areas of the facility on ground water recharge and base flows in local streams.

For existing facilities, the SWPPP must include a schedule specifying when each control will be implemented. Facilities that are not currently authorized will be required to demonstrate compliance with these requirements prior to authorization.

5.5 Connecticut Stormwater Recommendations

Pawcatuck Village is part of the Town of Stonington, Connecticut. Its stormwater is regulated under a General Permit issued by the CTDEP. Stonington was required to submit its SWMPP in July 2004. Stonington's 2008 Annual Report is posted online. The Annual Report details activities that Stonington completed in 2008 to comply with the six minimum measures. In the Annual Report, Stonington mentions that it has completed mapping its storm drain network and it intended to begin sampling its outfalls in 2009 under dry weather as part of its illicit discharge detection program. Housekeeping includes street sweeping of all roads at least once annually. Some roads in Pawcatuck are swept multiple times per year. Also, catch basin vacuuming is performed annually. RIDEM recommends that CTDEP and Stonington evaluate the mitigation measures described in Sections 5.1 through 5.3 for implementation throughout the Stonington portions of the study area.

This TMDL recommends that CTDEP and/or Stonington investigate several outfalls due to their proximity to areas in the Pawcatuck River where there are localized dry weather bacteria sources. CTDEP officials (personal communication, 2006b) report that they have asked their municipal facilities staff to conduct initial assessments an outfall near the Broad Street Bridge

(CT102) and an outfall at Riverside Drive (CT400). CT102, located in downtown Pawcatuck, had high dry weather fecal coliform concentrations. CT400 is located in the lower Pawcatuck River, upstream of Graves Neck, near Station 12-6. Also, during a 2006 CTDEP field visit to Hoxsie Farm, an oily and soapy discharge was reported from a pipe that appears to originate along River Road.

In wet weather, stormwater from downtown Pawcatuck and Westerly appear to impact the estuarine Pawcatuck River. RIDEM sampled several CT outfalls during its wet weather study. Results are reported in Table 3.4 and Appendix D. RIDEM is requiring that Westerly construct structural BMPs in its downtown area. It is recommended that Stonington investigate lowering bacteria concentrations in its municipal stormwater using available practices, including good housekeeping and pollution prevention source reduction activities, and construction of structural BMPs including LID techniques. Among the Connecticut sources, CT109 stood out for its wet weather coliphage results, the lowest of which was reported as >425 pfu/100 mL.

5.6 Onsite Wastewater Management

A properly designed and operating OWTS does prevent bacterial pollution from impacting the surrounding surface and ground waters. Inadequately treated wastewater from substandard and failed OWTS adds bacteria to waterbodies, contributing to water quality impairments. These sources can be mitigated through sewer extensions and tie-ins and, for those areas where sewers are not and will not be available, through replacement of sub-standard and/or failed systems. When extending new sewer lines, Westerly (Ordinance §206-22) requires that all properties with access connect to the sewer line within 180 days of notification with some exceptions.

Westerly has an approved Onsite Wastewater Management Plan. According to its 2008 Onsite Wastewater Management Plan, the town is considering the use of the Rhode Island Web-based Information System (RIWIS), which can help develop an initial inventory of OWTS and can track voluntary inspection and pumping program (Beta, 2008). Westerly's eligibility for Rhode Island's Community Septic System Loan Program (CSSLP) is pending RIDEM issuance of the certificate of approval. CSSLP enables communities to provide residents with low interest loans to repair and upgrade failing and substandard systems.

Westerly should work to create an Onsite Wastewater Management District to provide more comprehensive protection of surface and groundwater. RIDEM recommends that communities adopt ordinances for those areas where sewers are not planned to establish *enforceable* mechanisms to ensure that existing OWTS are properly operated and maintained. As part of the wastewater management planning efforts, communities should keep detailed records of which properties are not connected to the municipal sewer system, identify sub-standard systems through mandatory inspections, and adopt a schedule for replacement of those systems. Policies that govern substandard OWTS and cesspool replacement within a reasonable time frame should be adopted. In the estuarine Pawcatuck River watershed, businesses and homes in the Avondale and Watch Hill Cove neighborhoods use OWTS to treat wastewater. Watch Hill Cove was identified in Section 3.1 as having localized bacteria sources. Since Bay Street in Watch Hill has been identified as having a high number of system failures (Beta, 2008), it is especially important to have an inspection program to ensure that OWTS are not contributing to bacteria problems in Watch Hill Cove.

Statewide, failed cesspools are required to be replaced under current onsite wastewater treatment regulations. In addition, new OWTS rules effective January 1, 2008 require the replacement of cesspools that serve commercial facilities or multifamily dwellings. The Rhode Island Cesspool Act of 2007 took effect on June 1, 2008. It requires the replacement of cesspools located within 200 feet of all shoreline features bordering tidal areas, such as the Pawcatuck River and Little Narragansett Bay, within 200 feet of all public wells, and within 200 feet of a water body with an intake for a drinking water supply by January 1, 2013. Cesspools located in communities with comparable or more stringent replacement requirements are exempt from the new state law (RIDEM, 2007b).

5.7 Boats and Marine Pump-out Facilities

In 1989, there were eighteen marinas in the Pawcatuck River and Watch Hill Cove area (Dillingham et. al., 1993). EPA has designated the Rhode Island and Connecticut marine waters in the Pawcatuck River and Little Narragansett Bay as *Federal No Discharge Areas*. Five pump-out facilities, three fixed and two mobile, service the Pawcatuck River and Little Narragansett Bay. In 2008, 9000 gallons of sewage was dumped at the Avondale Boatyard and 25,000 gallons of sewage was dumped at the Westerly Yacht Club. An additional 27,780 gallons of sewage was dumped at the two mobile facilities (RIDEM, 2009c). The remaining fixed pump-out facility is in Connecticut and its sewage is not tracked by RIDEM. All pump-out facilities in this area should be maintained and operated to maximize boat usage.

RIDEM oversees the operation and maintenance of the Rhode Island pump-out infrastructure by participating in the Clean Vessel Act (CVA) program, which provides money for the construction, repair, and replacement of pump-out facilities and, by coordinating outreach and education programs. The two mobile pump-out facilities were purchased by the Town of Westerly using Rhode Island CVA grant funds and are operated with funds from the CTDEP. These pump-out boats service boats on both the Connecticut and Rhode Island sides of the river. RIDEM encourages all marinas with boats having Marine Sanitation Devices (MSDs) to have pump-out facilities available. RIDEM also recommends the construction of shore-side restroom facilities at all marinas and boat ramps if none are currently available.

CRMC should make marine pump-out facilities a mandatory maintenance item as a condition of minimum standard for operation of a marine facility.

Enforcing Rhode Island's No Discharge designation is required by the Clean Water Act. State laws §46-12-39, §46-12-40, and §46-12-41 give authority to local harbormasters, local police, Coast Guard, and RIDEM conservation officers and employees to enforce *No Discharge* laws. Boarding boats and inspecting marine sanitation devices (MSD) by all empowered agencies are needed in the Pawcatuck River as a follow-up to the last ten years of outreach and education. All agencies should develop a policy regarding the boarding of boats to inspect compliance with *No Discharge* requirements.

During the course of this study, Watch Hill Cove was found to have localized dry weather sources. Watch Hill Cove is filled with moored boats during the summer. These boats include transient boats, which moor for short periods of time while people stay aboard. Education and enforcement programs should be implemented to ensure the maximum usage of the pump-out boats and importance of limiting greywater discharges. Additionally, efforts that increase shore-based facilities, such as bathrooms and showers, may also help water quality by decreasing the amount of greywater that is generated.

Also, during the 2006 Joint Agency Shoreline Survey, CTDEP identified a houseboat on Mechanic Street (CT405) as a potential bacteria source. CT DA/BA reports that the houseboat does not contain a bathroom and its occupants use onshore facilities (personal communication, 2010).

5.8 Waterfowl, Wildlife, and Domestic Pets

Past TMDL studies have shown that waterfowl, wildlife, and domestic pets contribute significantly to elevated bacteria concentrations in surface water. Pet waste left to decay on the sidewalk, or on grass near the street, may be washed into storm sewers by rain or melting snow and cause water quality impairments (MADEP et. al., 2009).

Stormwater Phase II requirements include an educational program to inform the public about the impact of stormwater. Westerly's education and outreach programs should highlight the importance of picking up after pets and not feeding birds. Pet wastes should be disposed of away from any waterway or stormwater system that discharges to the study area. Westerly should work with volunteers from the town to map locations where pet waste is a significant and a chronic problem. This work should be incorporated into the municipalities' Phase II plans and should result in an evaluation of strategies to reduce the impact of pet waste on water quality. This may include installing signage, providing pet waste receptacles or pet waste digester systems in high-use areas, enacting ordinances requiring clean-up of pet waste, and targeting educational and outreach programs in problem areas.

Towns and residents can take several measures to minimize bird-related impacts. They can allow tall, coarse vegetation to grow in areas along the shores of the Pawcatuck River that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to the water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. With few exceptions, Part XIV, Section 14.13 of Rhode Island's Hunting Regulations prohibits feeding wild waterfowl at any time in the state of Rhode Island (2009a). Educational programs should emphasize that feeding waterfowl, such as ducks, geese, and swans, contributes to water quality impairments in Pawcatuck River and can harm human health and the environment. Westerly should ensure that mention of this regulation is included in their SWMPPs.

In response to the dramatic rise in the population of non-native swans in the northeast, as of 2006, swans are no longer protected under federal wildlife regulations. The RIDEM Division of Fish and Wildlife has developed a management plan to control the state's swan population, which includes the routine monitoring of swan populations (a summer aerial survey to identify swan nests and a fall productivity survey) as well as working to actively reduce the state's swan population from the currently estimated population of 1,400 to 300 (RIDEM, 2006a). While this program has been successful in reducing population to less than 1000, it is not currently funded.

According to Fish and Wildlife, the Pawcatuck River is one of six major swan-gathering spots in the state. RIDEM has not conducted reduction activities in the Pawcatuck River for many reasons including that the Pawcatuck River is a state boundary. Also, the waterfowl tend to congregate on the Connecticut side of the River and Connecticut does not have a control program (Osenkowski, 2009). This TMDL is recommending that Connecticut and Rhode Island work together with the USDA, if necessary to control nuisance waterfowl along the Pawcatuck River. Connecticut should also eliminate any artificial feeding that is occurring along the River.

5.9 Farms

Two farms abut the waterbodies covered by this TMDL. One is located in Rhode Island along Mastuxet Brook and the other is located in Connecticut along the lower Pawcatuck River.

NRCS and the RIDEM Division of Agriculture should conduct a thorough site visit to Silver Farm, which is located along Mastuxet Brook in Rhode Island. Aerial photographs show that a pond on the property may be hydrologically connected to Mastuxet Brook and there appears to be a crossing over the brook that connects two pastures. A plan should be developed which minimizes the access of livestock to the pond and the brook. Fencing or natural vegetative buffers can be installed to mitigate the potential for bacteria contamination from animals.

A site visit was conducted by CTDEP at Hoxsie Farm, which is located along the Pawcatuck River in Connecticut. At the time of the visit in 2006, seven beef cows lived at the farm. CTDEP recommended that the owner of the farm contact NRCS to investigate their programs. NRCS assistance was recommended for roofing a heavy use area 100 feet from the river and for fencing cows out of the tidal wetlands to create a buffer along the Pawcatuck River (CTDEP, 2006a). Since the farm has switched from cows to chickens, the need for fencing may have dissipated (CT DA/BA personal communication, 2010).

5.10 Bacteria Source Investigation – Clarks Village and Gavitt Point

RIDEM began investigating the source of increasing bacteria concentrations upstream of Stanton Weir Point, in the vicinity of Clarks Village and Gavitt Point, during its 2006 Shoreline Survey of the Pawcatuck River. As shown in Table 3.1, instream sampling showed that the trend of decreasing bacteria concentrations as one moved downstream of the freshwater Pawcatuck River ended upstream of Stanton Weir Point. Bacteria samples taken from two wastewater treatment facility outfalls in the area were much lower than the instream concentrations. RIDEM added additional stations in this area of concern in an attempt to characterize the problem and to determine the source of the bacteria. Appendix G contains the results from eight sampling surveys that have been conducted since August 2006.

While the bacteria source in this area has not been identified, the sampling has shown several things about this area. Potential bacteria sources from Stanton Weir Point (Station 17C) have been eliminated. Station 17A is opposite a sandbar upstream of Gavitt Point, which is home to numerous waterfowl. These waterfowl most likely contribute bacteria to the Pawcatuck River; but there appears to be another source causing the increased bacteria concentrations downstream since bacteria concentrations are usually higher downstream of Station 17A. The highest bacteria concentrations have been measured in the vicinity of the Pawcatuck WWTF outfall (station 19.6). This area contains a pump station and sewer lines in the vicinity of station 17B, which is located west of the station at the Pawcatuck WWTF outfall. This pump station is identified as Pump Station Number 3 in Figure 4.1 of Stonington's Wastewater Facilities Plan. It pumps all wastewater serviced by the Pawcatuck WWTF to the plant. The pump station wet well and its influent sewer lines should be inspected. Appendix G contains a detailed summary of the work that RIDEM has completed in this area along with recommendations for further investigation.

5.11 Freshwater Pawcatuck River

While the freshwater Pawcatuck River is not a significant dry weather source to the estuarine Pawcatuck River, it is a significant wet weather source. Upstream segments of the main stem of the freshwater Pawcatuck River were included on the 2008 List of Impaired Waters (RIDEM, 2008b) as impaired for enterococci bacteria. A TMDL is required for these segments. In addition, EPA requires that states develop Watershed Management Plans to become eligible for grant funding under Section 319 of the federal Clean Water Act. A Watershed Management Plan considers all uses, pollutant sources, and impacts within a drainage area and serves as guides for communities to protect and improve the water quality. The TMDL and the Watershed Management Plan, to be developed in the future, will identify and recommend mitigation activities that will improve water quality to the estuarine Pawcatuck River.

5.12 RIPDES Sources – Westerly WWTF

The RIPDES Permit for the Westerly WWTF expires in 2012. When the permit is reissued, the facility should be given a permit limit for enterococci that is consistent with the RI Water Quality Regulations (2009d). As discussed in Section 4.3, the permit should set a monthly geometric mean concentration of 35 colonies per 100 mL for enterococci and require the facility to monitor for fecal coliform.

5.13 Summary

RIDEM will continue to work with RIDOT, CRMC, and Westerly to identify funding sources and evaluate locations and designs for stormwater control BMPs throughout the watershed. The following tables summarize the required and recommended implementation activities described in the sections above.

Table 5.3 summarizes the recommended implementation activities that are required for the Town of Westerly and RIDOT to comply with their RIPDES permit to discharge stormwater. The required SWMPP amendments should be contained in a TMDL IP. Westerly and RIDOT should use the General Permit (RIDEM, 2003a) and Sections 5.1 and 5.2 of this TMDL when developing their TMDL IPs to ensure compliance. Table 5.4 contains a summary of other TMDL requirements and recommendations.

Table 5.3 Required RIPDES Phase II Stormwater TMDL Implementation Plan Summary[1].

Abatement Measure	Jurisdiction / Location	Notes
Expand Regulated Area	Westerly RIDOT	Expand regulated area to include the Avondale and Watch Hill Cove sections of Westerly.
Public Education / Public Involvement	Westerly RIDOT	Focus on both water quality and quantity issues. Educational issues should include: not feeding birds, cleaning up pet waste, planting buffers, etc. Continue involvement with the URI Phase II Public Outreach and Education Project.
Illicit Discharge Detection and Elimination	Westerly RIDOT	Investigate elevated dry weather bacteria readings at Broad Street Bridge (RI103) and Margin Street (RI100) outfalls. Continue work at School Street (RI101/RI102) outfalls.
Construction / Post Construction	Westerly RIDOT	Ensure that new land development and redevelopment follow the no net increase and reduction to the maximum extent practicable standards, respectively. Consider expanding these to projects that are less than 1 acre. Adopt revised Rhode Island Stormwater Design and Installations Manual.
Good Housekeeping / Pollution Prevention	Westerly RIDOT	Describe and implement practices to reduce bacteria in stormwater discharges from facilities.
Other TMDL IP Measures	Westerly RIDOT	Draft implementation schedule, determine contributing discharge land areas, describe discharges, etc.
Structural Stormwater BMPs	Westerly RIDOT	Comply with General Permit structural BMP requirements. Priority should be given to outfalls between Stillmanville Avenue and Margin Street, including, but not limited to, RI101/RI102, RI130, RI129, RI100, and RI103. Priority should also be given to areas that discharge to Mastuxet Brook.
Structural Stormwater BMP Evaluation	Westerly RIDOT	Evaluate whether the minimum measures will be sufficient to meet reduction targets for areas that drain to all other areas in the study area watershed, including Avondale and Watch Hill Cove. If not, then include structural BMP requirements, including schedule in the TMDL IP.

[1]Refer to General Permit and Sections 5.1 and 5.2 above to ensure compliance with permit.

Table 5.4 TMDL Implementation Summary.

Abatement Measure	Jurisdiction / Location	Notes
LID and Conservation Development	Westerly	Section 5.3
Industrial Stormwater	Industrial Stormwater Discharge Facilities	Section 5.4
Wastewater Treatment	Westerly	Adopt ordinances to establish enforceable mechanisms that ensure OWTS are properly operated and maintained.
No Discharge CVA Program	RIDEM Marina Owners	Continue participation to expand and maintain infrastructure.
No Discharge Infrastructure	CRMC	Require mandatory maintenance of pump-out facilities as a condition of marina operation.
No Discharge Boat Inspections	Local Harbormasters and Police Coast Guard RIDEM	Develop and implement policies for inspecting boats to ensure compliance with No Discharge.
No Discharge Facility Use	Marina Operators Local Harbormasters	Increase public awareness of No Discharge requirements and available facilities.
Silver Farm, Westerly	RIDEM NRCS	Inspect farm. If necessary, develop and implement plan to minimize bacteria inputs by animals.
Waterfowl	CT USDA RIDEM	Control nuisance waterfowl along the entire River, particularly those in the lower Pawcatuck River.
Westerly WWTF	Westerly	Set enterococci limits. Continue to monitor for fecal coliform.

6.0 PUBLIC PARTICIPATION

In August 2008, Save the Bay and RIDEM hosted an initial public meeting at the Westerly Land Trust's offices in downtown Westerly to discuss environmental activities and studies that were being conducted in the Pawcatuck River and Little Narragansett Bay. RIDEM presented information relating to its bacteria and low dissolved oxygen TMDL studies. Historic information concerning bacteria concentrations in the area and preliminary findings of the Joint Agency Shoreline Survey were presented. Twenty-two people representing the general public and the following organizations attended the meeting.

Nopes Island Conservatory	University of Connecticut
Providence Journal	Washington County Regional Planning Council
RIDOT	Weekapaug Foundation for Conservation
Salt Ponds Coalition	Westerly Harbor Commission
SE*CRES	Westerly Land Trust
Town of Stonington Conservation Commission	Wood Pawcatuck Watershed Association

RIDEM presented the TMDL plan to the general public and stakeholders, including public officials and other agencies in a public meeting on August 19, 2010. The public meeting began the 30-day public comment period, which ended on Friday, September 17, 2010. Letters were sent by email and postal mail to key stakeholders in advance of this meeting. In addition, the meeting was publicized in a press release and public notices, which were posted at the Westerly Town Hall and at the Westerly Library. RIDEM posted the draft TMDL on its website more than two weeks before the public meeting. Approximately twenty-five people attended the meeting, which was held at the Westerly Town Hall. RIDEM received comments from Save the Bay and the Watch Hill Conservancy during the public comment period. The RIDEM response to these comments is found in Appendix G. Where appropriate; the document was revised in response to comments received.

Prior to the public meeting, in June 2010, RIDEM sent a draft of the TMDL to EPA, the Town of Westerly, the Connecticut Department of Environmental Protection (CT DEP), and to the Connecticut Department of Agriculture's Bureau of Aquaculture (CT DA/BA). In July 2010, RIDEM met with Westerly and CTDEP to discuss the draft TMDL. Comments received from these agencies were incorporated into the draft TMDL that was presented for public comment. These agencies were afforded a second opportunity to comment on the document during the 30-day public comment period; none were received.

7.0 FOLLOW-UP MONITORING

This TMDL will require phased implementation. Additional monitoring will be required to ensure that water quality objectives are met as remedial actions are accomplished. Monitoring by RIDEM and Save the Bay will be the principle method of obtaining the data necessary to track water quality conditions in the watershed. Also, as proposed BMPs are installed in the watershed, post construction influent and effluent sampling may be required to assess the effectiveness of the selected technology.

It is recommended that the RIDEM sample this area ***at least*** twice per year. Sampling this area is difficult due to its location, environmental conditions, and its prohibited shellfish status. The Shellfish Monitoring Program places its highest priority for sampling on those shellfish growing area where harvesting is approved. It attempts to sample the prohibited areas throughout the state a few times a year as resources allow. When this area is sampled, it is recommended that the Shellfish Monitoring Program sample a few stations in addition to its historical stations. These stations should include the freshwater Pawcatuck River (PR01), the upper Pawcatuck River (PR4), and a station in the vicinity of Gavitt Point (17B). Save the Bay has offered to help RIDEM monitor this area by providing a boat and driver. The use of the Save the Bay boat and driver would help RIDEM monitor this area by reducing the staff and equipment needed to sample. Ultimately, attainment of the designated shellfish harvesting use requires compliance with the Rhode Island water quality standards including ambient water quality criteria and all NSSP requirements (including a current shoreline survey and evaluation of non-shellfish program data/surveys, special sampling site data, beach and volunteer monitoring, as appropriate).

Save the Bay is also conducting monitoring in conjunction with the University of Rhode Island's Watershed Watch Program. Watershed Watch is a statewide volunteer monitoring program that provides training, equipment, supplies, and analytical services. The program meets strict quality assurance and quality control guidelines in the field and in its state-certified laboratory, which allows its data to be used by RIDEM when assessing water quality conditions in monitored waters. Save the Bay conducts weekly measurements at six stations in this project area. Monthly enterococci samples are also collected.

Future monitoring of Mastuxet Brook will be conducted by the RIDEM Ambient Monitoring Program, which samples various basins throughout the state on a five-year schedule.

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APPENDIX A INSTREAM STATION LOCATIONS AND DATA

Instream Station Locations

Station ID		Description
PR01		Freshwater Pawcatuck River at Stillmanville Avenue – Land-based.
PR4	**Upper Pawcatuck River**	Upstream Rhode Island State Boat Ramp
12-1		Mid-channel opposite red brick building marked *1890 CB Cottrell + Sons*, north of rip-rap wall
PRWW1		Connors and O'Brien Boatyard (CT) – Land-based wet weather only station.
PRWW2		Pier 65 Marina (RI) – Land-based wet weather only station.
12-17		From Westerly WWTF plume at outfall
17A		Duck Channel West of Major Island
12-2		At Nun Buoy #26 – Land-based wet weather only station.
17B		South of Gavitt Point, Near Shore
19.6		From Pawcatuck WWTF plume at outfall
12-3		At Nun Buoy #20
2B		Westerly Yacht Club Dock F (RI)
12-4	**Lower Pawcatuck River**	At Nun Buoy #12
12-5		At Nun Buoy #8
PRWW3		Frank Hall Boatyard (RI) – Land-based wet weather only station.
12-6		At Can Buoy #7
12-7		At Nun Buoy #4
12-8	**Little Narragansett Bay**	At Flashing Buoy #23, mouth of the Pawcatuck River
12-9		The intersection of a line from Nun Buoy #2 at Dennison Rock to Flashing Buoy #9, and a line from the southern tip of Barn Island to the southern tip of Sandy Pt.
12-10		At Nun Buoy #24 at Dennison Rock
12-11		Midway between the southern extremity of Sandy Pt. and northeast extremely of Napatree Pt.
12-14	**Watch Hill Cove**	Midway across the breached entrance to "The Kitchen" at Napatree Pt.
12-15		At the Flashing Buoy at the entrance channel to Watch Hill Cove.
12-16		In Watch Hill Cove, just off dock opposite Watch Hill Cove.

Stations beginning with ***12*** are historical Rhode Island Shellfish Program Stations.

Instream Station Data

- Except as otherwise noted, samples analyzed using the MPN three-tube method and weather condition determined using the National Weather Service's Westerly Rain Gauge.
- Values in fuchsia were reported as less than or greater than the detection limits. They were decreased or increased one significant figure.
- Values in blue bold type are the average of field duplicate samples.
- Values in orange bold type are the geometric mean of multiple samples taken over the course of one day.
- Additional information about the sampling events can be found in the Final Data Report.

		Tide	Days Since / Rain Amount (inches)	PR01 B	PR4 SB1	12-1 SB1	PR WW1 SB1	PR WW2 SB1	12-17 SB1	17A SB1	12-2 SB1	17B SB1	19.6 SB1	12-3 SB1	2B SB1
07/01/02[1]	Dry	F	2 / 0.07	--	--	150	--	--	150	--	240	--	--	93	--
08/07/02[1]	Wet	E	5 / 0.62 in.	--	--	1100	--	--	150	--	210	--	--	240	--
06/06/03[1]	Wet	F	4 / 1.61 in.	--	--	390	--	--	240	--	460	--	--	240	--
06/15/05	Dry	E	15 / 0.48	--	--	43	--	--	460	--	460	--	--	1100	--
07/29/05[2]	Dry	L	1.5 / 0.29	--	--	460	--	--	430	--	460	--	--	460	--
09/02/05	Wet	E	3 / 2.5 in.	--	--	210	--	--	2400	--	750	--	--	1100	--
05/31/06	Dry	F	4 / 0.49	--	--	230	--	--	150	--	460	--	--	43	--
08/01/06[3]	Dry	L	4 / 0.25	49	--	130	--	--	110	--	--	--	1600	240	--
08/02/06[3]	Dry	L	5 / 0.25	49	110	140	--	--	170	--	--	--	350	220	--
08/03/06[3]	Dry	L	6 / 0.25	70	--	--	--	--	--	--	--	--	--	--	--
08/04/06[3]	Dry	E	7 / 0.25	--	--	--	--	--	1700	1700	--	1700	1600	1600	--
09/19/06[3]	Wet	E	4 / 0.74 in.	--	--	93	--	--	93	930	230	2300	430	430	--
09/20/06	Wet	L	<1 / 0.97 in.	--	--	460	--	--	240	--	1500	--	4600	430	--
06/04/07	Wet	H	<1 / 1.24 in.	4300	11000	--	--	--	--	--	--	--	--	--	2300
06/05/07	Wet	L	1 / 1.24 in.	2100	930	--	--	--	--	--	--	--	--	--	9300
06/06/07	Wet	L	2 / 1.24 in.	750	750	--	--	--	--	--	--	--	--	--	750
06/07/07	Wet	L	3 / 1.24 in.	150	930	--	--	--	--	--	--	--	--	--	460
06/08/07	Wet	L	4 / 1.24 in.	43	230	--	--	--	--	--	--	--	--	--	93
07/13/07	Dry	E	7 / 0.25	43	230	230	--	--	150	460	460	460	1100	460	--
07/26/07	Dry	L	7 / 0.28	230	930	230	--	--	230	430	4600	2400	11000	4600	--
08/30/07	Dry	H	9 / 0.27	**96.5**	460	240	--	--	23	93	240	240	64	93	--
08/07/08	Wet	F	<1 / 1.31 in.	430	460	1100	--	--	390	11000	4600	11000	4600	11000	--
09/23/08	Dry	L	9 / 0.42	93	23	43	--	--	93	390	150	43	93	93	--
09/25/08	Dry	NA	11 / 0.42	43	--	--	--	--	--	--	--	--	--	--	--
09/26/08	Wet	[4]	<1 / 2.52 in.	**1143**[4]	**3579**[4]	--	7500	4600	--	--	--	--	--	--	**1079**[4]
09/27/08	Wet	H	1 / 2.52 in.	24000	4300	--	4300	4300	--	--	--	--	--	--	4300
Dry Weather Count				8	5	10	NS	NS	11	5	8	5	7	11	NS
Dry Weather Geometric Mean				71	190	152	NS	NS	188	414	453	454	676	316	NS
Dry Weather 90th Percentile				137	742	262	NS	NS	460	1204	1702	2120	5360	1600	NS
Wet Weather Count				8	8	6	2	2	6	2	6	2	3	6	7
Wet Weather Geometric Mean				920	1359	402	5679	4447	302	3198	697	5030	2088	711	1180
Wet Weather 90th Percentile				10210	6310	1100	7180	4570	1395	9993	3050	10130	4600	6300	6050
TMDL (Dry/Wet) Count				16	13	16	NA	NA	17	7	14	7	10	17	7
TMDL (Dry/Wet) Geometric Mean				256	638	219	NA	NA	222	743	545	903	948	421	1180
TMDL (Dry/Wet) 90th Percentile				3200	4156	780	NA	NA	956	5420	3670	5840	5240	2800	6300

[1]Rainfall measured in Providence.
[2]Sampling event occurred one and a half days after a rain event of 0.29 inches of rain. Sample results were consistent with a dry weather event.
[3]A-1 Methodology
[4]At stations where multiple samples were taken on one day, one daily value was calculated for each station by taking the geometric mean of these multiple samples. Various tidal conditions were captured.

		Tide	Days Since / Rain Amount (inches)	12-4 SB	12-5 SB	PR WW3 SB	12-6 SB	12-7 SB	12-8 SA	12-9 SA	12-10 SA	12-11 SA	12-14 SA{b}	12-15 SA{b}	12-16 SA{b}
07/01/02[1]	Dry	F	2 / 0.07	43	93	--	240	43	23	2.9	9	2.9	2.9	2.9	28
08/07/02[1]	Wet	E	5 / 0.62 in.	43	93	--	23	4	23	9	93	39	4	9	23
06/06/03[1]	Wet	F	4 / 1.61 in.	1500	1200	--	930	4600	--	--	--	--	--	--	--
06/15/05	Dry	E	15 / 0.48	930	1100	--	430	240	240	240	43	4	43	23	15
07/29/05[2]	Dry	L	1.5 / 0.29	460	240	--	230	43	23	43	23	3	9	14	7
09/02/05	Wet	E	3 / 2.5 in.	2400	2400	--	930	1100	2400	1100	1100	75	240	390	460
05/31/06	Dry	F	4 / 0.49	150	75	--	93	43	150	43	93	2.9	2.9	93	39
08/01/06[3]	Dry	L	4 / 0.25	49	79	--	110	130	--	--	4.5	--	--	4.5	130
08/02/06[3]	Dry	L	5 / 0.25	79	170	--	170	170	--	--	2	--	--	49	49
08/03/06[3]	Dry	L	6 / 0.25	--	--	--	--	--	--	--	--	--	--	--	--
08/04/06[3]	Dry	E	7 / 0.25	--	--	--	--	--	--	--	--	--	--	--	--
09/19/06[3]	Wet	E	4 / 0.74 in.	230	--	--	--	--	--	--	--	--	--	--	--
09/20/06	Wet	L	<1 / 0.97 in.	460	230	--	1500	460	240	--	43	--	--	240	23
06/04/07	Wet	H	<1 / 1.24 in.	--	--	--	--	--	--	--	--	--	--	--	--
06/05/07	Wet	L	1 / 1.24 in.	--	--	--	--	--	--	--	--	--	--	--	--
06/06/07	Wet	L	2 / 1.24 in.	--	--	--	--	--	--	--	--	--	--	--	--
06/07/07	Wet	L	3 / 1.24 in.	--	--	--	--	--	--	--	--	--	--	--	--
06/08/07	Wet	L	4 / 1.24 in.	--	--	--	--	--	--	--	--	--	--	--	--
07/13/07	Dry	E	7 / 0.25	150	43	--	75	43	23	23	23	9	4	7	240
07/26/07	Dry	L	7 / 0.28	930	750	--	2400	430	23	7	15	2.9	4	2.9	93
08/30/07	Dry	H	9 / 0.27	9	9	--	43	4	9	2.9	2.9	2.9	15	**6**	4
08/07/08	Wet	F	<1 / 1.31 in.	11000	460	--	2500	930	240	93	93	9	9	9	460
09/23/08	Dry	L	9 / 0.42	43	43	--	43	15	23	2.9	4	9	4	7	9
09/25/08	Dry	NA	11 / 0.42	--	--	--	--	--	--	--	--	--	--	--	--
09/26/08	Wet	[4]	<1 / 2.52 in.	--	--	930	--	--	--	--	--	--	--	--	--
09/27/08	Wet	H	1 / 2.52 in.	--	--	**14650**	--	--	--	--	--	--	--	--	--
Dry Weather Count				10	10	NS	10	10	8	8	10	8	8	10	10
Dry Weather Geometric Mean				119	112	NS	164	58	35	14	11	4	6	11	30
Dry Weather 90th Percentile				930	785	NS	627	259	177	102	48	9	23	53	141
Wet Weather Count				6	5	2	5	5	4	3	4	3	3	4	4
Wet Weather Geometric Mean				752	490	3691	595	387	237	97	142	30	21	52	103
Wet Weather 90th Percentile				6700	1920	13278	2100	3200	1752	899	798	68	194	345	460
TMDL (Dry/Wet) Count				16	15	NA	15	15	12	11	14	11	11	14	14
TMDL (Dry/Wet) Geometric Mean				238	183	NA	252	110	66	24	23	7	9	17	43
TMDL (Dry/Wet) 90th Percentile				1950	1160	NA	2040	1032	240	240	93	39	43	196	394

[1]Rainfall measured in Providence.
[2]Sampling event occurred one and a half days after a rain event of 0.29 inches of rain. Sample results were consistent with a dry weather event.
[3]A-1 Methodology
[4]At stations where multiple samples were taken on one day, one daily value was calculated for each station by taking the geometric mean of these multiple samples. Various tidal conditions were captured.

At stations where multiple samples were taken on one day, one daily value was calculated for each station by taking the geometric mean of these multiple samples. This one daily value was used when calculating the TMDL reductions.

	Tide	Days Since / Rain Amount (inches)	PR01	PR4	2B
09/26/08	H	<1 / 2.52 in.	**121.5**	2400	240
09/26/08	H	<1 / 2.52 in.	750	2400	430
09/26/08	E	<1 / 2.52 in.	750	**1900**	4300
09/26/08	L	<1 / 2.52 in.	25000	15000	**3050**
		Daily Geometric Mean	**1143**	**3579**	**1079**

APPENDIX B MASTUXET BROOK STATION LOCATIONS AND DATA

Mastuxet Brook Station Locations

Station ID	Description	Latitude	Longitude
LPK02	Mastuxet Brook at End of Whipple Ave (off Rte 1)		
MAS1	Mastuxet Brook between Airport Rd and Babcock Rd	41.34664	71.81515
MAS2	Mastuxet Brook before Pawcatuck River at Watch Hill Rd	41.34302	71.82277
MAS3	Mastuxet Brook Tributary, Telephone Pole No. 16 on Airport Rd	41.35215	71.81084
MAS4	Mastuxet Brook Tributary off Lovat and Flicker Lanes	41.35752	71.81813

Mastuxet Brook Fecal Coliform Data

- All samples analyzed using the MPN method and weather condition determined using the National Weather Service's Westerly Rain Gauge.
- Values in fuchsia were reported as less than or greater than the detection limits. They were decreased or increased one significant figure.
- Values in blue bold type are the average of field duplicate samples.
- Values in orange bold type are the geometric mean of multiple samples taken over the course of one day.
- Additional information about the sampling events can be found in the Final Data Report.

		Days Since / Rain Amount (inches)	LPK02	MAS1	MAS2	MAS3	MAS4
09/25/08	Dry	11 / 0.42 in.	--	460	23	--	--
09/26/08	Wet	<1 / 2.52 in.	--	**22,989**[1]	**5286**[1]	--	--
09/27/08	Wet	1 / 2.52 in.	--	11,000	2500	--	--
06/17/09	Dry	1 / 0.11 in.	23	**161.5**	750	93	4300
08/05/09	Dry	5 / 0.25 in.	**121.5**	1500	43	93	43
10/15/09	Dry	4 / 0.02 in.	39	1100	**33**	2.9	--
Dry Weather Count			3	4	4	3	2
Dry Weather Geometric Mean			48	592	70	29	430
Dry Weather 90th Percentile			105	1380	538	93	3874
Wet Weather Count				2	2		
Wet Weather Geometric Mean				50,288	11,496		
Wet Weather 90th Percentile				208,005	47,828		
TMDL (Dry/Wet) Count			3	6	6	3	2
TMDL (Dry/Wet) Geometric Mean			48	1772	262	29	430
TMDL (Dry/Wet) 90th Percentile			105	16,995	3893	93	3874

[1]At stations where multiple samples were taken on one day, one daily value was calculated for each station by taking the geometric mean of these multiple samples. Various tidal conditions were captured.

At stations where multiple samples were taken on one day, one daily value was calculated for each station by taking the geometric mean of these multiple samples. This one daily value was used when calculating the TMDL reductions.

	Tide	Days Since / Rain Amount (inches)	MAS1	MAS2
09/26/08	H	<1 / 2.52 in.	430	11,000
09/26/08	H	<1 / 2.52 in.	9300	23,000
09/26/08	E	<1 / 2.52 in.	9300	46,000
09/26/08	L	<1 / 2.52 in.	21,000	24,000
		Daily Geometric Mean	22,989	5286

Mastuxet Brook Dry Weather Enterococci Data

The RIDEM Ambient Monitoring Program sampled Mastuxet Brook under dry weather conditions in 2006 and 2007. Water samples were analyzed for enterococci at two stations along the stream. The table below shows the results of this monitoring.

		LPK02	MAS1[1]
10/09/06	Dry	1	1
06/12/07	Dry	99	150
06/26/07	Dry	39	260
07/07/07	Dry	190	1200
08/09/07	Dry	3400	5800
	Count	5	5
	Geometric Mean	76	194

[1]RIDEM Ambient Monitoring Program identified this station as LPK03.

APPENDIX C PAWCATUCK RIVER KNOWN DIRECT STORMWATER DISCHARGES

The following tables list known direct stormwater discharges and structures that are in the estuarine Pawcatuck River watershed as identified by RIDEM, the Town of Westerly, and RIDOT. RIDEM-identified sources include all sources identified by multiple agencies during the 2006 Shoreline Survey. The stormwater discharges and structures are arranged into tables by location and by the entity that has identified the structure.

Upper Pawcatuck River (Rhode Island) – Class B Waters (Westerly-Identified)

Source ID	Latitude	Longitude	Description
W 71	41 22 50.2	-71 44 55.8	6” CI – Canal Street, behind fence
W 72	41 22 48.7	-71 49 54.9	30” CMP, broken bottom – Canal Street, upstream of Railroad Tracks
W 73	41 22 49.7	-71 49 55.5	6” CI – Canal Street, behind fence
W 74	41 22 50.0	-71 49 55.7	8” CI – Canal Street, behind fence
W 76	41 22 50.5	-71 49 56.1	8” CI w/ broken end – Canal Street, behind fence
W 77	41 22 51.2	-71 49 56.6	8” CI; 4-inch inside – Canal Street, behind fence
W 78	41 22 51.0	-71 49 56.5	4” CI – Canal Street, behind fence
W 79	41 22 51.7	-71 49 56.6	6” CI – Canal Street, behind fence
W 80	41 22 52.2	-71 49 56.1	10” box culvert – Canal Street
W 81	41 23 04.9	-71 49 58.7	24” CI – Canal Street, 200 feet downstream of bridge

CMP: Corrugated Metal Pipe, CI: Cast Iron

Upper Pawcatuck River (Rhode Island) – Class SB1 Waters (RIDEM-Identified)

Source ID	Latitude	Longitude	Description
RI127	41.379350	71.831133	24” C Upstream Broad Street Bridge. Pipe looks broken.
RI126	41.378967	71.830733	~18” C Upstream Broad Street Bridge. Pipe looks broken.
RI103	41.377650	71.831350	30” Box Outfall Under Broad Street Bridge
RI123	41.377250	71.831750	~8” Iron Under Broad Street Bridge
RI124	41.377250	71.831750	3 Small Pipes Under Broad Street Bridge (~3” Iron)
RI125	41.377250	71.831750	~6” Iron Under Broad Street Bridge
RI122	41.376850	71.831950	~24” Stone Square, Half-Submerged
RI129			36” C. Flared end. Commerce Street (RIDOT Outfall 5)
RI121	41.375283	71.832567	~18” C at State Boat Ramp
RI120	41.375200	71.832567	~18" Plastic Pipe Drains State Boat Ramp Parking Lot
RI119	41.373250	71.831900	24” C
RI101	41.372883	71.831600	36” C (South-Right) RI 101 – RI102 are double pipes.
RI102	41.372883	71.831600	36” C (North-Left) RI 101 – RI102 are double pipes.
RI118	41.372567	71.831800	18” C. RI115 – RI118 are four derelict pipes.
RI117	41.372567	71.831800	24” C. RI115 – RI118 are four derelict pipes.
RI116	41.372567	71.831800	24” C. RI115 – RI118 are four derelict pipes.
RI115	41.372567	71.831800	18” CMP. RI115 – RI118 are four derelict pipes.
RI114	41.371833	71.831633	18” CMP
RI130	41.37044	71.83139	181 Main Street (RIDOT Outfall 9)
RI100	41.369967	71.831800	48” C Pipe Margin Street (RIDOT Outfall 10)

Source ID	Latitude	Longitude	Description
RI131	41.36829	71.83358	Margin Street. Found 02/05/07.
RI128	41.382367	71.836767	Not visible by boat. Discharges to small cove, ~10' at Outlet.
RI310	41.35390	71.82987	11" C box at River Bend Cemetery
RI311	41.349150	71.826130	24" CMP North of Westerly Yacht Club
RI312	41.348110	71.826240	24" C at Westerly Yacht Club Boat Ramp
RI313	41.347430	71.827630	6" Iron at Westerly Yacht Club

C: Concrete, CMP: Corrugated Metal Pipe, CI: Cast Iron

Upper Pawcatuck River (Rhode Island) – Class SB1 Waters (Westerly-Identified)

Source ID	Latitude	Longitude	Description
W 4	41 21 10.4	-71 49 32.8	24" CPP – Detention Pond at development between Marylou Ave and Hubbard St
W 8	41 22 23.5	-71 49 08.2	6" RCP in Concrete Wall – Granite Street Ponds (Possible Discharge Estuarine)
W 9	41 22 22.5	-71 49 07.5	12" CI – Granite Street Ponds (Possible Discharge Estuarine)
W 30	41 21 51.5	-71 50 07.5	24" RCP with F.E.S. – Detention Pond off Peabody Lane
W 31	41 21 50.9	-71 50 07.0	12" RCP – Peabody Lane

CI: Cast Iron, RCP: Reinforced Concrete Pipe, Corrugated Plastic Pipe

Upper Pawcatuck River (Rhode Island) – Class SB1 Waters (RIDOT-Identified)

Source ID	Description
PAWC 342	Wetland – Beach Street
PAWC 343	Lake/Pond – Beach Street
PAWC 344	24" Metal Pipe, Lake/Pond – Beach Street

Upper Pawcatuck River (Connecticut Sources) – Class SB1 Waters (RIDEM-Identified)

Source ID	Latitude	Longitude	Description
CT100	41.377684	71.831716	6.5" CMP w/in 10' of Broad Street Bridge. Old pipe in retaining wall.
CT101	41.377649	71.831784	6.5" CMP w/in 15' of Broad Street Bridge. Old pipe in retaining wall.
CT102	41.377609	71.831803	42" C w/in 20' of Broad St Bridge
CT103			6" CMP w/in 30' of Broad St Bridge. Old pipe in retaining wall.
CT104	41.377511	71.831976	~5" CMP below wooden fence. Old pipe in retaining wall. Submerged.
CT105	41.376895	71.832323	6.5" CMP below dock across from restaurant
CT106			56" C and rock slab culvert
CT107	41.375243	71.832845	~6.5" Pipe across from Boat Launch. Cobweb visible in photo.
CT108	41.371046	71.831990	~8' by 8' C Outlet w closed trap door. Industrial Facility.
CT109	41.368193	71.836238	3' by 5' C Storm Drain
CT110	41.365761	71.838596	12" Black Plastic Pipe
CT111	41.365438	71.838771	VC in Stone Wall
CT112	41.364453	71.838529	24" C
CT405	41.363533	71.838283	House Boat Mechanic St
CT404	41.352183	71.837633	3" Steel Pipe off bulkhead underwater
CT403	41.352183	71.837650	3' – 4' CMP May Hall Road
CT500			12" C. Next to Pump Station on River Road.

C: Concrete, CMP: Corrugated Metal Pipe, CI: Cast Iron, RCP: Reinforced Concrete Pipe, VC: Vitrified Clay

Lower Pawcatuck River (Rhode Island Sources) – Class SB Waters (RIDEM-Identified)

Source ID	Latitude	Longitude	Description
RI410	41.352133	71.826600	6-8" Iron Inlet at Large Gray House (appears abandoned). Coordinates are incorrect.
RI411	41.341850	71.826983	4" Cast Iron at Same House
RI500	41.325800	71.840900	Inlet ~20' by 3'
RI501	41.326600	71.840500	Culvert Below Road ~5' by 2'. Discharge from Wetland
RI502	41.320800	71.841000	36" C Culvert Below Road. Discharge from Wetland
RI503	41.326600	71.845500	Inlet 4' by 2'
RI600	41.320400	71.849900	Small Stream 5' wide by 21" deep
RI705	41.314500	71.856900	3 Small Pipes - Foster Cove (3", 3", 6") in retaining wall.
RI704	41.315300	71.858300	3 Small Pipes - Foster Cove (2", 3", 4") in retaining wall.

C: Concrete, CMP: Corrugated Metal Pipe, CI: Cast Iron

Lower Pawcatuck River (Rhode Island) – Class SB Waters (Westerly-Identified)

Source ID	Latitude	Longitude	Description
W 55	41 20 17.6	-71 49 24.4	Bituminous swale – Happy Valley Road
W 58	41 20 30.0	-71 49 08.5	18" RCP with F.E.S. – Briar Patch Road[1]
W 68			8" CIP – Foster Cove Road
W 69			Suspected, but not located – Noank Road
W 70			10" CPP – Foster Cove Road, ~50 ft behind garage

[1]Description from GIS Layer locates this on Briar Patch Lane, but Illicit Discharge Detection and Elimination Report identifies it as a detention basin at Gallup Street

Lower Pawcatuck River (Rhode Island) – Class SB Waters (RIDOT-Identified)

Source ID	Description
PAWC 338	Non-Vegetated Bituminous Ditch – Watch Hill Road
PAWC 339	12” Metal Pipe – Watch Hill Road
PAWC 340	Wetland – Watch Hill Road
PAWC 341	Wetland – Watch Hill Road

Lower Pawcatuck River (Connecticut Sources) – Class SB Waters (RIDEM-Identified)

Source ID	Latitude	Longitude	Description
CT402	41.342550	71.831583	River Road Cows and Geese in Water
CT402A			4”. Drainage from River Road. Discharges to Hoxsie Farm pasture.
CT401	41.335767	71.839333	18” RCP Greenhaven Road
CT400	41.333317	71.845033	34” RCP Riverside Drive. Drains wetlands.
CT400A	41.333317	71.845033	Swans

C: Concrete, CMP: Corrugated Metal Pipe, CI: Cast Iron, RCP: Reinforced Concrete Pipe, VC: Vitrified Clay

Watch Hill Cove – Rhode Island Sources – Class SA{b} Waters (RIDEM-Identified)

Source ID	Latitude	Longitude	Description
RI703	41.312200	71.857000	9” CI submerged. Watch Hill Cove
RI702	41.312100	71.856900	12” CI Partially Submerged - Watch Hill Cove
RI701	41.311900	71.857000	12” CI - Watch Hill Cove
RI700	41.310200	71.858500	12” CMP - Watch Hill Cove

C: Concrete, CMP: Corrugated Metal Pipe, CI: Cast Iron

Mastuxet Brook (Rhode Island) – Class B Waters (Westerly-Identified)

Source ID	Latitude	Longitude	Description
W 5	41 21 38.4	-71 49 00.0	Headwall w 3? 18” RCPs – Detention Basin at condominiums near Chickadee Lane
W 32	41 21 38.0	-71 48 42.0	4 ft riprap swale that flows to a detention basin – US 1 near Whipple Ave
W 33	41 21 36.8	-71 48 41.3	18” RCP with F.E.S. flows to detention basin – US 1 near Whipple Ave
W 34	41 21 36.3	-71 48 40.8	18” RCP with F.E.S. flows to detention basin – US 1 near Whipple Ave
W 35	41 21 35.0	-71 48 39.4	18” RCP with concrete F.E.S. flows to detention basin – US 1 near Whipple Ave
W 52	41 20 53.6	-71 48 55.1	24” RCP with F.E.S. – Red Brook Drive
W 53	41 20 56.1	-71 48 54.6	Detention Basin corner of Red Brook Drive and Eddy Drive
W 54	41 21 00.0	-71 48 55.3	18” RCP with F.E.S. – Red Brook Drive

APPENDIX D DIRECT STORMWATER DISCHARGES STATION DATA

Direct Stormwater Discharges Data

- See Appendix C for station location information.
- All samples analyzed using the MPN method and weather condition determined using the National Weather Service's Westerly Rain Gauge.
- Values in fuchsia were reported as less than or greater than the detection limits. They were decreased or increased one significant figure.
- Values in blue bold type are the average of field duplicate samples.
- Additional information about the sampling events can be found in the Final Data Report.

Dry Weather Fecal Coliform Data

	Days Since / Rain Amount (inches)	CT102	CT109	CT112	CT400	CT500	RI103	RI129	RI101[2]	RI102[2]	RI100	RI313	RI700
08/01/06[1]	4 / 0.25	1700	79	540	220	--	1600	--	1700	1700	1600	33	17
08/03/06[1]	6 / 0.25	460	--	--	--	--	5400	--	5400	9200	9200	--	--
05/24/27	6 / 1.34	--	--	--	--	15	--	2.9	--	--	--	--	--
09/25/08	11 / 0.42	--	--	**121.5**	--	--	--	--	2300	--	--	--	--
	COUNT	2	1	2	1	1	2	1	3	2	2	1	1
	GEOMETRIC MEAN	884	79	256	220	15	2939	2.9	2764	3955	3837	33	17
	90th PERCENTILE	1576	79	498	220	15	5020	2.9	4780	8450	8440	33	17

[1]Samples taken on 08/01/06 and 08/03/06 were analyzed for fecal coliform using the A-1 methodology.
[2]Double pipe.

Wet Weather Fecal Coliform Data

	Days Since / Rain Amount (inches)	CT109	CT112	CT403	RI129	RI101	RI130	RI100
09/26/08 5:30	<1 / 2.52 in.	2300	4300	--	--	9300	4300	--
09/26/08 7:30	<1 / 2.52 in.	93,000	7500	--	--	**7500**	150,000	--
09/26/08 9:30	<1 / 2.52 in.	9300	9300	--	--	2300	24,000	2300
09/26/08 14:30	<1 / 2.52 in.	4300	15,000	9300	9300	46,000	24,000	15,000
09/27/08 8:30	1 / 2.52 in.	4300	750	--	--	46,000	--	15,000
	COUNT	5	6	1	1	6	4	3
	GEOMETRIC MEAN	8187	2726	9300	9300	9596	24,689	8029
	90th PERCENTILE	5	6	1	1	6	4	3

Male-Specific Bacteriophage Data

Male-specific bacteriophage (coliphage) is an indicator of enteric viruses that can be analyzed at local laboratories. The method used to enumerate coliphage is direct, rapid, and cost-effective. While coliphage is present in both humans and animals, mean densities of coliphage in pfu/g (phage forming units per gram) are generally greater in human wastes than in animal wastes (exceptions are chicken, landfill seagull, hog, horse, and bay seagull) (Calci *et. al.*, 1998). Since coliphage is present in high densities in treated and untreated effluent, RIDEM has been using the method as an additional tool for bacteria source tracking. Coliphage analysis was completed for all samples taken during the 2006 Shoreline Survey and for all samples taken during the September 2008 intensive wet weather study.

Dry Weather

	Days Since / Rain Amount (inches)	CT102	CT109	CT112	CT400	RI103	RI101[1]	RI102[1]	RI100	RI313	RI700
08/01/06[1]	4 / 0.25	<10	20	<10	10	30	480	347	<10	<10	<10
08/03/06[1]	6 / 0.25	10	--	--	--	<10	310	550	10	--	--
09/25/08	11 / 0.42	--	--	**<1, <1**	--	--	12	--	--	--	--

[1]Double pipe.

Wet Weather

	Days Since / Rain Amount (inches)	CT109	CT112	RI129	RI101	RI130	RI100
09/26/08 5:30	<1 / 2.52 in.	>425	<1	--	185	<1	--
09/26/08 7:30	<1 / 2.52 in.	>670	>434	--	**335, 122**	30	--
09/26/08 9:30	<1 / 2.52 in.	>800	51	--	<1	61	13
09/26/08 14:30	<1 / 2.52 in.	>800	<1	>546	68	>800	1
09/27/08 8:30	1 / 2.52 in.	>800	<1		>800		>800

APPENDIX E SAVE THE BAY STATION LOCATIONS AND DATA

RIDEM has evaluated the Pawcatuck River and Little Narragansett Bay for enterococci using data collected by Save the Bay in 2008 and 2009. Save the Bay conducts its monitoring in conjunction with the University of Rhode Island's Watershed Watch Program. Watershed Watch is a statewide volunteer monitoring program that provides training, equipment, supplies, and analytical services. The program meets strict quality assurance and quality control guidelines in the field and in our state-certified laboratory, which allows its data to be used by RIDEM when assessing water quality conditions in monitored waters. Save the Bay conducts weekly measurements at six stations in this project area. Monthly enterococci samples are also collected.

Save the Bay Station Locations

Station ID	Description	Latitude	Longitude
WWTF North	Upstream Westerly WWTF Outfall	41.364397	71.83723
WWTF South	At Nun Buoy #20	41.349881	71.82991
Pawcatuck Mouth	At Can Buoy #1	41.323425	71.8555
Watch Hill Harbor	At the Flashing Buoy at the entrance channel to Watch Hill Cove.	41.312644	71.86176
Sandy Point	Little Narragansett Bay – North of eastern end of Sandy Point.	41.3244	71.8837
Barn Island	Little Narragansett Bay – Barn Island Ramp (CT Waters)	41.334111	71.8774

Save the Bay Enterococci Data

- Values in fuchsia were reported as less than the detection limits. They were decreased one significant figure.

		Tide	Days Since / Rain Amount (inches)	WWTF North	WWTF South	Paw Mouth	Watch Hill Harbor	Sandy Point	Barn Island
06/18/08	[1]	E	<1 / 0.36	175	74	9.9	NS	9.9	9.9
07/17/08	Dry	H	7 / 0.03	9.9	9.9	9.9	NS	361.5	738
08/21/08	Dry	L	5 / Trace	41	9.9	9.9	NS	9.9	9.9
09/18/08	Dry	F	4 / 0.42	9.9	10	9.9	NS	31	9.9
10/16/08	Dry	H	7 / 0.27	20	9.9	9.9	NS	64	9.9
05/13/09	Dry	F	4 / 0.08	20	120	111	9.9	9.9	9.9
06/17/09	Dry	F	2 / 0.11	20	10	111	20	9.9	9.9
07/15/09	Dry	F	3 / 0.04	10	108	73	9.9	9.9	9.9
08/12/09	Dry	F	2 / 0.08	52	96	10	9.9	10	10
09/09/09	Dry	H	10 / Trace	63	41	9.9	9.9	9.9	9.9
10/14/09	Dry	L	1 / Trace	75	42	20	10	9.9	9.9
			Count	11	11	11	6	11	11
			Geometric Mean	29.3	29.6	19.7	11.1	18.1	14.7

[1]It is difficult to classify the sampling on this date as wet or dry weather sampling. The data from the upper two stations in the Pawcatuck River indicate that there was wet weather influence, while data collected at the remaining stations was consistent with values seen during dry weather conditions.

APPENDIX F CONNECTICUT SHELLFISH PROGRAM STATION LOCATIONS AND DATA

The Connecticut Shellfish Program of the Department of Agriculture (Bureau of Aquaculture & Laboratory Services) monitors the Pawcatuck River. Data were analyzed from 2005 through 2009.

Connecticut Shellfish Program Station Locations

Station ID	Location	Closest RI Shellfish Program Station
19.1	West of Pawcatuck Point (CT)	NA
19.2	At Flashing Buoy #23, mouth of the Pawcatuck River	12-8
19.4	At Greenhaven Marina (Avondale)	12-5
19.5	At Pawcatuck Rock	12-3

Connecticut Shellfish Program Fecal Coliform Data

	Tide	Days Since / Rain Amount (inches)	19.1	19.2	19.3	19.4
01/04/05	L	<1 / 0.67			32	96
02/07/05	E	3 / 0.63			34	78
03/15/05	E	6 / 0.71			1	6
04/19/05	E	11 / 0.78			22	10
05/10/05	E	3 / 0.54	3	10	18	
06/01/05	L	<1 0.04	32	24	171	
06/06/05	E	2 / 0.03	14	76	171	120
11/28/05	E	3 / 0.07	12	42	2	
02/28/06	E	4 / 0.03				3
03/20/06	E	5 / 0.03			10	42
04/11/06	E	2 / 0.61			29	36
06/05/06	E	1 / 2.02	81	81	81	
06/12/06	E	4 / 1.97	73	81	81	
06/21/06	E	<1 / 0.74	81	81		
07/05/06	L	6 / 0.13				171
10/16/06	E	4 / 1				38
11/07/06	E	4 / 0.19	12	24		
11/15/06	E	1 / 0.33	58	50		
12/18/06	E	4 / 0.15				28
01/02/07	E	1 / 2.87			171	171
01/16/07	E	1 / 0.26			32	20
01/30/07	E	2 / 0.03			4	6
03/14/07	E	3 / 0.26			8	2
04/11/07	E	6 / 1.6			1	1
06/11/07	E	1 / 1.5	116	171		

	Tide	Days Since / Rain Amount (inches)	19.1	19.2	19.3	19.4
06/13/07	E	3 / 1.5	8	116		
08/27/07	E	5 / 0.38	6	38		
11/14/07	E	1 / 0.38			2	30
04/16/08	L	3 / 0.06	1	1		
05/13/08	E	3 / 0.53			22	40
05/14/08	L	4 / 0.53	4	10		
06/11/08	E	2 / 0.24			86	171
06/16/08	E	1 / 0.02	84	92		
06/18/08	E	1 / 0.89	34	86		
07/01/08	L	1 / 0.07	6	82		
09/24/08	L	10 / 0.37		26		
10/06/08	E	1 / 0.11	7	21		
11/24/08	L	8 / 0.11			112	18
12/09/08	L	2 / 0.1			24	50
12/15/08	E	3 / 3.44			120	48
02/09/09	E	1 / 0.1			12	14
03/24/09	E	1 / 0.23				1
04/07/09	E	1 / 1.05			171	171
05/06/09	E	0 / 0.09	106	171		
05/19/09	L	2 / 0.53	8	56	78	
06/16/09	L	4 / 0.5	2	36		
08/03/09	E	10 / 2.5	36	90		
10/21/09	E				72	78
10/27/09	E		28	140		

COUNT	**23**	**24**	**27**	**26**
GEOMETRIC MEAN	**17.2**	**45.3**	**25.7**	**25.3**
90th PERCENTILE	**83.4**	**132.8**	**171.0**	**171.0**

APPENDIX G BACTERIA SOURCE INVESTIGATION – CLARKS VILLAGE AND GAVITT POINT

RIDEM began investigating the source of increasing bacteria concentrations upstream of Stanton Weir Point, in the vicinity of Clarks Village and Gavitt Point, during the Joint Agency 2006 Shoreline Survey of the Pawcatuck River. Instream sampling conducted during this study showed bacteria concentrations decreased as one moves downstream of the freshwater Pawcatuck River. This trend of decreasing bacteria concentrations ended upstream of Stanton Weir Point. While this area does contain two wastewater treatment facility outfalls, bacteria concentrations from effluent samples taken during the shoreline survey were much lower than the instream concentrations, suggesting that the outfalls are not the cause of the increasing bacteria concentrations. It is noted that daily fluctuations in WWTF effluent quality can occur and thus these sources cannot be ruled out.

Instream Sampling Results

At the time of the shoreline survey, RIDEM added additional stations in this area of concern. While the sampling was inconclusive at the time of the shoreline survey, RIDEM has continued sampling these stations in an attempt to characterize the problem and to determine the source of the bacteria. RIDEM has sampled this area eight times since August 2006, including the three sampling runs conducted during the shoreline survey. The data are presented in the Table below. Values shown in red are higher than bacteria concentrations at their upstream stations.

Table G.1 Upstream of Stanton Weir Point Bacteria Concentrations (MPN/100 mL)1.

		08/01/06[2] DW, Low Tide	08/02/06[2] DW, Low Tide	08/04/06[2] DW, Ebb Tide	09/19/06[2] DW, High Tide	09/20/06 WW, Ebb Tide	07/13/07 DW, High Tide	07/26/07 DW, Ebb Tide	08/30/07 DW, Flood Tide	08/07/08 WW, Flood Tide	09/23/08 DW, Low Tide
PR01	Freshwater Pawcatuck River						43	230	**96.5**	430	93
PR4	Upstream state boat ramp						230	930	460	460	23
12-1	Opposite red brick building	130	140		93	460	230	230	240	1100	43
1A	Radio Tower at River Bend				93						
12-17	Westerly WWTF	110	170	>1600	93	240	150	230	23	390	93
17A	CT side of 'Duck' Sandbar			>1600	930		460	430	93	11000	390
12-2	At nun buoy #26				230	1500	460	4600	240	1500	150
17B	Cove south of Gavitt Point, north of concrete pump station			>1600	2300		460	2400	240	11000	43
19.6	Pawcatuck WWTF	1600	350	1600	430	4600	1100	11000	64	4600	93
17C	Stanton Weir Point			540	430						
12-3	At nun buoy #20	240	220	1600	430	430	460	4600	93	430	93

[1]Values in blue bold type are the average of duplicate samples.
[2]Samples analyzed using the A-1 methodology.

As a result of this sampling and an evaluation of some potential sources, the following conclusions could be made.

- The sampling has eliminated potential sources within the channel of Stanton Weir Point (station 17C) as a source.

- Upstream of Gavitt Point, opposite the Westerly WWTF outfall, there is a sandbar that is exposed at low tide. Numerous waterfowl have been seen in this vicinity. Station 17A was added on the Connecticut side of the sandbar to attempt to isolate the waterfowl as a potential source. This station is not in the main flow path of the river. In general, this station samples higher than the sample taken at the Westerly WWTF outfall (Station 12-17), which is located in the main flow path of the river at the same latitude as Station 17A. Bacteria concentrations at Station 17A are usually lower than concentrations at stations downstream of the Westerly WWTF outfall. This indicates that while the waterfowl most likely contribute bacteria to the Pawcatuck River, there appears to be another source causing the increased bacteria concentrations downstream.
- The highest bacteria concentrations have been measured in the vicinity of the Pawcatuck WWTF outfall (station 19.6). While a further review of the plant data is needed to eliminate the outfall as a possible source, available data and discussions with CT DEP and CT Aquaculture have indicated that this plant operates as required. Another possible source is the pump station and sewer lines in the vicinity of station 17B, which is located west of the station at the Pawcatuck WWTF outfall. These should be inspected.
- RIDEM has reviewed Westerly WWTF monthly operating reports from January 2006 to July 2008. In 402 daily grab samples collected three times per week, the highest value was 220 MPN/100 mL. The remaining samples were less than 31 MPN/100 mL.)

Historic Water Quality Data

An analysis was conducted using RI Shellfish Program ambient water quality data collected between1989 and 2003 at four stations located in this area. Tidal analysis shows that bacteria concentrations were highest at the station upstream of the Pawcatuck WWTF (12-2) outfall on flood tides and highest at the station downstream of the outfall at ebb and low tides (12-3). The station at the Westerly WWTF outfall was high during high and low tides. The Rhode Island Shellfish Program did not sample at Pawcatuck WWTF outfall.

Table G.2 Tidal Analysis of Shellfish Program Data (MPN/100 mL).

		Flood Tide		High Tide		Ebb Tide		Low Tide	
		No.	Geometric Mean	No.	Geometric Mean	No.	Geometric Mean	No.	Geometric Mean
12-1	Upstream Westerly WWTF	12	240	5	96	9	229	4	114
12-17	Westerly WWTF	9	108	4	478	7	96	3	926
12-2	Upstream Pawcatuck WWTF	12	300	5	200	9	170	4	165
12-3	Westerly Yacht Club	12	181	5	122	9	204	4	521

The data were also separated between summer and winter months and weather conditions within the summer and winter months. There did not appear to be a trend between the summer and winter months other than summer data are higher than winter data.

Table G.3 Summer Analysis of Shellfish Program Summer Data (MPN/100 mL)[1].

		All		Dry		Wet	
		No.	Geometric Mean	No.	Geometric Mean	No.	Geometric Mean
12-1	Upstream Westerly WWTF	18	290	9	292	9	288
12-17	Westerly WWTF	13	350	8	268	5	535
12-2	Upstream Pawcatuck WWTF	18	330	9	388	9	280
12-3	Westerly Yacht Club	18	269	9	213	9	342

[1]June through September

Table G.4 Winter Analysis of Shellfish Program Summer Data (MPN/100 mL)[1].

		All		Dry		Wet	
		No.	Geometric Mean	No.	Geometric Mean	No.	Geometric Mean
12-1	Upstream Westerly WWTF	12	93	6	70	6	123
12-17	Westerly WWTF	10	74	6	29	4	307
12-2	Upstream Pawcatuck WWTF	12	117	6	72	6	193
12-3	Westerly Yacht Club	12	132	6	62	6	280

[1]October through May

Estimating the Scale of the Bacteria Source

An attempt was made to estimate the scale of the bacteria contamination entering the problem area. The goal of this illustration was to determine what source concentration and flow rate would be needed to increase the instream bacteria concentration from 200 MPN/100ml to 400 MPN/100 mL in this reach of the Pawcatuck River. For the exercise, the median daily Pawcatuck River flow of 200 ft^3/sec (Westerly USGS[5]) was used along with the above increase in bacteria concentration (200 MPN/100 mL) to determine the bacteria load in the reach. This resulted in a pathogen load rate of 1.13E+07 MPN/sec. This bacteria load rate was then applied to representative flows that ranged from a large outfall to the July – August median flow observed in the Pawcatuck River. The exercise showed that the concentration of the unknown bacteria source to Pawcatuck River would have to range from 606 MPN/100ml for a flow equivalent to the median of the Pawcatuck to over 200,000 MPN/100ml for flows typically observed from large outfalls. The table below shows the results of these calculations.
It can be surmised that the pathogen concentrations of the source(s) would have to be three orders of magnitude higher than the instream concentrations observed in the Pawcatuck River (e.g. as could be expected from a cracked or leaking sewer line).

[5] USGS graphs for this location show a median flow over the last 67 years of around 200cfs for July.

Table G.5 Estimates of Source Flow Rates and Concentrations.

Flow Rate Equivalent	Flow Rate			
	L/sec	ft^3/sec	gal/min	MPN/100 mL
Freshwater Pawcatuck River	5500	194.28	24.25	606
	500	17.66	2.20	2665
	250	8.83	1.10	4930
	100	3.53	0.44	11724
	10	0.35	0.04	113640
~ Pipe[6]	5	0.18	0.02	226880

An additional estimate was made of how many waterfowl it would take to increase bacteria concentrations in the problem area by 200 MPN/100 mL. Hussong et al (1979) and Koppelman and Tanenbaum (1982) calculated theoretical loading values for fecal coliform inputs from waterfowl. Ducks and swans were reported to produce 10^9 coliforms per day, while geese contributions were estimated at 10^7 fecal coliforms per day. It was calculated that it would take 978 ducks and swans or 97,800 geese to increase bacteria concentrations by 200 MPN/100 mL in a river the size of the Pawcatuck River.

It is estimated that the source may be even larger than these calculations due to some of the conservative assumptions used during this exercise. The flow from the freshwater Pawcatuck River enters this area over 3 kilometers (under 2 miles) upstream. Additional groundwater flow would be expected to enter the River in these 3 kilometers. Also, the instream bacteria increase was most likely underestimated at 200 MPN/100 mL. As shown in Table 1, it is not uncommon for instream concentrations to increase from the low hundreds to the low thousands.

Recommendations for Further Investigation

The TMDL program will continue to sample additional stations in this area throughout its sampling surveys. Additional recommendations include:

- Analysis of all bacteria data collected at the Pawcatuck WWTF within the last two years. These data along with information on sewer infrastructure should eliminate both plants as the source of the elevated bacteria concentrations. As mentioned previously, RIDEM has reviewed data from the Westerly WWTF.
- Investigate the sewage collection system infrastructure for leaks and/or failures, including the sewer lines and pump station in the vicinity of station 19.6 and 12-2B. This infrastructure is part of the Pawcatuck WWTF collection system. Since the source does not appear to be constant, an extensive investigation may be needed.
- Investigate the feasibility of using bacteria source tracking techniques (DNA, caffeine, etc.) in this area of the Pawcatuck River. Due to the large volume of water in the Pawcatuck River, some techniques may not be feasible due to the impact of dilution. The purpose of the testing would be to eliminate or to confirm human and/or waterfowl sources. The bacteria source testing would support these intensive investigations. Also, if the bacteria source tracking reveals that waterfowl are the problem, we can be more confident when telling the public that the WWTFs are not causing the problem despite

[6] During the 2006 Pawcatuck Shoreline Survey, sources RI101 and RI102, side-by-side 36 inch pipes were found to have a combined flow rate of just over 5 L/sec (1 L/sec for one side and 4 L/sec for the other side).

their presence in the area. One bacteria source tracking technique, coliphage, was tried during the 2006 Shoreline Survey. The values were very low.

APPENDIX H RESPONSE TO COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD

The following comments were received by RIDEM during the public comment period for the draft Pawcatuck River and Little Narragansett Bay Waters TMDL document. The complete text of all comments received is on file in the Office of Water Resources at DEM.

Save the Bay
Dave Prescott, South County Coastkeeper (letter sent by email September 17, 2010)
Comment 1
A watershed management plan needs to be developed for the freshwater portions of the Pawcatuck River. The freshwater portion of the river, as you mention in the TMDL, is a significant wet weather source of contamination and clearly needs to be addressed.
RIDEM Response
As stated in the TMDL, EPA requires that states develop Watershed Management Plans to become eligible for grant funding under Section 319 of the federal Clean Water Act. Also, an EPA contractor has begun work on a Statewide Bacteria TMDL, which includes two upstream freshwater Pawcatuck River segments and several tributaries. This project is scheduled to be complete in mid-2011. The TMDL and the Watershed Management Plan, to be developed in the future, will identify and recommend mitigation activities that will improve water quality to the estuarine Pawcatuck River. Also, it is our understanding that the CTDEP plans to begin monitoring of the furthest downstream freshwater reach of the Pawcatuck River in Summer 2011 as a first step in developing a TMDL.

Comment 2
An interstate management cooperative framework that involves the state agencies, towns, NGO's, and other concerned parties needs to be developed to address continued water quality impairments to the river. The Chesapeake Bay model could potentially serve as a template for dealing with such issues. Most importantly, more open and transparent communication needs to occur between the two states and two towns. Potentially, a one-day annual workshop dealing specifically with these issues might be an effective way to get all concerned parties to the table.
RIDEM Response
The Office of Water Resources agrees that an interstate management cooperative would be a useful tool to aid in the implementation of activities that would mitigate elevated bacteria concentrations, and would be happy to participate in a one-day workshop but does not have the resources to organize such an event. Possibly Save the Bay working with the Wood Pawcatuck Watershed Association or other area NGOs could take on the task of organizing such a meeting?

Comment 3
A wildlife management plan that deals directly with the waterfowl issue in the river is essential. This plan needs to be developed by both state agencies and both neighboring towns in order to reduce this population. Waterfowl, specifically swans and Canada geese, are having a detrimental effect on localized water quality as well as leading to the destruction of coastal habitats, such as salt marshes and coastal buffers.
RIDEM Response
RIDEM agrees that reducing the waterfowl populations along the Pawcatuck River will require a bi-State solution. RIDEM requests EPA's and CTDEP's assistance in bringing together state and

federal wildlife agencies to address nuisance swan and Canada geese populations on the Pawcatuck River. As mentioned in the TMDL, the RIDEM Division of Fish and Wildlife has developed a management plan to control the state's swan population, which includes the routine monitoring of swan populations (a summer aerial survey to identify swan nests and a fall productivity survey) as well as working to actively reduce the state's swan population from the currently estimated population of 1,400 to 300. While this program has been successful in reducing population to less than 1000, it is not currently funded.

Comment 4

A thorough education and outreach program to address feeding of local wildlife along the river is also an important step to informing the public about their individual actions. This program needs to be presented to landowners and the public on both sides of the river.

RIDEM Response

RIDEM agrees that this is an important step. This could be a potential role for Save the Bay or the Wood Pawcatuck Watershed Association (WPWA).

Comment 5

Approved harbor management plans for both Westerly and Stonington need to be completed and approved. This will give authority to the local harbormasters to enforce *No Discharge* laws. While the two towns have an incredible marine pump-out program, more on-the-water enforcement is essential.

RIDEM Response

RIDEM agrees that these communities should have approved Harbor Management Plans. It is our understanding that CRMC is working with the Westerly Harbor Management Commission in preparing a Harbor Management Plan. In the meantime, Rhode Island General Law §46-12-41 gives harbormasters the authority to enforce the state's *No Discharge* requirements.

Comment 6

A continued RIDEM enforcement presence in the river and Bay is vital. For the past two years, having RIDEM enforcement has been very effective in creating that presence, specifically in Little Narragansett Bay and Watch Hill Cove. We hope that the enforcement vessel and staff will be able to retain that presence in the future.

RIDEM Response

Assuming level funding, RIDEM Enforcement is anticipating that current level in the region can be maintained.

Comment 7

A thorough inspection of the Pawcatuck WWTF pump station along River Road and its infrastructure is needed. Save The Bay and RIDEM's water quality data continues to show high bacteria numbers in that area. More work needs to be conducted to determine if there is a localized source.

RIDEM Response

CTDEP indicates that they have inspected this pump station. CTDEP would like to re-sample the river to confirm that elevated bacteria concentrations are still present before undergoing additional investigations of the sewer infrastructure in this area.

Comment 8
Connecticut Department of Environmental Protection needs to develop its own TMDL for the Pawcatuck River and Little Narragansett Bay. These efforts need to supplement those that have been proposed by RIDEM in this draft TMDL, so that efforts can be made to improve the water quality on *both* sides of the river and Bay.
RIDEM Response
RIDEM agrees.

The Watch Hill Conservancy
Juliana Berry, Environmental Projects Coordinator, Napatree Point Conservation Area
The Napatree Point Conservation Area (the Napatree Point barrier beach, Watch Hill) is jointly managed by the Watch Hill Conservancy and the Watch Hill Fire District. Since 2007, water quality samples have been taken weekly and analyzed for dissolved oxygen, salinity, and chlorophyll in conjunction with the University of Rhode Island's Watershed Watch. Similarly, monthly samples have also been taken and analyzed for bacteria (fecal coliform and enterococci), total nitrogen, ammonia-nitrogen, nitrate+nitrite –nitrogen, total phosphorous, and pH. Water temperature and depth, wind and light levels, and the precipitation over the preceding 48 hours is also recorded during each sampling event. Samples taken in 2007-2010 were on the Atlantic Ocean/Fishers Island Sound side of Napatree (one quarter of the distance –east to west- between the Misquamicut Beach Club and Napatree's westernmost point in approximately 20 feet of Class SA waters) and on the Little Narragansett Bay side of Napatree (halfway –east to west- between Watch Hill Cove and "The Kitchen" in the Class SA{b} waters). An additional site in the middle of Foster's Cove was added in 2010. All samples are taken consistently between May and September by boat. (All samples referred to in the following Comments were taken on the Little Narragansett Bay side.)

Comment 1
It is not clear that the station referred to on page 23, first full paragraph, as "closest to shoreline" which reportedly violates standards during dry and wet weather, is actually station 12-16. The maps are not at a scale to adequately represent distance-to-shore differences for stations 12-14, 12-15, and 12-16, which are all referred to in the sentence beginning "In Watch Hill Cove …", and the paragraph does not refer to Table 3.1 wherein the violations are explicitly listed. We recommend including station numbers in this paragraph, with regards to Watch Hill Cove at least, for clarification purposes.
RIDEM Response
The sentence has been clarified.

Comment 2
The first paragraph on page 33, regarding Save The Bay enterococci data, states that "an evaluation…shows that all stations meet the enterococci recreational standard". It should be noted that our monthly sample taken and analyzed in August 2009 did violate HEALTH's single sample maximum with a measurement of 504 enterococci per 100mL. This sample was taken after relatively dry weather (<0.5 inches of rain in the previous 48 hours prior to sampling).

Further, that same paragraph states that "the fecal coliform and enterococci data for Little Narragansett Bay and Watch Hill Cove are consistent in that both meet their recreational criteria". Our 2009 sampling yielded fecal coliform measurements that violated both the variability (10%) recreational standard value of 400 (after <0.5 inches of rain in the previous 48 hours prior to sampling) and the geometric mean recreational standard value of 50 (all of the 2009 samples were taken after <1.0 inches of rain in the previous 48 hours prior to sampling).

These results seem to reinforce RIDEM's decision to continue to list the Pawcatuck River area as impaired for recreational uses. They also raise concerns about bacterial sources near and at Napatree Point since the Napatree area is heavily utilized for recreational purposes. Thus far in 2010, however, both fecal coliform and enterococci levels meet all criteria per our sampling.

RIDEM Response

It should be noted that the RIDEM water quality regulations for enterococci separate waters into designated and non-designated bathing beach waters. The single sample maximum only applies to samples taken at designated bathing beaches. Also, a single fecal coliform sample of 400 would not automatically violate the geometric mean and variability fecal coliform criteria. The statistics would be calculated only after this sample was included in the dataset being studied.

It should also be noted that the TMDL used a differing criterion than the one mentioned above for determining if a sample was taken under dry versus wet weather conditions. As detailed on page 33, wet weather conditions occurred when sampling within five days of receiving 0.5 inches or more of rain in a 24-hour period. Dry weather conditions generally occurred when no more than 0.1 inches of rain fell the in the day proceeding sampling and when there was more than five days since the area experienced 0.5 inches or more of rain. It is possible that the elevated samples mentioned above occurred after wet weather events. In any event, the sampling referenced above reinforces the TMDL conclusions and implementation recommendations.

Going forward, RIDEM will evaluate the data collected by the Watch Hill Conservancy, which is received directly from Watershed Watch, to assess compliance with criteria as part of the water quality assessment process.

Comment 3

There is a concern about the recent draft proposal of the Westerly Harbor Management Commission, especially in light of the localized dry weather bacteria sources in Watch Hill Cove as referred to on page 44 and 53 and listed in Appendix C on page 73.

The draft proposal suggests unlimited anchorage in Little Narragansett Bay, north of Napatree Point. Since it is admitted by RIDEM to be difficult to distinguish between natural bacteria sources vs. human/wildlife sources (page 39) and RIDEM has recommended the development of Marine Sanitation Device inspection policies in this TMDL, it seems possible that even if the identified pipes in Watch Hill Cove were properly regulated and subsequently mitigated the levels of bacteria could remain above criteria if moorings were allowed to multiply without restraint. This could easily result in numbers of vessels beyond the capacity of any municipality or organization to keep up with implemented inspection policies, beyond the pump-out capacities of nearby facilities, and beyond the capacity of the existing (and with no adjacent undeveloped space, the only possible) on-shore sanitary facilities.

Please also note that the draft proposal recommends a new on-shore pump-out facility in Watch Hill Cove. Although it would certainly assist the marina in terms of convenience, the Watch Hill Fire District (which owns and operates the docks in the Cove) has evaluated the Cove and deemed there to be no suitable location for such a facility. Moreover, the addition of such a facility would only exacerbate the potential for further fecal coliform and enterococci impairments in the relatively small Cove. Guidance from RIDEM would be welcome in this matter.

RIDEM Response

The Office of Water Resources has no Harbor Management Plan for Westerly on file at this time. When Westerly does submits its Harbor Management Plan to RIDEM for Water Quality Certification, the review process would ensure consistency with water quality standards. The process would include comparing the EPA-recommended ratio for pump-out facilities to boats with MSD to conditions proposed in the Plan. Greywater and other site-specific issues would also be considered in the review process.

Relative to meeting sewage disposal needs of the anchorage off Napatree Point, DEM finds that the most-effective way to meet the needs of such areas is with pump-out boats. There are currently two pump-out boats that are run by the Town of Westerly that service this area. In 2009, these boats pumped 39,237 gallons of waste with an additional 23,896 gallons deposited at the Westerly Yacht Club's facility.

Also, there is a Marine Sanitation Device (MSD) sticker program. Boats are certified every four years, usually by local marina before the boats are launched.

Final Meeting Notes and Comments

A public meeting was held on Thursday, August 19, 2010 at 7:00 PM. There were between 20 and 25 people who attended. Elizabeth Scott provided introductions. Heidi Travers provided detail on the specific project including project area, data collection, TMDL reductions, and implementation.

Public Meeting Comments

John Turano, Westerly Town Solicitor

Comment

Have we broken down the sources of bacteria by percent contribution?

Response

Human versus non-human sources of bacteria are treated the same in the Rhode Island water quality standards. That is, if there are fecal coliform and/or enterococci bacteria present in quantities that exceed criteria then there is a violation, regardless of the source of those bacteria. The TMDL document does describe the use of coliphage to determine which storm drains with elevated bacteria levels had a higher likelihood of being human as a tool for focusing implementation efforts.

Comment

What impact would the TMDL have on Harbor Management Plan approval?

Response

When Westerly submits a Harbor Management Plan to RIDEM for Water Quality Certification, the review process would ensure the plan is consistent with water quality standards. The process would include comparing the EPA-recommended ratio for pump-out facilities to boats with MSD to conditions proposed in the Plan. Greywater and other site-specific issues would also be considered in the review process.

John Mazzanier

Comment

Mr. Mazzanier described the headwaters of Mastuxet Brook as being located 50 feet off Wells Street. He described them as emerging from a storm water feeding system. Sampling data that he collected showed conductivity to be greater than 100.

Response

RIDEM will use this information next time we are doing fieldwork in the area to locate the headwaters of Mastuxet Brook. The dry weather problems in Mastuxet Brook have been isolated to an area downstream of the headwaters between Whipple Avenue and Rotary Park. The conductivity numbers are not inconsistent for freshwaters.

Dave Prescott, Save the Bay Coastkeeper

Mr. Presecott expanded on his comments from the public meeting in his written comments to the TMDL. RIDEM responded to these comments in the section above. Specifically his comments during the meeting dealt the need for inter-state cooperation, boater education, and an enforcement presence in the Pawcatuck River and Little Narragansett Bay. Mr. Prescott stated that the illegal shellfish harvesting is a problem in this area. He oftentimes finds people harvesting shellfish from areas that are closed due to elevated bacteria counts. When he sees people harvesting he will call the RIDEM enforcement phone number to report the incident.