TOTAL MAXIMUM DAILY LOAD STUDY FOR BACTERIA
MOUNT HOPE BAY AND THE KICKEMUIT RIVER ESTUARY

303(d) listings addressed in this study:
Kickemuit River (RI0007033E-01A)
Kickemuit River (RI0007033E-01B)
Kickemuit River (RI0007033E-01C)
Mount Hope Bay (RI0007032E-01A)
Mount Hope Bay (RI0007032E-01B)
Mount Hope Bay (RI0007032E-01C)
Mount Hope Bay (RI0007032E-01D)

State of Rhode Island
Department of Environmental Management
Office of Water Resources
Surface Water Protection Section

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ABSTRACT

Section 303(d) of the federal Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards. The objective of a TMDL is to establish water-quality-based limits for pollutant loadings that allow the impaired waterbody to meet standards. This TMDL addresses water quality impairments associated with fecal coliform bacteria in Mount Hope Bay and the Kickemuit River estuary in northeastern Rhode Island. All waterbody segments in Mount Hope Bay and the Kickemuit River estuary experience elevated levels of fecal coliform bacteria following rain events.

In the state's 2008 Integrated Report, RIDEM included 3 waterbody segments in Mount Hope Bay and 3 segments in the Kickemuit River estuary as candidates for TMDL development based on impairments due to elevated levels of fecal coliform (RIDEM 2008). Based on more recent data collected, an additional waterbody segment in Mount Hope Bay (RI0007032E-01A) will be included on the 2010 303(d) List of Impaired Waters for not meeting the shellfish consumption use, and is addressed by this TMDL.

This TMDL provides a detailed plan for reducing bacterial pollution so that the Kickemuit River and the Rhode Island portion of Mount Hope Bay can meet numeric water quality targets for all designated uses affected by bacteria pollution: shellfishing and primary and secondary contact recreational use. Combined sewer overflows from the City of Fall River, MA have been determined to be the largest source of fecal bacteria to Mount Hope Bay during wet weather. Ongoing construction of facilities to store and treat the combined sewage have begun to mitigate this source, though data documentating the reductions has not been collected. Stormwater runoff from the City of Fall River and other municipalities in both RI and MA also contribute to the observed impairments in the Rhode Island portion of the Bay.

In order for water quality to meet shellfishing criteria bay-wide under the critical condition of wet weather, significant reductions in all sources must be accomplished. This TMDL will establish requirements for those sources in RI, while the TMDL being developed concurrently by the Massachusetts Department of Environmental Protection (MADEP) will address bacteria sources in that state. The TMDL recommendations complement existing pollution reduction efforts in the watershed, namely the Fall River CSO abatement project, and TMDL development efforts in the Massachusetts portion of Mount Hope Bay by MADEP.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards. The objective of a TMDL is to establish water-quality-based limits for pollutant loadings that allow the impaired waterbody to meet standards. This TMDL addresses water quality impairments associated with fecal coliform bacteria in Mount Hope Bay and the Kickemuit River estuary in northeastern Rhode Island.

In the state's 2008 Integrated Report, RIDEM included 3 waterbody segments in Mount Hope Bay and 3 segments in the Kickemuit River estuary as candidates for TMDL development based on impairments due to elevated levels of fecal coliform (RIDEM 2008a). A pollutant reduction target will also be developed for an additional waterbody segment in Mount Hope Bay (RI0007033E-01A) that, while fully supportive of the uses of shellfish consumption and primary and secondary contact recreation is currently closed to shellfishing due to an administrative closure. All waterbody segments in Mount Hope Bay and the Kickemuit River estuary experience elevated levels of fecal coliform bacteria following rain events. All seven waterbody segments are listed in Table 1.1 and their geographic boundaries within Mount Hope Bay are shown in Figure 1.1.

This TMDL provides a detailed plan for reducing bacterial pollution so that the Kickemuit River and the Rhode Island portion of Mount Hope Bay can meet numeric water quality targets for all designated uses affected by bacteria pollution: shellfishing and primary and secondary contact recreational use. Combined sewer overflows from the City of Fall River, MA have been determined to be the largest source of fecal bacteria to Mount Hope Bay during wet weather. Ongoing construction of facilities to store and treat the combined sewage have begun to mitigate this source, though data documentating the reductions has not been collected. Stormwater runoff from the City of Fall River and other municipalities in both RI and MA also contribute to the observed impairments in the Rhode Island portion of the Bay.

In order for water quality to meet shellfishing criteria bay-wide under the critical condition of wet weather, significant reductions in all sources must be accomplished. This TMDL will establish requirements for those sources in RI, while the TMDL being developed concurrently by the Massachusetts Department of Environmental Protection (MADEP) will address bacteria sources in that state. The TMDL recommendations complement existing pollution reduction efforts in the watershed, namely the Fall River CSO abatement project, and TMDL development efforts in the Massachusetts portion of Mount Hope Bay by MADEP.

1.1 Study Area

This TMDL addresses waterbody segments located in the Rhode Island portion of Mount Hope Bay and the estuarine portion of the Kickemuit River as shown in Figure 1.1. Data collection efforts to support this TMDL study extended into the Massachusetts portion of Mount Hope Bay and included sampling in the Taunton, Lee, and Cole Rivers.

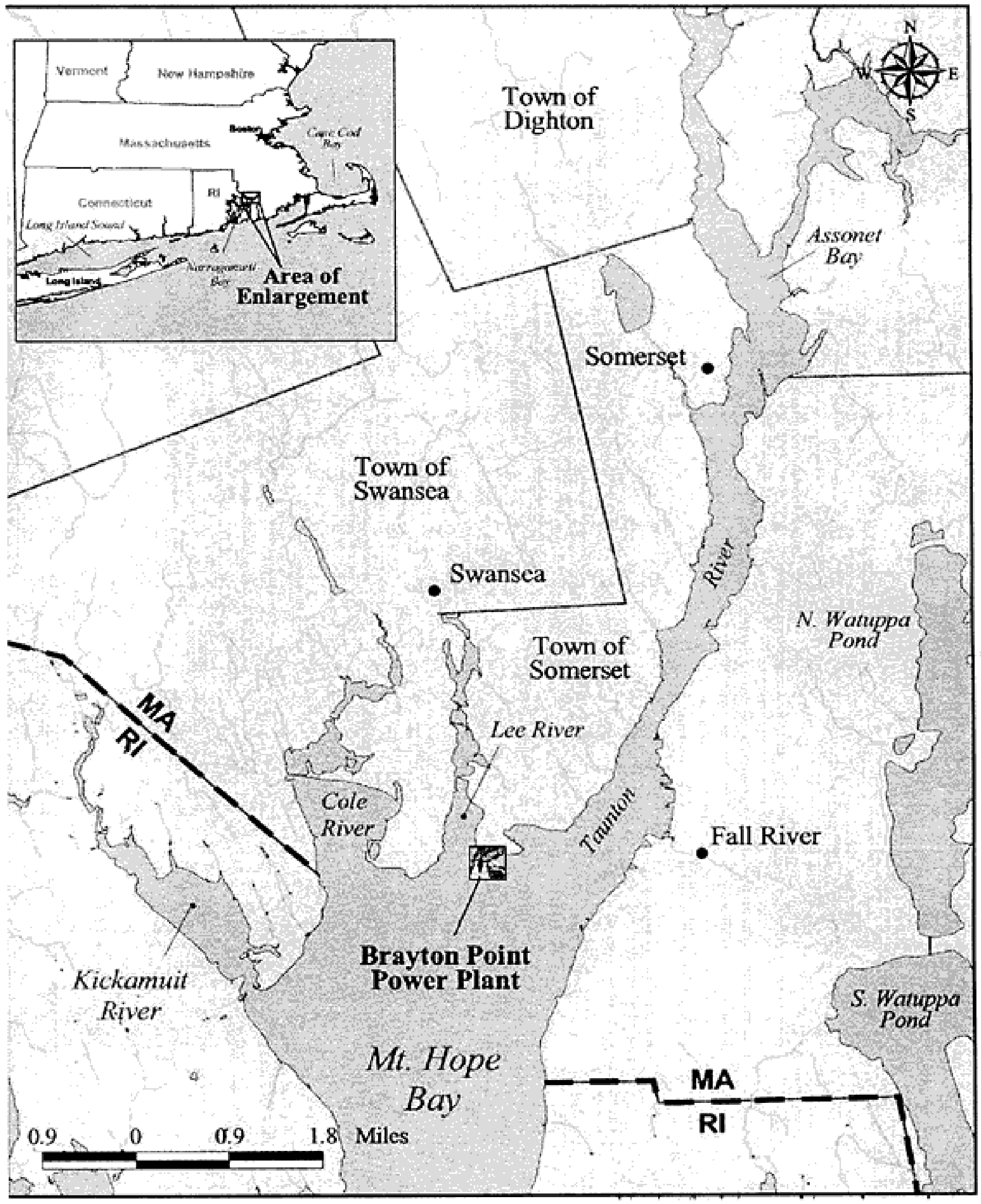


Figure 1.1 General location map of Mount Hope Bay and the Kickemuit River estuary.

Waterbody Descriptions

Waters of the state have been assigned to an assessment unit (AU), which refers to a geographically defined waterbody or waterbody segment. Each assessment unit has been assigned an identifying number, referred to as a waterbody ID number. These identifying numbers are unique to the waterbody and allow for tracking of assessment information and indexing in the RIGIS (Rhode Island Geographic Information System) for mapping purposes. Waters are segmented to reflect classification changes, hydrologic drainage basin, assessment changes, land use changes, specific sources of pollution to that segment, or, if applicable, any changes in shellfish growing area status.

The Rhode Island portion of Mount Hope Bay is divided into four (4) separate waterbody segments while the Kickemuit River is divided into three (3) waterbody segments. Table 1.1 presents additional information for these segments. Figure 1.2 complements Table 1.1 and displays the geographic boundaries of each waterbody segment.

Table 1.1 Waters in the Study Area and their Water Quality Classifications.

Waterbody ID	Waterbody	Water Use Classification	Current Shellfishing Status	Waterbody Size
RI0007032E-01A	Mount Hope Bay	SA[@]	Prohibited	4.28 mi^2
RI0007032E-01B	Mount Hope Bay	SA	Conditionally Approved	2.01 mi^2
RI0007032E-01C	Mount Hope Bay	SB	Prohibited*	3.05 mi^2
RI0007032E-01D	Mount Hope Bay	SB1	Prohibited*	0.48 mi^2
RI0007033E-01A	Kickemuit River	SA	Conditionally Approved	0.70 mi^2
RI0007033E-01B	Kickemuit River	SA{b}	Conditionally Approved Seasonal Closure	0.073 mi^2
RI0007033E-01C	Kickemuit River	SA{b}	Conditionally Approved Seasonal Closure	0.09 mi^2

[@]Closed Safety Zone- These waters are in the vicinity of an approved sanitary discharge which may be impacted in the event of complete failure of treatment and are therefore currently prohibited to shellfishing. Although shellfishing use is restricted, all SA criteria must be met.

* Shellfish harvesting is not a designated use assigned to SB water use classifications. These waters are impaired for primary and contact recreational use due to elevated levels of fecal coliform during and after wet weather.

Waterbody Segment Impairments

Figure 1.2 graphically displays waterbody segment locations in the study area (detailed descriptions are provided in Table 1, Appendix A). Table 1.2 describes the use descriptions, use attainment status, and all causes of impairment for each segment, as described in the 2008 303(d) List of Impaired Waters. This TMDL addresses impairments associated with the designated uses of primary and secondary contact recreation and shellfish consumption as described in Table 1.2. Based on more recent data collected, Segment RI0007032E-01A in Mount Hope Bay is proposed for listing on the 2010 303(d) List of Impaired Waters for not supporting the shellfish consumption use.

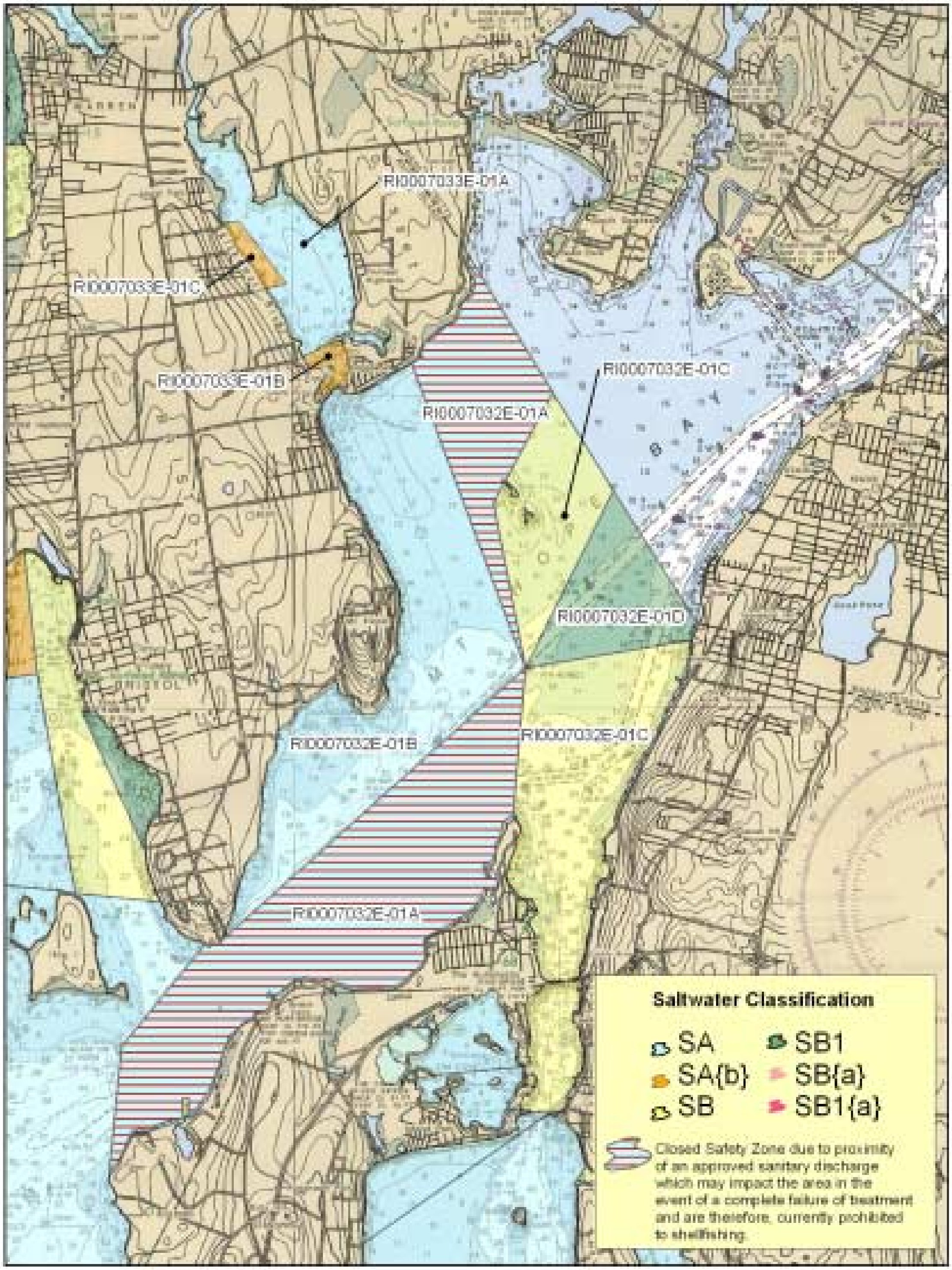


Figure 1.2 Applicable water use classifications in Mount Hope Bay and the Kickemuit River.

Table 1.2 Waterbody Segment Information from 2008 Integrated Report-303(d) List.

Waterbody Segment	Use Description	Use Attainment Status	Cause of Impairment
MOUNT HOPE BAY			
RI0007032E-01A	Fish and Wildlife Habitat	Not Supporting	Fish Bioassessments
			Total Nitrogen
			Dissolved Oxygen
			Water Temperature
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Fully Supporting	
	Secondary Contact Recreation	Fully Supporting	
	Shellfish Consumption	Fully Supporting	
RI0007032E-01B	Fish and Wildlife Habitat	Not Supporting	Fish Bioassessments
			Total Nitrogen
			Dissolved Oxygen
			Water Temperature
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Fully Supporting	
	Secondary Contact Recreation	Fully Supporting	
	Shellfish Consumption	Not Supporting	Fecal Coliform Bacteria
RI0007032E-01C	Fish and Wildlife Habitat	Not Supporting	Fish Bioassessments
			Total Nitrogen
			Dissolved Oxygen
			Water Temperature
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Not Supporting	Fecal Coliform Bacteria
	Secondary Contact Recreation	Not Supporting	Fecal Coliform Bacteria
	Shellfish Controlled Relay and Depuration	Fully Supporting	
RI0007032E-01D	Fish and Wildlife Habitat	Not Supporting	Fish Bioassessments
			Total Nitrogen
			Dissolved Oxygen
			Water Temperature
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Not Supporting	Fecal Coliform Bacteria
	Secondary Contact Recreation	Not Supporting	Fecal Coliform Bacteria
KICKEMUIT RIVER			
RI0007033E-01A	Fish and Wildlife Habitat	Not Assessed	
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Fully Supporting	
	Secondary Contact Recreation	Fully Supporting	
	Shellfish Consumption	Not Supporting	Fecal Coliform Bacteria
RI0007033E-01A	Fish and Wildlife Habitat	Not Assessed	
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Fully Supporting	
	Secondary Contact Recreation	Fully Supporting	
	Shellfish Consumption	Not Supporting	Fecal Coliform Bacteria
RI0007033E-01A	Fish and Wildlife Habitat	Not Assessed	
	Fish Consumption	Fully Supporting	
	Primary Contact Recreation	Fully Supporting	
	Secondary Contact Recreation	Fully Supporting	
	Shellfish Consumption	Not Supporting	Fecal Coliform Bacteria

1.2 Pollutant of Concern

The pollutant of concern, relative to this TMDL, is fecal coliform, a parameter used by Rhode Island as an indicator of potential pathogen contamination. More than 100 types of pathogenic microorganisms can be present in water that is polluted by fecal matter and can cause outbreaks of waterborne disease (Havelaar 1993). Recreational waters polluted by fecal matter, and shellfish harvested from waters contaminated by human sewage and/or animal wastes can be vectors of pathogenic disease.

1.3 Priority Ranking

The 303(d) List identifies impaired waterbodies and a scheduled time frame for development of TMDLs. As such, it is used to help prioritize the State's water quality monitoring and restoration planning activities. Scheduling is not necessarily representative of the severity of water quality impacts, but rather reflects the priority given for TMDL development with consideration to shellfishing waters, drinking water supplies and other areas identified by the public as high priority areas. The TMDL schedule for all waterbody segments addressed in this report is 2010.

1.4 Applicable Water Quality Standards

Water Use Classification

Surface waters of the state are categorized according to the water use classifications of rule 8.B of Rhode Island's Water Quality Regulations (RIDEM 2009) based on public health, recreation, propagation and protection of fish and wildlife, and economic and social benefit. Each class is identified by the most sensitive, and therefore governing, water uses to be protected. Surface waters may be suitable for other beneficial uses, but are regulated to protect and enhance the designated uses. Class SA, SA-closed safety zone, SA{b}, SB and SB1 waters are all found within Mount Hope Bay and the Kickemuit River estuary. These water quality classifications are described below and in Section 8.B(2) of Rhode Island's Water Quality Regulations.

- **Class SA waters** are designated for shellfish harvesting for direct human consumption, primary and secondary contact recreation, and fish and wildlife habitat, and shall have good aesthetic value.

- **Class SA (Closed Safety Zone) waters** within Mount Hope Bay are waters within the vicinity of an approved sanitary discharge which may be impacted in the event of a complete failure of treatment and are therefore currently prohibited from shellfishing. Although shellfishing use is restricted, all SA criteria must be met.

- **Class SA{b} waters** are located in the vicinity of marinas and/or mooring fields and therefore seasonal shellfishing closures will likely be required, however all Class SA criteria must be attained.

- **Class SB waters** are designated for primary and secondary contact recreation, fish and wildlife habitat, and shellfish harvesting for controlled relay and depuration, and shall have good aesthetic value.

- **Class SB1 waters** are designated for primary and secondary contact recreational activities and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges. However all Class SB criteria must be met.

Applicable Water Quality Criteria
The water quality standards for Class SA shellfishing waters are the National Shellfish Sanitation Program (NSSP) standards for “approved” shellfish harvesting areas: a geometric mean for fecal coliforms of less than 14 MPN/100ml and not more than 10% of samples to exceed 49 MPN/100ml as determined using NSSP protocols (NSSP 1997).

The water quality standards for primary contact recreation/swimming criteria are: a geometric mean value not to exceed 50 MPN/100ml and not more than 10% of the samples to exceed 400 MPN/100ml, applied only when adequate enterococci data are not available.

Numeric Water Quality Targets
The targeted goal for this TMDL is for the water quality <u>in all waters of Mount Hope Bay and the Kickemuit River estuary</u> to meet both portions of the shellfishing standard (geometric mean and 90th percentile concentrations) as measured in accordance with NSSP protocols and described above. Application of the SA water quality target to the SB classified portions of Mount Hope Bay was deemed necessary to meet SA targets in the SA classified portions-given the juxtaposition of SA/SB classified waters within this dynamic estuary. It is expected that bacteria loading reductions needed to meet the shellfishing standards will ensure that primary contact/swimming standards will also be met.

Other Applicable Standards in Shellfish Growing Areas
The closure and status of shellfish harvesting areas is not solely based on 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 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 a growing area is closed (NSSP 1997).

Administrative closures may apply to growing areas or portions of growing areas due to proximity to potential pollution sources such as marinas, wastewater treatment facilities, and concentrated stormwater outfall locations. These conditions typically warrant precautionary closures of shellfish waters on a seasonal or full time basis. Administrative closures exist in both the Kickemuit River and Mount Hope Bay (Figure 1.2). Two seasonal closures exist in the Kickemuit River due to seasonal use of mooring fields while a single administrative closure exists in Mount Hope due to proximity to the Fall River WWTF discharge.

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 of 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 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-RIDEM 2009). Tier 2 does not apply to Mount Hope Bay or the Kickemuit River because fecal coliform bacteria concentrations are greater than the water quality standards-particularly during and directly after typical wet weather events.

2.0 BACKGROUND

2.1 Description of Study Area

Taunton River

The Taunton River is by far the largest freshwater source to Mount Hope Bay with a mean daily flow rate of approximately18 cubic meters per second (cms) (636 cubic feet per second-cfs) at its mouth. The Taunton River Watershed (Figure 2.1) is also the second largest watershed in the State of Massachusetts at 1456 km^2. The river is formed by the confluence of the Matfield and Town Rivers in Bridgewater, MA and receives flow from 18 river systems as it courses through ten communities before discharging into Mount Hope Bay.

Ten Massachusetts communities and five Rhode Island communities are located partially or primarily within the lower Taunton River- Mount Hope Bay-Kickemuit River Watershed. The Massachusetts communities consist of Attleboro, Seekonk, Rehoboth, Berkley, Swansea, Dighton, Somerset, Fall River, Freetown, and Westport. The Rhode Island communities consist of Portsmouth, Warren, Bristol, and Tiverton. Land use statistics for the Taunton River-Mount Hope Bay and Kickemuit River estuary are presented in Table 2.1.

Land along the mainstream Taunton River is mostly undeveloped with approximately 50% of the land in forest and 25% in residential use. Because the watershed topography is flat to low hilly, the Taunton River has one of the flattest courses in Massachusetts. Streamflow fluctuates slowly due to the low gradient, extensive wetland areas, and underlying stratified drift. There are only a few short sections of rapids along the river. The absence of dams make it an important anadromous fish run by allowing fish species to reach their native spawning grounds.

Upper portions of the Taunton River are classified by the State of Massachusetts as a Class B Warm Water Fishery. The lower downstream portions are classified as Class SB and are identified as impacted by the discharge of CSOs. All three downstream segments of the Taunton River have been placed on the Massachusetts Year 2008 Integrated List of Waters – Category 5 as not meeting Water Quality Standards for pollutants such as pathogens and organic enrichment/low dissolved oxygen. The MA Department of Marine Fisheries (DMF) Shellfish Status Report of 2003 indicates that shellfish harvesting is prohibited in all growing areas within these downstream segments of the Taunton River.

Three facilities have Water Management Act (WMA) permits with authorized surface and groundwater withdrawals totaling 3.27 million gallons per day (MGD). Of these three facilities, the largest withdrawal at 3.03 MGD is for the municipal public water source. The USGS has noted that flow in the upper segment of the Taunton River is affected by diversions to and from the basin for municipal water supplies. The Taunton River receives wastewater discharges from six facilities permitted through the NPDES program, which include four municipal major, one industrial major and two minor NPDES permits (MADEP 2009). The distinction between major and minor NPDES permit is typically based on design flows. Major publicly owned treatment works (POTWs) include treatment works with design flows greater than one million gallons per day (MGD). Major non-POTWs include treatment works that score 80 or more points on the NPDES Permit rating worksheet. (http://www.epa.gov/npdes/pubs/owm0116.pdf) Minor POTWs and non-POTWs include all other dischargers.

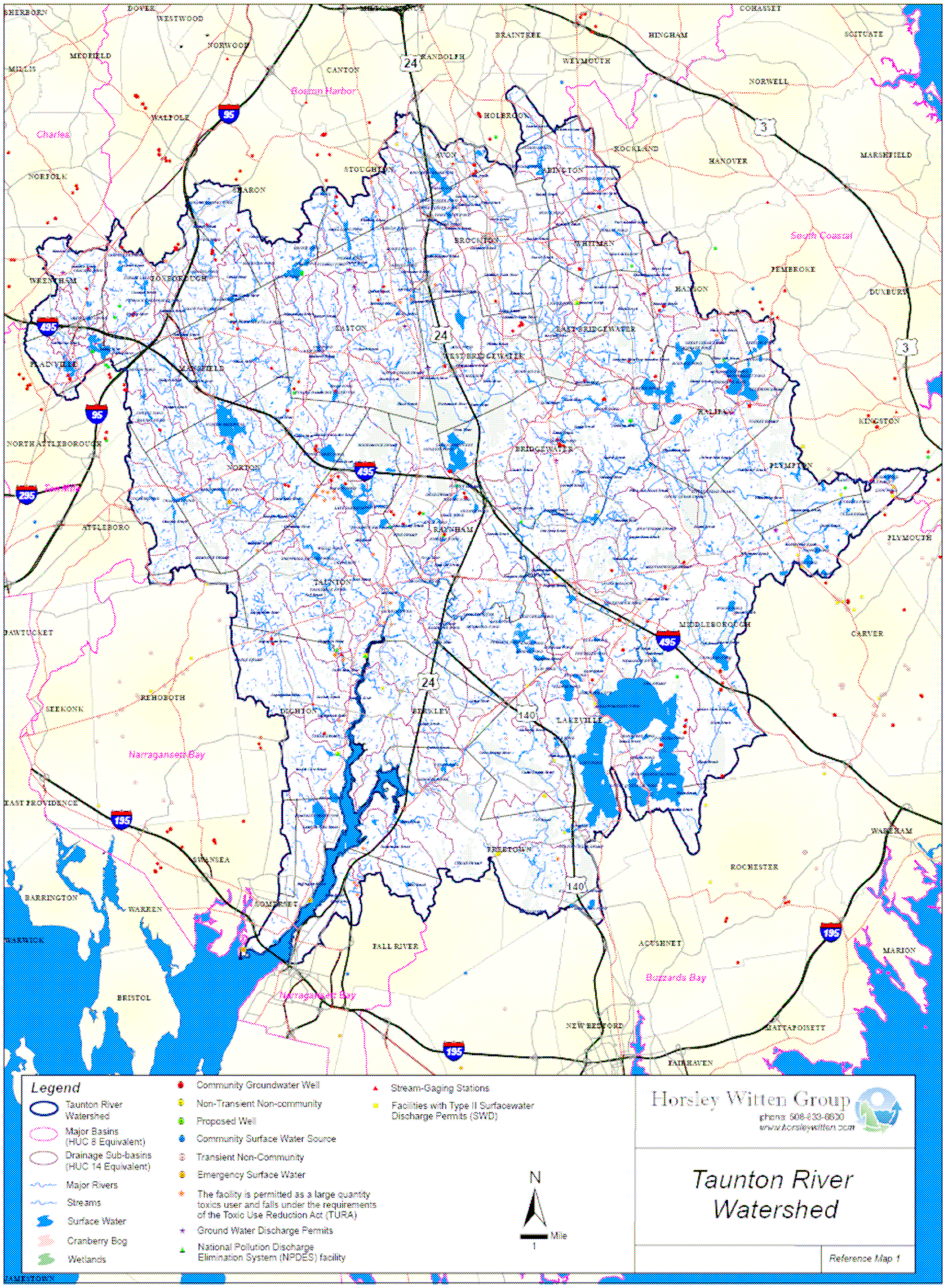


Figure 2.1 Taunton River Watershed. Taken from "Taunton River Watershed Management Plan Phase I - Data and Assessment Final Report December 2008" Reprinted with permission from Horsley Witten Group, Inc.

Table 2.1 Land Use Statistics[1] in Mount Hope Bay and the Kickemuit River.

Land Use	Taunton River-Mount Hope Bay		Kickemuit River	
	Hectares	Percent of Total	Hectares	Percent of Total
Forest/Wetland	93,624	**58.3**	859	**42.8**
High Intensity	3,342	**2.1**	33	**1.6**
Medium Intensity	8,845	**5.5**	210	**10.5**
Low Intensity	19,484	**12.1**	428	**21.4**
Open Space	9,189	**5.7**	215	**10.7**
Cultivated/Pasture	14,021	**8.7**	212	**10.6**
Water	12,016	**7.5**	47	**2.4**
Total	**160,521**		**2005**	

[1]Land use data acquired from National Land Cover Database 2001 (http://www.mrlc.gov/mrlc2k_nlcd.asp)

Both the Taunton Wastewater Treatment Plant and the City of Fall River are authorized to discharge stormwater/wastewater from combined sewer outfalls. Both facilities have taken steps to address pollution from the combined sewer outfalls. The Taunton WWTP completed significant upgrades to its system in 2001/2002 and is continuing other infrastructure upgrades, and the City of Fall River has developed a three-phase program under a management plan to address combined sewer overflows. The Fall River CSO abatement project will be described in more detail in further sections of this report. Additionally, there are numerous Multi-sector General Stormwater Permits for facilities in the communities of Bridgewater, Raynham, Dighton, Berkley, Somerset, Swansea, Taunton, and Fall River.

Mount Hope Bay

Mount Hope Bay forms the northeast corner of the Narragansett Bay estuary with the Rhode Island-Massachusetts State boundary traversing the area in a southeasterly direction. Although over 70% of Mt. Hope Bay is located in Rhode Island, over 90% of its drainage basin is located in Massachusetts. The drainage area covers more than 1600km^2. The Bay is 11.2 km in length along its north-south axis and covers an area of approximately 35.2 km^2 (Kauffman et al. 1981).

Mt. Hope Bay empties into the East Passage of Narragansett Bay and the Sakonnet River. Approximately 70% of the Bay has a mean low water depth of 5.5 meters or less, while the mean tide range is approximately 1.4 meters (Chinman et al. 1985). The average currents are approximately 0.4 and 0.5 knots on the flood and ebb tides, respectively (ASA 1990). Wind direction strongly influences the Bay water's mixing patterns, with the greatest mixing provided by southerly winds (ASA 1990).

Major rivers discharging into the Bay include the Taunton, Cole, Lee, Kickemuit, and Quequechan. Each of these rivers originates and terminates in Massachusetts, with the exception of the Kickemuit, which terminates in Rhode Island waters. Tidal influences reach 29 km inland in the Taunton River and a salt-water intrusion reaches approximately 21 km inland. A brief description of the Taunton River watershed is provided above.

Kickemuit River

The Kickemuit River estuary, with a surface area of approximately 2.2 km^2, forms the most northwestern embayment of Mt. Hope Bay, extending northwest from its mouth at Mt. Hope Bay into portions of the Towns of Swansea and Rehoboth, MA. The freshwater Kickemuit River originates in Rehoboth and flows into the Warren Reservoir in northern Swansea. From here, the river flows south under interstate 195 and then Rt. 6 toward the MA – RI border where it empties into the Kickemuit Reservoir. The dam at the southern end of the Kickemuit Reservoir marks the boundary between the river's fresh and salt-water segments. The watershed to the estuary is fairly small, covering an area of approximately 21 km^2.
The majority of the Kickemuit River watershed is still relatively undeveloped. Forest and open space cover 41 % of its area. High-density residential lots cover significant portions especially in the towns of

Warren and Bristol. The expansion of residential and commercial development has taken place principally at the expense of agriculture. However agriculture still comprises nearly 20% of land use in the watershed. One exception to this general land use pattern is the Smokerise Heights subdivision located in southern Swansea, MA near the RI border. Occupying approximately 183 acres (3% of the watershed), this older subdivision is comprised of very high-density residential housing. The area has a history of failing and substandard septic systems. Below the Kickemuit Reservoir, the watershed is largely residential along its western shore, while the eastern shore is evenly distributed between forest, residential, and agricultural land uses.

2.2 Environmental Setting

Mount Hope Bay

Beginning with the industrial revolution until the mid-twentieth century, Mount Hope Bay received wastes from textile mills, manufacturing industries, and sewer systems from the many communities within the watershed and adjacent to the Bay itself.

Fall River is the largest city in the Mount Hope Bay watershed and presently has the largest wastewater and stormwater system discharging directly to Mount Hope Bay. In the mid-nineteenth century, human and industrial waste disposal became a problem for Fall River, as it did for other urban areas. It was reported that streets periodically flooded with garbage and wastewater. Cesspools and large excrement collection ponds were public health hazards and nuisances. As in many cities, combined sanitary and storm pipes were built as a solution to carry wastes from streets and residences to Mount Hope Bay, and the Taunton and Quequechan Rivers. To protect public health, the MA Dept. of Public Health closed Mount Hope Bay shellfish beds, and threatened to sue Fall River if it did not stop discharging raw sewage.

In response, Fall River installed an interceptor pipe that ran parallel to the shoreline to receive the flows from the existing network of sewer pipes, and it constructed a wastewater treatment plant. The interceptor pipe was hooked up and the sewage treatment plant was sited and sized to accommodate only the sanitary flow. Above this limit, sewage and stormwater were diverted directly to Mount Hope Bay as combined sewer overflows. At that time, approximately eleven percent of all wastewater that entered the Fall River collection system left as untreated as a wet weather overflow. It has been estimated that historically, and until the operation of the storage tunnel, that approximately 1.3 billion gallons of stormwater and sewage were discharged annually to Mount Hope Bay. Previous studies had confirmed this to be the largest source of fecal coliform bacteria to the Bay during wet weather.

Surveys by the U.S. Food and Drug Administration (FDA) in 1987 indicated that, of all the potential sources of sewage contamination, CSO's represented the largest source masking all other inputs of fecal contaminants to Mount Hope Bay. During one wet weather event monitored by the FDA, CSO's accounted for 96% of total fecal coliform loading to Mount Hope Bay (Dixon *et al.*1990). Moreover, CSO pollution has not been restricted to times of heavy precipitation. Until quite recently, when the City of Fall River addressed the problem through improved maintenance, CSO discharges occurred during dry weather as well, contributing up to 98% of dry-weather coliform loading to Mount Hope Bay (Rippey and Watkins, 1987;Dixon *et al.*1990)

A Federal Court Order was issued which required the City to implement a Combined Sewer Overflow (CSO) Abatement Plan. The CSO Abatement Program, as currently planned, includes expansion of the Regional Wastewater Treatment Plant primary treatment capacity to 106-million gallons per day (already completed), construction of an 85-million gallon rock tunnel with surface piping and partial sewer separation of selected CSO areas along the waterfront. The storage tunnel is, at the time of this report, on-line and receives flow from six (6) of the combined sewer overflows located in the southern portion of the city.

The City has taken steps to eliminate overflows of raw sewage during dry weather through cleaning and repairs to the sewer lines. As a result, since 1989 dry weather discharges to the Bay have effectively been eliminated. A plan to construct a 4.8 km underground tunnel to provide storage of the polluted water during storms and convey the flows to the treatment plant was developed at an estimated cost of approximately $110 million. These improvements will significantly reduce the volume of CSO discharge into the rivers and bay, but will not eliminate them entirely. More detail regarding the City of Fall River, MA CSO abatement project is given in the Implementation Section of this report.

According to the MA Division of Marine Fisheries' historic files, the first shellfish closure in Mount Hope Bay occurred in January 1926 when the MA Dept. of Public Health closed the waters of the Taunton River and that portion of the bay north of a line drawn from the MA/RI border to Brayton Point in Somerset because of unacceptable water quality. In 1937, the shellfish closure was enlarged to encompass the Lee and Taunton River, and that portion of Mount Hope Bay north of a line drawn from the MA/RI border in Fall River to Bay Point in Swansea.

A year later, a portion of Mount Hope Bay and the Lees River was reclassified to allow the harvest of contaminated shellfish for purification purposes. In 1985, all of Mount Hope Bay and the Taunton, Lees, and Coles Rivers were closed to all shellfishing including contaminated relays. In 1997, following completion of the sanitary surveys the Coles and Lees River, Mount Hope Bay, and the portion of the Taunton River south of the Brightman Street Bridge were upgraded to a classification of "Restricted". With the new classification, the Division of Marine Fisheries reinstated the contaminated relay program. In the spring of 1997, dredge boats relayed approximately 960,000 lbs of quahogs from these areas to towns in Buzzards Bay, the Cape, and Islands for natural depuration. In the Taunton River, nearly 650,000 lbs of quahogs were harvested south of the Braga Bridge near the Borden Flat Lighthouse. In 2003, and continuing to the present time, these areas were reclassified to "Prohibited".

Kickemuit River

Expanded water quality monitoring by the RIDEM Shellfish Monitoring Program in 1988 and 1989, during varying tidal regimes, revealed elevated levels of fecal coliform bacteria in the Kickemuit River. This led to the closure of the entire estuary to shellfish harvesting in 1990. As a result, The Kickemuit River Council, a 501(c)(3) non-profit organization began to investigate this and other sources of bacterial pollution to the estuary. Investigations by the Kickemuit River Council revealed several sources in both Warren and Bristol, RI. As a result of these studies, sewer lines were been constructed in Bristol and Warren along the westerly shore of the Kickemuit.

In 2006, RIDEM completed a TMDL for pathogens and total phosphorus for the Kickemuit Reservoir and freshwater portion of the Kickemuit River. Numerous sources of bacterial pollution were identified as part of TMDL development for the upstream Kickemuit Reservoir. These include stormwater runoff from residential and commercial areas, failing and substandard septic systems, agricultural runoff, and wildlife and waterfowl.

2.3 Shellfish Growing Area Management

The Shellfish Growing Area Monitoring Program is part of the State of Rhode Island's agreement with the U.S. Food and Drug Administration's (USFDA) National Shellfish Sanitation Program (NSSP). The purpose of this program is to maintain national health standards by regulating the interstate shellfish industry. The NSSP is designed to oversee the shellfish producing states' management programs and to enforce and maintain an industry standard. As part of this agreement, the State of Rhode Island is required to conduct continuous bacteriological monitoring of the shellfish harboring waters of the State to maintain certification of these waters for shellfish harvesting for direct human consumption. Shoreline surveys are an additional requirement of the NSSP.

The RIDEM Shellfish Program collects samples from 17 separate shellfish growing areas in the state and analyzes them for fecal coliform bacteria. These growing areas encompass all of Narragansett Bay and its shellfish harboring tributaries, all the major south shore coastal salt ponds, Little Narragansett Bay, South Shore Coastal Waters, and Block Island. Shellfish Growing Area 17 (GA17) encompasses the entire Rhode Island portion of Mount Hope Bay while the majority of the saltwater portion of the Kickemuit River is considered as Growing Area 5 (GA5). Water samples are collected monthly at the ten stations in the Kickemuit River (Growing Area 5), and sixteen stations in Mt. Hope Bay (Growing Area 17), when those conditionally approved areas are open for shellfish harvesting. Figures 2.2 and 2.3 define the geographic boundaries of each growing area and display the locations of ambient water sampling stations.

Prior to 2005, portions of Mount Hope Bay and the Kickemuit River were operated on a conditionally approved basis. These areas were closed for a period of seven days following a wet weather event totaling 0.5" or greater. In 2005 the 'conditionally approved' area (WBID RI0007032E-01B) of Mount Hope Bay was reclassified to 'Prohibited'. This reclassification was due primarily to elevated levels of bacteria in the northern portion of that growing area. Recently, in 2008, the above-mentioned portion of Mount Hope Bay was upgraded back to "Conditionally Approved." Table 2.2 presents growing area status from 1946 to the present for Mount Hope Bay and the Kickemuit River estuary.

Table 2.2 Growing Area Status (1946-present) for the Kickemuit River and Mount Hope Bay.

Time/ Period	Waterbody	Status	Additional Information
1946-1972	Mount Hope Bay	Prohibited-Polluted area	Based on limited monitoring and existence of major sources (Fall River WWTF, Somerset WWTF, Taunton WWTF, Fall River CSOs)
	Kickemuit River	Approved area	
1973	Mount Hope Bay	Prohibited-Polluted area	
	Kickemuit River	Partial (Approved area and Prohibited)	Expanded sampling resulted in 'Polluted area' line extension northward into mouth of Kickemuit River.
1973-1990	Mount Hope Bay	Prohibited-Polluted Area	Static FDA-RIDEM dye study and microbiological sanitary survey in 1986.
	Kickemuit River	Partial (Approved area and Prohibited area)	Static
1990	Mount Hope Bay	Prohibited-Polluted Area	Static
	Kickemuit River	Prohibited-Polluted Area	'Polluted area' extended to all of Kickemuit River. Based on expanded monitoring during varying tidal regimes. Resulting statistical analysis of data showed the need to further downgrade entire Kickemuit to "prohibited"
1990-1994	Mount Hope Bay	Prohibited-Polluted Area	Static
	Kickemuit River	Prohibited-Polluted Area	Static
1995	Mount Hope Bay	Partial (Conditional-far southwest portion, Prohibited-remainder of Bay	Portions of Mount Hope Bay reclassified from "Prohibited" to "Conditional". Based on commitment to operate this area on a conditional basis, additional monitoring. Taunton WWTF relays information to RIDEM regarding bypasses and/or overflows.
	Kickemuit River	Conditional	All of the Kickemuit River reclassified from "Prohibited" to "Conditional". Based on commitment to operate this area on a conditional basis, additional monitoring. Taunton WWTF relays information to RIDEM regarding bypasses and/or overflows.
1997	Mount Hope Bay	Partial (Conditional-far southwest portion, Prohibited-remainder of Bay	Static
	Kickemuit River	'Conditional' and 2' Seasonal Conditional' Areas	Two (2) 'Seasonal Conditional' areas added on western shore of Bristol, RI. Resulting from the expansion of 2 existing mooring fields Prior to marine pumpout program.
1997-2005	Mount Hope Bay	Partial (Conditional-far southwest portion, Prohibited-remainder of Bay	Static
	Kickemuit River	'Conditional' and 2' Seasonal Conditional' Areas	Static
August 1998	**Rhode Island designates all coastal waters as "No Discharge Areas"**		
2005	Mount Hope Bay	Prohibited-Polluted Area	Downgrading of Conditionally Approved areas in Mount Hope Bay to 'Polluted-Prohibited' based on statistical analysis of data. Year was punctuated with several large rain events.
	Kickemuit River	Conditional, Seasonal Conditional, and Polluted-Prohibited	Managed as Conditional and Seasonal Conditional, except nr. Mouth where downgraded to 'Prohibited'
2005-2007	Mount Hope Bay	Prohibited-Polluted Area	Static
	Kickemuit River	Conditional, Seasonal Conditional, and Polluted-Prohibited	Static
2008	Mount Hope Bay	Partial (Conditional-far southwest portion, Prohibited-remainder of Bay	Upgraded far southwest portion from Prohibited to Conditional
	Kickemuit River	Conditional, Seasonal Conditional, and Polluted-Prohibited	Static

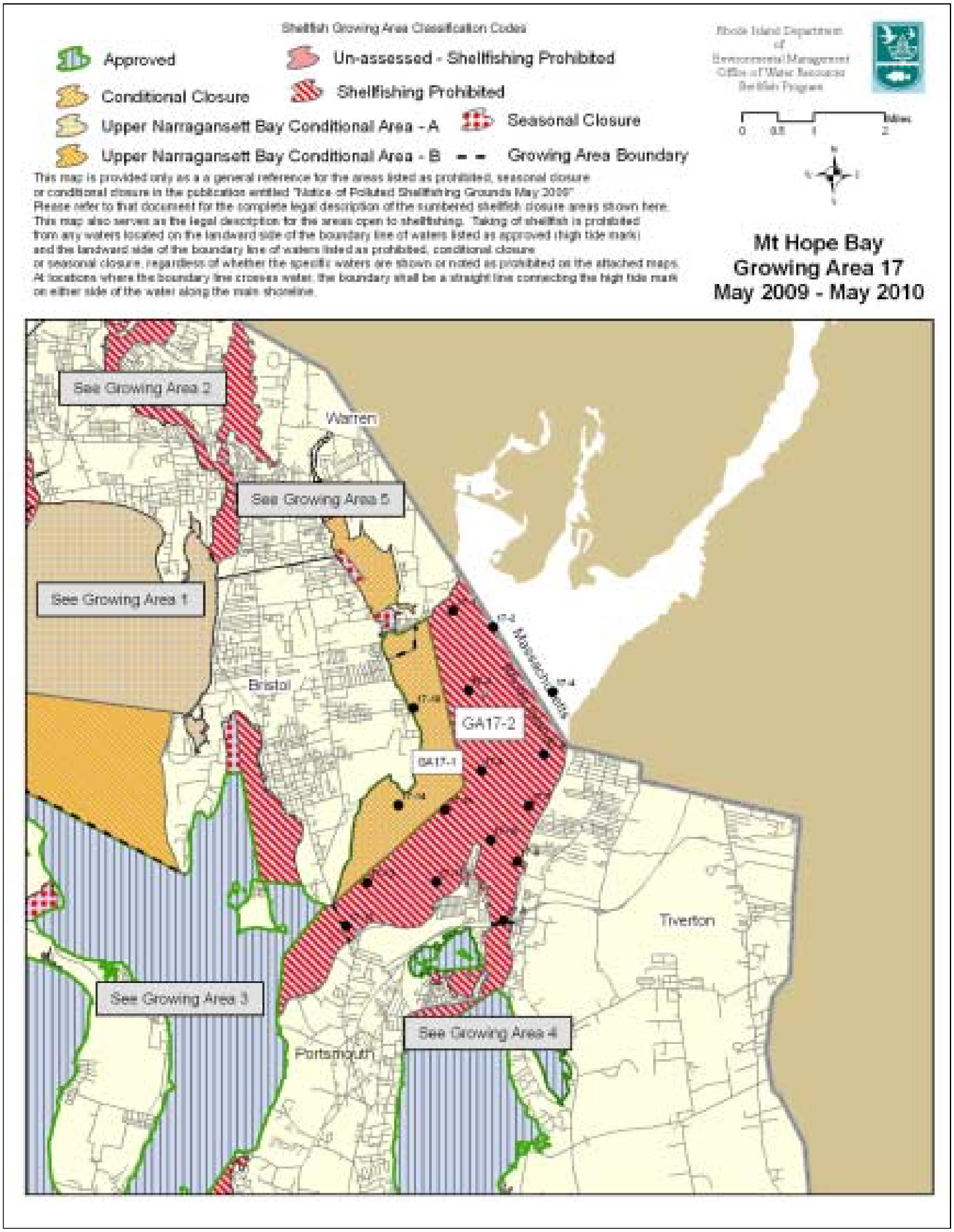


Figure 2.2 Geographic Boundary of Growing Area 17 and ambient shellfish monitoring locations.

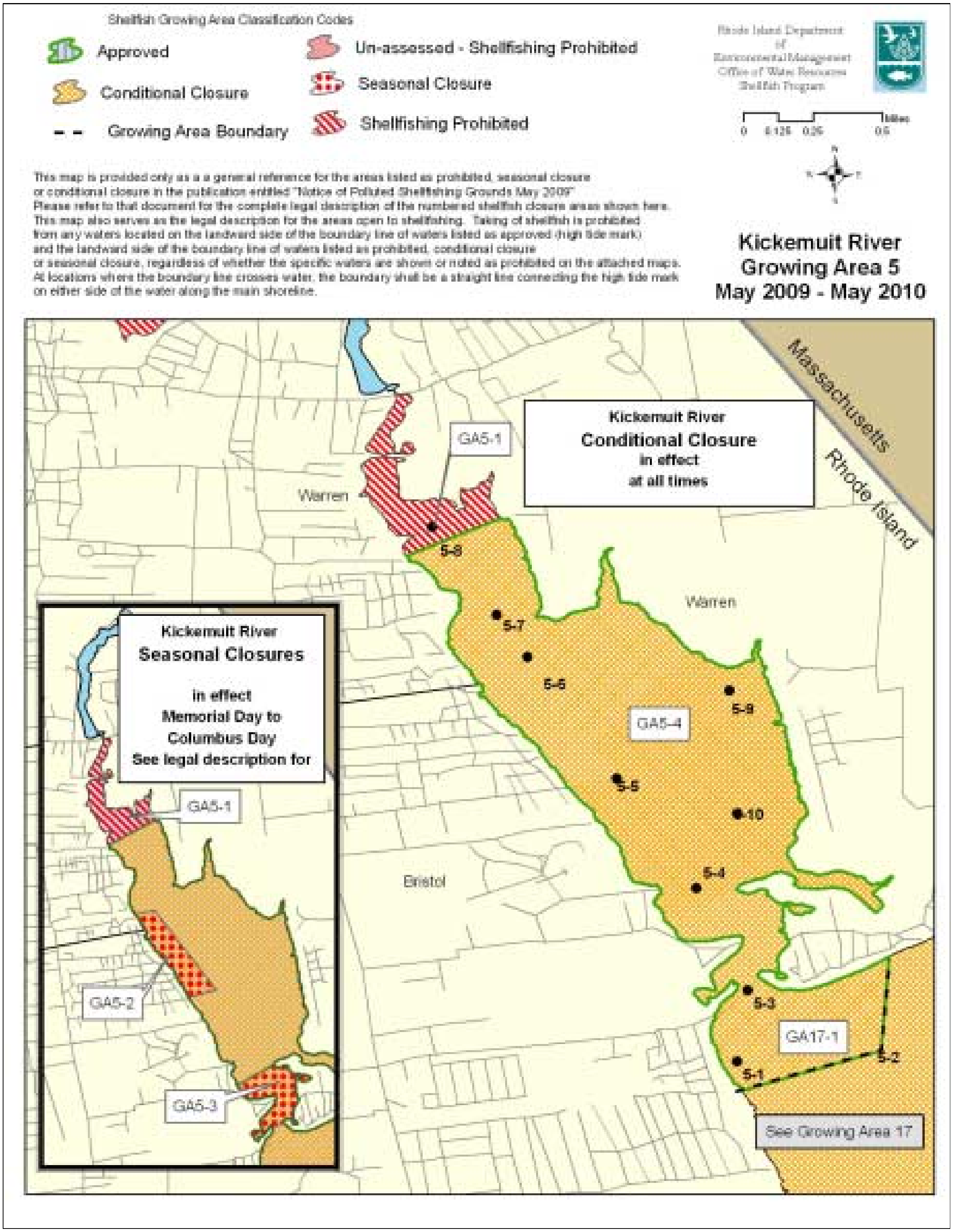


Figure 2.3 Geographic Boundary of Growing Area 5 and ambient monitoring locations.

3.0 WATER QUALITY CHARACTERIZATION

3.1 Overview/Summary

There have been numerous water quality studies and water quality monitoring programs in Mount Hope Bay and the Kickemuit River conducted over the past 20 years that are useful in assessing one or more attributes of water quality (These studies were conducted prior to completion of major portions of the Fall River CSO abatement project). Fecal coliform data continues to be collected by RIDEM’s Shellfish Monitoring Program. This data collection program began in 1984 and is summarized in Section 3.2. Studies deemed pertinent to this TMDL study are listed below and summarized in the following sections:

1. U.S. FDA microbiological survey of Mount Hope Bay (1987).
2. Applied Science Associates (ASA Inc.) water quality surveys in Mount Hope Bay (1990).
3. RIDEM wet weather bacteria sampling in Mount Hope Bay and the Kickemuit River (2006).

US FDA Microbiological Survey of Mount Hope Bay (1986-1987)

The U.S. Food and Drug Administration (FDA) (Rippey and Watkins 1987) performed a microbiological survey of Mount Hope Bay in 1986 and 1987. The purpose of the study, funded by the Narragansett Bay Project (NBP) was to determine whether the sanitary quality of MHB was sufficient to permit commercial harvesting of shellfish, either throughout the bay or in some conditional closure area.

Five (5) dry weather surveys were performed during 1986 and 1987 at 22 locations within Mount Hope Bay. Four (4) wet weather surveys were performed during the same time period with the majority of measurements made at ebb tide in order to determine the maximal extent of bacteriological contamination of the bay. Post-wet weather events were also conducted to characterize the recovery of water quality in the bay following a wet weather event. Several pollutant discharges were also measured during the wet weather sampling events, including the Fall River and Somerset wastewater treatment facilities, selected Fall River CSO discharges, as well as the mouths of the Quequechan and Taunton Rivers (sampled during dry and wet weather).

The principal study conclusions were:

1. The northeast portion of the bay and along the eastern shoreline showed the highest levels of fecal coliform bacteria. The National Shellfish Sanitation Program (NSSP) standards for shellfish waters were exceeded throughout the bay during wet weather and were only exceeded in the northeastern portion of the bay during dry weather.

2. Fecal coliform levels increased a factor of 10 or more between dry and wet weather conditions. It was reported that rainfalls in excess of 0.50 inches exerted a significant influence on water quality in the bay. The recovery time (time to return to acceptable fecal coliform levels of 14 MPN/100ml) of the bay depended on the pollutant loading rate and hence the rainfall volume. When rainfall was modest (defined as <0.50 inches) water quality was found to recover in 2-4 days. For heavy rainfall events (defined as > several inches) the recovery times approached 15 days.

3. The area (GA17 and GA5) could be managed conditionally and can remain open as long as rainfall does not exceed 0.5 inches in a 24 hr period 7 days prior to harvesting. If between 0.5 and 1.0 inches of rainfall falls within a given 24-hr period, the area should remain closed to shellfish harvesting for a period of seven (7) days following the event.

4. Of all the potential sources of sewage contamination, CSO's represent the largest source masking all other inputs of fecal contaminants to Mount Hope Bay. During one monitored event, CSO's accounted for 96% of total fecal coliform loading to Mount Hope Bay.

ASA Water Quality Surveys in Mount Hope Bay (1990)

In 1990, Applied Science Associates, Inc. (ASA) conducted dry and wet weather water quality surveys, including CSO monitoring and dye studies, in Mt. Hope Bay, primarily the Massachusetts portion. The study was a component of the Fall River Phase II facilities plan study that was conducted for the City of Fall River to determine the most effective solution for controlling Fall River's storm-related discharge of pollutants to the Taunton River and Mount Hope Bay.

The dry weather sampling component consisted of four surveys at nine stations within the Taunton River and Mount Hope Bay during June through October 1990. The wet weather component consisted of three intensive measurement studies, each spanning a three-day period, beginning shortly before a storm of at least 0.4 inches (1.0 cm) of precipitation. The majority of stations were located within the upper northeast portion of the bay, within Massachusetts.

Results from the ASA surveys showed that fecal coliform levels in the bay were dramatically affected by storm-related runoff. In addition, the study showed that the combined loadings of the CSO's along the bay clearly accounted for the high fecal coliform levels observed in the bay during and shortly thereafter the storm. Typical fecal coliform densities from the CSOs ranged from 10^5 to over 10^6 per 100ml. Mid- and post-storm fecal coliform levels typically exceeded several hundred colonies per 100ml at the stations adjacent to the shoreline of Fall River. Peak values ranging from 220 to 12000 col/100ml were observed in the bay during wet weather studies. For all three wet weather surveys, fecal coliform levels in the bay dropped rapidly once CSO flows ended and dropped to background levels within 24 hours.

Survey data also indicated that the CSO effluent from the city of Fall River discharged to the bay during the storms remained concentrated near the surface, while diffusing slowly downward during the course of each study. Most of the effluent remained near the east shore of the bay, moving slowly toward the Mt. Hope Bridge.

RIDEM wet weather monitoring (2006)

RIDEM TMDL staff conducted targeted water quality investigations to support the Total Maximum Daily Load (TMDL) evaluation of Mount Hope Bay and the Kickemuit River. Two separate wet weather surveys were conducted during June and October of 2006. All ambient shellfish monitoring stations were sampled during each survey. The Massachusetts Department of Marine Fisheries (MADMF) Shellfish Sanitation and Management staff concurrently collected samples for fecal coliform analysis from a majority of established stations within growing areas in Mount Hope Bay, Taunton River, Lee River, and Coles River during the June wet weather sampling event. In addition to estuarine fecal coliform sampling, RIDEM staff collected samples from selected outfalls and streams for analysis for fecal coliform bacteria and male-specific bacteriophage. This study was conducted according to a US EPA approved quality assurance project plan developed by RIDEM in 2006 (RIDEM, 2006) and available on-line at http://www.RIDEM.ri.gov/pubs/qapp/mthope.pdf.

The main objectives of the study were to: (1) provide a more up-to-date characterization of the sanitary quality in the study area, (2) characterize bacteria conditions at existing shellfish sampling stations in Mt. Hope Bay and the Kickemuit River during periods of wet weather, (3) expand the geographical scope of the study area to include upper Mount Hope Bay, Taunton River, Lee River, and Cole River-all located within Massachusetts, (4) evaluate human and non-human bacterial contributions to the study area from prioritized sources in Rhode Island, and (5) assess the spatial and temporal extent of bacterial pollution during 'typical' wet weather events in the study area.

Results of the sampling indicated that the majority of Mount Hope Bay and the Kickemuit River exceeded the state's water quality standards for fecal coliform bacteria during both wet weather events.

The sanitary quality of the bay under these conditions appears to be primarily dominated by sources within the Fall River area (combined sewer overflows and stormwater runoff), as well as upstream sources in the Taunton River. Smaller sources exist within Rhode Island and have a notable, although localized impact on water quality during wet weather events, particularly in the Kickemuit River. The final data report (RIDEM, 2008) is available on –line at: http://www.RIDEM.ri.gov/programs/benviron/water/quality/rest/pdfs/mthopeby.pdf and provides a complete synthesis of the study objectives, methods, and analytical and field standard operating procedures. The data report also provides all collected field data, as well as in-depth analysis of the data.

The results of five days of sampling associated with the first wet weather event are shown in Figures 3.1-3.3. Results of the second 7-day sampling event are shown in Figures 3.4-3.7.

Figure 3.1 Estuarine fecal coliform concentrations (June 1 and June 3, 2006).

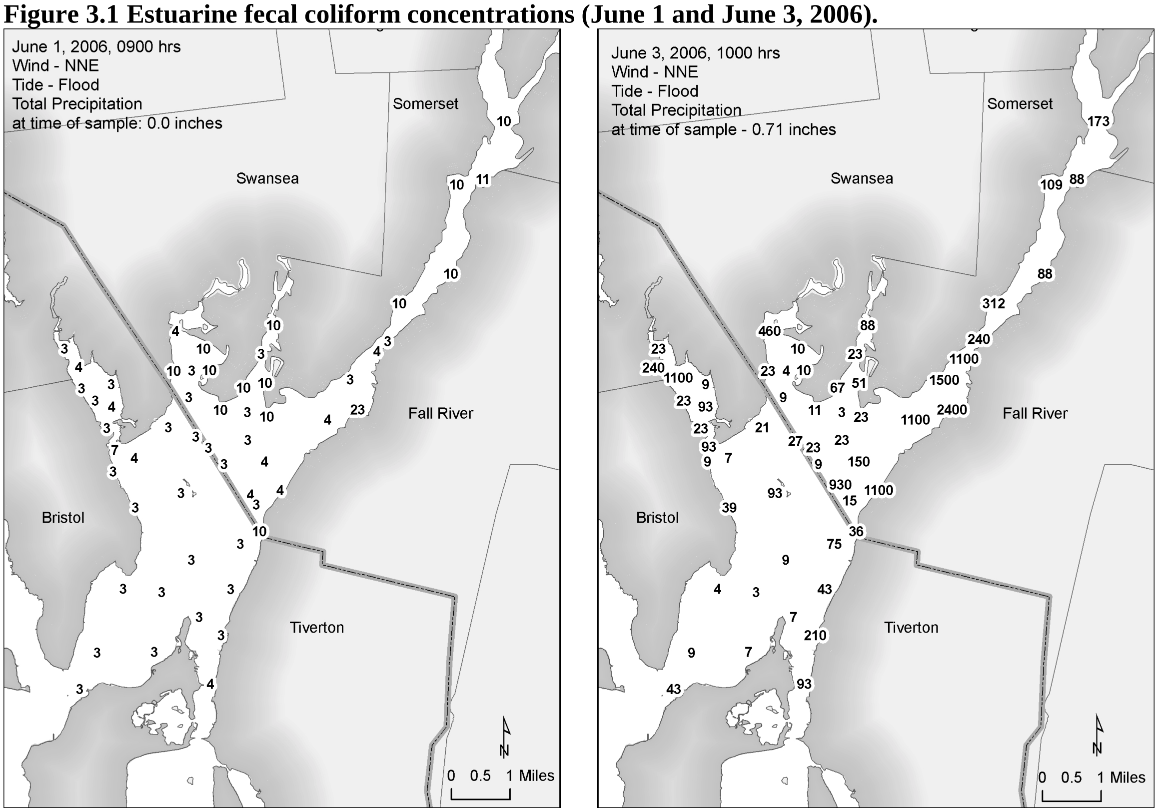


Figure 3.2 Estuarine fecal coliform concentrations (June 4 and June 5, 2006).

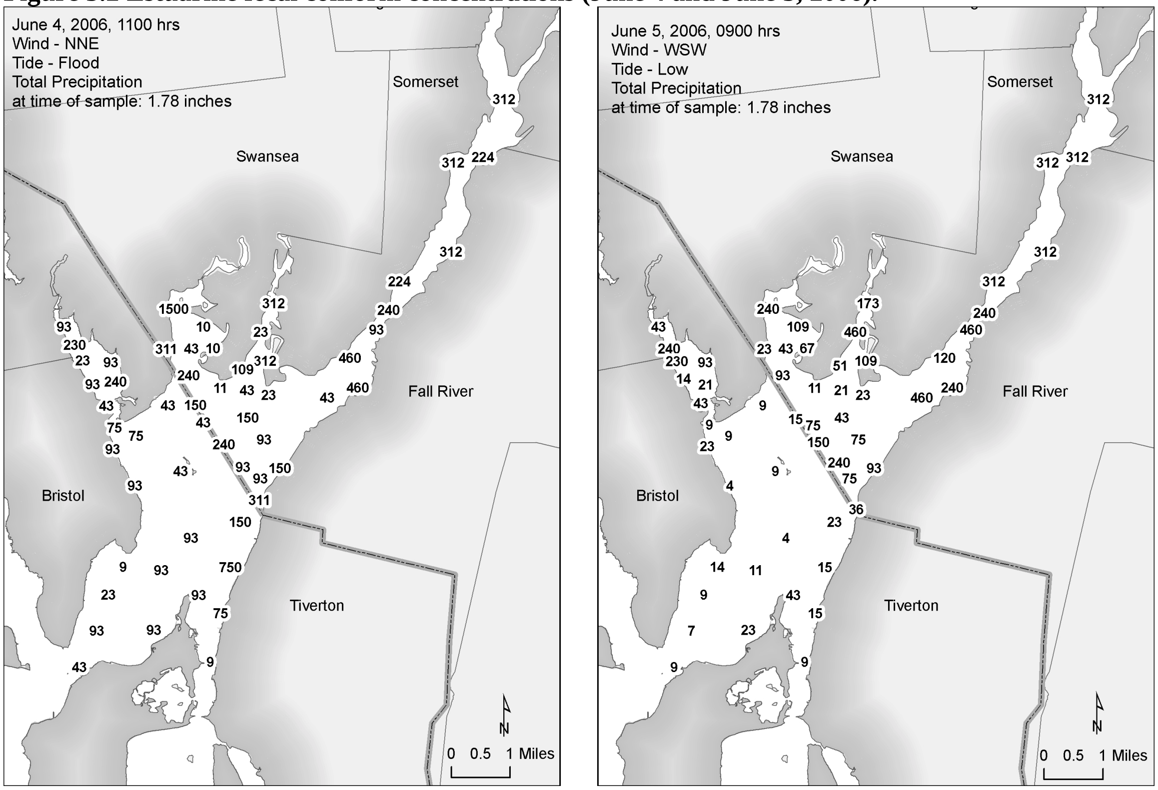


Figure 3.3 Estuarine fecal coliform concentrations (June 6, 2006).

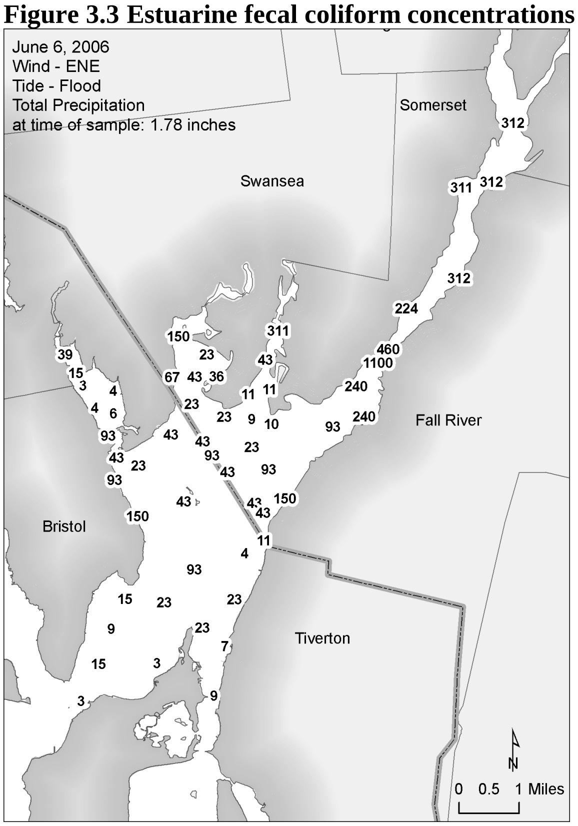


Figure 3.4 Estuarine fecal coliform concentrations (October 11-12, 2006).

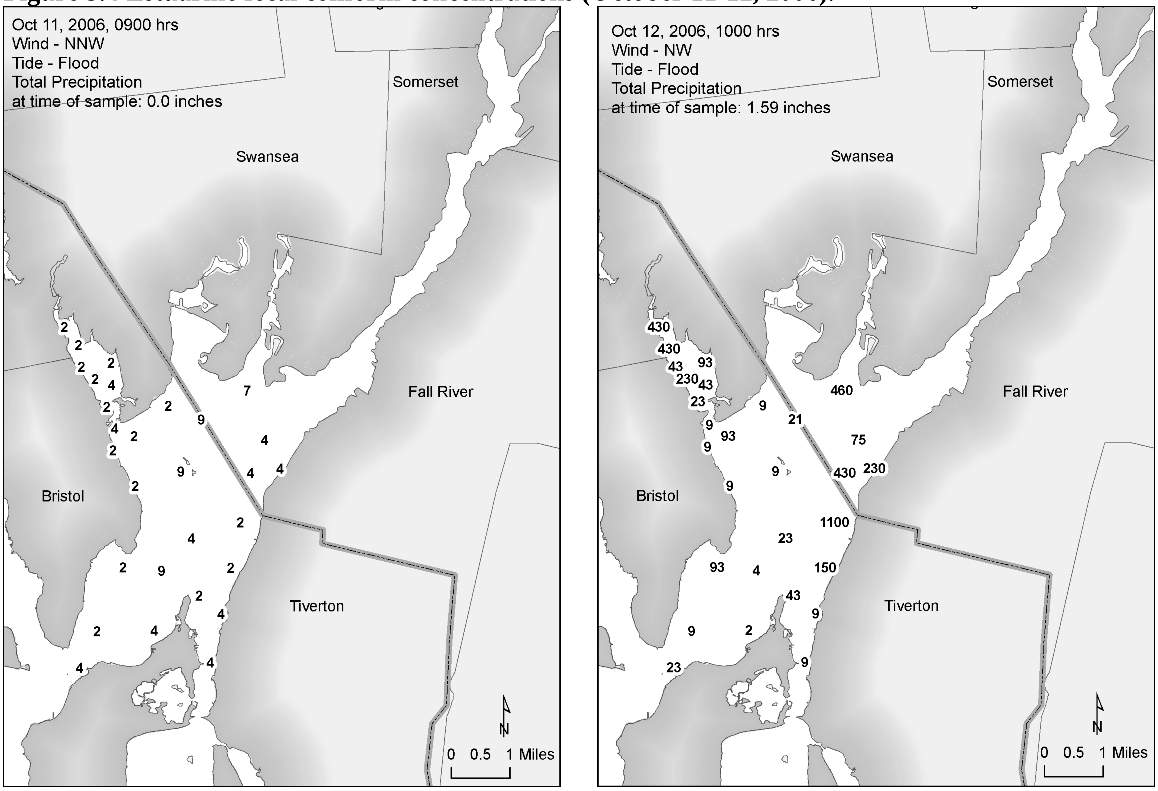


Figure 3.5 Estuarine fecal coliform concentrations (October 13-14, 2006).

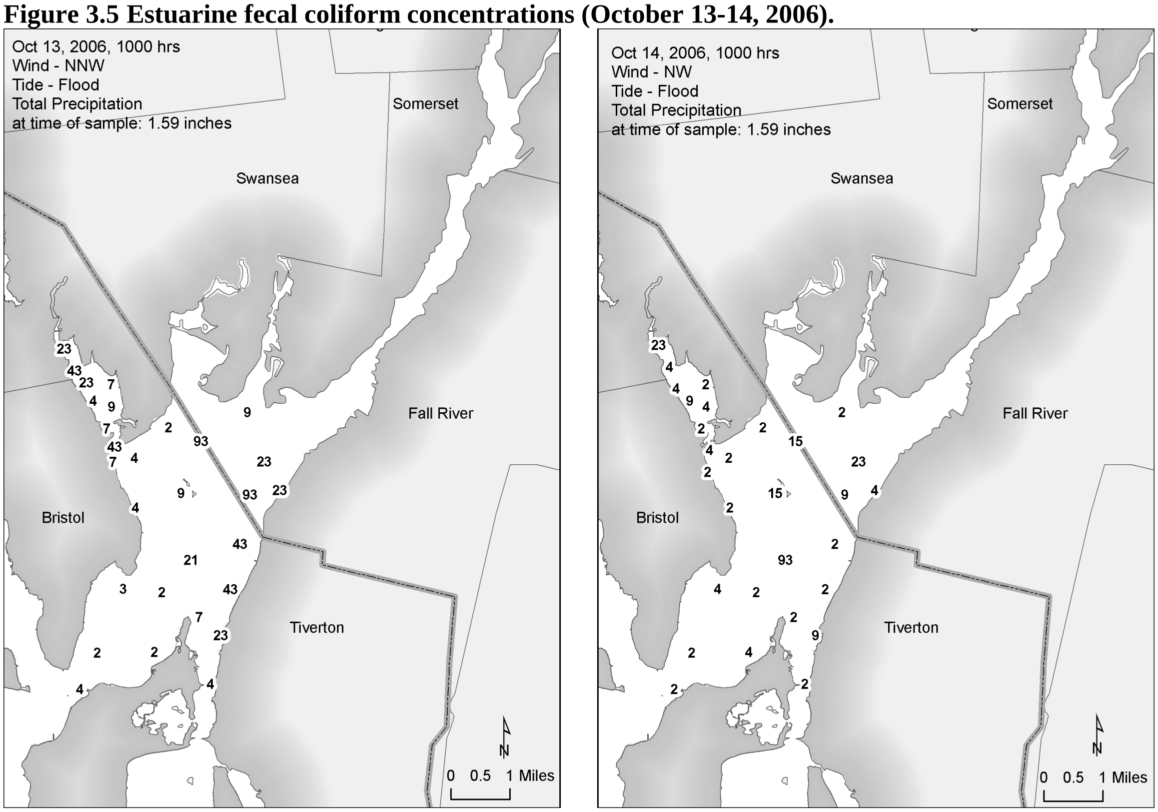
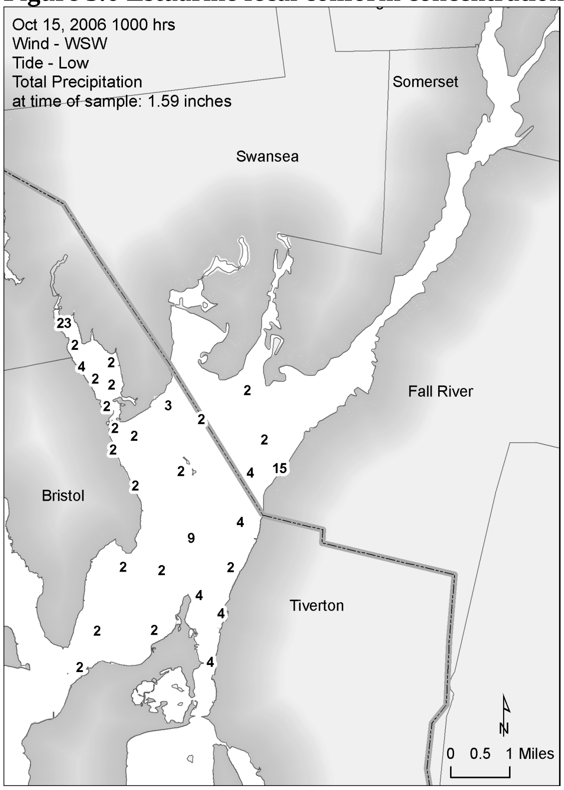


Figure 3.6 Estuarine fecal coliform concentrations (October 15-16, 2006).



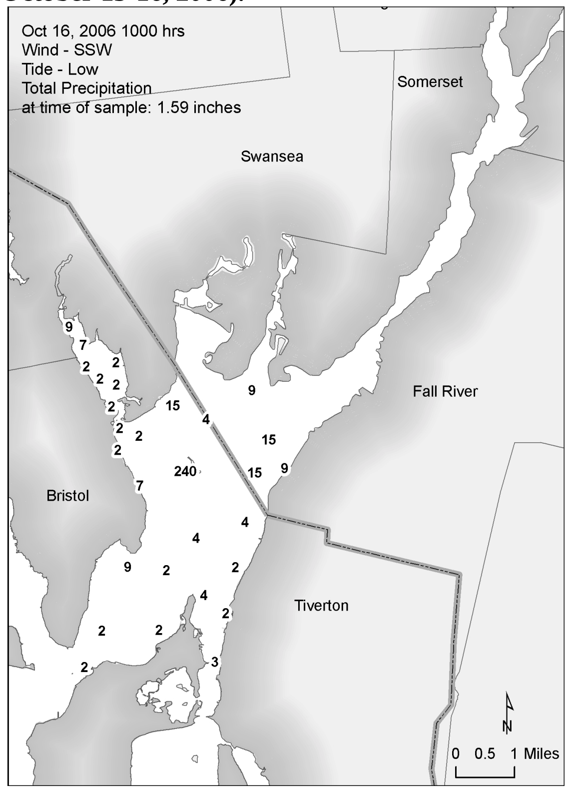
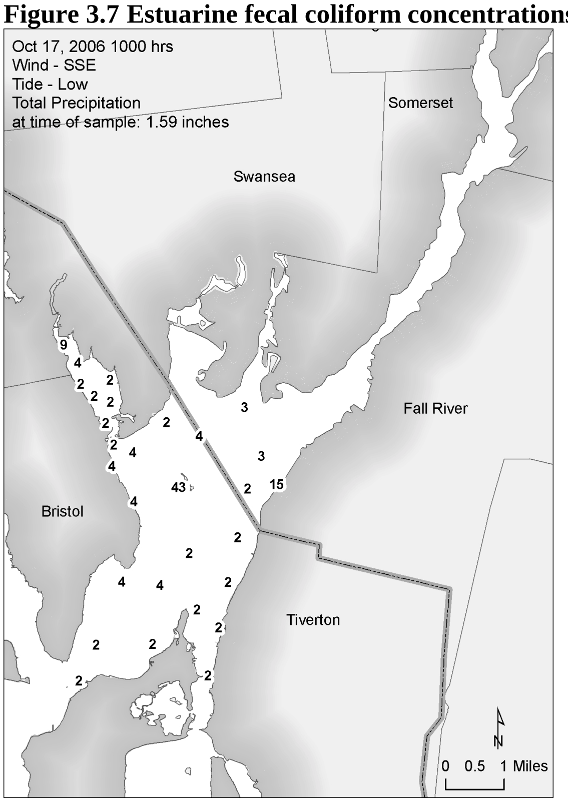


Figure 3.7 Estuarine fecal coliform concentrations (October 17, 2006).



3.2 Shellfish Program Annual Review of Bacteriological Data

Once a year a statistical evaluation of the routine bacteriological monitoring data is performed for purposes of determining whether the state's shellfish growing areas are appropriately classified. The results of the statistical analyses are compared with the National Standards as prescribed by the National Shellfish Sanitation Program (NSSP). Along with a review of shoreline survey results, the routine bacteriological monitoring data are used to evaluate the appropriateness of growing areas' classification. The annual statistical evaluation of growing areas 5 (Table 3.1) and 17 (Table 3.2) include the last 15 samples collected during dry weather conditions (i.e. at least 7 days since 0.5 inches or more of precipitation in 24 hrs). These statistics were calculated from 1 sample in 2009, 11 samples in 2008 and 3 samples from 2007. The data in Tables 3.1 and 3.2 were used in the 2009 annual shellfish classification review.

Table 3.1 Rhode Island Shellfish Program Monitoring Data for the Kickemuit River.

Station	Water Quality Classification	Number of samples	Geometric Mean (MPN/100ml)		90th Percentile (MPN/100ml)	
			Criteria	Calculated Value	Criteria	Calculated Value
GA5-1	SA	15	14	3.6	49	12.5
GA5-2	SA	15	14	4.5	49	16.9
GA5-3	SA	15	14	4.4	49	18.4
GA5-4	SA	15	14	3.5	49	9.8
GA5-5	SA	15	14	2.8	49	5.0
GA5-6	SA	15	14	2.7	49	4.9
GA5-7	SA	15	14	2.9	49	5.6
GA5-8	SA	15	14	3.5	49	13.4
GA5-9	SA	15	14	3.4	49	12.1
GA5-10	SA	15	14	3.3	49	11.7

Table 3.2 Rhode Island Shellfish Program Monitoring Data for Mount Hope Bay

Station	Water Quality Classification	Number of samples	Geometric Mean (MPN/100ml)		90th Percentile (MPN/100ml)	
			Criteria	Calculated Value	Criteria	Calculated Value
GA17-1	SA	15	14	6.7	49	119.1
GA17-2	SA	15	14	4.8	49	19.5
GA17-3	SB	15	200	8.4	400	45.3
GA17-4	SB	15	200	2.8	400	7.9
GA17-5	SB	15	200	4.3	400	21.4
GA17-6	SB	15	200	3.8	400	14.0
GA17-7	SB	15	200	2.8	400	6.4
GA17-8	SB	15	200	3.2	400	8.5
GA17-9	SB	15	200	2.7	400	4.8
GA17-10	SB	15	200	3.1	400	11.3
GA17-11	SA	15	14	3.0	49	9.3
GA17-12	SA	15	14	2.8	49	9.9
GA17-13	SA	15	14	4.4	49	33.6
GA17-14	SA	15	14	3.5	49	11.6
GA17-15	SA	15	14	3.1	49	7.4
GA17-16	SA	15	14	3.8	49	13.7

[1]Growing Areas are considered 'Open' when they are not under the influence of the pre-determined precipitation amount of 0.5" or greater.

3.3 Water Quality Summary and Resource Impairments

Historic and recent data collection efforts confirm water quality impairments under wet weather conditions. Results from the 2006 sampling events indicate that Mount Hope Bay and the Kickemuit River exceeded the state's water quality standards for fecal coliform bacteria in Class SA and SB waters during wet weather. The data shown in Figures 3.1-3.7 confirm this, particularly when comparing the very low levels of bacteria present bay-wide during dry weather to those levels seen during and after a given precipitation event.

Examination of the RIDEM shellfish closure records reveals the extent of resource impairments for these particular waterbodies. The most apparent loss of use is shellfish harvesting from Class SA waters in the Kickemuit River and Mount Hope Bay. Approximately 520 ha of Mount Hope Bay are temporarily closed for harvesting when there is more than one-half inch of rainfall. In the Kickemuit River, over 220 ha are temporarily closed when there is more than one-half inch of rainfall. These temporary wet weather-driven shellfish harvesting closures average 180 days per year.

The data presented in Tables 3.1 and 3.2 show that, with a single exception at station 17-1, water quality standards for fecal coliform bacteria are met in the study area during dry weather. Exceedances of water quality criteria occasionally occur under steady state dry weather, however they are typically localized and sporadic. In many cases it is difficult to identify the cause(s) of the exceedance. These types of exceedances are likely caused by nonpoint sources such as wildlife or waterfowl, failing septic systems conveyed via groundwater or seeps, or marine vessel discharges. Point sources responsible for these periodic exceedances may include illicit discharges to storm drains or leaking sewer lines.

The wet weather data collected during this TMDL study was combined with other available data for the 2010 assessments. Based on this analysis, Segment RI0007032E-01A in Mount Hope Bay is proposed for listing on the 2010 303(d) List of Impaired Waters for not supporting the shellfish consumption use. While these data would also indicate that Segments 01C and 01D support their swimming use designations, additional water quality sampling during larger rain storms is necessary to determine whether the swimming use is in fact supported given the proximity of Combined Sewer Overflows in the City of Fall River to these waters. Thus the designated uses assigned to Segments 01C and 01D are still considered to be impaired.

4.0 POLLUTANT SOURCE ASSESSMENT

Given the diffuse and intermittent nature of bacteria sources, as well as data and resource limitations, this report does not quantitatively estimate bacteria contributions from the various sources in the study area. However, both recent and historic water quality studies and monitoring programs in Mount Hope Bay and the Kickemuit River lead to general conclusions about the likelihood and significance of the different identified fecal coliform sources.

Both point and nonpoint sources of pollution impact the sanitary quality of the study area. Point sources of pollution are those that discharge to a waterbody from a fixed location or through a single point of entry such as a discrete pipe or ditch. Non-point sources encompass those pollution sources that have no single identifiable point of entry for the contamination.

Combined sewer overflows from the City of Fall River have historically been and may continue to be the most significant point source of bacterial pollution to Mount Hope Bay during wet weather. Due to the ongoing control actions regarding this source, it is presently unquantifiable- both in magnitude and significance. CSO discharges from the City of Taunton may impact the study area during significant wet weather events. Other significant point sources to Mount Hope Bay include direct stormwater runoff from municipal separate storm systems (MS4s) in Swansea, Somerset, and Fall River, Massachusetts and stormwater runoff from MS4s in Bristol and Tiverton, Rhode Island.

Other potential point sources to Mount Hope Bay in both RI and MA may also include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, as well as accidental malfunctions of wastewater treatment facilities. Additional point sources exist, including MS4s within the upper portions of the Taunton River watershed, but the significance of these sources is difficult to evaluate without extensive monitoring data and/or complex water quality modeling.

The largest point sources to the Kickemuit River include direct stormwater runoff from MS4s in Warren and Bristol, Rhode Island as well as stormwater runoff from the upper portions of the watershed in Massachusetts contributed via the Kickemuit Reservoir. Other potential sources in both RI and MA may also include point sources such as leaking sewer pipes and illicit connections of sanitary sewers to storm drains.

Potential nonpoint sources in both Mount Hope Bay and the Kickemuit River may include failing septic systems, unregulated shoreline runoff, marine vessel discharges, both migratory and non-migratory waterfowl, and pet waste. Given the acceptable water quality in Mount Hope Bay and the Kickemuit River during dry weather conditions it is not thought that nonpoint sources of bacteria are of sufficient magnitude to cause chronic impacts to the sanitary quality in the study area (during these time periods). Exceptions may include pet waste, which has been shown in many studies to be a significant source of fecal coliform in stormwater runoff in urban areas, as well as unregulated shoreline runoff and failing septic systems.

Known and suspected sources of fecal pollution to Mount Hope Bay and the Kickemuit River are discussed below. Section 4.1 provides information on combined sewer overflows from the City of Fall River and Taunton. Section 4.2 discusses the significance of stormwater runoff as a pollutant source to the study area and other sources such as wildlife/waterfowl, failing septic systems, marine vessel discharges, and illicit connections are discussed in Section 4.3.

Pollution source information was obtained from review of historic studies, recent RIDEM wet weather sanitary investigations and data collection efforts, 12-year sanitary survey reports published by both RIDEM and MA Department of Marine Fisheries, and the draft pathogen TMDL for the Narragansett Bay/Mount Hope Bay watershed recently completed by MADEP (MADEP Aug 2008).

4.1 Combined Sewer Overflows

Fall River's existing Wastewater Collection and Treatment System is primarily a Combined Sewer System transporting both sanitary and stormwater flows from approximately 75% of the sewered areas of the City. These facilities have the capacity to collect, transport and treat dry-weather average daily flow of 31-million gallons per day. The present peak hydraulic capacity for combined dry and wet-weather flow is 106-million gallons per day.

Fall River's existing Combined Sewer System collects and transports wastewater from a service area of approximately 90,000 residents and stormwater runoff from approximately 2,020 ha (20 km^2). The Collection System Facilities consist of 179-miles of sewer pipeline, 13-pumping stations, 4,500 manholes, 5,000 catch basins and 19 Combined Sewer Overflow (CSO) outfalls. The Fall River WWTF has historically discharged approximately 1.5 billion gallons per year of untreated and/or partially treated sewage to Mt. Hope Bay (Burns 2001).

Water quality studies conducted by the U.S. Food and Drug Administration (FDA) in 1987 and Applied Science Associates (ASA) Inc. in 1990 have confirmed that of all the potential sources of sewage contamination in Mount Hope Bay, CSO's represent the largest source - potentially masking all other inputs of fecal contaminants. During one wet weather event monitored by the FDA, CSO's accounted for 96% of total fecal coliform loading to Mount Hope Bay (Dixon et al. 1990).

Currently the three mile, 20-ft diameter tunnel and nine connecting shafts are online and operational, although it is uncertain what percentage of the total annual CSO volume previously discharged to the bay is being captured and treated. The tunnel has an approximate storage capacity of 38 million gallons. Beginning in March of 2009, the City will be conducting an evaluation and assessment of the operation of the South /Central tunnel system and the Cove Street CSO Screening and Disinfection Facility, for a period of about a year. This information will provide the data needed in order determine the scope of work for the remaining screening and disinfection facilities. It is impossible at this point to quantitatively assess water quality improvements as a result of the recent upgrades. Until the assessment phase is completed it is not known to what extent the combined sewer overflows continue to contribute to bacterial pollution in the Mount Hope Bay.

The Taunton Wastewater Treatment Facility collects and treats municipal wastewater from a portion of the surrounding municipal area including industrial wastewater from 9 non-categorical significant industrial users and 14 categorical industrial users (mostly metal finishers). The facility provides advanced treatment and one stage ammonia-nitrogen removal. Portions of the collection system are over 100 years old, and are subject to large amounts of inflow and infiltration. During springtime high ground water conditions, flows to the plant may reach 22.4 mgd, from a dry weather average flow of 6.5 mgd (2004 M&E Sewer System Evaluation Survey). At least 300 manhole covers in the system had holes drilled in them so that they acted as catch basins during storm events, and an additional 33 manholes had combined drainage and sanitary pipelines in the same structure (August 28, 2006 letter from Veolia Water).

There is a single CSO in the City of Taunton, located on West Water Street (Outfall 004). The City of Taunton has been subject to several enforcement actions for high flow related effluent violations, including EPA administrative orders No. 94-31 issued in 1994 and No. 96-04 issued in 1996 and a MADEP order issued in 2005. RIDEM's Shellfish Program staff are notified when overflows occur from the West Water Street outfall. The past four years of overflow events are summarized in Table 4.1. The overflows are associated with heavy rainfall events and are due primarily to infiltration and inflow (I/I) into the system. Infiltration is groundwater that enters the collection system through physical defects such as cracked pipes, or deteriorated joints. Inflow is extraneous flow entering the collection system through point sources such as roof leaders, yard and area drains, sump pumps, manhole covers, tide gates, and cross connections from storm water systems. Significant I/I in a collection system may displace sanitary flow reducing the capacity and the efficiency of the treatment works causing bypasses to secondary treatment and overflows into the Taunton River.

It is unclear whether these overflows cause discernable water quality impacts in Mount Hope Bay, since the overflow site is approximately 35 km (56 miles) upstream of the bay's RI/MA border. In addition, impacts from Taunton's overflow events have likely been masked by the simultaneous occurrence of combined sewer overflows from the 19 sites from the City of Fall River. Put into perspective, Fall River historically discharged approximately 1.3 billion gallons of stormwater and sewage from the 19 outfalls on an annual basis. The average overflow per year (Figure 4.1) from the single outfall in Taunton is approximately one million gallons; putting the ratio of annual overflow volume between Fall River and Taunton at over 1300:1.

Regardless of dilution from simultaneously occurring CSOs from Fall River, this TMDL still considers CSO events from the Taunton River WWTF to be a source of bacteria to Mount Hope Bay.

Table 4.1 Reported Overflow Events from Taunton WWTF.

Date of Reported Overflow	Reported Overflow Amount (gallons)	Prior Day (or 2 Days) Rainfall (inches)
12/12/2008	3,911,000	3.46
9/27/2008	8,000	4.03
9/06/2008	208,000	3.01
7/23/2008	59,000	1.71
3/08/2008	2,190,000	2.89
2/02/2008	179,000	1.15
4/06/2007	5,684,000	1.05
3/17/2007	2,222,000	3.62
3/02/2007	408,000	2.22
2/14/2007	355,000	>1.74
6/25/2006	1,471,000	3.69
6/07/2006	13,768,000	5.21
11/22/2005	262,000	2.59
10/15-10/17 2005	12,123,000	6.54
10/09/2005	245,000	3.04
9/15/2005	770,000	3.19
8/30/2005	2,000	2.55
5/29/2005	134,000	1.54
4/02/2005	183,000	1.07
3/28-3/30 2005	2,012,000	2.62

4.2 Stormwater Discharges from MS4s

Stormwater in the study area originates from regulated discharges from Phase I and Phase II Municipal Separate Stormwater Sewer Systems (MS4s), and from non-regulated runoff. Stormwater discharges from MS4s are a concern because of the potential for high pollutant concentrations. Urbanized and suburban land use within the study area increases the amount of impervious surface relative to undeveloped areas. The result is increased rates and volumes of runoff. Bacteria from a wide range of sources including pet waste and urban wildlife and waterfowl are washed untreated into runoff and discharged into surface waters through stormwater systems or by direct overland flow.

Pet waste left on trails, sidewalks, streets, and grassy areas is often flushed into the nearest waterway or catch basin when it rains. Like human waste, animal waste can contain harmful bacteria and viruses that make water unfit for drinking, swimming, or irrigation. According to recent research, non-human waste represents a significant source of bacterial contamination in urban watersheds. Genetic studies by Alderiso et al. (1996) and Trial et al. (1993) both concluded that 95 percent of the fecal coliform found in urban stormwater was of non-human origin.

DNA fingerprinting techniques have clearly shown pet waste to be a major contributor of bacteria in urban and suburban watersheds. Dogs in particular are likely a major source of fecal coliform bacteria, given their population density and daily defecation rate. A study by Lim and Oliveri (1982) found that dog feces were the single greatest source contributing fecal coliform and fecal strep bacteria in highly urban Baltimore catchments. Trial et al. (1993) reported that cats and dogs were the primary source of fecal coliforms in urban sub watersheds in the Puget Sound Region. Bacterial source tracking studies in a watershed in the Seattle, Washington area found that nearly 20% of the bacteria isolates that could be matched with host animals were matched with dogs (Samadpour, M. and N. Checkowitz, 1998). A study conducted by the Washington State Department of Ecology determined that in an area with a population of approximately 100,000 individuals, dogs were found to generate approximately two and a half tons of feces per day, equating to nearly two million pounds per year.

The presence of pet waste in stormwater runoff has a number of implications for urban stream water quality with perhaps the greatest impact from fecal bacteria. It has been estimated that for watersheds of up to twenty-square miles draining to small coastal bays, two to three days of droppings from a population of about 100 dogs would contribute enough bacteria and nutrients to temporarily close a bay to swimming and shellfishing (US EPA, 1993).

There are numerous Phase II General Stormwater Permits for municipalities in Massachusetts that are located within the Taunton River/Mount Hope Bay or Kickemuit watersheds. These include the communities of Bridgewater, Raynham, Dighton, Berkley, Somerset, Swansea, Taunton, Freetown, and Fall River. According to the draft pathogen TMDL for the Narragansett/Mount Hope Bay Watershed (MADEP 2008), each community was issued a stormwater general permit from EPA and Mass DEP in 2003/2004 and is authorized to discharge stormwater from their municipal drainage system.

Specific stormwater outfalls have been identified either as part of the respective communities Phase II stormwater outfall mapping requirements or as part of sanitary survey work conducted by the MA Division of Marine Fisheries Shellfish Program staff (MADMF 1997 and 1999). Providing a detailed list of these outfalls is beyond the scope of this TMDL.

Historically, the sanitary quality of the bay has been dominated by sources within the Fall River area (combined sewer overflows and stormwater runoff) as well as upstream sources in the Taunton River. To the extent that this remains the case is uncertain, however smaller sources exist within Rhode Island and have a notable, although localized impact on water quality during wet weather events, particularly in the

Kickemuit River. MS4s contributing to the wet weather degradation of the sanitary quality in the study area include those owned by the Towns of Bristol, Warren, and Tiverton in Rhode Island.

As part of this TMDL study, RIDEM has prioritized stormwater outfalls in the northern portion of the Kickemuit River within the Town of Warren, several outfalls located in Bristol discharging mainly to Mount Hope Bay, and several outfalls in the northern portion of Tiverton, RI which discharge directly to Mount Hope Bay. RIDEM's wet weather studies indicate that these sources do impact water quality in localized areas of the bay and the Kickemuit River. These are the sources of contamination to Mount Hope Bay and the Kickemuit River which merit the highest consideration for resources allocated to both illicit discharge detection investigations and pollution abatement measures.

Although there are several outfalls at the northern end of Portsmouth, no priority outfalls were identified in this area. The highest bacteria level in the subject area, documented during the 2002 Shoreline Survey conducted by the Shellfish program, was 2,300 fc/100 ml. This concentration was recorded at the outfall of Founders Brook, which has since undergone a significant restoration, resulting in increased tidal flushing and transforming this coastal wetland area from freshwater marsh to a saltwater marsh system. Sampling of outfalls in the Mount Hope Bay watershed was also conducted by the Town of Portsmouth, as part of its Phase II requirements. Outfalls were sampled in April and October 2007, during high and low water table conditions. The highest recorded bacteria concentration was 200 fc/100 ml.

RIDEM staff expended significant time and effort conducting shoreline surveys and preliminary sampling to help target known pollution sources in Rhode Island for wet weather sampling. These efforts are described in detail in the final wet weather data report (RIDEM, 2008). It is available on RIDEM's website at: (http://www.RIDEM.ri.gov/programs/benviron/water/quality/rest/pdfs/mthopeby.pdf).

Those sources thought to be significant, in terms of actual or potential impact to the growing areas, have been prioritized and are described below in detail. The RIDEM OWR Shellfish Program conducted a comprehensive 12-year shoreline survey of Mt. Hope Bay in 2002 and a 12-year survey of the Kickemuit River in 2008 to identify pollution sources that have potential to impact these waters during periods when the growing area is open to harvest (i.e. 0.5 inches of rain or less). The surveys involve a shoreline reconnaissance of the entire study area to locate and catalog pollution sources and collect bacteriological samples from all sources actively flowing into the survey area. Sources may typically include outfalls, streams, groundwater seeps, or other identified surface flow paths draining land uses capable of producing fecal pollution. The shoreline survey reports are available at RIDEM Office of Water Resources at 235 Promenade Street in Providence, RI.

Follow up investigation, wet weather sampling, and prioritization for pollutant removal was performed as part of this TMDL study. For the TMDL study, dry weather fecal coliform bacteria levels exceeding 2,300 fc/100 ml were generally flagged as priority sources for immediate follow-up. RIDEM's Office of Compliance and Inspection uses this fecal level as a general guideline because at this level there is a reasonable possibility that any human source of fecal pollution can be traced to its source. Standard Operating Procedure for RIDEM's Shellfish program specifies a similar threshold concentration (2,400 fc/100 ml), which triggers follow-up sampling and referral to the Office of Compliance and Inspection. Also, sources exceeding this dry-weather fecal guideline generally also had high levels of coliphage. Many of the sources of fecal contamination to stormwater drains, such as pets and most wildlife, may be discounted during dry weather. It is therefore more likely that high fecal concentrations measured during dry weather are derived from human sources, such as failing septic systems, illicit connections, leaky sewers, or cross connections.

Fecal coliform are ubiquitous in the environment and are produced from a variety of watershed sources including human waste from sewer lines and failing septic systems, as well as livestock, wildlife, waterfowl, pets, soils, plants, and even within the stormwater system itself. Moderate or even high concentrations of fecal coliform, observed during wet weather may not necessarily be associated with a human source. Pitt (1998) reported a mean fecal concentration in stormwater runoff of about 20,000 MPN/100 ml and suggests that human sources of sewage should be suspected when fecal coliform concentrations are consistently higher than 10^5 MPN/100 ml. This threshold for fecal coliform was exceeded in only one instance during sampling conducted for this study (a stream at Summerfield La. in Tiverton).

High coliphage concentrations are reportedly a more reliable indicator of human sources of fecal pollution than high fecal concentrations alone (Calci, et al.,1998; Long et al., 2005). Calci (1998) reports that the mean coliphage concentration in wastewater from single-family dwellings is 1.0×10^5 pfu (particle forming units)/100ml. This is supported by Long et al. (2005) who reports that that the mean coliphage concentration in septic system liquid is 7.2×10^5 pfu/100ml. In addition, Calci et al. (1998) report that the mean coliphage concentration for in-line sewage and sewage plant influent is 2.3×10^5 and 5.2×10^5 pfu/100 ml, respectively. Again this is corroborated by Long et al. who report a mean coliphage concentration in wastewater influent of 1.1×10^5 pfu/100 ml.

Although feces from other animals, including seagulls, chickens, hogs, horses, may have relatively high coliphage concentrations, it would take thousands of birds and over a million dogs to equal the coliphage load of a single failing septic system or illicit connection (Calci et al., 1998). Since the reported coliphage levels derived from both septic systems and sewage pipes are on the order of 10^5 pfu/100 ml, and a dilution of 1:1,000 or even 1:10,000 can occur once the effluent discharges to a storm drain, a coliphage concentration of 50 pfu/100 ml was selected as a general guideline to flag priority outfalls for further investigation or pollution abatement.

Outfalls were also prioritized for purposes of abating wet weather loads of bacteria. This was done at least partially by pipe diameter, deducing that the culverts were sized according to their drainage areas and the potential for fecal contamination increases with the size of the catchment. Measured loadings were also used to a limited extent to determine the relative impacts of streams and pipes. Prioritizing sources by loading rates was difficult, since flow measurements were not taken over a discrete time period. Lastly, sources were also prioritized according to proximity to localized elevated fecal concentrations observed in the estuary during the two wet-weather events.

Prioritized Sources in the Town of Warren

Nearly all of the area in the vicinity of the priority outfalls is sewered. The priority sources in Warren generally had high dry weather values for both fecal coliform and coliphage (Table 4.2). It should be noted that all dry-weather samples were collected from outfalls within a few days of a significant rain. Although there was no direct runoff from impervious areas at the time of the dry-weather sampling, recent rainfall probably led to increased groundwater infiltration into storm drains. Potentially contaminated groundwater infiltrating storm drains may have had an influence on the observed higher levels of bacteria. In contrast, sampling conducted in the railroad right-of-way storm water drainage system after an extended dry period, discussed in greater detail below, showed very low bacteria and coliphage levels. The relatively high dry weather values may be an indication of leaking sewer lines or possibly failing septic systems. The wet weather coliphage concentrations were generally below the detection limit, while the fecal concentrations recorded during wet weather were generally typical of stormwater.

Railroad Right-of-Way Outfall (Source #5-18)
This 24 in. culvert conducts stormwater from Metacom Avenue and discharges at the southern edge of the broken railroad bridge near Barker Avenue. The culvert extends perpendicularly from Metacom Avenue, just north of Libby Lane, along a wooded abandoned railroad right-of-way. This culvert had the highest observed dry-weather fecal concentration and coliphage loading rate of any of the priority outfalls located in the Town of Warren. A small stream, originating at a pasture to the immediate south of Libby Lane, discharges to the subject drainage system. The cow pasture itself could be a significant source of bacteria to the priority outfall.

RIDEM staff sampled the railroad right-of way-outfall and drainage system in an attempt to bracket the source(s) of bacterial pollution. Samples were collected on April 17, 2008, after four days without significant rain. In addition to the outfall, samples were also taken at two manholes located within the wooded right-of-way. A sample was taken at a manhole approximately 1300 feet west of the outfall. Another two samples were taken at two side pipes within a manhole approximately 1100 feet west of the outfall. One of the pipes carries discharge from a stream flowing from the cow pasture (mentioned above) through the Warren Housing Authority on Libby Lane and the other carries discharge from a stream flowing out of a small manmade pond behind an industrial building on Metacom Avenue. Both bacteria and coliphage levels from all sampling stations were extremely low. The maximum bacteria and coliphage concentrations were 23 fc/100 ml and 5 pfu/100 ml.

Parker Avenue Box Culvert (Source #5-12)
The box culvert at Parker Avenue drains Metacom Avenue in addition to Parker Avenue itself. The Parker Avenue box culvert had the highest observed wet-weather fecal load of any of the Warren outfalls.

Child Street Outfall (Source #5-21)
This 18-in. culvert drains Child Street and intersecting roads to the north. The outfall is located to the west of the Child Street Bridge. This outfall had the highest dry weather coliphage concentration of any of the Warren outfalls.

Parker Avenue Culvert (Source #5-13)
The 30-inch Parker Avenue outfall drains Patterson Street to the south. Coliphage concentrations were higher during wet weather, possibly indicating that the source is from a failing septic system rather than an illegal tie-in or cross-connection.

Libby Lane Outfall (Source #5-17)
The Libby Lane outfall had both high dry weather fecal coliform and coliphage concentrations. The Libby Lane outfall appears to drain the lower half of Libby Lane only.

Table 4.2 Priority Outfalls in the Town of Warren.

Warren, Rhode Island				Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
Source ID	Receiving Water	Location	Description	Fecal (fc/100 ml)	Phage (pfu/100 ml)	Fecal (fc/100 ml)	Phage (pfu/100 ml)
5-18	KR	Broken R.R. bridge at Barker Av.	24" culvert	43,000	835	15,000	0
5-12	KR	Parker Av.	42 x 20" box culvert	15,000	49	23,000	0
5-21	KR	Child St. west of bridge	18" culvert	≥24,000	1725	NS	NS
5-13	KR	Parker Av.	30" culvert	4,300	0	23,000	130
5-17	KR	Libby La.	18" culvert	23,000	749	21,000	0

KR=Kickemuit River NS=No Sample

Prioritized Sources in the Town of Bristol

Six priority outfalls were identified in the Town of Bristol (Table 4.3). These include: three streams and two culverts that discharge to Mount Hope Bay and one stream that discharges at the mouth of the Kickemuit River. All or nearly all of the area adjacent to the streams and pipes are sewered. The only unsewered area, within the Mount Hope Bay watershed in Bristol, is a small area east of Metacom Avenue between Tower Street and Weetamoe Farm Drive. With the exception of the Annawamscutt culvert, all of the priority outfalls were characterized by high coliphage concentrations during wet weather possibly indicating the presence of sewer overflows, leaking sewer systems, cross-connections or perhaps failing septic systems. Although the Annawamscutt outfall had extremely low coliphage levels, it had the highest dry and wet-weather bacteria concentrations of any of the priority outfalls located in the Town of Bristol. The three streams that discharge to Mount Hope Bay, at the state boat ramp, Roger Williams University and Bristol Landing condominiums, also had dry-weather bacteria concentrations that were slightly higher than is typical. There could be a dry-weather source to these streams, or it is possible that the relatively high dry-weather bacteria levels, recorded within 24 hours of the end of a rain event, could be the result of longer travel times relative to storm drain systems.

RIDEM Boat Launch Stream (Source #17-14)

This unnamed stream discharges into Mount Hope Bay immediately south of the RIDEM boat launch off Annawamscutt Road. Inspection of aerial photographs reveals that the stream originates in a large swamp located between Hopeworth Avenue and Tower Road, east of the Minturn Farm Landfill. High-density residential development flanks the swamp in the vicinity of Hopeworth Avenue. Coliphage concentrations were particularly high (4530 pfu/100 ml) during wet weather.

Roger Williams University Stream (Source #17-45)

This stream or manmade swale originates at a detention basin located at the FCAS South Lecture Hall on the campus of Roger Williams University. Several pipes conduct stormwater to the basin. Coliphage concentrations were high during both dry and wet weather (2270 and 2054 pfu/100 ml, respectively).

Bristol Landing Stream (Source #17-7)

This unnamed stream discharges into Mount Hope Bay east of Bristol Landing condominiums. The only residential development in the immediate vicinity of the stream is along Russell Avenue and few large unsewered properties east of Metacom Avenue, between Tower Street and Weetamoe Farm Drive. The stream flows through two old farm ponds. The stream may be accessed from a grassed cart path at Bristol

Landing condominiums, which extends to the shoreline from the intersection of Weetamoe Farm and Sequoia Drive. There are two streams that are culverted underneath the cart path. The subject stream is the easternmost one. High coliphage concentrations (297 pfu/100 ml) were recorded at this location during wet weather.

Narrows Road Stream (Source #5-1)
This unnamed stream discharges into the Kickemuit River at a small cove, just north of Narrows Road. This stream originates from an outfall at the eastern end of Sowams Drive and flows through a swamp that straddles Narrows Road. The swamp is flanked by high-density residential development to the south of Narrows Road. A sewer line crosses the swamp from Sowams to Sunrise Drive. The sewer line has failed catastrophically in the past, discharging raw sewage directly into the swamp and stream. High coliphage concentrations were recorded during wet weather (232 pfu/100 ml).

Viking Drive Outfall (Source #17-13)
This 18-inch culvert is located east of Viking Drive, approximately 150 feet north of its intersection with Glen View Drive. The drains appears to service an isolated neighborhood straddling the terminus of Hopeworth Avenue. High coliphage concentrations were recorded during wet weather (>800 pfu/ml).

Annawamscutt Drive (Source #17-15)
This 18-inch culvert is located at the eastern terminus of Annawamscutt Drive. It had the highest observed dry and wet-weather bacteria concentrations of all the Bristol outfalls (23,000 and 93,000 fc/100 ml, respectively). However, both dry and wet-weather coliphage levels were exceptionally low.

Table 4.3 Priority Outfalls located in the Town of Bristol.

Bristol, Rhode Island				Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
Source ID	**Receiving Water**	**Location**	**Description**	**Fecal (fc/100 ml)**	**Phage (pfu/100 ml)**	**Fecal (fc/100 ml)**	**Phage (pfu/100 ml)**
17-14	MHB	State boat ramp south of Annawamscutt Dr.	Stream	2,400	29	23,000	4530
17-45	MHB	Roger Williams University	Stream from detention pond	4,300	2270	23,000	2054
17-7	MHB	Bristol Landing Condominiums	Stream	4,600	7	24,000	297
5-1	KR	Kickemuit mouth north of Narrows Rd.	Stream	430	1	2,300	232
17-13	MHB	Viking Dr.	18" culvert	NS	NS	≥24,000	>800
17-15	MHB	Annawamscutt Dr.	36" culvert	23,000	0	93,000	7

MHB=Mount Hope Bay KR=Kickemuit River NS=No Sample

Prioritized Sources in the Town of Tiverton

Two priority sources (a 24-in. outfall and a stream) were identified in the Town of Tiverton (Table 4.4), both located in close proximity to each other between Robert Gray and Summerfield Lane. This area is serviced by older individual septic systems, including cesspools. The area is characterized by a high water table, high ledge, extreme slopes, and high-density residential development, which increase the likelihood of septic system failure.

State Avenue Outfall
High dry weather fecal coliform (21,000 fc/100 ml) and coliphage concentrations (Too Numerous To Count) were recorded at a 24-in. outfall at State Avenue (17-40), which is located along the Rhode Island-Massachusetts border. The case was referred to the Office of Compliance & Inspection (OCI) for further investigation. OCI staff determined that most of the catchment area associated with the State Avenue outfall is located within Massachusetts. OCI staff contacted staff from the Fall River Wastewater Treatment facility, which is located to the immediate north of the outfall. Staff from the wastewater treatment facility voluntarily sampled several manholes associated with the Bay Street/State Avenue storm drain system on four separate occasions, during dry-weather conditions. The highest recorded bacteria level was 1,350 fc/100 ml. RIDEM staff subsequently sampled the State Avenue outfall as well as an upgradient manhole during dry weather. Again the bacteria levels were not dramatically high (a maximum of 1,500 fc/100 ml). Although early sampling indicated a dry-weather problem, subsequent sampling failed to confirm high bacteria levels during dry weather. In any case, since most of the drainage associated with this outfall is from Massachusetts, this outfall was not identified as a priority outfall in this TMDL.

Robert Gray Avenue Outfall (Source #17-28)
This 24-in. culvert discharges into Mount Hope Bay just north of the intersection of Robert Gray and Colony Terrace, near 621 Old Colony Terrace. The pipe drains a portion of Main Road (Route 138), Pleasant Avenue, most of Robert Gray Avenue, Kearns Avenue west of Terry Lane, and Brackett Avenue east of Terry Lane (Figure 4.1). This drainage system has a history of surcharging. There is an overflow pipe, located at the intersection of Kearns Avenue and Terry Lane that directs stormwater to a stream to the north (source 17-27) during periods of high discharge. Both observed bacteria and coliphage levels were consistently higher than concentrations recorded at the Summerfield Lane outfall. Results from the outflow show high fecal coliform and coliphage concentrations during both dry and wet weather (Table 4.4). The results appear to indicate the presence of illicit tie-ins as well as failing septic systems.

RIDEM staff sampled the Robert Gray Avenue outfall and drainage system in an attempt to bracket the source(s) of bacterial pollution. The drainage system was sampled, on September 26 2008, during a significant rain event, at four locations including the western terminus of Kearns Avenue, the northern terminus Terry Lane, and at two locations on Bracket Avenue. A strong sewage odor was detected at the Robert Gray outfall and in the three catch basins upgradient of the outfall, but not at the most upgradient catch basin on Bracket Avenue. A resident of Bracket Avenue reported strong sewage odors even during dry weather. The wet-weather bacteria concentrations at the Robert Gray Avenue outfall and storm water system were generally relatively low (< 9,300 fc/100 ml). There was one high concentration (93,000 fc/100 ml) at a catch basin just upgradient of the outfall, at the lower end of Kearns Avenue, but the bacteria concentration at the outfall itself was only 4,300 fc/100 ml. The significance of this high bacteria level just upgradient of the outfall is not clear, since there does not appear to be enough additional flow entering the system, between the subject catch basin and the outfall, to account for the apparent dilution. However, the coliphage data appears to be more conclusive. Coliphage levels at the outfall and four catch basins were all high (>698 pfu/100 ml). The high coliphage levels and presence of strong sewage odors appear to indicate that significant contamination originates along Main Rd. It is difficult to determine how much additional contamination occurs in the Robert Gray area since concentrations were pegged above the maximum detection limit.

The high coliphage and bacteria levels at the Robert Gray Avenue outfall and associated storm water drainage system were reported to OCI for further investigation. OCI staff sampled the outfall and several catch basins within the drainage system on five separate occasions between March 2007 and April 2008. Sampling focused on the lower end of the drainage system, along Old Colony Terrace, the western end of Kearns Avenue, and the northern terminus of Terry Lane. The drainage system was sampled four times during dry weather and once during wet weather. Coliphage levels were extremely low and bacteria concentrations were generally low or fairly typical. At no time were sewage odors detected. The maximum dry-weather fecal coliform bacteria and coliphage concentrations were 4,600 fc/100 ml and 16 pfu/100 ml, respectively. The maximum wet weather bacteria concentration was 24,000 fc/ml.

Summerfield Lane Outfall (Source #17-27)
This stream discharges into Mount Hope Bay west-southwest of the cul-de-sac of Summerfield Lane. Inspection of aerial photographs reveals that the stream originates north of Kearns Avenue, down-gradient of Rose Road. Another stream, originating north of Randolph Avenue and down-gradient of the western terminus of Cleg Avenue, and culverted under Last Street, discharges into the stream at a 36-in. outfall to the south-southeast of the cul-de-sac of Summerfield Lane. This same 36 in. culvert conducts stormwater from Randolph Avenue and probably Main Road. A 12-in. outfall drains stormwater from Summerfield Lane and discharges into the stream south-southwest of its cul-de-sac. A 24-in. stormwater overflow pipe from the Kearns Avenue storm drain system discharges to the subject stream near the intersection of Kearns Avenue and Terry Lane.

The Summerfield Lane outfall was sampled several times and on most occasions both bacteria and coliphage levels were low. The highest bacteria concentration (>240,000 fc/100 ml) at the Summerfield Lane outfall was recorded when the discharge from the outfall was not directly storm-influenced (Table 4.4). Although it had rained 0.48 inches the day prior to sampling, there was apparently no direct street runoff contributing to the flow at the time of sampling. The high bacteria concentration may have been caused by increased discharge of contaminated groundwater from failing septic systems following the rain event, or by a transitory source such as an illicit connection.

The coliphage concentrations were high only during and immediately after the October 2006 rain event, with several very low coliphage results recorded during dry weather. A strong sewage odor was also detected during heavy rainfall on the October 2006 event and not during the other sampling events. Local residents also reported strong sewage odors during heavy rainfalls. The wet-weather coliphage data and presence of sewage odors during rain events would appear to indicate the presence of failing septic systems.

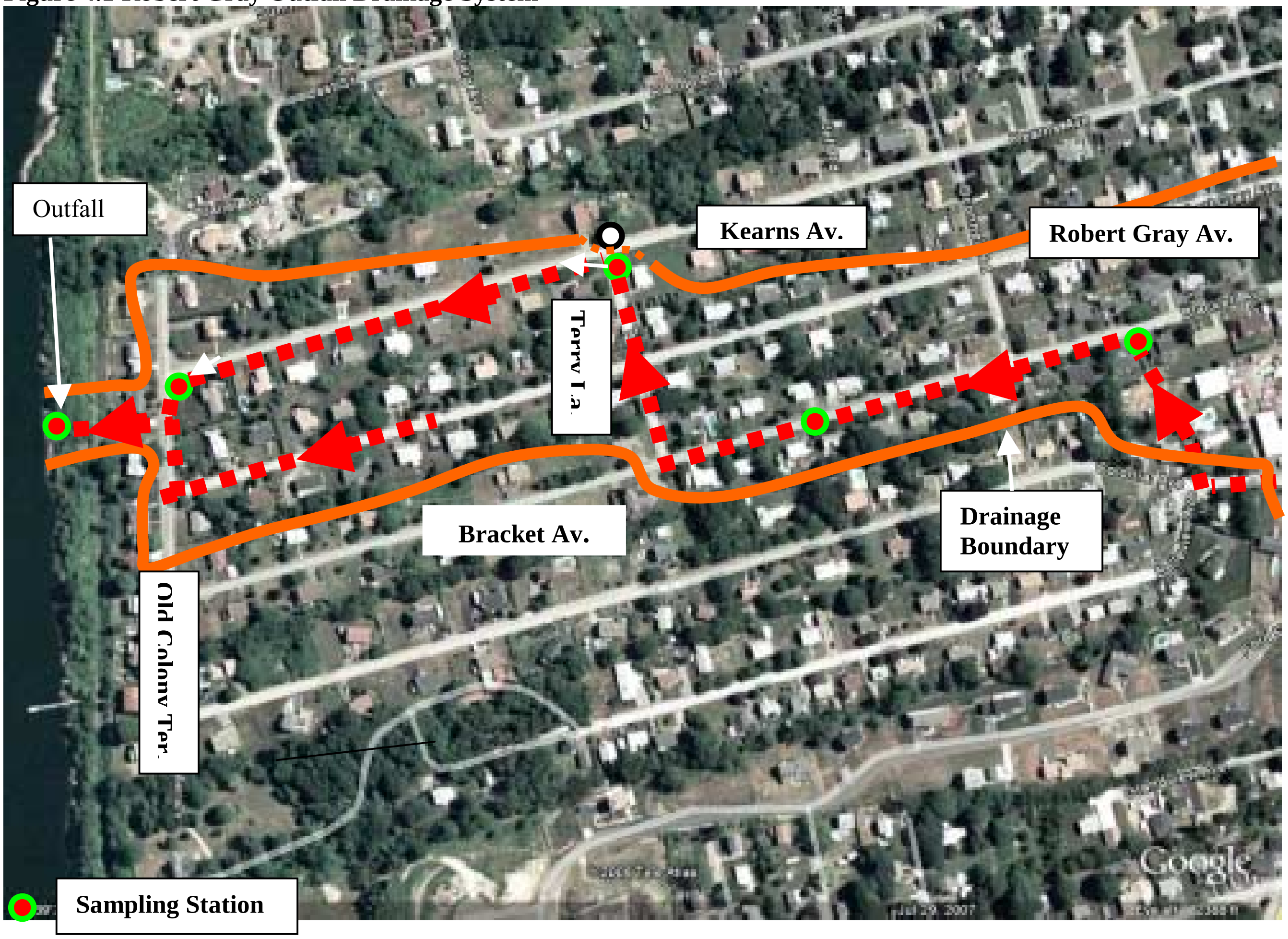
The high bacteria and coliphage concentrations at the Summerfield Lane outfall were reported to the Office of Compliance & Inspection (OCI) for follow-up investigation. OCI staff sampled the outfall, upgradient in-stream stations, and pipes discharging to both forks of the stream on three separate occasions in March and November 2007 and in February 2008. Concentrations were low even during relatively wet weather. The highest recorded bacteria and coliphage concentrations were 7,500 fc/100ml and 42 pfu/100 ml, respectively. Since OCI staff were not able to document high concentrations anywhere within this drainage system, the file on the Summerfield Lane outfall has been officially closed.

Table 4.4 Priority Outfalls located in the Town of Tiverton.

Tiverton, Rhode Island				Max. Concentration During Dry Weather		Max. Concentration During Wet Weather	
Source ID	**Receiving Water**	**Location**	**Description**	**Fecal (fc/100 ml)**	**Phage (pfu/100 ml)**	**Fecal (fc/100 ml)**	**Phage (pfu/100 ml)**
17-28	MHB	Robert Gray Av.	24" culvert	≥24,000	6120	93,000	TNTC
17-27	MHB	Summerfield La.	Stream	≥240,000	30	9,300	4150

MHB=Mount Hope Bay TNTC=Too Numerous to Count

Figure 4.1 Robert Gray Outfall Drainage System



4.3 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 Mount Hope Bay and the Kickemuit River. Stormwater from industrial activities may be discharged to these waters directly or via MS4s and may contain bacteria concentrations that contribute to the impairments.

4.4 Streams and Wetlands draining to Mount Hope Bay and the Kickemuit River

Numerous tributaries to Mount Hope Bay and the Kickemuit River were investigated as potential sources of fecal coliform bacteria. Samples were collected from most major streams and analyzed for both fecal coliform bacteria and coliphage. These samples were collected during both wet and dry weather conditions. For the most part, results were unremarkable with both phage and fecal coliform values well within what is typically observed by RIDEM staff. Insufficient data were collected to fully assess the water quality of these streams as waters of the state. These data are provided in the Final Data Report (RIDEM 2008) available on-line at http://www.RIDEM.ri.gov/programs/benviron/water/quality/rest/pdfs/mthopeby.pdf.

4.5 Localized Estuarine Areas Characterized By High Fecal Coliform Levels

Mount Hope Bay

A localized area of elevated fecal coliform levels exists at estuarine sampling stations GA17-6 and GA17-7 in the northern Tiverton area of Mount Hope Bay. Elevated fecal concentrations at these stations were recorded within one or two days after significant rain events. The elevated levels are likely due to their proximity to several of Fall River's combined sewer overflows and to the Fall River wastewater treatment facility. However, the Town of Tiverton's priority outfalls are also located within very close proximity to estuarine station GA17-7 and may also have an impact on the local water quality.

Elevated levels of fecal coliform bacteria also occur with regularity at station GA17-3, which is located approximately 20 meters southwest of Spar Island in Mount Hope Bay. These elevations are notable in the routine monthly monitoring conducted by the Shellfish Program. As mentioned earlier, the island is more or less a sand bar consisting primarily of large amounts of shell fragments and gravel and is made up entirely of an intertidal zone.

Additional field investigations were carried out by RIDEM staff in 2008. These consisted of digging circular pits in the substrate at ten random locations on the island. Pits were dug to a depth at which water consistently filled the hole (approximately 2-3 feet). When water was allowed to come to an equilibrium level in the pit a water sample was collected. Samples were then analyzed for fecal coliform bacteria. These data are displayed below in Table 4.5. A station map (with plotted data) is provided in Appendix A, Figure 1.

Table 4.5 Sample results from Spar Island field investigations.

Pit ID	MPN/ 100ml	Pit ID	MPN/ 100ml	Pit ID	MPN/ 100ml	Pit ID	MPN/ 100ml	Pit ID	MPN/ 100ml
SI-1	4600	SI-3	2400	SI-5	11000	SI-7	23	SI-9	750
SI-2	230	SI-4	11000	SI-6	4600	SI-8	1500	SI-10	240

The results in Table 4.5 appear to show elevated levels of bacteria relative to those observed in surrounding surface water. The island is regularly utilized by various species of waterfowl and seabirds. The large amounts of droppings over much of the island confirm this observation. Both geometric mean and percentile statistics calculated from data collected at station GA17-3 during periods of ebb and low tide are notably elevated relative to those calculated from the flood and high tide dataset.

One possible hypothesis is that during flood and high tide, water covering the island dissolves the waterfowl droppings that are deposited during periods of low tide when the island is usable to birds and percolates downward. As the tide ebbs, the contaminated water is pulled outward and through and south of the island. While not proven in a scientific manner, this may explain the more elevated bacteria levels consistently measured during ebb and low tide.

Kickemuit River

During wet weather, the upper portion of the tidal Kickemuit River in the Town of Warren is characterized by elevated fecal coliform concentrations. Elevated fecal levels were recorded at stations GA5-6 through GA5-8, from one to three days following sampled rain events. This portion of the Kickemuit River is narrow and constricted relative to the lower portion, perhaps contributing to diminished tidal flushing. Five of the six priority outfalls discharging to the Kickemuit River discharge to this upper portion of the river (north of the Bristol-Warren Town line). The combined effect of these priority outfalls likely has a significant impact on the water quality of the area.

Discharge from the freshwater portion of the Kickemuit River likely impacts the northern area of the estuary-particularly during prolonged wet weather events. Elevated fecal levels (75 and 93 fc/100 ml) were recorded during wet weather at the outflow of the freshwater portion of the Kickemuit River at the Child Street bridge. A mean wet-weather fecal concentration of 212 fc/100 ml has also been previously reported at the terminus of the freshwater portion of the Kickemuit River (RIDEM, 2006).

4.6 Other Potential Sources

Sanitary Waste

There are no WWTFs, located within the State of Rhode Island that discharge into the Kickemuit River/Mount Hope Bay watershed. Sewered areas of Warren, on the western bank of the Kickemuit River, are serviced by pumping stations that lift sewage to a treatment facility that discharges to Bristol Harbor. Pumping stations in Warren pump sewage to a WWTF that discharges to the Warren River. Select sewered areas of North Tiverton are connected to the Fall River WWTF.

Leaking sewer pipes, illicit sewer connections, failing septic systems, and combined sewer overflows (discussed above) represent a direct threat to public health, since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source, because the magnitude is directly proportional to the volume of the source and its proximity to the surface water (MADEP 2008). Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Leaking sewer pipes may contribute to the high dry-weather fecal and coliphage levels observed at the Warren priority outfalls. As discussed in greater detail in Section 6.1, five residences east of Metacom Avenue, between Child Street and Overhill Road, were not connected to Warren's sewer system and the status of eleven homes remained unconfirmed as of 2004. In 2008 the Town conducted an inspection of the storm drain system east of Metacom Avenue, between Child Street and Patterson Avenue, and found no illicit tie-ins. Given the apparent lack of illicit tie-ins, cross connections, and septic systems in the area and the high dry-weather bacteria and coliphage levels observed within a few days following a rainfall, it appears that leaking sewer pipes may be a source of contamination to local storm drains.

Several sewer overflows and leaks have been documented in the Town of Bristol. A sewer line between Sowams and Sunset Drives failed catastrophically in the past, discharging raw sewage directly into a swamp at the headwaters of an unnamed stream discharging at the mouth of the Kickemuit River (priority source 5-1). Sewer overflows have occurred at the Mount Hope and Kickemuit pumping stations, located at intersection of King Phillip Avenue and Annawamscutt Drive and at the intersection of Kickemuit Avenue and Harrison Street, respectively. A few sewer manhole overflows have also been documented in the Mount Hope Bay watershed at 15 Jennifer Drive, 104 King Phillip Avenue, and 3 Polk Court (BETA Group Inc., 2007). These sewer system overflows occur during extreme rainfall events that take place in the high groundwater season. The Town of Bristol is working with USEPA, RIDEM and BETA Group, Inc. to eliminate the problems with sewer system overflows.

An illicit connection is an illegal connection between a sanitary sewer or septic system and a storm drain. Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. It is probable that numerous illicit sewer connections exist in storm drainage systems serving the older developed portions of the Mount Hope and Kickemuit drainage basins. Illicit connections have been found in the past through field studies conducted by the Kickemuit River Council as well as sanitary surveys of growing areas in both MA and RI. Typically, these sources have short-term impacts on water quality since once they are discovered they are remediated fairly quickly.

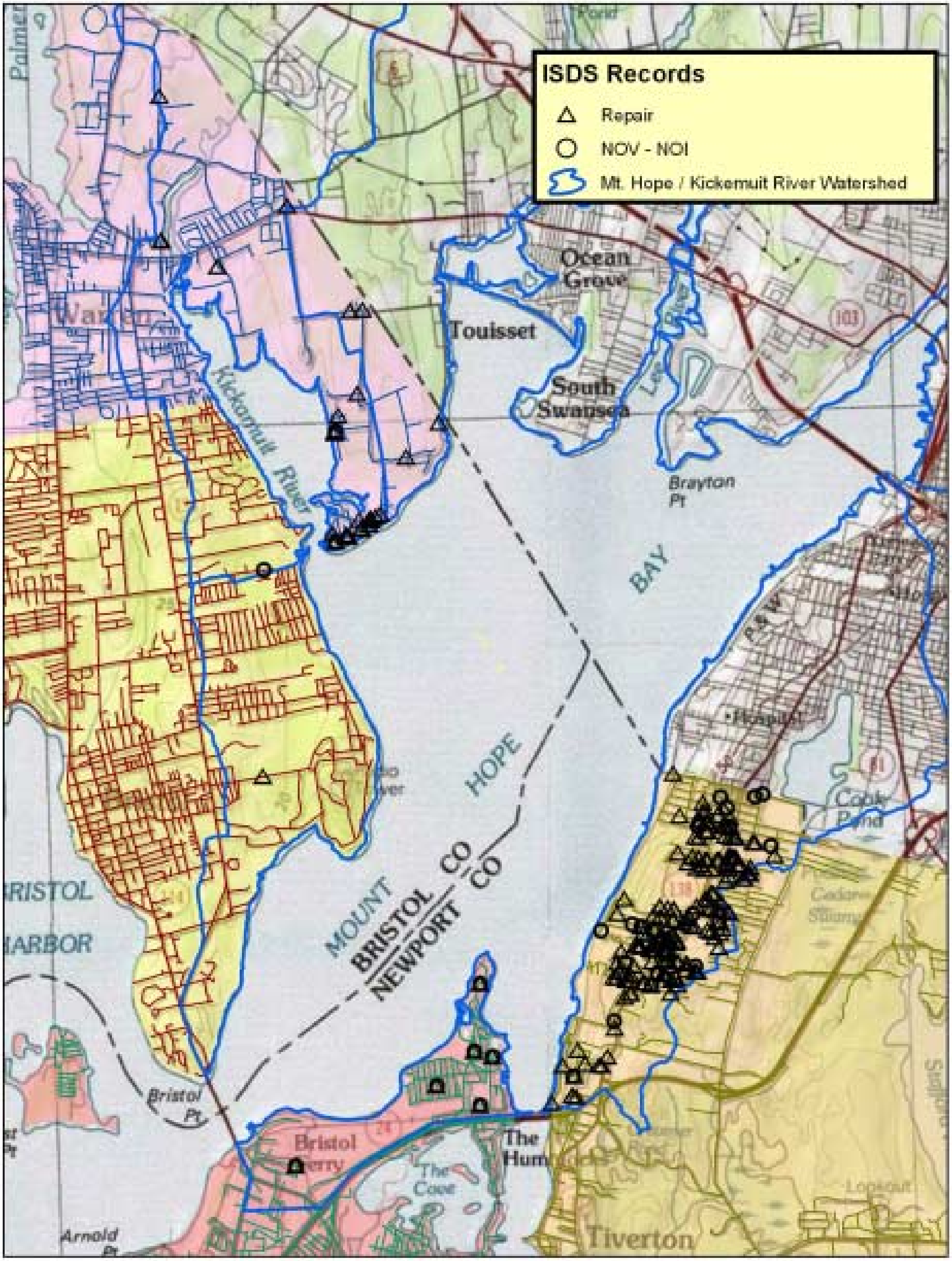
Septic systems, when properly designed, installed, and maintained, provide an effective and efficient means for treating wastewater. However, they are prone to failure with age, overuse, poor soil conditions, high water tables, or improper installation, repair, and/or maintenance. Failed or non-conforming septic systems can be a major contributor of fecal coliform to the Narragansett/Mt. Hope Bay watershed. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

As reported in the 1997 and 1999 MADMF Sanitary Surveys for Mount Hope Bay and the Taunton River, both Somerset and Fall River are sewered, however it was suspected that some homes and businesses along the shoreline may not be connected. Several drains in the area were reported to be flowing during dry weather and staff from MADMF recommended follow-up by the City of Fall River. It is uncertain at this time, whether this situation still exists. The draft pathogen TMDL by MADEP does not identify areas of concern in the MA watershed regarding this source category but rather states that as a source category, failing septic systems may still be a concern in non-sewered areas of the Taunton River, Mount Hope Bay, and the Kickemuit River.

Figure 4.2 shows septic system-related violations in the Mount Hope Bay/Kickemuit River watershed between June 1999 and June 2009, including Notices of Violation (NOVs) and Notices of Intent (NOIs). Permit applications for septic system repairs within the watershed are also depicted. NOIs are written notification by RIDEM's Office of Compliance & Inspection (OCI) to private or public property owners that a violation of state environmental law has occurred and that the infraction must be corrected or further enforcement action will be taken. NOVs are written notification by OCI to owners that enforcement action is pending. NOVs are issued for more serious violations or after there has been an inadequate response to a NOI. All septic system repairs, whether the result of NOVs or NOIs, or initiated by the owner to correct a failing or malfunctioning septic system, require a state permit. These permits are recorded with the Office of Water Resources (OWR). The vast majority of NOVs and NOIs displayed in Figure 4.2 are associated with septic system failures. The displayed NOVs and NOIs may also include illegal tie-ins to storm drain systems (including both illicit septic and/or laundry connections), illegal direct discharges, and System Suitability Determination Infractions (SSDIs). SSDIs are issued when owners make significant upgrades to residences, such as adding bedrooms, without submitting an application to the Office of Water Resources to determine if the existing system is adequate to service additional demands.

Failing sewage disposal systems have, in the past, resulted in the temporary closure of shellfish harvesting in several growing areas in the state. Inspection of Figure 4.2 shows that the vast majority of septic system violations and repairs within the watershed have occurred in North Tiverton. The increased occurrence of septic system failure in North Tiverton is due to high water tables, high ledge, steep slopes, relatively impermeable soils, antiquated systems, and relatively dense residential development. A significant number of violations and repairs have also occurred in the Touisset section of Warren on the eastern bank of the Kickemuit River, and to a lesser extent at the northern end of Portsmouth. In a recent (2008) 12-year sanitary survey of the Kickemuit River conducted by Shellfish Program staff, a seep sampled from a retaining wall located off Shore Drive in Touisset had levels of fecal coliform exceeding 100,000 MPN. This seep drained directly to the eastern shore of the Kickemuit. Follow up sampling by RIDEM is planned for this site. The portion of Warren on the western bank of the Kickemuit River is sewered, although there may be a few properties that are not tied in. Almost all of the Town of Bristol is sewered, but some onsite systems are in use. These systems are located east of Metacom Avenue, between Tower Street and Weetamoe Farm Drive. In the Town of Bristol's Phase II Stormwater Management Plan, it is noted that some older sections of the sewer system have under drains that were intended to lower the groundwater table in the vicinity of the wastewater system. Some of these drains apparently discharge to Mount Hope Bay, although the exact locations of these drains are not known.

Figure 4.2 Septic System Violations in the Mount Hope Bay/Kickemuit River Watershed (6/99-6/09)



Marine Vessel Discharges
The discharge of untreated sanitary waste from marine vessels is a concern in marine and coastal environments. Studies have documented a correlation between boating activity and elevated levels of fecal coliform, especially in areas of poor flushing. (Milliken and Lee, 1990; JRB Associates, 1980). A study in Martha's Vineyard, Massachusetts, identified significant increases in fecal coliform bacteria during high boat use times (Gaines, 1990). This was also documented in studies conducted in Rhode Island's Block Island Great Salt Pond between 1986 and 1991. Although accurate measurements for the volume of boater discharge are difficult to make, the Narragansett Bay Project estimates that 3.9 million gallons of sanitary waste could be discharged in Narragansett Bay in a single boating season (Dixon et al, 1991). Even if only a fraction of this potential occurs, the illegal discharge of untreated waste is an existing problem, particularly in sheltered and poorly flushed areas of the bay.

The predominant concern is the impact that sewage, from urban sources and boats, has on shellfish that are harvested and sold for human consumption. A variety of pathogens in sewage can cause acute gastroenteritis, hepatitis, typhoid, and cholera (Milliken and Lee, 1990). Areas where fecal coliform reaches unsafe levels are closed to shellfishing. In harbors where boats congregate, total input of untreated sewage may have a significant impact. This problem is compounded by the fact that boaters are drawn to closed harbors, which inherently do not provide adequate flushing. Problems can exist for swimmers and others who come in direct contact with water in these congested areas.

Wildlife/Waterfowl
A variety of terrestrial wildlife such as birds, raccoons, fox, deer, muskrat, and rodents inhabit the open space lands, as well as urban and suburban lands, adjacent to Mount Hope Bay and the Kickemuit River. These animals may contribute pathogens through stormwater runoff or direct deposition. No accurate information as to the magnitude and geographic dispersion of this potential waste source is available. Marine birds and mammals are also present in Mount Hope Bay and the Kickemuit River. Migratory waterfowl are numerous during the winter months and routinely utilize Spar Island in Mount Hope Bay as a roosting site (discussed above). Because of the great variety, complex distribution and dispersal patterns, and fluctuating populations of waterfowl it is very difficult to assess their impact on water quality in the study area. They have a potential for localized, intermittent impact, particularly during the winter months and in the vicinity of Spar Island in Mount Hope Bay.

It is likely that localized problems may be present in certain areas of Mount Hope Bay and the Kickemuit River where wildlife densities are particularly high. Low to moderate fecal coliform levels have been observed at sampling stations not thought to be impacted by human activities. This suggests that wildlife (the only other potential source) is not, in general, a significant source to either Mount Hope Bay or the Kickemuit River. However, due to lack of data, wildlife contributions cannot be fully characterized at this point. The wildlife source is also not readily controllable and therefore will not be addressed in the Implementation Section of this TMDL.

Non-Migratory Geese and Swans
Non-migratory geese are frequently reported along the shorelines of the Kickemuit River and Mount Hope Bay. These geese are now known as resident geese, since they do not migrate in the winter. The birds have adapted well to living in urban and suburban areas and their populations flourish with ample food sources - mainly green lawns - and a lack of predators. Studies have shown that a well-fed, healthy adult Canada goose can produce up to 1.5 pounds of fecal matter per day and that where resident goose populations are sizeable (>100 birds), the continuous influx of bacteria contained in feces can contribute to the degradation of the sanitary quality of smaller water bodies, especially those that have restricted circulation (French et al. 2001). Significant populations of swans have been reported in certain areas of Mount Hope Bay and the Kickemuit River

It is likely that localized degradation occurs certain areas of Mount Hope Bay and the Kickemuit River where populations of swans and/or geese are particularly high. Due to lack of data, fecal contributions from this source cannot be fully characterized. However, unlike the wildlife source which is not readily controllable, cost-effective strategies exist that can reduce non-migratory geese and swan populations from utilizing specific areas and causing water quality problems.

Kickemuit Reservoir and Upper Kickemuit River

In 2006 EPA approved the bi-state fecal coliform and total phosphorus TMDLs for the upper Kickemuit and Kickemuit Rivers and the Kickemuit Reservoir prepared by RIDEM and MADEP. The TMDL found that the reservoir, which discharges to the estuarine portion of the saltwater Kickemuit, exceeds fecal coliform criteria during wet and dry weather. Sources of bacteria to the reservoir were found to include loading from upstream segments, the Upper Kickemuit Reservoir, the Shad Factory Reservoir Pipe and direct inputs from the drainage area immediately surrounding the reservoir, which included dairy farms and other agricultural activities. There are fifteen direct stormwater discharge pipes to the drinking water reservoir. The direct input estimate in the TMDL also included loading from waterfowl and other wildlife that frequent the reservoir.

Over 40 direct stormwater outfalls and other direct stormwater conveyances were identified within the upper Kickemuit River and Kickemuit Reservoir as part of the TMDL study (RIDEM 2006). The hydraulic connection between the terminal reservoir and the estuarine portion of the Kickemuit River is variable due to the existence of the recently constructed denil fish ladder. It appears that there is not always a hydraulic connection between the two waterbodies and this makes it difficult to determine the dry and wet weather pollutant loadings from the reservoir to the estuary. However it’s likely that during some periods the bacteria loadings from the reservoir do have an impact on the northern portion of the estuary.

5.0 TMDL ANALYSIS

5.1 Applicable Water Quality Criteria

The applicable water quality standards for all SA and SA-partial use waters in the RI-portion of Mount Hope Bay and the Kickemuit River are: a geometric mean for fecal coliforms of less than 14 MPN/100ml and not more than 10% of samples to exceed 49 MPN/100ml as determined using NSSP protocols (NSSP 1997). The water quality standards for all SB and SB-partial use waters in Rhode Island are: a geometric mean value not to exceed 50 MPN/100ml and not more than 10% of the samples to exceed 400 MPN/100ml, applied only when adequate enterococci data are not available.

5.2 Numeric Water Quality Targets

Oftentimes, the sanitary conditions in tidal waterbodies such as Mount Hope Bay and the Kickemuit River are difficult to assess given the dynamic circulation patterns dominated by tide, river flow, and wind, as well as spatial and temporal variability in pathogen sources and contributions, watershed characteristics, and other factors. Having a single bay-wide water quality target is a conservative measure (incorporating a large margin of safety in Class SB waters) that circumvents the inherent difficulties of applying a particular water quality target to a specific parcel of water with defined boundaries within a dynamic estuary.

Of the two most sensitive designated uses (shellfish harvesting and primary contact recreation) assigned to these waterbodies, the water quality standards for shellfish harvesting are the most stringent. <u>Therefore, the targeted goal for this TMDL is for fecal coliform concentrations in all areas of both waterbodies to meet the shellfishing water quality criterion</u> (geometric mean and 90th percentile concentrations) as measured in accordance with NSSP protocols. The SA water quality goal will be applied to all SB waters within Mount Hope Bay (Shellfish Growing Area 17) for purposes of determining necessary pollutant reductions.

5.3 Water Quality and Resource Impairments

Pollution source surveys, water quality monitoring, and analysis of historic water quality studies were used to help establish the link between actual and/or potential pollutant sources and the observed sanitary conditions in the study area. Data collected in the study area while under the influence of wet weather conditions confirm the 303(d) fecal coliform bacteria listings for a majority of segments in Mount Hope Bay and the Kickemuit River. The impaired uses are shellfish harvesting and primary and secondary contact recreation. These impairments primarily occur during and after wet weather events.

The “Conditionally Approved” portions of Mount Hope Bay and the Kickemuit River estuary are operated by RIDEM as “Conditionally Approved” with shellfishing closures in effect for 7 days following a rain event of 0.50-inches or greater in a 24-hr period. Growing areas within the study area are closed to shellfish harvesting, due to pollution from wet weather sources, an average of 183 days per year.

5.4 Critical Conditions and Seasonal Variation- Analysis

The technical approach used to develop these TMDLs includes conservative assumptions that take into account critical conditions and seasonal variability. Even with the use of sophisticated computer models, tidal waterbodies are difficult to assess given the dynamic flow regime, flushing characteristics, spatial and temporal variability in fecal coliform sources and contributions, as well as changing watershed characteristics. In addition, the sanitary quality of shellfish growing areas can be influenced to a large degree by meteorological conditions such as wind, tide, solar radiation, and temperature. A detailed analysis of critical conditions and seasonality is presented below.

Consideration of Critical Conditions
Clean Water Act Section 303(d)(1)(C) states that determination of "TMDLs shall take into account critical conditions for streamflow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. The intent of this requirement is to ensure that water quality is protected during times when it may be most vulnerable to pollution. Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and help in identifying the actions that may have to be undertaken to meet those standards. As part of the critical condition analysis, bacteria data were evaluated against environmental variables such as tide, weather (wet versus dry) and river stage. The dataset used for a majority of this analysis consisted of the past five years (2004-2008) of fecal coliform bacteria data collected by RIDEM's Shellfish Program. Wet weather data collected in 2006 as part of the TMDL study were also included.

Weather
Table 5.1 presents a statistical analysis of two separate datasets; the past three years (2007-2009, n=15) of sampling data collected during dry weather by the Shellfish Program and data collected by TMDL staff from two targeted wet weather sampling events conducted in summer and fall of 2006. The data collected by RIDEM's Shellfish Program is considered to be representative of sanitary conditions during dry weather, while the TMDL-related data collection represents sanitary conditions during wet weather.

This analysis shows that, with the exception of a single ambient station located near the mouth of the Cole River in MA, all remaining ambient stations in the study area meet both the applicable geometric mean and percentile criteria for all SA and SB waters in dry weather conditions (i.e. less than 0.5" of rain in past 24 hrs). The data in Table 5.1 also show that elevated fecal coliform levels in Mount Hope Bay and the Kickemuit River are almost entirely associated with wet weather events with the highest concentrations reflected by the 90^{th} percentile values.

River Flow
The United States Geological Survey (USGS) maintains a single stream flow site along the Taunton River at Bridgewater, MA. This station (01108000) is located approximately 35 miles (56 km) upstream of the RI-MA border in Mount Hope Bay. Since the Taunton River is by far the largest contributor of freshwater to Mount Hope Bay it follows that the sanitary quality in the bay is due, in part, to inputs from the Taunton River. For the critical condition analysis, mean daily flow, as recorded at USGS station 01108000 was regressed against available data for stations nearest its influence (GA17-4 and GA17-2).

This analysis showed no relationship between discharge and bacteria concentrations in the upper portions of the bay. Additional analysis of this variable included regressing only bacteria data collected under low and ebb tide conditions against river flow. While this resulted in an observable trend in bacteria concentration with respect to discharge, the correlation coefficient (r^2-value) was poor (0.1). The results of this particular analysis should not be used to conclude that bacteria loadings from the Taunton River have minimal effect on the sanitary quality of Mount Hope Bay. The data limitations make it difficult to determine if a critical condition can be defined as being singularly caused by changes in flow in the Taunton River.

Table 5.1 Statistical Summary of routine shellfish monitoring data collected during dry weather conditions and wet weather TMDL data.

Waterbody Name	Waterbody Segment ID	Class	Shellfish Stations Representative of Water Quality in Segment	Dry Weather Geometric[2] Mean Value	Dry Weather 90th[2] Percentile Value	Wet Weather Geometric Mean Value	Wet Weather 90th Percentile Value
Mt. Hope Bay	**RI0007032E-01A**	SA*	GA17-1	6.7	**119.1**	8	43
		SA*	GA17-2	4.8	19.5	**17**[1]	**99**
		SA*	GA17-5	4.3	21.4	**16**	**93**
		SA*	GA17-11	3.0	9.3	5	30
		SA*	GA17-12	2.8	9.9	6	43
		SA*	GA17-13	4.4	33.6	5	23
		SA*	GA17-15	3.1	7.4	5	30
Mt. Hope Bay	**RI0007032E-01B**	SA	GA5-1	3.6	12.5	9	**93**
		SA	GA5-2	4.5	16.9	8	**77**
		SA	GA17-14	3.5	11.6	8	23
		SA	GA17-16	3.8	13.7	10	**99**
Mt. Hope Bay	**RI0007032E-01C**	SB	GA17-3	8.4	45.3	**23**	**108**
		SB	GA17-7	2.8	6.4	**16**	**210**
		SB	GA17-8	3.2	8.5	12	**89**
		SB	GA17-9	2.7	4.8	6	17
		SB	GA17-10	3.1	11.3	10	**48**
Mt. Hope Bay	**RI0007032E-01D**	SB1	GA17-4	2.8	7.9	**46**	**480**
		SB1	GA17-6	3.8	14.0	**18**	**245**
Kickemuit River	**RI0007033E-01A**	SA	GA5-4	3.5	9.8	10	48
		SA	GA5-6	2.7	4.9	**19**	**317**
		SA	GA5-7	2.9	5.6	**31**	**259**
		SA	GA5-8	3.5	13.4	**33**	**127**
		SA	GA5-9	3.4	12.1	9	**93**
		SA	GA5-10	2.8	5.0	11	**108**
Kickemuit River	**RI0007033E-01B**	SA(b)	GA5-3	4.4	18.4	11	**77**
		SA(b)	GA5-4	3.5	9.8	10	**48**
Kickemuit River	**RI0007033E-01C**	SA(b)	GA5-5	2.8	5.0	8	30
		SA(b)	GA5-6	2.7	4.9	**19**	**317**

[1] Bold font indicates violation of Class SA criteria. For this TMDL, Class SA criteria are used to set targets for all class SA and SB waters.

[2] Calculated from analysis of 3 years (fifteen samples monthly from Oct 2007 to Jan 2009) of routine shellfish monitoring data.

[3] "Dry weather" is defined as at least 7 days since 0.5" or more of rain within a 24 hour period

* Class SA Closed Safety Zone.

Tide
Existing shellfish monitoring data for Mount Hope Bay and the Kickemuit River was analyzed for any observable trends with regard to tidal condition. At the time of sample collection, RIDEM Shellfish Unit staff record the observed tidal condition, which is then entered into a database. Analysis of this information showed no meaningful differences in the bacterial quality of any stations when the dataset was separated into either ebb, low, flood, or high tide. Although it has been suggested that the combination of flood tide and wet weather produces the most elevated bacteria concentrations in the bay an additional analysis of tide and weather condition was not performed. In terms of a "critical condition", the overlying factor determining the sanitary quality of the study area would be wet weather, regardless of tide.

Tide does appear to play a role in dry weather fecal coliform concentrations at Station 17-3, located just southwest of Spar Island. The island, more or less a sand bar consisting primarily of large amounts of shell fragments and gravel is made up entirely of an intertidal zone and is only visible at low tide. Both geometric mean and percentile statistics calculated from data collected during periods of ebb and low tide are notably elevated relative to those calculated from the flood and high tide dataset.

Consideration of Seasonal Variation
Addressing seasonal variations is an important and required component of TMDL development. Routine monitoring data are available throughout the year, therefore if a seasonal component exists, it should be discernable from analysis of this data. Figure 5.1 displays geometric mean and 90th percentile values calculated from five years (2003-2007) of shellfish sampling data collected at ambient stations in Mount Hope Bay and the Kickemuit River. Dark symbols represent those samples collected during the May-Oct timeframe while open symbols represent data collected between November and April.

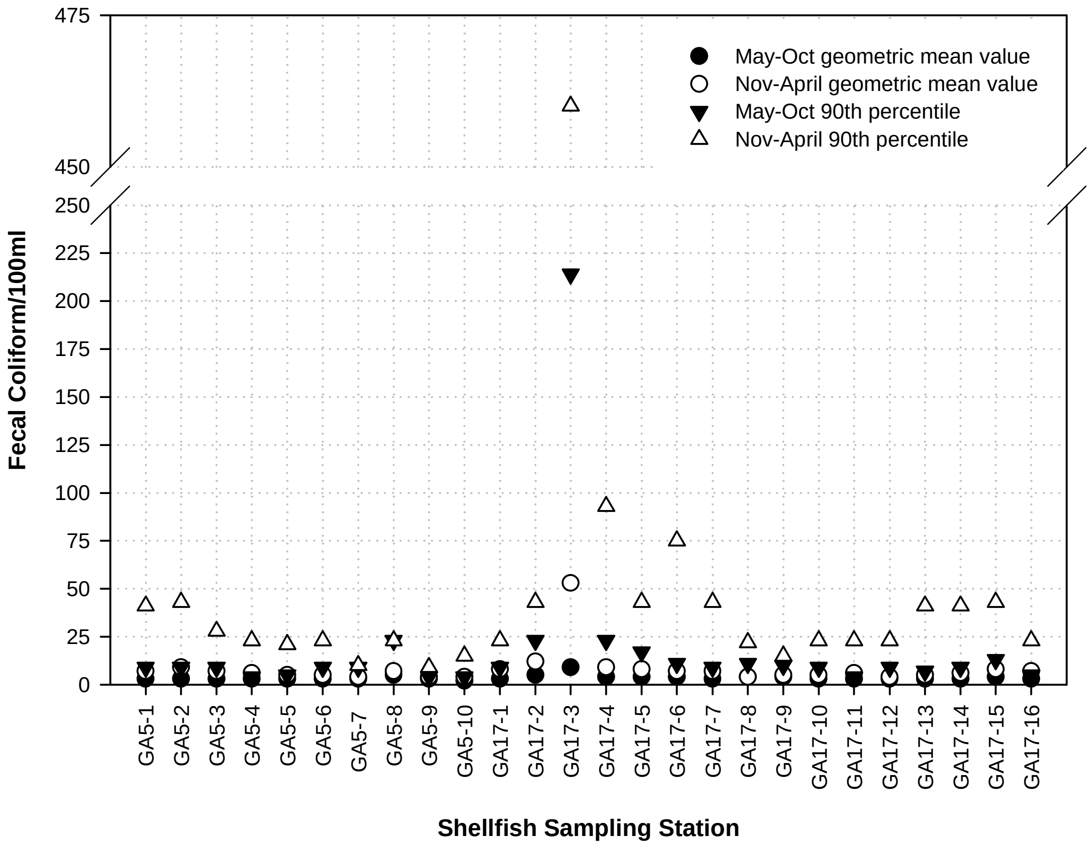


Figure 5.1 Seasonal analysis of fecal coliform bacteria data in Growing Areas 17 and 5.

The most elevated levels of bacteria concentrations in Mount Hope Bay and the Kickemuit River are reflected in the winter (Nov-April) 90th percentile statistics. As shown in Figure 5.1 the greatest variability in fecal coliform bacteria concentrations in both the Kickemuit River and Mount Hope Bay occurs during the winter (April-Nov) period. The reason(s) for this is unclear but may be due, in part to factors contributing to fecal coliform die off, such as solar radiation and temperature. Regardless of the seasonal differences, for the most part, all ambient stations in both growing areas meet shellfishing criteria during dry weather. Furthermore, wet weather conditions occur during all seasons. Therefore it was determined that seasonality was not an issue in terms of developing the TMDL.

Critical Condition and Seasonal Variation-Summary

As shown in Table 5.1, the wet weather 90$_{th}$ percentile values for fecal coliform bacteria exceeded the NSSP thresholds most often, and were therefore, determined to be the most sensitive indicator during that condition. The 90th percentile values are also consistently higher than the geometric mean values. Closures of shellfish growing areas are usually based on a station's water quality failing to meet the 90$_{th}$ percentile standard criteria, which means that water quality at the station is more variable than the inherent variability of the MPN method used for examining samples.

For this TMDL, the 90th percentile values calculated from the wet weather dataset define the critical condition. Data from this critical period is used to estimate the required percent reductions in fecal coliform concentrations in Mount Hope Bay and the Kickemuit River. The percent reduction required was based on the difference between the calculated wet weather 90th percentile and the Shellfishing Use 90th percentile criteria (49 MPN/100ml). A combination of pollution reductions based on wet weather bacteria loadings and identification and correction of other nonpoint loadings is expected to result in attainment of SA and SB water quality criteria during a majority of the time.

5.5 Margin of Safety

Oftentimes, the sanitary conditions in tidal waterbodies such as Mount Hope Bay and the Kickemuit River are difficult to assess given the dynamic circulation patterns dominated by tide, river flow, and wind, as well as spatial and temporal variability in pathogen sources and contributions, watershed characteristics, and other factors.

A margin of safety (MOS), designed to account for uncertainty in TMDL calculations, is a required element of a TMDL [40 CFR 130.33(b)7]. The MOS can be expressed explicitly as unallocated assimilative capacity, or can be incorporated implicitly in the TMDL through the use of conservative assumptions when calculating the allowable load (EPA 1991). The TMDL must contain a margin of safety (MOS) to account for uncertainty in the analysis. An explicit margin of safety equal to an additional five (5) percent of the calculated percent reduction was assumed to conservatively account for possible uncertainties in this TMDL analysis.

5.6 Technical Analysis

The bacteriological data used to develop these TMDLs consists of the most recent wet weather dataset: two (2) separate wet weather water quality surveys in June and October of 2006.   Approximately 5-6 samples were collected at each fixed ambient shellfish station during and after specified precipitation events. Event 1 was conducted during and after an average of 1.90 inches of rainfall in the watershed. Event 2 was conducted during and after approximately 1.40 inches of rainfall in the watershed. All collected data, synthesis of all data, and other findings from the 2006 wet weather studies are reported in the final data report (RIDEM, 2008) and can be found at:
http://www.RIDEM.ri.gov/programs/benviron/water/quality/rest/pdfs/mthopeby.pdf.

5.7 Establishing the Allowable Loading

For most pollutants, TMDLs are expressed on a mass-loading basis (e.g., kilograms per day). For indicator bacteria (i.e., fecal coliform), however, it is the number of organisms in a given volume of water (i.e. their concentration), and not their mass or total number that is significant with respect to public health risk and protection of beneficial uses. The concentration of fecal coliform bacteria in the receiving waters is the technically relevant criterion for assessing the relative impact of pollution sources, the quality of the shellfish harvesting area, and the public-health risk.

EPA protocol (EPA 2001) on the development of pathogen TMDLs recommends establishing a TMDL in this manner (concentration-based) for a pollutant that is not readily controllable on a mass basis.
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 volume of the waterbody. Table 5.2 lists the current ambient shellfish growing-area sampling stations that were chosen to best represent the sanitary quality within each defined segment.

Table 5.2 Established Waterbody Segments and Ambient Shellfish Sampling Stations.

Waterbody ID Number (Waterbody Segment)	General Waterbody Description[1]	Representative Ambient Shellfish Growing Area Monitoring Stations
RI0007032E-01A	Class SA water in Mount Hope Bay (operated as closed safety zone)	GA17-1, GA17-2, GA17-5, GA17-11, GA17-12, GA17-13, GA17-15
RI0007032E-01B	Class SA water in Mount Hope Bay	GA5-1. GA5-2. GA17-14, GA17-16
RI0007032E-01C	Class SB water in Mount Hope Bay	GA17-3, GA17-7, GA17-8, GA17-9, GA17-10
RI0007032E-01D	Class SB1 water in Mount Hope Bay	GA17-4, GA17-6
RI0007033E-01A	Class SA water in Kickemuit River	GA5-4, GA5-6, GA5-7, GA5-8, GA5-9, GA5-10
RI0007033E-01B	Class SA {b} in Kickemuit River	GA5-3, GA5-4
RI0007033E-01C	Class SA {b} in Kickemuit River	GA5-5, GA5-6

[1]For a graphical display of waterbodies see Figure 1.2.

5.8 Required Reductions

Both the allowable load and the existing load are expressed in this TMDL as concentrations. The allowable concentration is set equal to the percentile portion of the applicable state water quality standard for fecal coliform bacteria (49 MPN) and the existing concentration is set to the greatest of the pooled station wet weather percentile values. The percent concentration reduction is then calculated from the difference between these two values. Percent reductions were calculated for each ambient station with the largest ambient station reduction applied to the entire segment. Reductions were also calculated by comparing the 14 MPN water quality target to the wet weather geometric mean value. In all cases, the largest required reductions are comprised of exceedances of the 90th percentile criteria. It is expected that if the specified reductions to the 90th percentile values take place, the geometric mean values will also be met.

Table 5.3 presents ambient station and waterbody segment 90th percentile values and required segment reductions, inclusive of the 5% MOS. As shown in Table 5.3, waterbody segment reductions range from 56 to 95 percent in Mount Hope Bay and 41 to 90 percent in the Kickemuit River. The largest required waterbody segment reductions in Mount Hope Bay (segments 01C and 01D) occur in areas most immediately impacted by combined sewer overflow discharges and stormwater runoff from the City of Fall River, MA. The largest required waterbody segment reduction in the Kickemuit River (90%) is driven primarily by elevated levels of bacteria in the northern portion of the estuary, and nearest local stormwater impacts originating along the western shore of the towns of Warren and Bristol, RI and possibly from sources upstream in the watershed including the Kickemuit Reservoir. Final segment reductions are presented graphically in Figure 5.2.

The draft pathogen TMDL for the Narragansett /Mount Hope Bay Watershed recently developed by the Massachusetts Department of Environmental Protection (MADEP 2008) requires a 96% reduction in bacteria concentrations in all waterbody segments of Mount Hope Bay that border RI. These concentration reductions are based on meeting the 14 MPN shellfish harvesting standard.

Table 5.3 Fecal coliform TMDL expressed as percent reductions to meet concentration targets.

Waterbody Name/ Waterbody Segment ID[2]	Class	Representative Shellfish Sampling Station	Geometric Mean Value (MPN)[5]	90^{th} Percentile Value (MPN)[3]	Allowable concentration (MPN) geometric mean/90^{th} percentile value	Required Segment Reduction[1,4]
MOUNT HOPE BAY **RI0007032E-01A**	SA	GA17-1	8	43	14 / 49	**56**
		GA17-2	**17**	**99**	14 / 49	
		GA17-5	**16**	**93**	14 / 49	
		GA17-11	5	30	14 / 49	
		GA17-12	6	43	14 / 49	
		GA17-13	5	23	14 / 49	
		GA17-15	5	30	14 / 49	
MOUNT HOPE BAY **RI0007032E-01B**	SA	GA5-1	9	**93**	14 / 49	**56**
		GA5-2	8	**77**	14 / 49	
		GA17-14	8	23	14 / 49	
		GA17-16	10	**99**	14 / 49	
MOUNT HOPE BAY[6] **RI0007032E-01C**	SB	GA17-3	**23**	**108**	14 / 49	**82**
		GA17-7	**16**	**210**	14 / 49	
		GA17-8	10	**89**	14 / 49	
		GA17-9	12	17	14 / 49	
		GA17-10	6	**48**	14 / 49	
MOUNT HOPE BAY[6] **RI0007032E-01D**	SB1	GA17-4	**46**	**480**	14 / 49	**95**
		GA17-6	16	**245**	14 / 49	
KICKEMUIT RIVER **RI0007033E-01A**	SA	GA5-4	10	48	14 / 49	**90**
		GA5-5	8	30	14 / 49	
		GA5-6	**19**	**317**	14 / 49	
		GA5-7	**31**	**259**	14 / 49	
		GA5-8	**33**	**127**	14 / 49	
		GA5-9	9	**93**	14 / 49	
		GA5-10	11	**108**	14 / 49	
KICKEMUIT RIVER **RI0007033E-01B**	SA(b)	GA5-3	11	**77**	14 / 49	**41**
	SA(b)	GA5-4	10	**48**	14 / 49	
KICKEMUIT RIVER **RI0007033E-01C**	SA(b)	GA5-5	8	30	14 / 49	90
	SA(b)	GA5-6	19	317	14 / 49	

[1] The required segment reduction consists of the largest ambient station reduction within a specified waterbody segment.
[2] Refer to Figure 1.2 for waterbody segment boundaries.
[3] Calculated 90^{th} percentile value from wet weather dataset.
[4] All segment reductions are based on 90^{th} percentile values with respect to the 49 MPN criteria and include a 5% MOS.
[5] Calculated geometric mean value from wet weather dataset.
[6] Overall water quality conditions in these SB classified segments meet criteria associated with their designated uses and are proposed for de-listing in 2010; however, pollutant reductions are still necessary to meet the TMDL's bay-wide water quality target (90^{th} percentile not to exceed 49 MPN)and to restore shellfishing use in the adjoining SA classified waters.

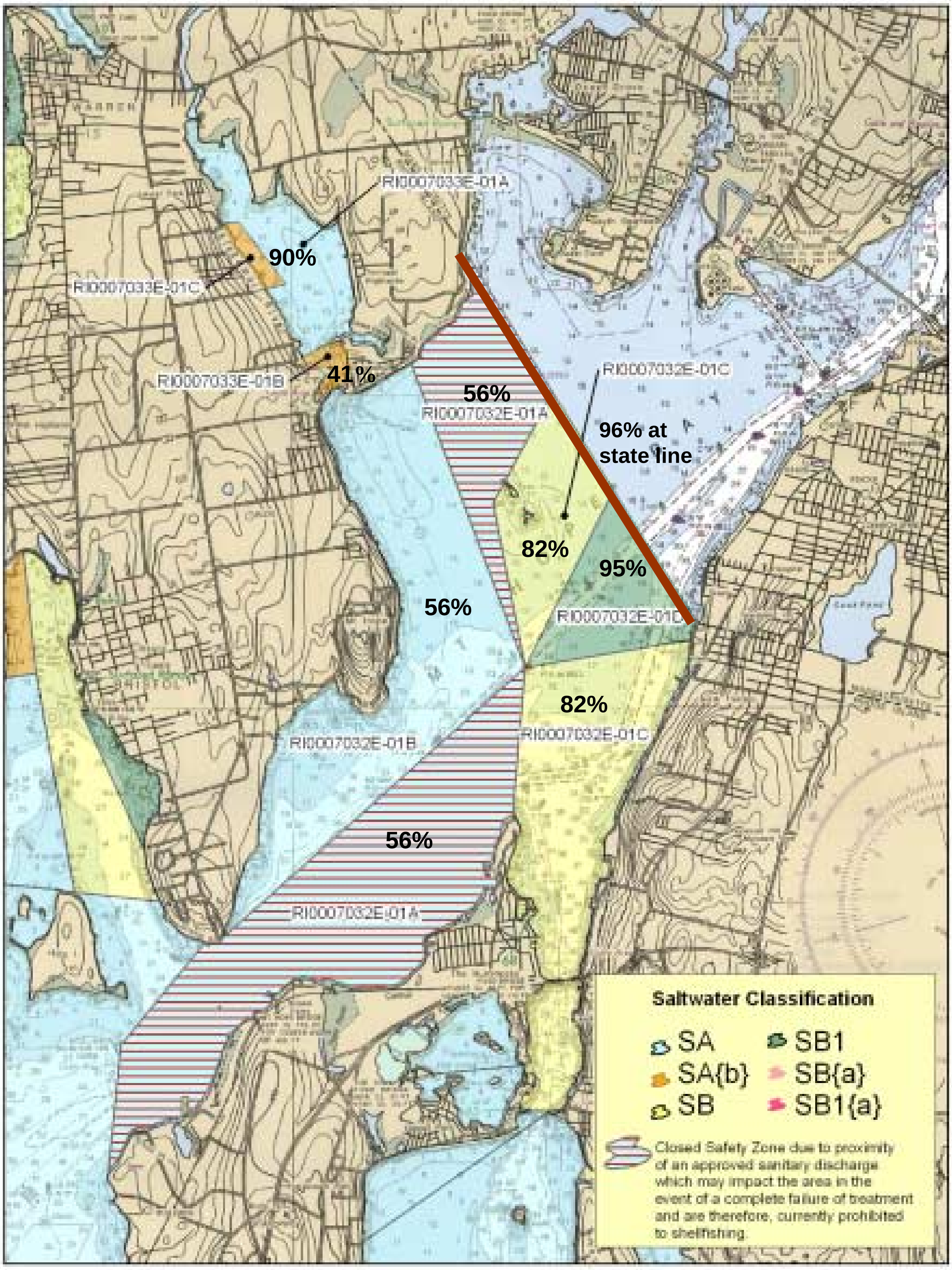


Figure 5.2 Graphical display of required waterbody segment reductions the study area.

5.9 Load and Waste load Allocations

During dry weather, the sanitary quality in a vast majority of the study area is fully supportive of the designated uses of shellfish harvesting and primary and secondary contact recreation. These areas may occasionally be impacted by sources such as wildlife, waterfowl, failing residential septic systems, transitory dry weather discharges such as leaking sewer lines or illicit connections to storm drains, and marine vessel discharges. Input from these types of sources may result in markedly elevated bacteria concentrations at various established shellfish monitoring stations.

In contrast to dry weather, the sanitary quality in the study area during wet weather is not supportive of designated uses. Areas notably affected include the eastern portions of Mount Hope Bay adjacent to and south of the City of Fall River, MA as well as in the western portion of the Kickemuit River adjacent to the Rhode Island towns of Bristol and Warren. By far, the largest and most persistent sources of bacteria to these waterbodies include CSO discharges from the City of Fall River and stormwater runoff, both locally (in Rhode Island) and from municipalities in the State of Massachusetts.

The above conditions justify developing the TMDL under the critical condition of wet weather. The allowable load for each waterbody segment is defined in terms of a 90th percentile fecal coliform bacteria concentration value (49 MPN) and the current condition is defined as the 90th percentile value of the existing wet weather dataset within each waterbody segment.

EPA guidance requires that load allocations be assigned to either point (waste load) or nonpoint (load) sources. As is the case for most bacteria impairments, insufficient data exist to accurately differentiate between point and nonpoint sources of bacteria. In addition, there is no meaningful method to determine specific bacterial loading from multiple stormwater systems with hundreds of major and minor outfalls distributed through a combined watershed area of over 1600 square kilometers. It has been clearly documented in previous studies that combined sewer overflows and/or stormwater runoff account for most of the bacteria load to Mount Hope Bay. For reasons stated above, this TMDL sets the load allocation to zero.

As recommended by EPA Region 1, all bacteria source reductions for this TMDL are combined into the waste load allocation. However, in implementing this TMDL, both point and nonpoint controls in RI and MA will be necessary to meet the TMDL plan's water quality targets. As a source, stormwater runoff will receive 100% of the waste load allocation. Sources of fecal coliform bacteria such as failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, leaking sanitary sewer lines, and marine vessel discharges will receive a waste load allocation of zero (0) since they are prohibited.

MADEP's Draft Pathogen TMDL for the Narragansett/Mount Hope Bay Watershed (August 2008) contains the following language with respect to setting waste load allocations for point sources of fecal pollution to Mount Hope Bay and the Cole and Lee's River:

"Point sources within the study area include several wastewater treatment plants and other NPDES-permitted wastewater discharges. NPDES wastewater discharge WLAs are set at the water quality standards. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore a WLA set equal to the WQS criteria will be assigned to the portion of the stormwater that discharges to surface waters via storm drains. For any illicit sources including illicit discharges to stormwater systems and sewer system overflows (SSO's) the goal is complete elimination (100% reduction). Source categories representing discharges of untreated

sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. The specific goal for controlling combined sewer overflows (CSO's) is meeting water quality standards." These waste load allocations would apply to all MA municipalities including the Towns of Somerset, Swansea, and the City of Fall River-which have various point source discharges directly to Mount Hope Bay near the RI/MA border. The waste load allocations within the MA portion of the Bay are meant to attain the 97% reduction of fecal coliform concentrations required by MADEP's Draft Pathogen TMDL.

The vast majority (over 75%) of stormwater from the City of Fall River discharges to the city's CSO system. The City is currently implementing a CSO abatement plan that will likely benefit all waterbody segments in Mount Hope Bay. MADEP's Draft Pathogen TMDL for the Narragansett/Mount Hope Bay Watershed (August 2008) sets a waste load allocation for both CSO's and all regulated stormwater discharges as the applicable water quality standard, which in this case is a median or geometric mean of: 88 organisms per 100 ml and not more than 10% of the samples be greater than 260 organisms per 100 ml.

Inclusive of these controls, it is thought that untreated stormwater runoff from municipalities in Bristol, Warren, and Tiverton will continue to cause localized water quality impairments during wet weather. With the reduction of combined sewer overflows as a source, stormwater runoff from MS4's in the watershed will make up a greater portion of the total pollutant load to the Bay.

There is evidence that illicit connections, failing septic systems, failing septic systems and/or sanitary sewer leaks are causing the observed bacteria elevations during wet weather in some of these stormwater "problem" areas. Priority must be given to eliminating illicit connections and ensuring adequate sanitary waste disposal as a first step, where relevant.

It is difficult to determine the scale of reductions specifically necessary for regulated stormwater discharges such that water quality criteria will be met in the Bay during wet weather. However, the WLA given to stormwater for these municipalities will require that the Phase II mandated six minimum measures be fully implemented and following an adaptive management approach, that structural best management practices be constructed to treat priority stormwater discharges such that fecal coliform loads are reduced to the maximum extent feasible.

A summary of waste load allocations, by waterbody segment, is presented below.

Kickemuit River (Segments RI0007033E-01A, RI0007033E-01B, RI0007033E-01C)
The most prevalent source of fecal coliform bacteria to the Kickemuit River is stormwater runoff from the Towns of Bristol and Warren as well as wet weather inputs from the freshwater Kickemuit River. Other possible sources present during both wet and dry weather may include (and have historically included) illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl. The final concentration reduction for segments 01A and 01C is 90% and the required reduction for segment 01B is 41%. As a source, stormwater runoff will receive 100% of the wasteload allocation in all segments. A wasteload allocation of zero (0) is set for illicit discharges to stormdrains, leaking sanitary sewer lines, and failing septic systems.

Mount Hope Bay (Segment RI0007032E-01A and Segment RI0007032E-01B)
The required concentration reduction for these segments of Mount Hope Bay is 56%. The largest sources of bacteria during wet weather are combined sewer overflows from the City of Fall River, MA and stormwater runoff from MS4s from Fall River, Somerset, and Swansea in MA and the Towns of Bristol, and Warren in RI. Other important sources likely include stormwater runoff from MS4s throughout the watershed of the Taunton River.

Other possible sources present during both wet and dry weather may include (and have historically included) illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl, and transient marine vessel discharges.

As a source, stormwater runoff will receive 100% of the wasteload allocation in this segment. A wasteload allocation of zero (0) is set for illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and marine vessel discharges.

Mount Hope Bay (Segment RI0007033E-01C)
The required concentration reduction for this segment of Mount Hope Bay is 82%. The largest sources of bacteria during wet weather are combined sewer overflows from the City of Fall River, MA and stormwater runoff from MS4s from Fall River, MA and Tiverton, Rhode Island. Other important sources likely include stormwater runoff from MS4s throughout the watershed of the Taunton River.

Other possible sources present during both wet and dry weather may include (and have historically included) illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl, and transient marine vessel discharges.

As a source, stormwater runoff will receive 100% of the wasteload allocation in this segment. A wasteload allocation of zero (0) is set for illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and marine vessel discharges.

Mount Hope Bay (Segment RI0007033E-01D)
The required concentration reduction for this segment of Mount Hope Bay is 95%. The largest sources of bacteria during wet weather are combined sewer overflows from the City of Fall River, MA and stormwater runoff from MS4s from Fall River, MA and Tiverton, Rhode Island. Other important sources likely include stormwater runoff from MS4s throughout the watershed of the Taunton River.

Other possible sources present during both wet and dry weather may include (and have historically included) illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl, and transient marine vessel discharges.

As a source, stormwater runoff will receive 100% of the wasteload allocation in this segment. A wasteload allocation of zero (0) is set for illicit discharges to stormdrains, leaking sanitary sewer lines, failing septic systems, and marine vessel discharges. MADEP’s Pathogen TMDL establishes wasteload allocations to address MA sources.

6.0 IMPLEMENTATION PLAN

This section describes the actions necessary to implement the TMDL to attain and maintain fecal coliform water quality criteria in Mount Hope Bay and the Kickemuit River. The plan describes implementation responsibilities assigned to cooperating agencies and other responsible parties. The goal of the Implementation Plan is to ensure that Mount Hope Bay and the Kickemuit River meet water quality criteria for fecal coliform at all times and in all areas of the bay and river. Compliance with the TMDL will be accomplished by ensuring that all point source discharges meet the wasteload allocations set forth in Section 4 of this report. Many dry-weather non-point sources, such as leaky sewers, failing septic systems, and marine vessel discharges, are prohibited and therefore the load allocations for these sources are set to zero. No load reductions were assigned to such nonpoint sources as wildlife and waterfowl, since these sources are difficult to control.

Eliminating bacterial impairments in the greater Mount Hope Bay-Kickemuit River watershed requires a reduction in both dry and wet weather inputs. The majority, if not all, of the stations in Mount Hope Bay and the Kickemuit River violate water quality standards for fecal coliform bacteria after significant rain events. Elevated bacteria concentrations originate from within the watershed and can be traced from tributaries, stormwater outfalls, and wet weather CSO discharges. The cumulative impacts of stormwater runoff and CSO discharges degrade water quality and necessitate a watershed-wide pollution reduction approach.

Recommended implementation activities and current pollution reduction strategies for the Mount Hope Bay and the Kickemuit River are detailed in the following sections. Several key projects in the greater Mount Hope Bay-Kickemuit River watershed have reduced or are expected to reduce pollution in the waterbodies. These include the Fall River CSO Abatement Project, improvements to the Fall River and Taunton WWTFs, and implementation of Phase II Stormwater Project Plans by the Rhode Island Towns of Tiverton, Warren, Bristol, Barrington, and Portsmouth and the Massachusetts communities of Fall River, Attleboro, Seekonk, Rehoboth, Berkley, Swansea, Dighton, Somerset, Freetown, and Westport, as well as the RI and MA Dept. of Transportation.

Continuing monitoring efforts by the RIDEM Shellfish program in the greater Mount Hope Bay-Kickemuit River watershed will help further identify pollution sources, track water quality trends, and evaluate pollution control efforts.

RIDEM continues to respond to environmental complaints, conduct inspections, and issue RIPDES permits as part of its responsibilities under state and federal laws and regulations.
RIDEM will continue to work with DOT, local municipalities, private property owners, and watershed groups to identify funding sources, and evaluate locations and designs for stormwater control BMPs throughout the watershed.

The continued implementation of Phase II SWMPPs, as well as amendments to SWMPPs required by this TMDL, give reasonable assurance that the TMDL goals will be met. The ongoing Fall River CSO Abatement Project, as well as improvements made to the Fall River and Taunton WWTFs, offer the greatest assurance of reaching the water quality goals set for Mount Hope Bay. The considerable local involvement and commitment to water quality and natural resources of the Kickemuit River watershed, spearheaded by the Kickemuit River Council, is also expected to help meet the water quality target set for that waterbody.

6.1 Stormwater Runoff and the RIPDES Phase II Program

Phase II – Six Minimum Measures

While other wet weather sources of bacteria exist, the volume of stormwater generated by the large amounts of impervious areas within the greater Mount Hope Bay/Kickemuit River watershed suggests that it is the major source of wet weather impairments to the bay and river. Significant stormwater is generated in the urban areas within the Towns of Warren, Bristol, Portsmouth and Tiverton. Large amounts of stormwater are also generated on RIDOT owned roadways.

The Towns of Warren, Bristol, Portsmouth and Tiverton, and the RI Dept. of Transportation operate small Municipal Separate Storm Sewer Systems (MS4s) that discharge to the surface waters of Mount Hope Bay and the Kickemuit River and their tributaries. These entities have applied for and obtained coverage under the RIPDES General Permit and have developed and submitted the required Storm Water Management Program Plans (SWMPPs). The plans contain implementation schedules that include interim milestones, frequency of activities and reporting of results. The SWMPPs describe BMPs for the six minimum measures and include measurable goals and schedules for each measure:

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

Storm sewers associated with stormwater runoff frequently cross municipal boundaries, and have multiple interconnections between MS4s. RIDEM encourages cooperation between operators of MS4s (including RIDOT) in developing and implementing the six minimum measures and constructing Best Management Practices throughout the drainage area contributing to a discharge, by the way of inter-agency agreements. 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.

Post-construction storm water management in areas undergoing new development or redevelopment is necessary because runoff from these areas has been shown to significantly affect receiving waterbodies. To meet the requirements of the Phase II minimum control measure relating to Post Construction Runoff Control, the operator of a regulated small MS4 will need to at a minimum:

- Develop and implement strategies which include a combination of structural and/or nonstructural BMPs;
- Develop an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls to the extent allowable under State or local law;
- Ensure adequate long-term operation and maintenance of controls;

- Determine appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

Amendments to Phase II Stormwater Management Program Plans Required by General Permit
Part IV.D of the General Permit states that the operator must address the TMDL provisions in the SWMPP if a TMDL has been approved for any waterbody into which storm water discharges from the MS4 contribute directly or indirectly the pollutants(s) of concern (Part II.C3). Accordingly, upon approval of this TMDL, the RI Department of Transportation, and the Towns of Warren, Bristol, and Tiverton will be required to submit SWMPP amendments addressing the TMDL provisions within one hundred and eighty (180) days of the date of written notice from the RIPDES Program (Rule 31 (f)(8)(iii), as described in greater detail below. It is noted that the Town of Portsmouth is a Phase II community that is located at the southern end of the Mount Hope Bay watershed (the Town of Portsmouth is authorized to discharge stormwater under a General Permit-RIR040003). However, given that there was no evidence of wet weather water quality violations in the adjacent offshore waters, and no priority outfalls were identified within the town, no modifications to the Phase II plan is required.

More specifically, the SWMPPs must be revised to describe the six minimum measures and other additional controls that are or will be implemented to address the TMDL pollutant of concern (bacteria). The operators must provide measurable goals for the development and/or implementation of the six minimum measures and additional structural and non-structural BMPs that will be necessary to address provisions for the control of storm water identified in this TMDL including an implementation schedule, which includes all major milestone deadlines including the start and finish calendar dates, the estimated costs and proposed or actual funding sources, and the anticipated improvement(s) to water quality. If no structural BMPs are recommended, the operator must evaluate whether the six minimum measures alone (including any revisions to ordinances) are sufficient to meet the TMDL's specified pollutant reduction targets. The revised SWMPP must specifically address the following:

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 in the SWMPP 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. the location of discharge (latitude/longitude and street or other landmark;

    b. size and type of conveyance (e.g. 15" diameter concrete pipe);

    c. any 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 BMP(s) that have or will be implemented to address TMDL provisions and bacteria-related impairments;

h. schedule for construction of structural BMPs including those for which a **Scope of Work** (SOW) is to be prepared, as described below.

This TMDL has determined that structural BMPs are necessary, therefore all operators of MS4s identified herein must also prepare and submit a **Scope of Work** describing the process and rationale that will be used to select BMPs and measurable goals to ensure that the TMDL provisions will be met. The revised RI Stormwater Design and Installation Standards Manual (RIDEM and CRMC, draft 2009) provides detailed information on BMPs found to be effective at reducing bacterial loads. The manual is available online at http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/desman.htm. In some areas, discussed below, high bacteria and/or coliphage levels observed at stormwater outfalls could be at least partially caused by wastewater contamination from nearby failing sewer or septic systems. In these cases, the Town or institution must address failing wastewater systems in a timely manner. Upon resolution of problems associated with inadequate sewage disposal, the Town must sample these storm drains to confirm that these outfalls are no longer significant sources of bacteria. If it is determined that elevated bacteria levels are found to persist, the Town will be expected to undertake actions to abate the stormwater related bacteria loads from these priority outfalls. The Scope of Work must be accompanied with a schedule prioritizing outfalls for the construction of structural stormwater BMPs. A targeted approach to construction of stormwater retrofit best management practices (BMPs) at state and locally-owned stormwater outfalls is recommended. Priority outfalls have been identified in Section 4.2. Operators of MS4s must work to identify any other outfalls that may contribute significant pollutants loads and prioritize these for BMP construction, as detailed in the following sections.

The Scope of Work Must:

1) Describe the tasks necessary to design and construct BMPs that reduce the concentration of bacteria and stormwater volume from outfalls to *the maximum extent feasible* including:

    a) the delineation of the drainage or catchment area,

    b) 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, and

    c) 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 the pollutants(s) of concern, 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.

2) Establish a schedule to identify and assess all remaining discharges not identified in the TMDL (owned by the operator) contributing to the impaired waters addressed by the TMDL, to delineate the drainage or catchment areas to these discharges, and as needed to address water quality impairments, to design and construct structural BMPS. To determine the prioritization for BMP construction, the assessment of identified discharges shall determine the relative contribution of bacteria taking into consideration pollutant loads (i.e. concentrations and flows) as indicated by drainage area, pipe size, land use, known hot spots and/or sampling data.

TMDL Specific Amendments to Phase II Stormwater Management Program Plans
To realize water quality improvements in Mount Hope Bay and the Kickemuit River, both bacteria concentrations in storm water *and* the volume of storm water discharged must be reduced. The large amount of impervious areas within the urban watersheds contributes substantial increases in the amount of runoff and bacteria entering these estuarine waters during and immediately after rain events. As the amount of impervious area in a watershed increases, the peak runoff rates and runoff volumes generated by a storm increases 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.

While municipalities and RIDOT must implement the Phase II minimum measures town-wide, they should prioritize implementation of Phase II minimum measures in the Mount Hope Bay/Kickemuit River as well as in the watersheds of other impaired waters for which a TMDL has been completed, and should target the construction of stormwater BMPs for priority outfalls, identified in Section 4.2. Addressing priority outfalls would of course first entail the identification of each of the catchments associated with each of these outfalls. Illicit discharge detection and elimination, required by the General Permit, should be prioritized for the outfalls that discharge into Mount Hope Bay, the Kickemuit River, or to any of their tributaries.

Municipalities and RIDOT must conduct BMP feasibility studies to identify locations and technologies for installing infiltration or equivalent BMPs in these priority catchments. The owners of those portions of MS4s that discharge via interconnections to priority outfalls owned by another MS4 are also required to conduct catchment area feasibility analyses. These studies must evaluate the feasibility of distributing infiltration or equivalent BMPs throughout the drainage area of priority outfalls as an alternative to end-of-pipe technologies. This concept is particularly important in highly urbanized areas where rain events increase the storm water flows and pollutant loads as a result of the large amount of impervious surfaces and there is a small amount of undeveloped land available for BMP construction. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

There are many opportunities to address both water quality and water quantity and tailor efforts to the local concerns in the SWMPP as follows:

<u>Modifications to Six Minimum Measures</u>

<u>Public Education/Public Involvement</u>
The public education program should focus on both water quality and water quantity concerns within the watershed. Public education material should target the particular audience being addressed. For example, the residential community should be educated about the water quality impacts from residential use and activities and the measures they can take to minimize and prevent these impacts. Examples include proper septic system maintenance, prohibiting illegal tie-ins to storm drains from failing septic systems, and proper disposal of pet waste. Public involvement programs should actively involve the community in addressing these concerns.

The residential community should also be informed about water quantity impacts as a result of large areas of impervious surfaces and what measures they can take to minimize or help offset these impacts. Measures include the infiltration of roof runoff where feasible (green roofs, dry wells, and roof drains redirecting drainage to lawns and forested areas) and landscaping choices that minimize runoff. Some examples of landscaping measures are grading the site to minimize runoff and to promote storm water attenuation and infiltration, the creation of rain gardens, reducing paved areas such as driveways, and to consider porous driveways (cost effective options may include crushed shells or stone). Runoff can also be slowed by buffer strips and swales that add filtering capacity through vegetation. These examples can also be targeted to residential land developers and landscapers. The revised RI Stormwater Design and Installation Standards Manual (RIDEM and CRMC, 2009) provides detailed information regarding low impact development (LID) techniques.

Other potential audiences include commercial property owners, land developers, and landscapers. BMPs that minimize runoff and promote infiltration should be used when redeveloping or re-paving a site. Examples include minimizing road widths, porous pavement, infiltrating catch basins, breaking up large tracts/areas of impervious surfaces, sloping surfaces towards vegetated areas, and incorporating buffer strips and swales where possible.

RIDOT, in conjunction with RIDEM, has signed an agreement with the University of Rhode Island Cooperative Extension (URI) for a Public Education and Outreach Program. This program will provide participating MS4s the opportunity to use prepared education and outreach programs for their individual use, which could be easily tailored to the TMDL public education recommendations. To date, with the exception of Warren, each of the MS4s designated in the TMDL study are participating in the Program. More information may be found on the URI NEMO website http://www.ristormwatersolutions.org/

Illicit Discharge Detection and Elimination

An illicit connection is an illegal connection between a sanitary sewer or septic system and a storm drain. Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. It is probable that numerous illicit sewer connections exist in storm drainage systems serving the older developed portions of the Mount Hope and Kickemuit drainage basins. Illicit connections have been found in the past through field studies conducted by the Kickemuit River Council as well as sanitary surveys of growing areas in both MA and RI.

Much of the Mount Hope Bay/Kickemuit River watershed is sewered including almost the entire portion of the watershed lying in the Town of Bristol and most of Warren. However, significant areas of the watershed are not sewered and remain on septic systems, including the Touisset area of Warren located on the east bank of the Kickemuit River, the northern tip of Portsmouth, and most of North Tiverton. As previously discussed in Section 4.5, the vast majority of septic system failures occur in North Tiverton, due to high water tables, unfavorable soil conditions, high ledge, steep slope, and the general age of systems. There is also a significant history of failed septic systems in the Touisset area of Warren, and to a lesser extent at the northern end of Portsmouth.

Construction/Post Construction

Among the six minimum measures described earlier is the requirement for operators to establish post construction storm water runoff control programs for new land development and redevelopment sites disturbing one or more acres. It is imperative that land development and re-development projects utilize best management practices if Mount Hope Bay and the Kickemuit River are to be successfully restored. Storm water volume reduction requirements for development and redevelopment of commercial and industrial properties should be considered in the development of ordinances and zoning regulations to comply with the construction and post construction minimum measures (see General Permit Part IV.B.4.a.1 and Part IV.B.5.a.2 respectively, consistent with this TMDL's recommendations). Municipalities are also required to adopt these policies for city-owned facilities and infrastructure (Part IV.B.6.a.2 and Part IV.B.6.b.1 of the Storm Water General Permit). To ensure consistency with the goals and recommendations of the TMDL, the revised SWMPP must address revisions to the local ordinances to ensure that:

1. **new land development** employ stormwater controls to prevent any net increase in bacteria for sites contributing to MS4s which discharge to Mount Hope Bay or the Kickemuit River

2. **redevelopment projects** employ stormwater controls to reduce bacteria to the *maximum extent feasible*.

The Towns should consider expanding these ordinances town-wide and lowering the threshold of applicability for these ordinances to less than 1 acre, and that the more stringent requirements apply to discharges to all surface waters within the watershed. The revised plan must include an assessment of impacts of imposing these requirements on lower threshold developments.

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.

Good Housekeeping/Pollution Prevention

The Storm Water General Permit (see Part IV.B.6.a.2 and Part IV.B.6.b.1) extends storm water volume reduction requirements to operator-owned facilities and infrastructure. Similarly, municipal and state facilities could incorporate measures such as reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, incorporating buffer strips and swales, using porous pavement and infiltration catch basins where feasible. In addition, any new municipal construction project or retrofit should incorporate BMPs that reduce storm water and promote infiltration such as the before-mentioned measures.

Town-Specific Storm Water Measures

Town of Warren

In October 2008, the Town of Warren submitted an amended Phase II Stormwater Management Program Plan. The southeastern portion of town, mainly east of Metacom Avenue and south of Child Street, is located within the watershed of the tidal Kickemuit River. The majority of the land use west of the river is medium-density residential development, with small areas of high-density residential development, and commercial development along Metacom Avenue and Child Street, an area of pasture at Adams Lane and a forested area to the immediate north of Libby Lane. That portion of the watershed east of the river is composed mainly of forest and cropland with lesser amounts of medium and high-density residential development. Limited water quality data of sources on the western shore of the Kickemuit River, indicates that both bacteria and coliphage concentrations are high during dry weather.

The Kickemuit River Council retained the consulting firm of Woodward & Curran to perform an investigation of residential sewer tie-ins in the Town of Warren. The study area was located on the western shore of the Kickemuit River, and included the sewered streets located east of Metacom Avenue, between Child Street and Overhill Road. The purpose of the study, conducted between 2002 and 2004, was to identify any residences that were not hooked up to the sewer system. Sewer permit records and as-built plans were examined to confirm residential tie-ins, however when the Town adopted the 911 emergency system many street numbers were changed and many house numbers could not be matched to permit records. In some cases Brian Remy, chairman of Warren's Sewer Commission, had to be relied upon to resolve many questionable homes. Some homes were confirmed by the presence of pavement patches, marking the sewer connection. Dye tests were performed on many of the remaining questionable homes, but access was not gained to many others, whose tie-in status remains unknown. Overall, five residences were not connected to Warren's sewer system and the status of eleven homes remains unconfirmed.

In 2008, the Kickemuit River Council contracted Fuss& O'Neil to conduct a closed circuit televised inspection of the RIDOT and town-owned storm water drainage systems. The study area included pipes associated with four of the five priority outfalls identified in this TMDL study (Metacom Avenue from Child Street to Patterson Avenue, Libby Lane, Parker Avenue, Patterson Avenue, and the railroad right-of-way north of Libby Lane). Metacom Avenue drains to both the railroad-right-of-way and the Parker Avenue box culvert priority outfalls. Patterson Street drains to the 30-inch priority outfall at Parker Avenue. No illegal connections were identified, however cracked and fractured pipes were observed along Metacom and Parker Avenues, Libby Lane, and especially the railroad right-of-way.

The Town of Warren has presently contracted Fuss& O'Neil to conduct a groundwater study to identify areas where exfiltrating wastewater from leaky sewers pipes may be contaminating storm drains. The preliminary proposal is for the installation of three small-diameter wells at Parker Avenue, Libby Lane, and the railroad right-of-way.

Given the apparent lack of illicit tie-ins, cross connections, and septic systems in the drainage area of the priority outfalls, and the high dry-weather bacteria and coliphage levels observed within a few days following a rainfall, it appears that leaking sewer pipes may be a source of contamination to local storm drains. The Town of Warren should conduct inflow and infiltration studies to identify areas where gravity sewers may have leaks, contaminating ground water and potentially storm drain systems. Pressure tests should be conducted on force mains for the same purpose. The Town should also require any residents in the priority catchments, currently not tied into the sewer, to tie into the existing sewer system. Any future efforts of storm drain sampling should be conducted during the high water table season, within one or two days after a rain event. Bracket sampling of any given priority storm drain system, during these conditions, may have the best results of identifying areas of groundwater contamination.

A cow pasture, located on the south side of Libby Lane, may be a significant source of bacteria to the railroad-right-of-way outfall. The headwaters of a short stream are located in the pasture. The stream is culverted under Libby Lane and flows north through the property of the Warren Housing Authority. It enters the drainage system via a short pipe discharging to a manhole within the wooded right-of-way. It is recommended that the Town conduct both dry and wet-weather sampling of the stream on the southern shoulder of Libby Lane in order to establish the significance of the cow pasture as a source of bacteria. If other local sources in this immediate area are ruled out, and the stream is identified as a significant source, then the Town is encouraged to work with the private property owner to install fencing, which would provide separation of the cattle from the stream – as well as other BMPs as appropriate.

The Town of Warren has located stormwater outfalls town-wide and is currently in the process of developing a comprehensive GIS-based map of the Town's stormwater system, showing all identified outfalls, pipes and catch basins. The Town has completed two dry weather surveys in September-October, 2007 and February-March, 2008, as required by Phase II regulations. Only 4-6 of the 55 identified storm drains were flowing at the times of sampling. The bacteria levels at the outfalls were generally quite low. The box culvert at Parker Avenue was the only priority outfall identified by RIDEM that was flowing. The bacteria concentrations at this outfall were 64 and 60 fc/100 ml. With the exception of an outfall on the west side of Asylum Road, south of the Kickemuit Middle School, all other outfalls had bacteria levels less than those recorded at the Parker Avenue outfall. The Asylum Road outfall had a bacteria level of 2,220 fc/100 ml. Follow-up sampling revealed a bacteria concentration of only 40 fc/100 ml.

The Town has plans to construct stormwater BMPs at several outfalls that discharge to the Kickemuit (AKA Warren) Reservoir. The outfalls are located along Serpentine Road and were identified as sources in the Kickemuit Reservoir/Upper Kickemuit River TMDL. The BMPs include vegetated filter strips and water quality swales.

The Town of Warren is authorized to discharge stormwater under a General Permit (RIR040003). Upon approval of this TMDL, the Town will have 180 days to amend its SWMPP consistent with Part IV.D of the General Permit and more specifically, Sections 5.1 and 5.2 of this TMDL. The Town should coordinate with RIDOT to complete the identification, mapping, and determination of ownership and interconnections for all stormwater outfalls discharging directly to the river.

Five Warren stormwater outfalls were identified as the most significant potential sources of bacteria to the Kickemuit River. These outfalls are located at the former railroad bridge near Barker Avenue (5-18), Parker Avenue (5-12 and 5-13), Child Street (5-21), and Libby Lane (5-17) (Section 4.2). As discussed previously, the catchments associated with each of the priority outfalls must be identified and a feasibility study must be conducted to determine the types and locations of BMPs that will be most effective in reducing stormwater volumes and bacteria loading to the river to the maximum extent feasible. RIDEM recommends infiltration, and/or filtration BMPs throughout the identified subwatersheds to reduce runoff volume and bacteria loading of stormwater reaching the river, rather than end-of-pipe solutions.

To demonstrate that the fecal contamination has been reduced to maximum extent feasible, all BMP evaluations must investigate the feasibility of distributing water quality treatment and/or infiltration BMPs, which specifically address fecal contamination, throughout the drainage area of priority outfalls. RIDEM encourages the Town to evaluate the feasibility of also reducing the runoff volume and fecal load generated on private properties, which drain to the MS4 by investigating opportunities to treat and/or infiltrate runoff on-site (i.e. infiltrating roof and site runoff and/or redirecting stormwater to areas on the property where infiltration can occur).

Town of Bristol

The eastern portion of town, roughly east of Metacom Avenue, is located within the watershed of the tidal Kickemuit River and Mount Hope Bay. The majority of the Kickemuit River watershed is composed of medium-density residential, with significant areas of forest and pasture, and lesser areas of high-density residential development. The majority of the Mount Hope Bay watershed, within the town of Bristol, is less developed, and is dominated by forest, with significant areas of medium-density residential development, and lesser areas of pasture and high and low-density residential development. The campus of Roger Williams University and the former Bristol Landfill are also located within the Mount Hope Bay watershed. Six priority sources were identified in the Town of Bristol. These sources include four streams and two culverts.

With the exception of the Annawamscutt culvert, all of the priority outfalls were characterized by high coliphage concentrations during wet weather possibly indicating the presence of sewer overflows, leaking sewer systems, cross-connections or perhaps failing septic systems. Although the Annawamscutt outfall had extremely low coliphage levels, it had the highest dry and wet-weather bacteria concentrations of any of the priority outfalls located in the Town of Bristol. The two priority stream outfalls that discharge to Mount Hope Bay, which may have town-owned outfalls associated with them, are located at the state boat ramp and Bristol Landing condominiums. These two streams also had dry-weather bacteria concentrations that were slightly higher than is typical. There could be a dry-weather source to these streams, or it is possible that the relatively high dry-weather bacteria levels observed within 24 hours of the end of a rain event, could be a relic of longer travel times relative to storm drain systems. Note that the third stream located within the Town of Bristol is located entirely on the campus of Roger Williams University, and does not appear to have any town-owned outfalls associated with it.

In November 2008, the Town of Bristol submitted an amended Phase II Stormwater Management Program Plan. In January 2008, RIDEM determined that the Town of Bristol failed to comply with the RIPDES Phase II General Permit for Storm Water Discharge from Small Municipal Separate Storm Sewer Systems (Small MS4 GP). This determination was focused on Required Measurable Goals for the first five years of the General Permit. RIDEM determined that the Town had not adequately documented compliance with certain Required Measurable Goals. Among many other deficiencies, the Town has failed to report findings of two required dry weather sampling surveys of all town-owned outfalls and has also failed to document that it is fully implementing an annual catch basin inspection and cleaning program. The Town has located outfalls town wide, and is apparently in the process of creating a GIS-based map. The Town has yet to conduct any dry-weather sampling of outfalls.

As identified in the Wastewater Facilities Plan, dated April 2000, the Bristol sewer system experiences high influent flows due to high groundwater table and the age and condition of pipes. There is also a history of sewer overflows in the Town of Bristol, including 11 overflow events between 1997 and 2000 upgradient of the Mount Hope pump station. Because of the high influent flows, the Town and RIDEM entered into a consent agreement, resulting in the completion of a comprehensive Sewer System Evaluation Survey (SSES) to identify and assess the sources of infiltration and inflow. Smoke and dye testing of catch basins and roof leaders was performed to identify illegal connections to the sewer system. No illicit connections were found within the Kickemuit River/Mount Hope Bay watershed. Portions of the sewer were also cleaned and televised to identify areas in need of repair. The Town of Bristol contracted Beta Group Inc. to clean and seal main sewer lines, service connections and manholes, and replace lines where needed. Both the SSES and the Wastewater Facilities Plan have identified and prioritized future projects, including upgrades, expansions and extensions to the existing sewer system. Sewer expansion along Metacom Avenue between San Francisco Street and Butterworth Avenue resulted from concerns about failing septic systems. Pump station upgrades are currently being designed for Harrison Street and Mount Hope Pump Stations. The Town is also considering rerouting the force main along Narrows Road to relieve stress on the Mount Hope pump station. Future upgrades to these pump stations are expected to reduce occurrences of surcharging and overflow.

As previously discussed, the wet-weather problem affecting all of the priority outfalls was primarily identified through high coliphage levels, and not bacteria levels, which were generally typical of urban runoff. Future identification of wet-weather problem areas should include both fecal coliform and coliphage sampling. It appears that the wet-weather problem could be caused by sewer overflows, leaking sewer systems, cross-connections and perhaps failing septic systems. The improvements made to the town's sewer system are anticipated to improve the quality of stormwater.

A slight to moderate dry-weather problem was identified in most of the priority streams, while the dry-weather problem identified at the Annawamscutt outfall appears to be more pronounced. Elevated dry-weather bacteria levels are probably the result of illicit connections, cross-connections, or perhaps leaky sewers. Work done on the town's sewer system can be expected to help alleviate the dry-weather, as well as the wet-weather problem. Dry-weather sampling required by Phase II regulations and yet to be conducted by the Town of Bristol, may help to further identify problem areas. Any future work done to abate identified dry-weather problem areas may also alleviate problems during wet weather. Once the Town completes work on the sewer system and addresses the dry-weather problem, the priority outfalls should be resampled during wet-weather to determine if the problem persists.

The Town of Bristol is authorized to discharge stormwater under a General Permit (RIR040018). Upon approval of this TMDL, the Town will have 180 days to amend its SWMPP consistent with Part IV.D of the General Permit and more specifically, Sections 5.1 and 5.2 of this TMDL. The Town should coordinate with RIDOT to complete the identification, mapping, and determination of ownership and interconnections for all stormwater outfalls discharging directly to the river.

Five Bristol stormwater outfalls were identified as the most significant potential sources of bacteria to Mount Hope Bay and the Kickemuit River (the outfall on the RWU campus is privately owned). These outfalls include two streams and two culverts that discharge to Mount Hope Bay near Bristol Landing Condominiums, the RIDEM Boat Launch south of Annawamscutt Drive, Viking Drive and Annawamscutt Drive. Another priority stream discharges to the Kickemuit River near its mouth. All of the priority outfalls were characterized by high coliphage concentrations during wet weather, possibly indicating the presence of leaking sewer systems, cross-connections, or perhaps failing septic systems. Upon resolution of problems associated with inadequate sewage disposal, the Town must sample these storm drains to confirm that these outfalls are no longer significant sources of bacteria. If it is determined that elevated bacteria levels are found to persist, the Town will be expected to undertake actions to abate the stormwater related bacteria loads from these priority outfalls. As discussed previously, the catchments associated with each of the priority outfalls must be identified and a feasibility study must be conducted to determine the types and locations of BMPs that will be most effective in reducing stormwater volumes and bacteria loading to the bay and river to the maximum extent feasible. RIDEM recommends infiltration, and/or filtration BMPs throughout the identified subwatersheds to reduce runoff volume and bacteria loading of stormwater reaching the river and bay, rather than end-of-pipe solutions.

The drainage system(s) contributing to any priority streams should be evaluated for possible BMP construction. The Town of Warren should examine LID options and surface BMP's such as infiltration swales to reduce and/or treat stormwater runoff before it enters these priority streams.

To demonstrate that the fecal load has been reduced to maximum extent feasible, all BMP evaluations must investigate the feasibility of distributing water quality treatment and/or infiltration BMPs, which specifically address fecal contamination, throughout the drainage area of priority outfalls. RIDEM encourages the Town to evaluate the feasibility of also reducing the runoff volume and fecal load generated on private properties, which drain to the MS4 by investigating opportunities to treat and/or infiltrate runoff on-site (i.e. infiltrating roof and site runoff and/or redirecting stormwater to areas on the property where infiltration can occur).

Roger William University

As previously discussed, a priority outfall was identified on the campus of Roger William University. This grassed swale originates at a detention basin located at the FCAS South Lecture Hall. Several pipes conduct stormwater to the basin. Coliphage concentrations were extremely high during both dry and wet weather. Dry-weather bacteria levels also appear to be slightly elevated, but wet-weather levels are fairly typical of urban storm water. The campus of Roger Williams University is sewered and the problems identified there could be the result of leaky sewers, cross-connections, or illicit connections. RWU must identify the source(s) and correct this problem.

It is suggested that the University perform dry weather sampling of the outfalls that discharge to the detention basin. Since the problem was identified primarily through high coliphage, and not bacteria levels, future identification of problem outfalls should include both fecal coliform and coliphage sampling. Once problem outfalls are identified, it is suggested that the catchments associated with each of the problem outfalls be identified and the University perform sampling concurrently at the outfall and at several upgradient locations within the drainage system to identify areas of contamination. Unless the wet weather bacteria loads at the priority outfalls are determined to be related to problems with the sewage system and follow-up sampling by the university confirms that the priority outfalls are no longer significant sources of bacteria, the university must undertake actions to abate the stormwater related bacteria loads from this priority outfall. A feasibility study should be conducted to determine the types and locations of BMPs that will be most effective in reducing stormwater volumes and bacteria loading to the bay to the maximum extent feasible.

If stormwater discharges from Roger Williams University are ultimately determined to be significant sources to Mount Hope Bay, a stormwater permit could be required. According to RIPDES Regulations Rule 31 (a)(1)(vii), a storm water permit may be required for a discharge within a geographic area which the Director determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the State. This designation may include a discharge from any conveyance or system of conveyances used for collecting and conveying storm water runoff.

Town of Tiverton

The western portion of north Tiverton, mostly west of Main Street (Route 138) and north of the Sakonnet Bridge is located within the watershed of Mount Hope Bay. Land use within the watershed is dominated by medium-density residential development, with significant areas of forest, and lesser areas of commercial and high-density residential. Two priority outfalls were identified in the Town of Tiverton. These outfalls are located in close proximity to each other at the termini of Summerfield Lane (17-27) and Robert Gray Avenue (17-28). The area is serviced by older, individual septic systems, including cesspools and is characterized by a high water table, high ledge, extreme slopes, and high-density residential development, which increase the likelihood of septic system failure. Limited water quality data of these pollution sources indicates that coliphage concentrations were generally high only during rain events, with several very low coliphage results recorded during dry weather. However, the highest fecal coliform concentration was recorded during dry weather. This would appear to indicate the presence of failing septic system(s) and/or illegal connections.

As previously discussed, the Robert Gray outfall had fairly consistent high dry and wet-weather bacteria and coliphage levels. The Summerfield outfall generally had low dry and wet- weather bacteria levels, however the highest bacteria concentration (240,000) recorded in this study was recorded at the Summerfield outfall during dry weather. The high bacteria concentration was recorded within 24 hours of a significant rain and may have been caused by increased discharge of contaminated groundwater from failing septic systems following the rain event, or by a transitory source such as an illicit connection. The coliphage levels at the Summerfield outfall, during both dry and wet weather were also generally low. However, there was one sampling day when both dry and wet-weather coliphage levels were high. Sewerage odors at both priority outfalls were observed only during periods of intense rainfall, although a resident within the Robert Gray catchment reported odors even during dry weather.

In March 2008, the Town of Tiverton submitted an amended Phase II Stormwater Management Program Plan. The Town has located and mapped stormwater outfalls in the North Tiverton area and has performed extensive dry-weather sampling of outfalls in April 2007 and very limited sampling in September 2007. The maximum fecal coliform level was 650 fc/100/ml. The maximum concentration recorded at the two priority outfalls was 63 fc/100ml.

As previously discussed, it appears that both failing septic systems and illicit connections may be responsible for the problems in the Summerfield and Robert Gray catchments. It appears that the dry-weather problem primarily stems from illegal connections. Illicit connections should be abated through the Illicit Discharge Detection and Elimination (IDDE) work, required by Phase II. Any sampling used to bracket illicit sources should be conducted during dry weather. The wet-weather problem appears to be caused by failing septic systems. Any sampling conducted to bracket failing septic systems should be conducted during heavy rainfall, preferably during the high water table season. Any complaints of failing systems will be investigated by OCI and residents with confirmed failures will be required to replace or repair their systems. Illicit detection work should be conducted prior to any wet weather studies. The elimination of illicit connections is expected to benefit the quality of both dry and wet-weather storm drain discharge. Once IDDE is completed, the town should resample during wet-weather to determine if the problem still persists.

There is an existing sewer interceptor in North Tiverton located within the former railroad right-of-way along the shoreline of Mount Hope Bay. The only areas currently hooked up to the interceptor are the State Avenue area, Sakonnet Bay Manor, and the Village at Mount Hope Bay. There are plans to hook up the Riverside Dr. area as soon as funds become available. The Robert Gray drainage area was also put on the 2008 Priority List for funding from the State Revolving Fund, and may possibly qualify for funding for a sewage system build out from the Robert Gray drainage area. The Town is also working with the homeowners association in the Summerfield Lane area to construct a low-pressure sewage system to hook up to the existing sewer interceptor. The design of the Summerfield Lane sewage system has been completed. However, plans for the remaining aforementioned areas have not progressed into the design phase. The 2000 Tiverton Facilities Plan approved by RIDEM proposes sewering the entire North Tiverton area. The Town must commit to a schedule to commence the design and construction of sewers for these problem areas. IDDE work as well as the identification and repair of failed septic systems is expected to improve the quality of storm drain discharge but sewer construction is the appropriate long term solution to the problem of failing septic systems in this area. Timely implementation of the sewer construction project will reduce the degree to which IDDE investigations and septic system repairs and/or replacements are necessary.

The Town of Tiverton is authorized to discharge stormwater under a General Permit (RIR040039). Upon approval of this TMDL, the Town will have 180 days to amend its SWMPP consistent with Part IV.D of the General Permit and more specifically, Sections 5.1 and 5.2 of this TMDL. The Town should coordinate with RIDOT to complete the identification, mapping, and determination of ownership and interconnections for all stormwater outfalls discharging directly to the river.

As presented above, available data indicate that the source of elevated wet and dry weather bacteria in the storm drains is related to inadequate sewage disposal. Upon implementation of sewering, the Town must sample these storm drains to confirm that these outfalls are no longer significant sources of bacteria. If it is determined that elevated bacteria levels persist, the Town will be expected to undertake actions to abate the stormwater related bacteria loads from these priority outfalls. As discussed in previous sections, the catchments associated with the priority outfalls must be identified and a feasibility study must be conducted to determine the types and locations of BMPs that will be most effective in reducing stormwater volumes and bacteria loading to the bay to the maximum extent feasible. RIDEM recommends infiltration and/or filtration BMPs throughout the identified subwatersheds to reduce runoff volume and fecal loading of stormwater reaching the bay, rather than end-of-pipe solutions.

To demonstrate that the fecal contamination has been reduced to the maximum extent feasible, all BMP evaluations must investigate the feasibility of distributing infiltration and/or filtration BMPs, which specifically address fecal contamination, throughout the drainage area of priority outfalls. RIDEM encourages the Town to evaluate the feasibility of also reducing the runoff volume and fecal load generated on private properties, which drain to the MS4 by investigating opportunities to treat and/or infiltrate runoff on-site (i.e. infiltrating roof and site runoff and/or redirecting stormwater to areas on the property where infiltration can occur).

RIDOT

RIDOT owns one priority outfall and several storm water drains that are interconnected with town drain systems that discharge to priority outfalls. In the Town of Warren, drains associated with Metacom

Avenue, a state road, are connected to both the box culvert at Parker Avenue and the outfall at the railroad right-of way. The Child Street priority outfall on the west side of the Kickemuit River in Warren is a state-owned outfall. The two priority outfalls in the Town of Tiverton, located at Summerfield Lane and Robert Gray Avenue, receive storm water from Main Road, another state-owned roadway. It is not known whether any of the priority outfalls in the Town of Bristol are connected to RIDOT storm drains associated with Metacom Avenue.

RIDOT is authorized to discharge stormwater under a General Permit (RIR040036). Upon approval of this TMDL, RIDOT will have 180 days to amend its SWMPP consistent with Part IV.D of the General Permit. RIDOT should coordinate with Towns within the Mount Hope Bay/Kickemuit River watershed to complete the identification, mapping, and determination of ownership and interconnections for all stormwater outfalls discharging directly to the bay and river.

As discussed in previous sections, the catchments associated with the priority outfalls must be identified and a feasibility study must be conducted to determine the types and locations of BMPs that will be most effective in reducing stormwater volumes and bacteria loading to the bay to the maximum extent feasible. RIDEM recommends infiltration and/or filtration BMPs throughout the identified subwatersheds to reduce runoff volume and fecal loading of stormwater reaching the bay, rather than end-of-pipe solutions.

6.2 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 Mount Hope Bay and the Kickemuit River. 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 SWPPPs to RIDEM.

The owner/operators of facilities currently authorized to discharge to Mount Hope Bay are listed below:

- Brewer Sakonnet Marina
- Standish Boat Yard

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:

1. The quantity and nature of the pollutants, and their potential to impact the water quality of receiving waters.
2. 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.).
1. 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.

6.3 Septic System Maintenance

As previously discussed, septic systems when properly designed, installed, and maintained, provide an effective and efficient means for treating wastewater. However, they are prone to failure with age, overuse, poor soil conditions, high water tables, or improper installation, repair, and/or maintenance. Failed or non-conforming septic systems can be a major contributor of fecal coliform to the Narragansett/Mt. Hope Bay watershed.

To address potential problems with failing and non-conforming septic systems, many municipalities across the State of Rhode Island, have developed Onsite Wastewater Management Plans (OWMPs). An OWMP summarizes the status of septic systems in a municipality or region, assesses causes and impacts of septic system failure, further identifies areas or resources of particular concern, and outlines goals for a wastewater management program. An OWMP may include public outreach, education, and technical assistance, a septic system inspection and maintenance program, zoning and subdivision standards related to septic system setbacks and performance, and a financial incentive program to repair and upgrade failing and substandard systems. In Rhode Island, an approved wastewater plan qualifies towns for the State's Community Septic System Loan Program (CSSLP), enabling towns to provide residents with low interest loans to repair and upgrade failing and substandard systems.

Areas of concern regarding failing or non-conforming septic systems include North Tiverton and the Touisset area of Warren. The Town of Tiverton, with the support of a $35,000 grant form RIDEM, has developed an OWMP. The Tiverton OWMP was approved by RIDEM qualifying the Town for financial assistance under the State's CSSLP. The Tiverton Town Council has recently passed an onsite wastewater management ordinance, requiring system inspection and maintenance, and mandating the installation of access risers and effluent filters when systems are repaired or upgraded. Conventional septic systems will be put on an inspection and pumpout schedule based on the individual usage (once annually to once every 5 years). All cesspools in the Town of Tiverton must be inspected and pumped on an annual basis. Failing cesspools must be upgraded to a conventional system within one year. Cesspools within the Mount Hope Bay watershed must be upgraded to conventional systems by 2014.

The Town of Warren has developed an OWMP for the Touisset area and has submitted it to RIDEM for approval. The plan recommends a financial assistance program to help phase out cesspools and upgrade non-conforming systems, as well as a 3-5 year regular maintenance program.

The Town of Portsmouth is in the process of preparing both a final Wastewater Facilities Plan and an On-Site Wastewater Management Plan to address wastewater needs town-wide. It is noted that studies conducted by engineering consultants for the Town of Portsmouth have analyzed the suitability of various areas for continued reliance on septic systems and has recommended sewering the Common Fence neighborhood, among areas in the town.

6.4 Marine Sanitation Device Pumpout Facilities

Since the adoption of the Clean Water Act in 1972, it has been illegal to discharge untreated waste into coastal waters. Legally, waste has to flow to a Marine Sanitation Device (MSD), before discharge or be held in a holding tank, until such a time that it can be pumped out or discharged offshore. On August 18, 1998, EPA designated Rhode Island's marine waters as a Federal No Discharge Area. 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.

Brewer-Sakonnet Marina is the only recreational boat marina having pump-out facilities located in the vicinity of Mount Hope Bay and the Kickemuit River. In addition, the Bristol Pump-out Boat operates as a mobile pump-out facility and serves the Kickemuit River and Bristol Harbor. It does not service boats moored in Mount Hope Bay.

In 2007 the State of Massachusetts launched an initiative to designate all Massachusetts coastal waters as a No Discharge Area (NDA)-prohibiting any discharge of boat sewage, whether treated or not. The MA Office of Coastal Zone Management is providing substantial support to this initiative, and NDA efforts are now underway in Nantucket Sound; Cape Cod Bay; the coastal waters of Marshfield, Scituate, and Cohasset; Boston Harbor; the coastal waters of Revere, Saugus, Lynn, Nahant, and Swampscott; Salem Sound; and the coastal waters from Gloucester to the New Hampshire border. The MA Office of Coastal Zone Management (MAOCZM), in partnership and cooperation with the municipalities of the lower Taunton River and Mount Hope Bay area, and in conjunction with the Taunton River Watershed Alliance, are requesting that the Commonwealth of Massachusetts designate the coastal waters of Mount Hope Bay, the lower Taunton, Lee and Cole Rivers, as a No Discharge Area (NDA) pursuant to the Clean Water Act, Section 312(f)(3). The goal is to establish the NDA designation for the Mount Hope Bay area, as well as all Massachusetts coastal waters, by the end of 2010.

6.5 Waterfowl Control

There are many ways to discourage nuisance waterfowl and especially swans and geese from settling adjacent to a bacteria-impaired waterbody. No single technique is universally effective and feasible in a suburban or urban setting. Persistent application of a combination of methods is usually necessary and yields the best results. Some methods for controlling nuisance waterfowl populations include the following: discontinuing feeding, modifying habitat, installing fencing, using visual scaring devices, applying repellents, using dogs to chase geese, and controlling goose nesting and capturing and removing geese.

Although many people enjoy feeding waterfowl, feeding waterfowl is illegal in the state of Rhode Island and may cause large numbers of geese to congregate in unnatural concentrations. Well-fed domestic waterfowl, often act as decoys, attracting wild birds to the site. Geese that depend on supplemental feeding are also less likely to migrate when winter arrives. Feeding usually occurs in the most accessible areas such as lawns, streets, walkways, and parking areas. Some success in reducing goose feeding may be achieved through simple public education such as “Do not feed the geese” signs (the Division of Fish & Wildlife will provide examples on request). Further reduction of feeding may require the adoption and enforcement of local ordinances such as fines or community service (cleaning up droppings for example) for violations.

Geese are grazing birds that prefer short, green grass or other herbaceous vegetation for feeding. Well-manicured lawns adjacent to the shoreline provide excellent habitat for these grazing birds. Wherever possible, grass should be allowed to grow to its full height (10-14 in.) around waterbodies. Lawn areas immediately adjacent to the shoreline of ponds may be allowed to re-vegetate naturally to discourage the congregation of waterfowl. In addition to discontinuing mowing next to ponds, the installation of a buffer of native vegetation is recommended to further discourage waterfowl and to limit the establishment of invasive plant species.

Fencing or other physical barriers installed along the shoreline can be effective where nuisance waterfowl tend to land on water and walk up to adjacent lawns to feed. Fencing works best when geese are in their summer molt and unable to fly. Fences must completely enclose a site to be effective. Fencing around large open areas, such as athletic fields, have little effect for free flying birds.

Various materials may be used to create a visual image that nuisance waterfowl will avoid, especially if they are not already established on a site. Waterfowl are normally reluctant to linger beneath an object hovering overhead. One very effective visual deterrent for waterfowl is Mylar tape that reflects sunlight to produce a flashing effect. Owl decoys may also be effective. If waterfowl become acclimated to any of these devices, frequent relocation may be necessary. The use of remote control boats can also be used to repel geese, and may be practical if local hobbyists are willing to participate.

The U.S. Environmental Protection Agency has approved the product, ReJeXiT ®, as a goose repellent for lawns. The active ingredient in ReJeXiT ® is methyl anthranilate (MA), which is a human-safe food flavoring derived from grapes. Geese will avoid feeding on treated lawns because they dislike the taste. However geese may still walk across treated areas.

Dogs trained to chase but not harm geese have been used effectively to disperse geese from parks, golf courses, and athletic fields. Border Collies or other breeds with herding instincts work best. The dogs must be closely supervised during this activity.

The control of swan and goose nesting and the capture and removal of nuisance waterfowl are two other methods that could be used to reduce excessive populations on waterbodies. Both activities require federal permits. RIDEM's Division of Fish & Wildlife should be contacted if this method is being considered.

Without efforts to reduce nuisance waterfowl populations, non-lethal methods of control may just shift the populations and their associated negative water quality impacts to other waterbodies. In areas where waterfowl populations are particularly problematic, the involvement of cities and towns working with property owners, and the Division of Fish & Wildlife and USDA Wildlife Services is necessary to develop a more comprehensive and publicly acceptable strategy.

6.6 Stormwater Runoff in Massachusetts

As previously discussed, there are numerous General Stormwater Permits for municipalities in Massachusetts that are located within the Taunton River/Mount Hope Bay or Kickemuit watersheds. These include the communities of Bridgewater, Raynham, Dighton, Berkley, Somerset, Swansea, Taunton, Freetown, and Fall River. According to the draft pathogen TMDL for the Narragansett/Mount Hope Bay Watershed (MADEP 2008), each community was issued a stormwater general permit from EPA and Mass DEP in 2003/2004 and is authorized to discharge stormwater from their municipal drainage system. Specific stormwater outfalls have been identified either as part of the respective communities Phase II stormwater outfall mapping requirements or as part of sanitary survey work conducted by the MA Division of Marine Fisheries Shellfish Program staff (MADMF 1997 and 1999).

The Town of Seekonk has produced permanently mounted NPS control posters, to be put on display in all municipal buildings. A stormwater information message plays monthly on the local cable channel, as well as in the town's website. Also a stormwater action committee meets frequently, and holds quarterly review meetings with various interests in town. Sixty five percent of the town outfalls have been identified and mapped on GIS. Housekeeping includes street sweeping of all main, and connector roads three times annually, with secondary roads swept once a year. Catch basin cleaning is performed annually, with an inventory produced of vital repairs needed.

The Town of Rehoboth filed a Phase II SWMPP in 2004. In the report, the Town claims there are serious problems in being able to implement a six point Phase II Stormwater program, mainly because they have not been able to retain the continuous services of a part time or full time conservation agent/ planner. This position was designed to help facilitate the Phase II program in Rehoboth. The Town attempted to set up a stormwater committee, but was unsuccessful in finding anyone interested within the Town.

The Town of Swansea has also only filed a Phase II SWMPP in 2004. The Town does indicate some progress on the six point Phase II requirements. Stormwater information links have been added to the town's website. However, informational brochures on stormwater have not been produced or sent out yet. Sampling in the Compton Corner Estuary has been conducted. The Town has also received a 604b EPA grant project to assess stormwater management systems and non-point pollution within the town. Fifty percent of the town's drainage system had been mapped on GIS, and all outfalls have been mapped and inspected, with samples taken at suspected outfalls (particularly in the Compton Corner area). Odor complaints in the Sandy Beach area have been investigated by the town, with illicit discharges identified, and property owners notified by the Town that upgrades or replacement will be necessary. Street sweeping and catch basin cleaning are performed annually.

The City of Fall River filed a Phase II SWMPP in 2004. This report indicates that the town is investing $150 million in a CSO tunnel remediation project which will improve overall water quality in the entire estuary area. Most of their resources for the environment are going toward that effort. The City has updated its website to include stormwater information. It also sponsors an annual cleanup day in some estuary beach areas. City staff man a stormwater information table at the annual Earth Day event. Stormwater notices and posters have been prepared and displayed in public locations such as the public library. There is an annual update of the GIS database on the stormwater collection and outfall system. The 2004 SWMPP report indicates that a number of illicit connections have been discovered and removed. A stormwater BMP manual for the city is being considered. City employee training on stormwater is done one day per year. All streets are swept once in the spring.

6.7 City of Fall River, MA Combined Sewer Overflow Abatement Project

A Federal Court Order was issued which required the City of Fall River to implement a Combined Sewer Overflow (CSO) Abatement Plan. As a result, the City has completed construction of a CSO tunnel as well as 4 drop shafts. Five additional drop shafts are currently under construction. The deep-rock tunnel is 3 miles long and 20 feet in diameter. The tunnel is currently operational and has a 38 million gallon capacity.

Prior to the construction of the tunnel, the Fall River WWTF had historically discharged approximately 1.5 billion gallons per year of untreated and/or partially treated sewage to Mt. Hope Bay from 19 CSOs (Burns 2001). As previously discussed, water quality studies conducted by the U.S. Food and Drug Administration (FDA) in 1987 and Applied Science Associates (ASA) Inc. in 1990 have confirmed that of all the potential sources of sewage contamination in Mount Hope Bay, CSO's represent the largest source - potentially masking all other inputs of fecal contaminants. During one wet weather event monitored by the FDA, CSO's accounted for 96% of total fecal coliform loading to Mount Hope Bay (Dixon et al. 1990).

The City of Fall River has also completed the expansion of the Regional Wastewater Treatment Plant, increasing the primary treatment capacity to 106-million gallons per day. The City is also planning the partial sewer separation of selected CSO areas along the waterfront. The City has also constructed a screening and disinfection facility at Cove Street and is considering additional such facilities at a few other locations, north of Interstate 195. Beginning in March of 2009, the City will be conducting an evaluation and assessment of the operation of the tunnel system and the Cove Street CSO Screening and Disinfection Facility, for a period of about a year. This information will provide the data needed in order to determine the scope of work for the remaining screening and disinfection facilities. It is impossible at this point to quantitatively assess water quality improvements as a result of the recent upgrades. Until the assessment phase is completed it is not known to what extent the combined sewer overflows presently contribute to bacterial pollution in the Bay. It is recommended that the City of Fall River sample all discharge from the new screening and disinfection facility as well as the effluent from the Fall River WWTF during wet-weather, for a period of at least one year, to assess the improvements to stormwater and wastewater discharge, as a result of the significant improvements made by the City.

6.8 Taunton, MA WWTF

The Taunton Wastewater Treatment Facility collects and treats municipal wastewater from a portion of the surrounding municipal area, including industrial facilities. The facility provides advanced treatment and one stage ammonia-nitrogen removal. As previously discussed, portions of the collection system are over 100 years old, and are subject to large amounts of inflow and infiltration. During springtime high ground water conditions, flows to the plant may reach 22.4 mgd, from a dry weather average flow of 6.5 mgd.

The City of Taunton is currently under an Administrative Consent Order with MassDEP, and the City is working on improvements to its collection system. If these improvements do not eliminate the CSO outfall, the Order requires the City submit a plan and schedule for additional options (i.e. storage and pump back, generic bypass with high flow management, etc.) to eliminate the CSO outfall by October 1, 2013, or on the shortest feasible schedule. The Order requires the City to commit to the following:

- monitor combination manholes to determine if there are interconnections between the City's storm water and sewer systems during storm events;
- locate all combination manholes and provide schematics of storm drain and sewer systems;
- present storm water monitoring results and action plan with a schedule of completion for construction activities to prevent transfer between sanitary and storm drains;
- clean the entire collection system;
- perform a television inspection of the collection system;
- clean, inspect, and dye test storm drain catch basins and manholes;
- and investigate and report all efforts to identify and address roof leader and sump pump discharges to the collection system.

7.0 PUBLIC PARTICIPATION

RIDEM and the Massachusetts Department of Environmental Protection (MADEP) hosted a public meeting in Tiverton, RI on October 9th, 2008 to discuss water quality assessment and restoration studies that were being conducted in Mount Hope Bay and the Kickemuit River estuary. Letters were sent to key stakeholders in both Rhode Island and Massachusetts in advance of the meeting. In addition, the meeting was publicized through public notices that were posted at Town Halls in Tiverton, Warren, and Bristol, as well as the City of Fall River.

Staff from RIDEM provided an overview of the Federal Clean Water Act and the states water quality and TMDL programs. RIDEM staff also presented an overview of the TMDL process for Mount Hope Bay and the Kickemuit River. Background issues such as study area, applicable water quality criteria, water quality impairments, the shellfish monitoring program, and existing conditions were discussed. Detailed information and results of the 2006 wet weather sampling program was provided, along with pollution source monitoring information. RIDEM staff then provided information on next steps with respect the bacteria TMDL and gave a brief update on Brayton Point issues.

Staff from MADEP then discussed their efforts with respect to developing TMDLs for both bacteria and nitrogen. Terry Sullivan of the City of Fall River Sewer Commission presented detailed information at the meeting regarding the progress of the Fall River combined sewer overflow abatement project.

RIDEM presented the final draft TMDL plan to the general public and stakeholders, including public officials and other agencies, in a public meeting on November 12, 2009 at the Bristol Town Hall in Bristol, RI. Letters (via email) were sent to a list of over 60 stakeholders in advance of the meeting. These stakeholders included town administrators (or city mayor), public works directors, planners, and conservation commissions for the towns of Bristol, Warren, Tiverton, and Portsmouth, Rhode Island as well as the City of Fall River, and the Town of Somerset and Swansea, MA. Also included were watershed groups, as well as other interested individuals. In addition, the meeting was publicized through public notices that were posted at town halls and public libraries in Bristol, Warren, Tiverton, and Portsmouth.

The draft TMDL was made available to the public on RIDEM's website approximately two weeks prior to the public meeting. The meeting was attended by approximately 20 people. Meeting notes and comments can be found in Appendix B. A single comment was received by EPA during the 30-day public comment period, which ended on December 14, 2009. This comment was incorporated into the final TMDL.

8.0 FOLLOW UP MONITORING

Additional water quality monitoring will be required to ensure that water quality objectives are met as remedial actions are accomplished. The RIDEM Shellfish Program will continue to sample Mount Hope Bay and the Kickemuit River for fecal coliform twelve times a year as well as complete shoreline surveys of the ponds in accordance with NSSP protocol. This will help RIDEM to continually monitor fecal coliform bacteria levels under dry weather conditions while identifying possible new sources.

The City of Fall River intends to conduct sampling in 2010 to assess changes in the sanitary quality of the lower Taunton River and upper Mount Hope Bay during wet weather events. Sampling will be conducted at approximately eight (8) stations with two (2) of these stations located in Rhode Island and at the same location as RIDEM Shellfish station GA17-2 and GA17-3. RIDEM intends to coordinate with the City of Fall River and if possible add additional stations in the Rhode Island portion of the Bay.

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APPENDIX A

Table A.1 Applicable Waterbodies within the Rhode Island Portion of the Study Area.

Waterbody ID Number	Waterbody Description	Classification
RI0007032E-01D	Mt. Hope Bay waters south and west of the MA-RI border and north of a line from Borden's Wharf, Tiverton to buoy R "4" and east of a line from buoy R "4" to Brayton Point in Somerset, MA. Bristol, Portsmouth, and Tiverton	SB1
RI0007032E-01C	Mt. Hope Bay waters south of a line from Borden's Wharf, Tiverton, to buoy R "4" and west of a line from buoy R "4" to Brayton Point, Somerset, MA, and east of a line from the end of Gardiner's Neck Road in Swansea to buoy N "2" through buoy C "3" to Common Fence Point, Portsmouth, and north of a line from Portsmouth to Tiverton at the railroad bridge at "The Hummocks" on the northeast point of Portsmouth.	SB
RI0007032E-01A	Mt. Hope Bay south and west of the MA/RI border, and east of a line from Touisset Point to the channel marker buoy R "4" and south and east of a line from buoy R "4" to the southernmost landward end of Bristol Point and south of a line from Bristol Point to the Hog Island shoal light to the southwestern extremity of Arnold Point in Portsmouth where a RIDEM range marker has been established; And west of a line form the end of Gardiner's Neck Road, Swansea to buoy N "2", through buoy C "3" to Common Fence Point, Portsmouth excluding the waters defined in RI0007032E-01E below. Warren, Portsmouth	SA
RI0007032E-01B	Mt. Hope Bay waters north and west of a line from the southernmost landward end of Bristol Point to buoy R "4" and west of a line from buoy R "4" to the DEM range marker on Touisset Point, and south of the Bristol Narrows. Bristol, Warren	SA
RI0007033E-01A	Kickemuit River from the Child Street bridge (Route 103) in Warren, south to the river mouth at "Bristol Narrows" excluding the waters described below. Bristol, Warren	SA
RI0007033E-01B	Kickemuit River south of a line from the eastern extension of Kickemuit Avenue in Bristol to the DEM range marker located on the western tip of Little Neck in Touisset, and north of a line from the DEM range markers located on the east shore and west shore at the entrance to the Kickemuit River including the "Bristol Narrows" in its entirety. Bristol, Warren	SAb
RI0007033E-01C	Kickemuit River west of a line from the DEM range marker located on the western tip of Little Neck in Touisset to the brick stack located at 426 Metacom Avenue in Warren (formally known as the Carol Cable Building), north of a line from the eastern extension of Sherman Avenue in Bristol to the western extension of Chase Avenue Touisset, and south of a line from the eastern extension of Harris Avenue in Warren to the "5MPH No Wake" buoy. Bristol, Warren.	SAb

Figure A.1 Spar Island test pit locations.

APPENDIX B

Final Meeting Notes and Comments

Meeting began at approximately 1810 hrs. Approximately 20 people in attendance. Elizabeth Scott provided introductions. Brian Zalewsky provided detail on the project including purpose, scope, data collection, TMDL reductions, and pollution source identification. Scott Ribas provided specific information on sources of bacteria, priority outfalls, data from priority outfalls, stormwater Phase II program and other implemented implementation activities. Terrry Sullivan from the City of Fall River

Summary of comments and responses during Nov 12 TMDL meeting
Mount Hope Bay and Kickemuit River estuary TMDL.

Comment 1: from Keith Maloney: Would like to know DEM's position on the proposed LNG siting in Mount Hope Bay. Why did DEM miss the comment period deadline?

Answer (Angelo Liberti): Would get back to him.

Comment 2: What efforts are being made by RIDEM in Mount Hope Bay with respect to nitrogen/dissolved oxygen issues?

Answer: The Massachusetts Estuaries Project effort will address excessive nutrient and low dissolved oxygen issues in Mount Hope Bay by determining all of the factors specific to each estuary that are causing the problem. Project partners will determine the geographic area contributing nutrients to a specific estuary, determine what the nutrient sources are, what the nutrient load is, and how great a nutrient load the estuaries can tolerate without dramatically changing their character and usages.

Question: What percent of the required reductions are allocated to the Wasteload Allocation?

Answer: Stormwater receives 100% of the wasteload allocation in this TMDL. A WLA of zero is assigned to illicit discharges, failing septic systems, leaking sewer lines, and marine vessel discharges…since they are illegal.

Question: What is the story with cesspools in Rhode Island?

Answer: The Rhode Island cesspool act of 2007 requires a phase-out of all cesspools that present the highest risk to public health and/or the environment, namely all cesspools located in close proximity to tidal water areas and public drinking waters. 2012 is the target date for phase-out of all cesspools.

Question: Some pollution sources to the upper Kickemuit appear to come from farmers. How does DEM "work things out" with farmers to control pollution?

Answer: NRCS has a suite of best management practices, or BMPs, that are useful at controlling pollution from farms. To assist the farming community with developing farm resource management plans for agricultural operations, we have created standards and specifications for agricultural best management practices (BMP) which aim to prevent, abate, or minimize pollution of surface and ground water. These standards and specifications are guidelines only however, by implementing these practices, not only will our natural resources be protected and conserved, but economic benefits can be gained as well.

Question: Where does “coliphage” come from?

Answer: A coliphage is a type of bacteriophage that attacks e. coli. A bacteriophage is a virus that attacks bacteria and they are one of the most common organisms on earth. Phages are estimated to be the most widely distributed and diverse entities in the biosphere. Phages are ubiquitous and can be found in all reservoirs populated by bacterial hosts, such as soil or the intestines of animals. One of the densest natural sources for phages and other viruses is sea water, where up to 9×10^8 virions per milliliter have been found in microbial mats at the surface, and up to 70% of marine bacteria may be infected by phages. It has been reliably used as an indicator of human sewerage.

Question: What is enterococci?

Answer: A genus of bacteria. In terms of water quality…In 2004, *Enterococcus spp.* took the place of fecal coliform as the new federal standard for water quality at public beaches. It is believed to provide a higher correlation than fecal coliform, with many of the human pathogens often found in city sewage.

Question: Where is the iron coming from near the “broken bridge” in the Kickemuit?

Answer: It appears that the pipe comes from Parker Mills. DEM TMDL staff and staff from the Office of Compliance and Inspection plan to investigate this in the next few weeks.

Question: What kinds of BMPs will be recommended to treat stormwater?

Answer: Specific BMPs for priority outfalls will be determined by completing an extensive site evaluation during the Scope of Work process. There are a multitude of BMPs available that treat stormwater but we are recommending upland infiltration and or subsurface infiltration systems. The whole concept is to capture and retain as much stormwater as possible.