TOTAL MAXIMUM DAILY LOAD ANALYSIS FOR

GREEN HILL POND,
NINIGRET POND,
FACTORY POND STREAM AND
TEAL POND STREAM
SOUTH KINGSTOWN and CHARLESTOWN, RHODE ISLAND

FINAL

February 9, 2006

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Office Of Water Resources
235 Promenade Street
Providence, Rhode Island 02908

Table of Contents

LIST OF FIGURES

LIST OF TABLES

List of Acronyms and Terms

Best Management Practices (BMP) means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of and impacts upon waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

CFR is the Code of Federal Regulations.

Clean Water Act (CWA) refers to the Federal Water Pollution Control Act (33 U.S.C. § 1251) et seq. and all amendments thereto.

DEM or RIDEM refers to the Rhode Island Department of Environmental Management.

Depuration is the artificial holding of shellfish for purification purposes.

Designated uses are those uses specified in water quality standards for each waterbody or segment whether or not they are being attained. In no case shall assimilation or transport of pollutants be considered a designated use.

DOT refers to the Rhode Island Department of Transportation.

EPA refers to the United States Environmental Protection Agency.

FDA refers to the United States Food and Drug Administration.

Fecal coliform (fc) bacteria are found in the intestinal tracts of mammals. Their presence in water or sludge is an indicator of pollution and possible contamination by pathogens, disease-causing organisms.

Load allocation is the portion of a receiving water's loading capacity that is attributed either to one of its nonpoint sources of pollution or to natural background sources.

Loading Capacity means the maximum amount of loading that a surface water can receive without violating water quality standards.

MOS refers to the Margin of safety.

Most Probable Number (MPN) is an estimate of microbial abundance per unit volume of water sample, based on probability theory.

NSSP refers to the National Shellfish Sanitation Program, which is a part of the Food and Drug Administration (FDA).

Natural background conditions are all prevailing dynamic environmental conditions in a waterbody or segment thereof, other than those human-made or human-induced.

No Discharge Area/Zone means an area of the surface waters of the state that has been requested by the Director of the Department of Environmental Management and declared by the United States environmental Protection Agency, pursuant to Section 312 of the Clean Water Act, to be an area in which any discharge of sewage from vessels is prohibited.

Nonpoint Source (NPS) means any discharge of pollutants that does not meet the definition of Point Source in section 502.(14) of the Clean Water Act and these regulations. Such sources are diffuse, and often associated with land-use practices, and carry pollutants to the waters of the State, including but not limited to, non-channelized land runoff, drainage, or snowmelt; atmospheric deposition; precipitation; and seepage.

Point source means any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation or vessel, or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture.

Primary Contact Recreational Activities are those activities in which there is prolonged and intimate contact by the human body with the water, involving considerable risk of ingesting water, such as swimming, diving, water skiing and surfing.

Rhode Island Pollutant Discharge Elimination System (RIPDES) is the Rhode Island system for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing point source discharge permits and imposing and enforcing pretreatment requirements pursuant to Title 46, Chapter 12 of the General Laws of Rhode and the Clean Water Act.

Runoff means water that drains from an area as surface flow.

SRICD refers to the Southern Rhode Island Conservation District.

SWMPP is a storm water management project plan.

Secondary Contact Recreational Activities are those activities in which there is minimal contact by the human body with the water, and the probability of ingestion of the water is minimal, such as boating and fishing.

Storm water means precipitation-induced runoff.

Surface waters are any waters of the state that are not ground waters.

Total Maximum Daily Load (TMDL) means the amount of a pollutant that may be discharged into a waterbody and still maintain water quality standards. The TMDL is the sum of the individual wasteload allocations for point sources and the load allocations for nonpoint sources and natural background taking into account a margin of safety.

URI refers to the University of Rhode Island

Wasteload allocation is the portion of a receiving water's loading capacity that is allocated to one of its point sources of pollution.

Water quality criteria means elements of the State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use.

Water quality standard means provisions of State or Federal law, which consist of designated use(s) and water quality criteria for the waters of the State. Water Quality Standards also consist of an antidegradation policy.

TMDL: Green Hill Pond (RI0010043E-02), Ninigret Pond (RI0010043E-04B) Factory Pond Stream, (RI0010043R-02) and Teal Pond Stream, (RI0010043R-04)

ABSTRACT

The following document contains the required components for a Total Maximum Daily Load (TMDL) as described by the USEPA (EPA) for compliance with the Federal Clean Water Act. As well, the document and its attached final data report provide an analysis of pollutant sources and accumulation processes in the Green Hill Pond-Ninigret Pond watershed.

This document addresses fecal coliform impairments to Green Hill Pond, two of its tributaries, Factory Pond Stream and Teal Pond Stream, and a portion of Ninigret Pond, all located in the Towns of South Kingstown and Charlestown, Rhode Island. Green Hill Pond, Ninigret Pond, Factory Pond Stream and Teal Pond Stream have been listed on Rhode Island's 2002 303(d) List of Impaired Waters. A Total Maximum Daily Load (TMDL) is developed by locating all pollution sources, determining the amount of pollution a waterbody can accept and still meet water quality standards, and outlining an implementation strategy to abate pollution sources.

Green Hill and Ninigret Ponds are designated as Class SA waters. Factory and Teal Pond Streams discharge to Green Hill Pond, and are therefore designated as Class A waterbodies. For this reason, the mouths of Factory and Teal Pond Streams must meet the more stringent Class SA waterbody fecal coliform standard, which has a numeric standard for fecal coliform bacteria of 14 fc/100ml. All main stem and tributary segments upstream of the mouths of Factory and Teal Pond Stream are considered Class A and must meet the numeric standard of 20 fc/100ml. All four waterbodies are listed as Group 1 waterbodies, given the highest priority for TMDL development.

In Green Hill and Ninigret Ponds, the weighted geometric mean at one shellfish (Station GA11-16) station violated the first part of the state's water quality standard of 14 fc/100 ml. In both of the ponds, the weighted 90th percentile value at 3 stations (Stations GA11-14, GA11-14A, and GA11-16) violated the second part of the state's water quality standard of not more than 10% exceeding 49 fc/100 ml. Based on a review of the data the DEM Shellfish Program determined that one station should be added to their sampling protocol in Green Hill Pond to better account for sources from Unnamed Brook 2. This station, GH24, is located in Gooseberry Cove. At this station both parts of the state's water quality standard were violated and a reduction of 55% is needed to bring this station into compliance. All stations except one (FB01) in Factory and Teal Pond Streams violate both portions of the water quality standards. The reductions in concentration needed to bring all waterbody segments in the Factory and Teal Pond Stream watersheds into compliance range between 20 to 99 %.

A DNA based bacterial source tracking study, conducted September and October 2002, indicated that dry and wet weather sources of fecal coliform bacteria include direct deposition and storm water conveyance of feces from wildlife, waterfowl and pets. Septic systems were included in the bacterial source tracking. Septic systems were found to account for near 0% (Allen's Cove) to 30% (Unnamed Brook 2) of bacteria isolates found in surface waters. The samples are considered representative of the time of year and the conditions sampled. A follow-up study is recommended, however, to examine whether results are typical of other times of the year and for non-drought years.

The Phase II Program requires operators of municipal separate storm sewer systems (MS4s) in urbanized areas (UAs) or those areas with TMDLs to develop storm water management program plans (SWMPPs) and obtain a permit for those MS4s. Charlestown and South Kingstown will be asked to develop a SWMPP to address storm drains identified in the TMDL. Septic systems in both towns are in the process of being inspected. Other recommended BMPs to address elevated dry weather bacteria concentrations include pet waste management, waterfowl management, a public education campaign addressing proper disposal of pet waste, feeding waterfowl, and street sweeping periodically throughout the year especially during the critical summer season. Waterfowl such as mute swan and Canada geese should be discouraged from residing in the area by planting buffers along properties with lawns to the water and by encouraging residents to not feed the birds. Population control of mute swans and Canada geese should be continued.

1.0 INTRODUCTION

1.1 Study area
The study area for this TMDL includes the entire Green Hill Pond watershed and the impaired areas in easternmost Ninigret Pond, located in the Towns of South Kingstown and Charlestown, Rhode Island and several small freshwater tributaries (Figure 2.1). Factory Pond Stream, Teal Pond Stream and several unnamed streams discharge to Green Hill Pond.

1.2 Pollutant of concern
As reported in the State's 2002 303(d) list of impaired waterbodies, Green Hill Pond (0.66 mi^2), and an adjacent portion of Ninigret Pond (0.158 mi^2), Factory Pond Stream and Teal Pond Stream are impacted by fecal coliform bacteria.

1.3 Priority ranking
Green Hill Pond, Ninigret Pond, Factory Pond Stream and Teal Pond Stream are listed as Group 1 waterbodies and given the highest priority for TMDL development.

1.4 Applicable water quality standards
Designated uses
Green Hill Pond and the adjacent portion of Ninigret Pond are designated as Class SA waterbodies by the State of Rhode Island. Class SA waters are designated for shellfish harvesting, direct human consumption, primary and secondary contact recreation activities, and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation and industrial cooling. Teal Pond Stream, Factory Pond Stream and their tributaries are designated Class A waterbodies by the State of Rhode Island. Class A waters are designated as a source for public drinking water supply, for primary and secondary contact recreation and fish and wildlife habitat and shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses navigation and irrigation and other agricultural uses. Class SA and Class A waters should have good aesthetic value.

Numeric water quality criteria
The fecal coliform water quality standard for Green Hill and the adjacent portion of Ninigret Pond is a geometric mean value of 14 fc/100 ml with not more that 10% of the samples exceeding an value of 49 fc/100 ml. These criteria are applicable for Green Hill and Ninigret Ponds and at the mouths of all entering tributaries.

The fecal coliform water quality standard for Teal and Factory Pond Streams is a geometric mean value of 20 fc/100 ml with not more than 10% of the samples exceeding a value of 200 fc/100 ml. These criteria are applicable for the reaches above the mouths of Teal and Factory Pond Streams.

Antidegradation policy
Rhode Island's antidegradation policy requires that, at a minimum, the water quality necessary to support existing uses be maintained (see Rule 18, Tier 1 in the State of Rhode Island's Water Quality Regulations). If water quality for a particular parameter is of a higher level than necessary to support an existing use (i.e. bacterial levels are below Class SA or A standards), that improved level of quality should be maintained and protected (see Rule 18, Tier 2 in the State of Rhode Island's Water Quality Regulations). Because water quality in

Green Hill and Ninigret Ponds and in Factory and Teal Pond Streams violates water quality standards, Tier 2 does not apply.

Numeric water quality target

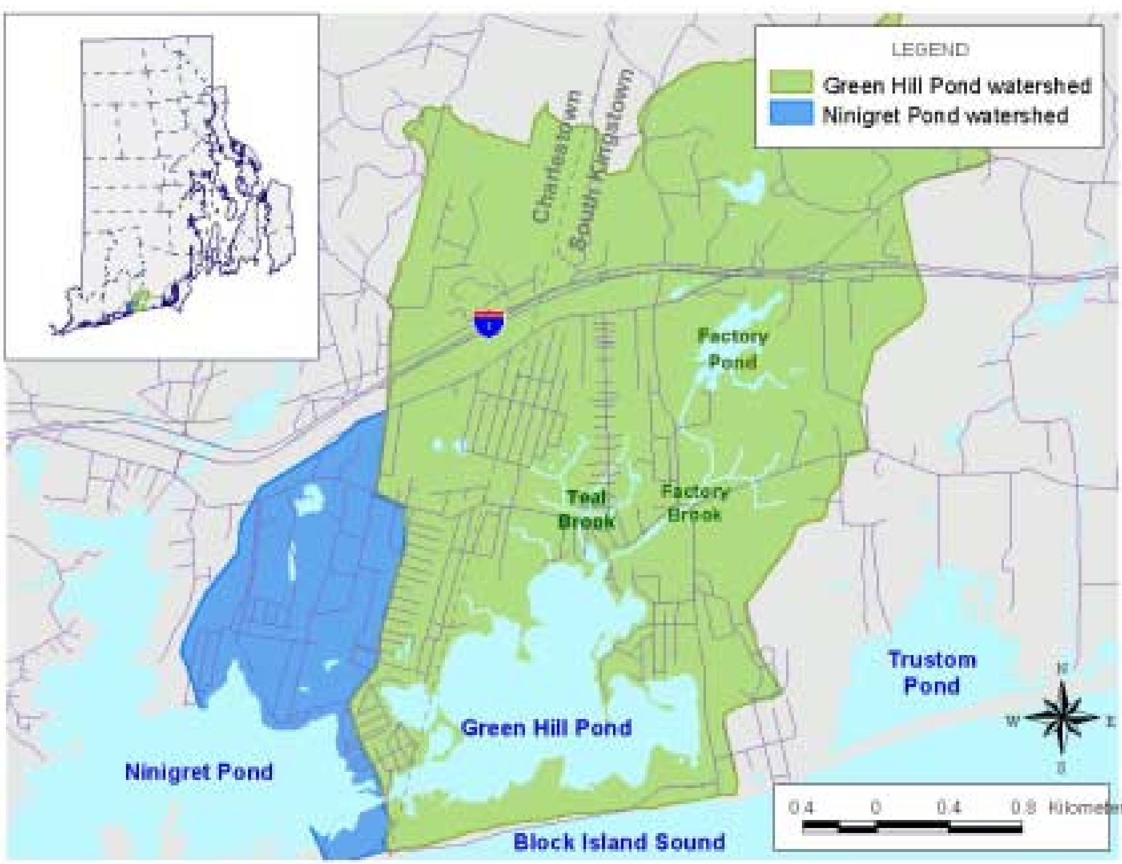
The numeric water quality target for Green Hill Pond and adjacent Ninigret Pond is the Class SA water quality standard geometric mean of 14 fc/100ml with an upper 90th percentile value of 49 fc/100ml. The numeric water quality target for Factory and Teal Pond Streams is the Class A water quality standard geometric mean of 20 fc/100ml with a upper 10th percentile value of 200 fc/100ml except at the point of discharge into Green Hill Pond where the numeric water quality target is the Class SA water quality standard of 14 fc/100 ml with and upper 90th percentile value of 49 fc/100 ml. Because bacteria levels are presently well above the Class SA and Class A standards, the Tier 2 protection of the antidegradation policy does not apply. These targets incorporate an implicit Margin of Safety (MOS) through conservative assumptions explained in section 4 to ensure that the Class A and SA standards are reached.

2.0 DESCRIPTION OF WATERBODY AND WATERSHED

2.1 Study area - Green Hill and Ninigret Ponds

The Charlestown lagoon system, (Figure 2.1) located on the southern coast of Rhode Island, consists of two major basins, Ninigret Pond (6 km long and 1.4 km wide) and Green Hill Pond (1.5 km long and 1.4 km wide). Both of these shallow coastal lagoons are microtidal estuaries, receiving restricted tidal flushing through a narrow man-made breachway. Ninigret Pond is located entirely within the Town of Charlestown and is bounded on its northern side by Route 1 and the Charlestown end moraine. Green Hill Pond is located primarily in the southwestern corner of the Town of South Kingstown, with a small portion of the pond extending into southeastern Charlestown.

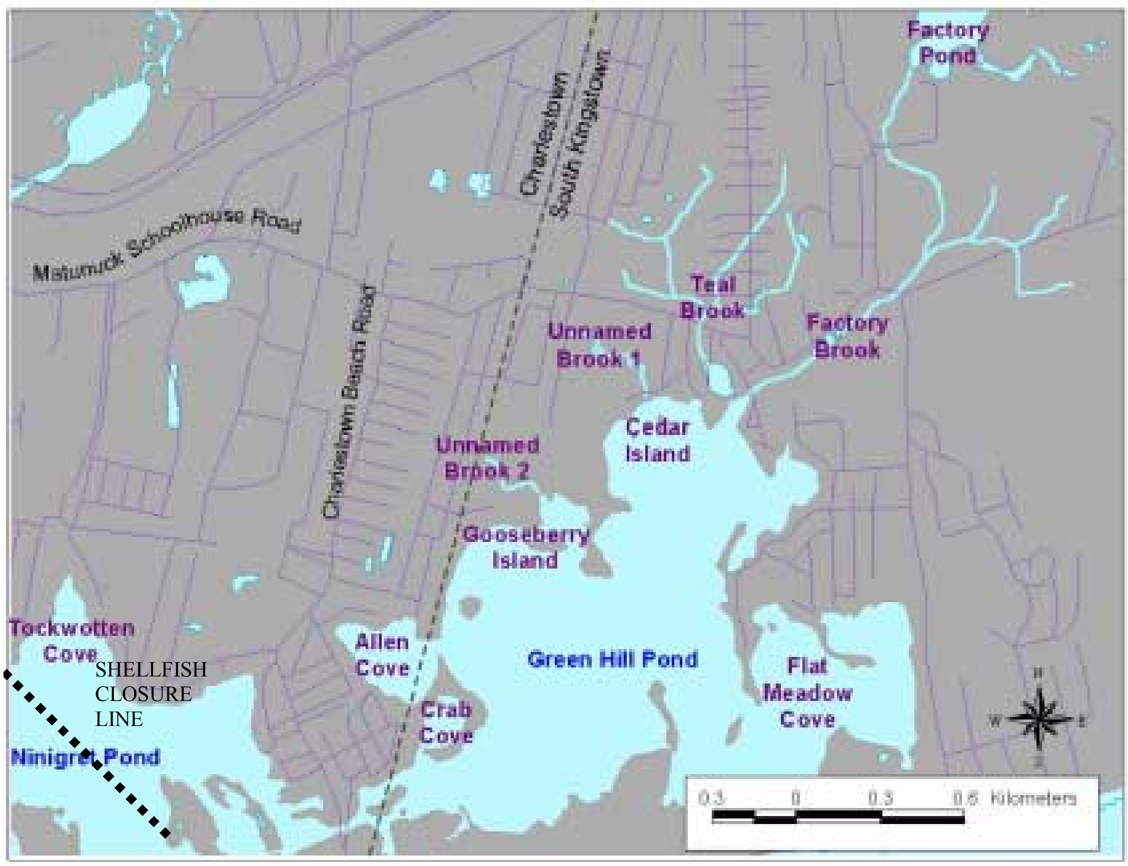
Figure 2.1 The Green Hill Pond Watershed.



This TMDL focuses on the waters in Green Hill and Ninigret Ponds that are closed to shellfishing and Factory and Teal Pond Streams (Figure 2.2). The northern part of the watershed (North of Route 1) is a terminal moraine. The southern section is a glacial outwash plain and is bounded by the coastal barrier beach. Soils within the watershed are characterized as being excessively well drained. Land uses in the watershed include residential, commercial, recreational, and some agricultural. Most of the watershed is zoned residential.

The entire Salt Pond region is located in one of the fastest growing areas of the state and has experienced steady growth over the past forty years. The majority of the area surrounding the ponds is medium to high density residential (Figure 2.3). The existing residential and commercial properties in the Green Hill and Ninigret Pond watersheds are not served by sewers and rely on Individual Sewage Disposal Systems (ISDS) for sewage disposal. Many of these houses, which were originally constructed as summer cottages, have since been converted to year-round residences without updating or replacing the existing ISDSs. The Green Hill area of Charlestown is a prime example in that most of the homes were built pre-1970 (the year Rhode Island ISDS regulations went into effect) and the houses are on small lots with hand dug cesspools. High seasonal use of the area potentially impacts the health of the ponds. The population in the area increases dramatically in the summer. This high summer rental population raises concerns due to the uncertainty of septic discharge volumes within the watershed.

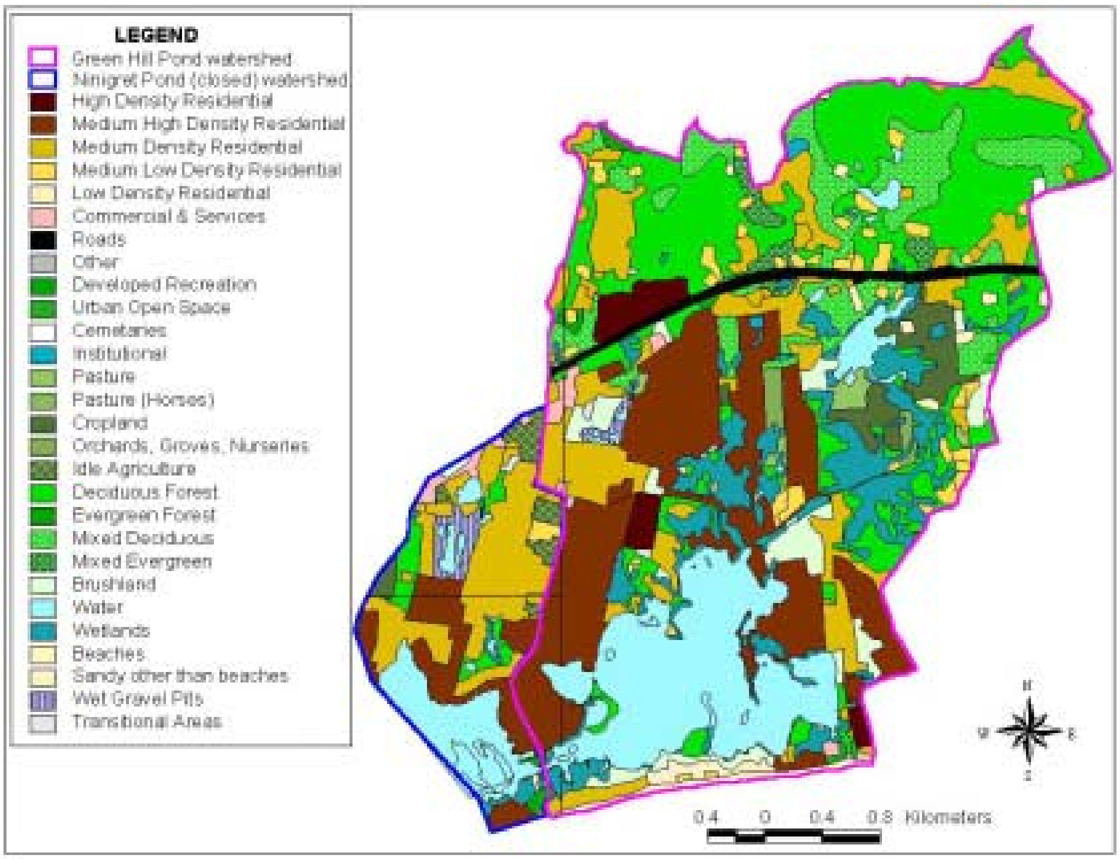
Figure 2.2 Green Hill-Ninigret Pond TMDL study area.



During the 1980's, new construction spread throughout the watershed, and by 1997, residential development occupied about 37 percent of the watershed, with about 2200 homes. Based on present zoning, approximately 600 additional homes could be built in the Green Hill Pond watershed. Most of this buildable land is in sensitive wellhead areas or close to the pond and its streams where the threat of water quality impact is the greatest.

The majority of the land use in Green Hill Pond and the adjacent portion of Ninigret Pond is either residential, forest or wetland. Land uses in the area are presented in Figure 2.3 for these areas. The residential properties are located in close proximity to the pond where as the forests are in the upper portion of the watershed. There are wetland areas that remain undeveloped and some of these are located along the pond shores and along the several streams that flow into the pond. Actual percentages of land use are presented in Table 2.1. Ninety percent of the residential land use is high or medium residential with lot sizes 1 acre or less, and over half of those are lot sizes categorized as 1/4 acre to less than 1/8 acre.

Figure 2.3 Land Use in Green Hill Pond and the closed portion of Ninigret Pond.



As far back as 1981, studies conducted by the R.I. Department of Health (RIDOH) and URI (University of Rhode Island) researchers (Nixon et al, 1982) revealed that fecal coliform concentrations exceeded the Class SA shellfishing standard in Green Hill Pond. In 1994, Green Hill Pond was permanently closed for shellfishing by RIDEM. In 1996, RIDEM extended the permanent closure into the eastern portion of Ninigret Pond from the westernmost boundary of Tockwotten Cove to Heather Island.

In August of 1994, RIDEM initiated an enforcement project in the 'twin peninsula' area of Green Hill Pond and Allen Cove on the western shore of Green Hill Pond. The purpose of the project was to uncover failed systems during the tourist season and maximum occupancy period. A total of 20 violations were observed in the Allen Cove area, which translates into a 7.8% failure rate. However, all 20 violations were observed in the "old" section of

Charlestown (the peninsula surrounding Allen Cove) where 147 homes were inspected for a 13% failure rate. These failed systems were believed to be the cause of elevated fecal coliform concentrations in Allen Cove. Only one violation was observed in the Twin Peninsula area.

Table 2.1 Land use within the Green Hill and Ninigret Pond study area.

Land use category	Acres	% Cover
Forest or wetland	1532.2	44.8
Medium to high density residential (¼ to <1/8 acre lots)	625.1	18.4
Medium density residential (1 to ¼ acre lots)	419.5	12.3
Medium to low density residential (1 to 2+ acre lots)	108.2	3.2
Recreation and beaches	24.1	0.7
Agriculture (cropland, pasture, orchards or nurseries)	143.5	4.2
Open or vacant land	8.0	0.23
Commercial, schools or hospitals	26.7	0.8
Roads	56.8	1.66
Water	470	13.8

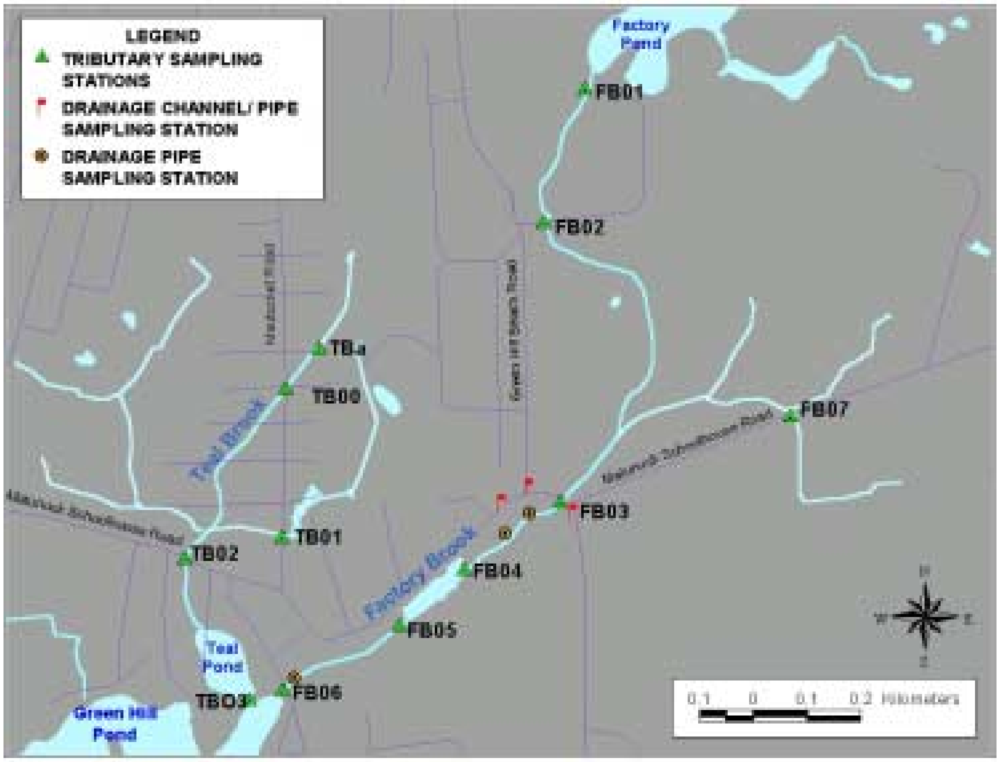
2.2 Study area - Teal and Factory Pond Streams

Teal Pond Stream and Factory Pond Stream are freshwater streams that flow into a small cove in the northeast corner of Green Hill Pond (Figure 2.4). Several small tributaries make up the headwaters of Teal Pond Stream. The largest tributary originates in a small wetland area located east of Mautucket Road and west of Bedford Drive. As this stream crosses Matunuck Schoolhouse Road, it is joined by three smaller tributaries, which originate in wetland areas between Mautucket Road and Hemlock Road. Teal Pond Stream then flows south-southeast as a third-order stream approximately 0.6 kilometers before emptying into Teal Pond. Teal Pond drains directly to Green Hill Pond via a small rock lined channel approximately 1.5 meters in length and 1.0 meter in width. Teal Pond Stream is a slow moving shallow stream ranging between 1.0-1.5 meters in width.

Factory Pond Stream originates in Factory Pond, a small pond approximately 10 ha in size, located just south of Route 1. At its outlet, Factory Pond Stream flows south approximately 0.4 km before turning southeast and flowing into the northeast corner of Green Hill Swamp. Here, three smaller tributaries that drain the middle and upper sections of the swamp join the main stem. Factory Pond Stream then continues through Green Hill Swamp for approximately 0.6 km before flowing into a small impoundment approximately 1.0 ha in size. The brook then flows SSE approximately 0.1 km and empties into Green Hill Pond as a second order stream approximately 10 meters east of Teal Pond Stream.

The Factory Pond Stream and Teal Pond Stream watersheds are small- approximately 210 ha and 85 ha in size, respectively, and consist of forest, forested wetland, and swamp, with some low to mid-density residential areas situated in the lower portion of the watershed. Septic systems and cesspools are the primary means of wastewater treatment in the Teal and Factory Pond Stream watersheds. Soils in the Factory and Teal Pond Stream drainage are characterized as having rapid permeability, slow runoff, high water table, and a high susceptibility to flooding. The Soil Survey of Rhode Island (Rector, 1981)

Figure 2.4 Freshwater Tributary study area.



describes these soils as having severe limitations for the placement of septic tank absorption fields. Salt Pond Watcher monitoring data and RIDEM preliminary data have indicated that both Teal and Factory Pond Streams have elevated fecal coliform concentrations.

Two other tributaries, Unnamed Brook 1 and Unnamed Brook 2, also flow into the northern portion of Green Hill Pond. These two small groundwater-fed streams drain forested wetland that include some low density residential. Dry weather flows typically range from 1-3 cfs while wet weather flows range from 3-5 cfs.

3.0 WATER QUALITY IN THE GREEN HILL POND WATERSHED

Water quality has been a concern in Green Hill Pond since it was permanently closed to shellfishing by RIDEM in 1994. For this TMDL the shellfish program sampling stations presented in Figure 3.1 and the instream water quality stations in Factory and Teal Pond Streams, Unnamed Brook 2 and at station GH 24 in Green Hill Pond in the vicinity of Gooseberry Cove (Figure 3.2 and 2.4), will be used to evaluate compliance with water quality standards and to set reductions (Section 5.0). All other sampled stations were used for source identification and data from these stations (including station GH24) are presented in the source section (Section 3.2) of this document.

3.1 Current water quality conditions

3.1.1 RIDEM Shellfish Program sampling and TMDL water quality surveys

The RIDEM Shellfish Program conducts water quality sampling six times a year on a systematic random basis. Six years of data from the shellfish program from December 1996 through October 2002 were used for the TMDL analysis. RIDEM TMDL personnel also conducted water quality surveys in the Green Hill Pond watershed from 1999-2001. Dry weather surveys were conducted on the twelve days listed in Table 3.1. Dry weather sampling occurred only during the summer months. A single wet weather survey was carried out in September 2000.

Table 3.1 Dry and wet (*) weather survey dates.

1999	2000	2001
June 22	June 21	June 11
July 27	August 18	June 22
September 24	September 19	July 17
	September 19-20 *	August 06
		September 20
		September 24

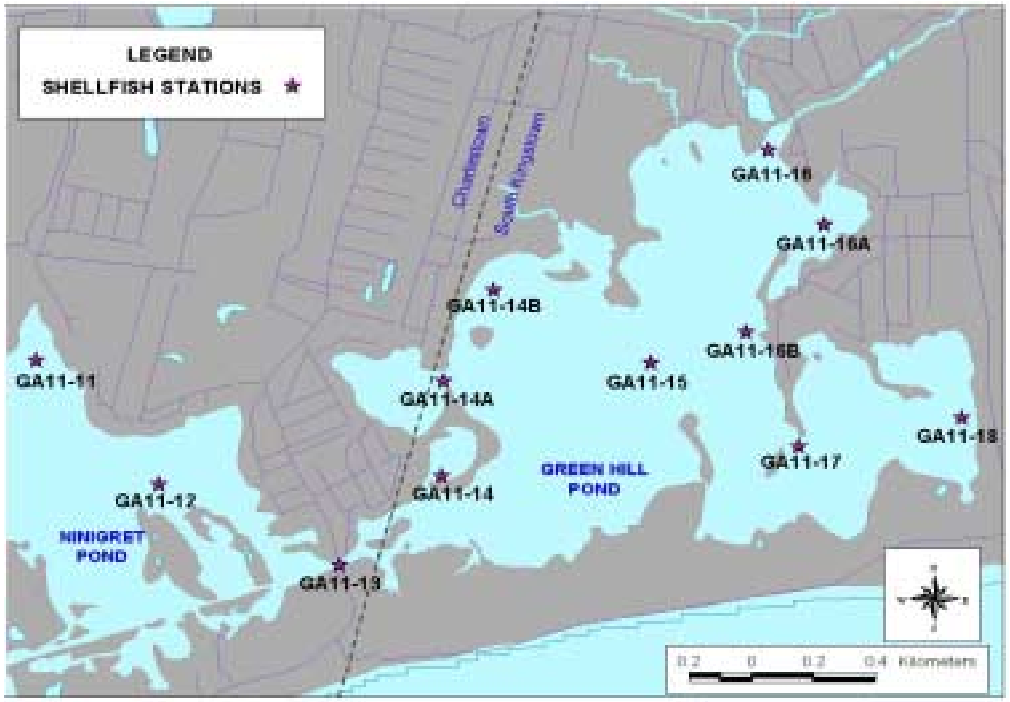
Sampling locations

A complete description of the Green Hill Pond water quality stations can be found in the Green Hill Pond TMDL Data Report (RIDEM, 2001). The locations of the shellfish stations in Ninigret and Green Hill Ponds are presented in Figure 3.1. All sampled stations are presented in Figure 3.2, including the Factory and Teal Pond Stream Stations as well as near shore storm water conveyances, which are all given a station number beginning with DP (drainage pipe) and DC (drainage channel).

3.1.2 Green Hill Pond and Ninigret Pond Dry Weather Water Quality Conditions

Current dry weather geometric mean fecal coliform concentrations in Green Hill and Ninigret Ponds are presented in Table 3.2. Data were combined at stations where both TMDL and Shellfish Program data were collected. The geometric mean fecal coliform concentrations were compared to the Rhode Island state water quality standard of 14 fc/100 ml. Any station exceeding the limit is given an asterisk. The data indicate that one of the twelve in-pond sampling stations exceeded the geometric mean of 14 fc/ 100 ml water quality standard. The station violating water quality standards was station GA11-16, which is located in the cove where Factory and Teal Pond Streams enter Green Hill Pond.

Figure 3.1 Locations of TMDL shellfish stations in Green Hill and Ninigret Ponds.



State water quality standards also require that, for Class SA waterbodies, not more than 10% of the samples shall exceed a value of 49 fc/100. The 90th percentile value is a number that describes the threshold of the top 10 percent of all the sample results at a given station. The dry weather 90th percentile values for Green Hill and Ninigret Ponds are presented in Table 3.2. Three stations in

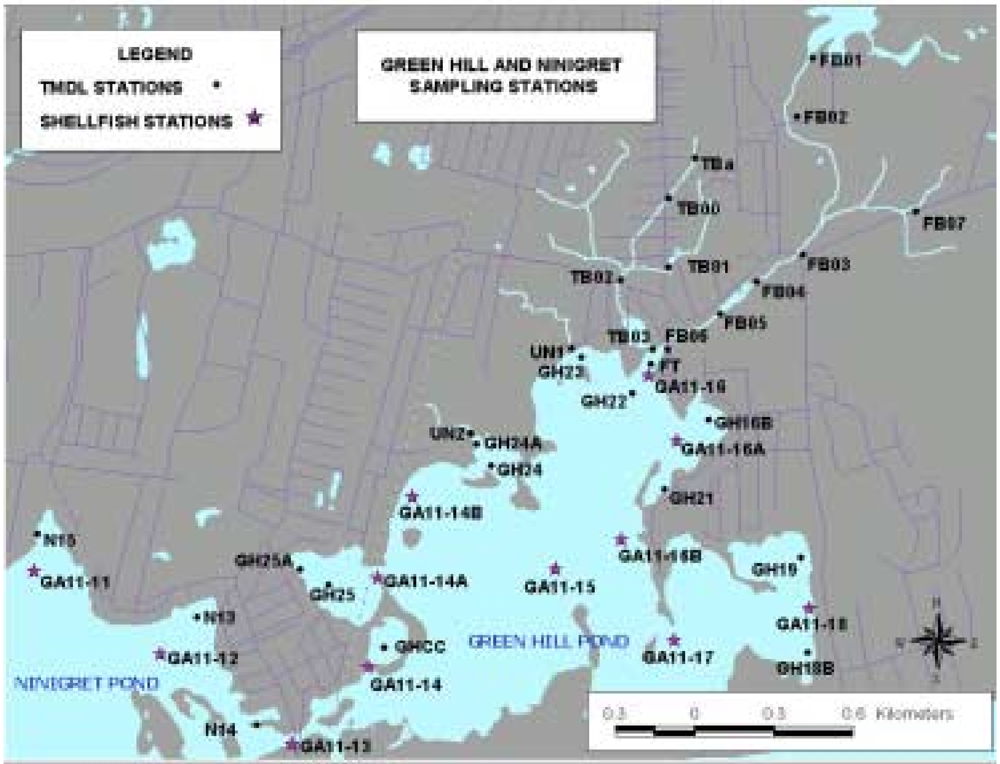
Table 3.2 Dry weather geometric mean fecal coliform concentrations at DEM Shellfish stations.

Station	Geometric mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
GA11-11	5.1	93	1	21	17
GA11-12	4.7	160	1	21	30
GA11-13	3.8	43	2	10	12
GA11-14	6.0	230	1	21	60*
GA11-14A	10.6	130	1	21	57*
GA11-14B	4.5	150	2	10	23
GA11-15	2.6	23	1	20	11
GA11-16	14.8*	230	2	19	92*
GA11-16A	4.0	35	1	20	12
GA11-16B	3.6	23	2	9	12
GA11-17	2.8	15	2	10	5
GA11-18	3.0	230	1	20	5

*Indicates violations of state water quality standards.

Green Hill Pond exceeded the 90th percentile value of 49 fc/100 ml in dry weather. These stations include stations GA11-14, GA11-14A and GA11-16 located in Horseshoe Cove, Allen's Cove and at the confluence of Factory and Teal Pond Streams, respectively.

Figure 3.2 Station locations in the Ninigret and Green Hill Pond watersheds.



3.1.3 Green Hill Pond and Ninigret Pond wet weather water quality conditions

A single wet weather survey was conducted September 19-22, 2000. Light rain initially began at 4:00pm on the 19th then stopped after about 2 tenths of an inch of rain accumulated at around 6:00pm. The rain resumed at 8:00pm and finally ended at 4:15 am on September 20, 2000. The total accumulation was 1.66 inches. Fecal coliform data collected during this wet weather event and data collected during shellfish surveys that were considered wet sampling days are presented in Table 3.3. The geometric mean values were elevated compared to the dry weather data, however only one station, GA11-16, exceeded the geometric mean water quality standard of 14 fc/100 ml during wet weather.

Also presented in Table 3.3 are the wet weather 90th percentile values. According to state water quality standards the limit is not more than 10% of the samples shall exceed a value of 49 fc/100. Five stations in Green Hill Pond exceed the 90th percentile value of 49 fc/100 ml in wet weather. These stations include stations GA11-14, GA11-14A, GA11-16, GA11-16A and GA11-16B

3.1.4 Factory Pond Stream and Teal Pond Stream dry weather water quality conditions

Factory Pond Stream and Teal Pond Stream, empty into a small cove in the Northeast section of Green Hill Pond. Factory and Teal Pond Streams were sampled eleven times in dry weather and five times during a single wet weather event. The resulting geometric mean fecal coliform concentrations are presented in Table 3.4. For dry weather, all stations exceed the first part of the state's water quality standards

Table 3.3 Wet weather geometric mean fecal coliform concentrations at DEM Shellfish stations.

Station	Geometric mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
GA11-11	8.6	1800	2	30	43
GA11-12	10.0	930	1	29	12
GA11-13	8.7	93	2	26	41
GA11-14	11.2	2400	2	30	94*
GA11-14A	8.3	410	2	29	120*
GA11-14B	5.2	93	2	26	23
GA11-15	5.5	93	1	30	27
GA11-16	21.4*	3300	2	30	234*
GA11-16A	11.0	4000	2	29	79*
GA11-16B	6.2	93	2	26	68*
GA11-17	5.9	210	2	30	39
GA11-18	7.3	400	2	30	30

*Indicates violations of state water quality standards.

(20 fc/100 ml, except 14 fc/100 ml at mouth) in Factory and Teal Pond Streams except for station FB01, which is located at the mouth of Factory Pond in the upper watershed. The second part of the state water quality standard (< 10% exceeding 200) is exceeded at all stations except for stations FB01. Fecal coliform concentrations generally increase in the downstream direction.

3.1.5. Factory Pond Stream and Teal Pond Stream wet weather water quality conditions

Wet weather fecal coliform data for Factory and Teal Pond Streams is presented in Table 3.5. All stations in Factory and Teal Pond Streams exceed both water quality standards in wet weather with the exception of station FB01. Fecal coliform samples collected during both dry and wet weather in the main stem of both Factory and Teal Pond Streams have shown a consistent trend of increasing concentration in the downstream direction except at the outlet of Teal Pond where a slight decrease in concentrations was seen. The sources of bacteria appear to be scattered throughout the Factory and Teal Pond Stream watersheds. In Teal Pond Stream increases were seen between stations TB01 and TB02, and a decrease was seen between TB02 and TB03. In Factory Pond Stream, increases were observed from FB01 through FB03, and FB05 and FB06. The concentrations in Factory Pond Stream decreased between station FB03 and FB05.

Table 3.4 Factory and Teal Pond Stream dry weather geometric mean fecal coliform concentrations.

Station	Geometric mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
FB01	15.4	97	1	12	63
FB02	49.4*	350	7	13	264*
FB03	127.9*	480	30	13	306*
FB04	104.4*	280	53	11	240*
FB05	183.4*	1400	54	13	924*
FB06‡	289.5*‡	910	81	13	578*‡
FB07	261.0*	3500	45	7	2000*
TBa	225.1*	520	100	4	478*
TB00	112.4*	1100	22	7	752*
TB01	36.1*	210	11	8	203*
TB02	211.9*	550	58	12	530*
TB03‡	179.6*‡	660	38	12	299*‡

*Indicates violations of state water quality standards of 20 fc/100 ml and <10% exceeding 200 fc/100 ml.
‡These stations are required to meet the state water quality standard of 14 fc/100 ml and <10% exceeding 49 fc/100 ml.

Table 3.5 Wet weather geometric mean fecal coliform concentrations in Factory and Teal Pond Streams

Station	Geometric mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
FB01	11	15	8	2	14
FB02	180*	4,800	21	6	3,700*
FB03	1,891*	14,000	100	9	10,480*
FB04	1,587*	7,700	170	6	6,400*
FB05	1,241*	6,000	66	6	5,450*
FB06‡	3,766*‡	28,000	410	9	15,200*‡
FB07	NS	-	-	-	-
TBa	761*	2,200	230	3	1,934*
TB00	NS	-	-	-	-
TB01	653*	2,700	15	6	2,500*
TB02	2,053*	12,000	140	9	9,360*
TB03‡	1,150*‡	6,400	110	8	4,440*‡

*Indicates violations of state water quality standards of 20 fc/100 ml and <10% exceeding 200 fc/100 ml.
‡These stations are required to meet the state water quality standard of 14 fc/100 ml and <10% exceeding 49 fc/100 ml.

4.0 POLLUTANT SOURCES

The identification of sources in the Green Hill and Ninigret Pond watersheds was conducted using several different techniques. These included bracketed sampling of tributaries, an optical brightener study, and a DNA-based Bacterial Source Tracking study. Work done by other organizations and offices including fecal coliform data from the DEM, Salt Ponds Coalition and Watershed Watch were used to help characterize sources.

Septic systems

A search of the database of complaints filed at DEM's Office of Compliance and Inspection identified 44 complaints about odors and failed systems in the Green Hill and Ninigret Pond watersheds between 1992 and 2002. The failure symptoms included overflowing septic systems and cesspools, raw sewage breakouts and illegal installations. Of these complaints, fifteen were overflowing septic systems or breakouts, nine were illegal constructions, eight were failed cesspools, eight were gray water/ laundry discharges, two had damaged pipes and one had a complaint of odors. The complaints were primarily centered on the Sea Lea and Charlestown Beach Road areas of Green Hill Pond. Current records indicate that nine of these have conformed the septic systems to meet standards and the complaints were dropped in eleven of the cases when corrections were made.

The towns of South Kingstown and Charlestown are currently in the process of having all septic systems inspected. The programs in both towns are phased and both have completed phase one which focused on the Green Hill Pond area. All systems are required to be pumped if they are found to be failing. In South Kingstown the owner has 45 days to begin the permitting process and in Charlestown the owner has 60 days to begin the permitting process. In South Kingstown cesspools must be replaced within 5 years. Roger Pease, Chairman of the Charlestown Wastewater Management Commission, has proposed a resolution that would require all cesspools found in Charlestown to be replaced by May 2007. Results of the inspections as of May 13, 2003 are presented in Table 4.1.

Table 4.1 Results of ISDS inspections in South Kingstown and Charlestown as of May 13, 2003.

	South Kingstown	Charlestown
Number of homeowners contacted	1278	1254
Completed inspections	1039	1117
Passed	1008	1092
Cesspools	43	139 (4 failed)
Failed	31	25
Under Review	25	50

Source sampling

Sources of pollution were determined by sampling the tributaries and storm drains that flow into Green Hill and Ninigret Ponds and inshore areas of the ponds. These stations were sampled during dry and wet weather. Pipes discharging into the various areas were sampled when they were flowing during wet weather. Data collected by the Salt Ponds Coalition and Watershed Watch have also been included to identify sources in Green Hill and Ninigret Ponds.

Wet weather Optical Brightening studies conducted by RIDEM in 2001 at each of the stations in Factory and Teal Pond Streams produced no evidence of septic effluent or gray water discharges in Factory and Teal Pond Stream watersheds.

Additional source identification was conducted with a bacterial source tracking technique using DNA based Polymerase Chain Reaction (PCR) methodology. The bacterial source tracking project focused on the Factory and Teal Pond Stream areas, Allen's Cove and the Gooseberry Cove area. More specific information on the bacterial source tracking project can be found below. Identified sources to the waterbodies include wildlife, waterfowl, pets and possible failing septic systems or cesspools.

For the purposes of identifying sources to the different regions of Green Hill Pond, the pond is divided into four areas. The areas are: Northeast Green Hill Pond, which includes the influences of Factory and Teal Pond Streams and Unnamed Brook 1; Southeast Green Hill Pond including the center of the pond and Flat Meadow Cove; Northwest Green Hill Pond, which comprises the Gooseberry Island area, Unnamed Brook 2, Allen Cove and Horseshoe Cove; and Eastern Ninigret Pond from Tockwotten Cove to the Charlestown Beach Road Bridge.

Bacteria source tracking

A pilot project for the State of Rhode Island aimed at identifying possible sources of bacteria was tested in the Green Hill Pond watershed during 2002. The project utilized the molecular laboratory technique called Polymerase Chain Reaction (PCR). This bacteria source tracking project consisted of collecting samples of identifiable animal feces and surface water samples in Green Hill Pond and its tributaries. The scat samples were collected to contribute to a DNA library of known sources. Up to five unidentified bacteria isolates in each of the water samples were analyzed using PCR. The results were then compared to the library of known sources to determine the sources of the bacteria in the water samples.

RIDEM Fish and Wildlife personnel assisted in searching for and identifying the source of these samples in the field. The criteria for identification consisted of location, consistency, size and shape of the scat. Species included but were not limited to domestic dog and cat, raccoon, deer, otter, Mute Swan, and Canada Goose. The complete data report from this project is presented in Appendix A. All samples were brought to BAL laboratory for fecal coliform analysis and preparation on petri dishes for transport to Cape Cod Community College. Fecal coliform enumeration was performed on solid and water samples. Polymerase Chain Reaction (PCR) was used to analyze the DNA of the bacteria.

Polymerase Chain Reaction or PCR is a laboratory technique used to amplify DNA or certain portions of the DNA strand. The purpose to using this technique is to create a genetic fingerprint that is reproducible and comparable to the fingerprints other individuals. The method works by using primers to mark the segments of DNA that will be amplified. The primers are short sequences of DNA that attach at the beginning and end of a specified DNA sequence. The primers form the beginning of a template for the sequence that is to be amplified or copied many times over. In the presence of a polymerase derived from the hot spring bacterium *Thermus aquaticus* (Taq polymerase for short), the DNA is subjected to a series of heating and cooling cycles which when repeated thirty times result in about one billion copies of the desired DNA segment. The resulting mixture of segments is separated using gel electrophoresis, creating a "fingerprint" made up of a specific reproducible pattern of bands. The banding pattern is then compared to the patterns in the library of known sources using cluster analysis to determine the source of the bacteria. The more bands two individual isolates share increases the likelihood that they are related. A cluster analysis is used to determine how closely related the patterns are to the patterns in the known source library.

The results came in the form of a percent similarity known here as the Similarity Index (SI). The Similarity Index describes how closely related the banding pattern of each isolate is to the banding pattern of a specific animal type in the source library. A percent similarity of 70% (0.7) or greater indicates a likely match. The reliability of the result increases with an increasing percent similarity. In general the similarity index values ranged from 0.7 to 0.9 with a few isolates having a similarity index lower than 0.7. Any isolate with a similarity index less than 0.7 was omitted from the final data analysis. Of the 251 analyzed isolates, 31 were omitted for having a low similarity index, leaving 219 isolates that were kept.

DEM believes that the sources identified during this study provide an adequate representation of the bacteria present in the Green Hill Pond area during the study period. It is possible, however, that other sources present in the watershed were not identified during this study. The possible reasons for a non-identification of a source could include: not enough isolates were analyzed from each sample, not enough samples were collected, and 2002 was a drought year affecting possible groundwater inputs to the pond. Because this was a discrete study that took place during two months in 2002, it is possible that the bacteria analyzed may not be representative of the bacteria sources to the pond during the entire year.

Known source samples were collected only during dry weather. A total of 70 scat and septic system samples were collected. Unknown water samples, collected in dry and wet weather totaled 58. Results are presented for the different areas in Green Hill Pond below. Positive identifications are grouped into the following categories: bird, dog, human, wildlife and unidentified. The wildlife category includes deer, raccoon, rabbit, rat, and rodent. The unidentified category includes all isolates with an SI less than 0.7. The number of isolates for each contributing species is presented in Figure 4.1. Wildlife was the highest contributor of fecal coliform in the samples from areas studied in Green Hill Pond. Birds were second in their contributions of bacteria in the samples. Human and dogs were third and fourth in their contributions. About 12% of the isolates were unidentified.

4.1 Northeast Green Hill Pond

The northeastern area of Green Hill Pond includes shellfish stations GA11-16 and GA11-16A. Additional pond stations (Stations GH16B, GH21, GH22, and GH23) were sampled to assess locations of bacteria sources to the pond and tributaries. These stations are presented in Figure 4.2.

Dry and wet weather fecal coliform concentrations for this area are presented in Tables 4.2 and 4.3. Stations GH21 and GH23 violate both portions of the water quality standard in dry and wet weather. Stations GH16B and GH22 violate both parts of the water quality standards in wet weather only. Station GH21 is primarily influenced by the Twin Peninsula area and is closer to sources because concentrations are higher here than at station GA11-16A. The Salt Pond Coalition data, described in more detail below, also indicates that the

Twin Peninsula area affects station GA11-16A because the geometric mean concentration at station 16T is 40 fc/100 ml, which exceeds water quality standards. Station GH16B is also closer to sources than stationGA11-16A, but only in wet weather.

Figure 4.1 Distribution of sources identified in the bacteria source tracking study.

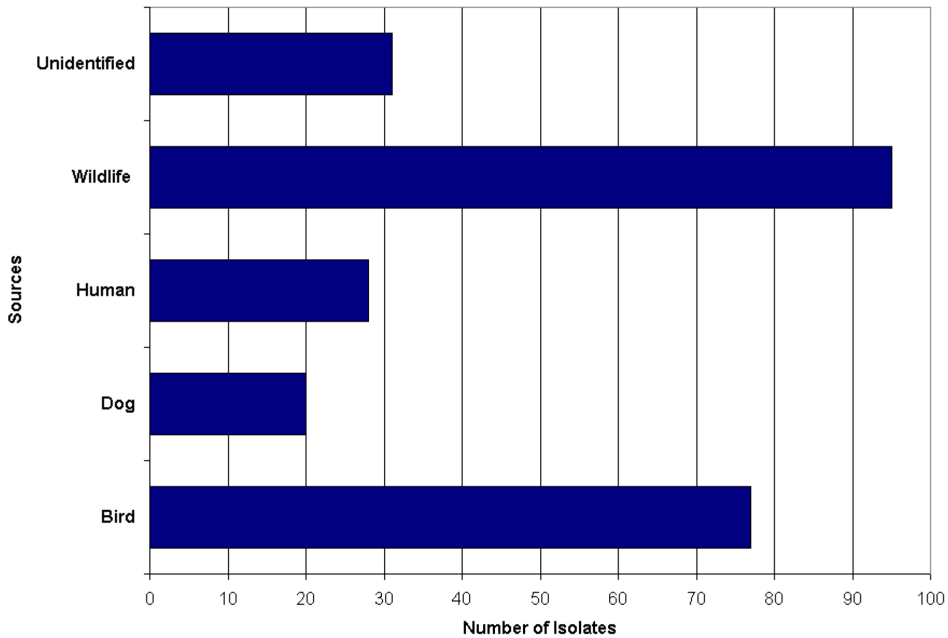
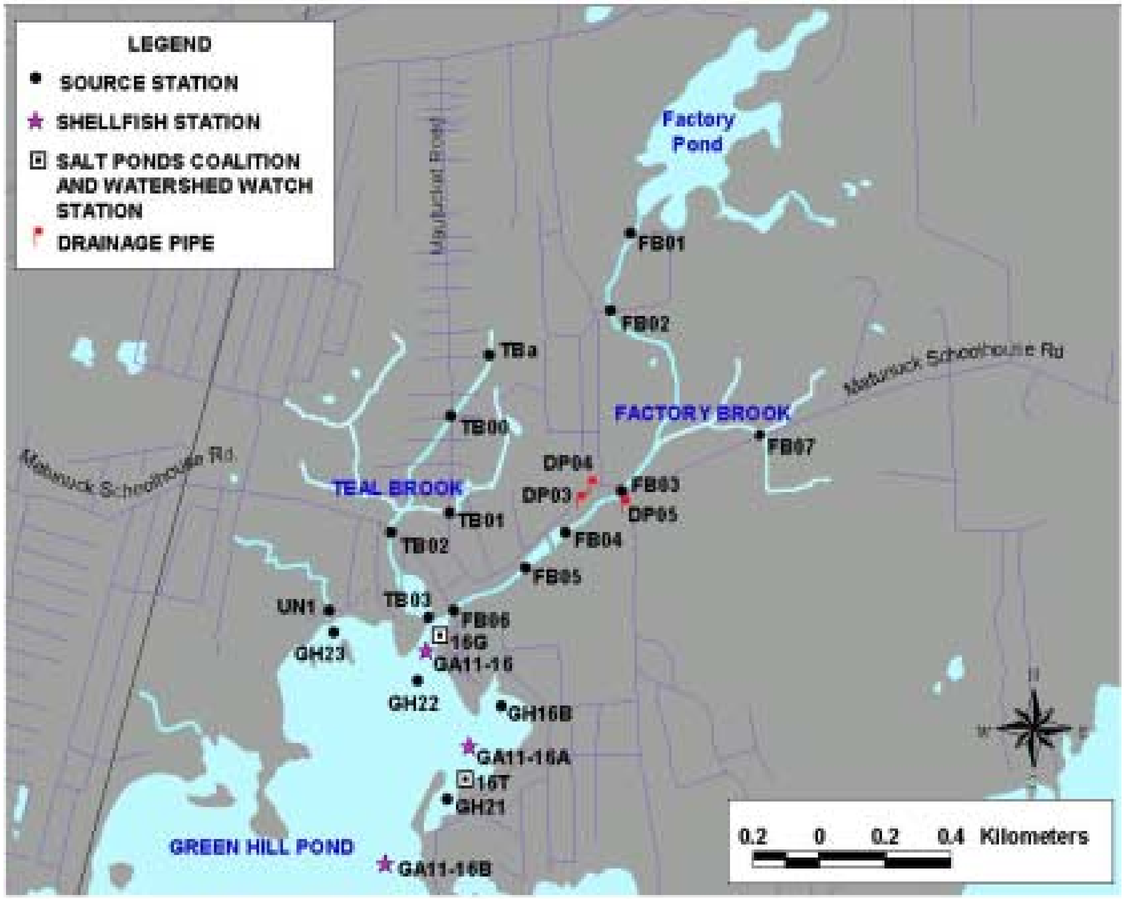


Figure 4.2 Station locations in Northeastern Green Hill Pond.



The high concentrations of fecal coliform in these areas could be influenced by failing septic systems, but are more likely affected by storm water runoff from this densely residential area, given the results obtained from stations in similar areas of the pond. The sources in storm water may include waterfowl, pet waste and wildlife. Station GH23 is probably partially influenced by Unnamed Brook 1 however, large numbers of waterfowl have been observed in this area, which could be the major contributors of bacteria in this cove.

Table 4.2 Dry weather in–pond source stations in Northeast Green Hill Pond.

Station	Geometric Mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
GH16B	7.3	56	1	10	27
GH21	14.7*	250	1	7	160*
GH22	13.3	53	1	8	40
GH23	18.5*	99	5	8	55*

* Indicates violation of water quality standards

Table 4.3 Wet weather in–pond source stations in Northeast Green Hill Pond.

Station	Geometric Mean fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
GH16B	25*	480	6	4	285*
GH21	79*	1000	2	4	766*
GH22	58*	2700	1	4	1941*
GH23	95*	1900	8	4	1375*

* Indicates violation of water quality standards

Station GH22 is primarily influenced by Factory and Teal Pond Streams, which are described in detail below. Since GA11-16 is greater than GH22, sources must be upstream of GA11-16. Factory and Teal Pond Streams are the upstream sources of fecal coliform bacteria and flow into a small cove in the Northeast section of the pond. The fecal coliform concentrations at the mouths of these brooks are presented in Table 4.4. Dry and wet weather concentrations of fecal coliform at these locations consistently violate state water quality standards.

Table 4.4 Factory and Teal Pond Stream fecal coliform contributions to Green Hill Pond.

Station	Dry weather geometric mean fecal coliform concentration fc/100 ml	Wet weather geometric mean fecal coliform concentration fc/100 ml
Mouth of Factory Pond Stream (FB06)	294*	3,766*
Mouth of Teal Pond Stream (TB03)	139*	1,150*

*Indicates violations of state water quality standard of 14 fc/100 ml

RIDEM expended significant time and resources investigating the potential cause(s) of elevated dry weather bacteria concentrations in Factory and Teal Pond Streams. Optical Brightening studies conducted by RIDEM in 2001 showed no evidence of the brightening agents contained in detergents present in gray water discharges in the main stem and tributaries. Field reconnaissance, in combination with extensive land use analysis uncovered no evidence of anthropogenic sources of fecal coliform bacteria.

The bacteria source tracking study provided more specific answers as to the actual sources of fecal coliform in Factory and Teal Pond Streams and the results are presented in Table 4.5. The results indicate that primary sources of bacteria isolates analyzed appear to be wildlife (56%) and birds (19%). Human sources comprised 9% of the total isolates identified in the Factory and Teal Pond Stream area.

Table 4.5 Number of positively identified isolates in the northeast area of Green Hill Pond.

Station	Bird	Dog	Human	Wildlife	Unidentified	Total
FB06	7	1	0	17	4	29
FB03	5	0	6	17	7	35
TB02	6	0	5	21	2	34
TB03	3	0	1	21	2	27
GA11-16	1	0	2	7	2	12
GH23	3	2	0	0	0	5
UN1 UP	3	2	0	0	0	5
Percent contribution	19%	3%	10%	56%	12%	147

No dry weather surface discharges exist to Factory or Teal Pond Streams. Fecal coliform bacteria introduced into the streams during dry weather conditions likely occur via direct deposition by wildlife and/or waterfowl. Failing septic systems could potentially contribute to the human sources in Teal and Factory Pond Stream. TB02 is located next to a known failing septic system and human bacteria were found at that location. The human bacteria were also carried downstream but occurrences were less frequent. There are not any known failing septic systems in the vicinity of FB03 and investigations should be undertaken to determine the source of human bacteria in this area. Wet weather sources include storm water runoff, septic systems, and wildlife and pet waste carried in overland flow to the pond.

Factory Pond Stream

Factory Pond Stream flows from Factory Pond through forested wetland and along Matunuck Schoolhouse Road. Very little of the area is residential. Factory Pond Stream fecal coliform concentrations are presented as geometric means for dry and wet weather and as means for all conditions in Figure 4.3. The sampling stations are arranged in the upstream to downstream direction (see Figure 2.3) except for FB07, which is located along a secondary fork. Concentrations generally increase in the downstream direction with FB01 having the lowest fecal coliform concentrations and increasing to FB06 at the mouth, which has the highest fecal coliform concentrations. The area between FB01 and FB03 has very few homes, and the majority of the stream is forested wetland. It is in this area that weighted geometric mean fecal coliform concentrations increase in the downstream direction from 14 fc/100 ml at FB01, to 102 at FB02 and then to 1691 at FB06.

Bacteria source tracking was conducted at two stations in Factory Pond Stream. The results are presented in Table 4.5. In Factory Pond Stream, 69% of the isolates were identified as wildlife, birds comprised 18% of the isolates and humans represented 10%. Human bacteria were found at station FB03, which is downstream of an area that is mostly forested wetland, with little development. The large percentage of positively identified wildlife isolates at both Factory Pond Stream stations reflect the undeveloped land use in the area. There are one or two houses nearby on Green Hill Beach Road, however, and further study of this stream may be necessary to elucidate the source of human bacteria near station FB03.

Several roadways drain into the stream in the area of FB03 and below. Two storm drains that flow into Factory Pond Stream were sampled during wet weather. The pipes drain local roadways and were sampled during the September 20, 2000 rain event. The outfalls were found to be flowing for 5 hours after the storm. At hour seven the flow had ended. The locations of the storm drains are presented in Figure 4.2. Average fecal coliform concentrations for the storm drains are presented in Table 4.6. The fecal coliform concentrations in these drains are somewhat high. The nature of land used along the road, which travels through a forested area with some homes is considered to reflect the sources seen at stations FB06 and FB03 (Table 4.5). These storm water sources are considered to be controllable.

Figure 4.3 Fecal coliform concentrations at Factory Pond Stream Stations.

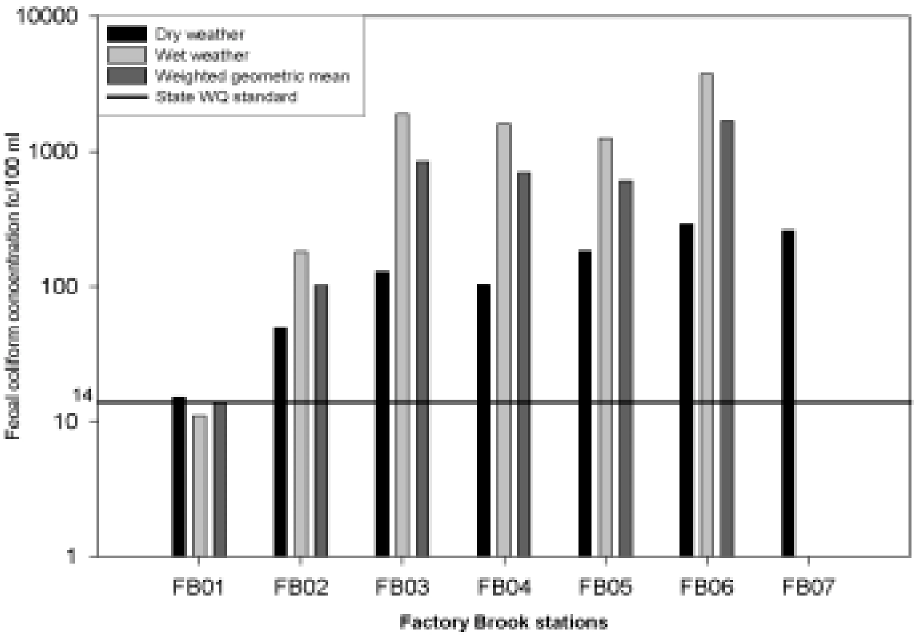


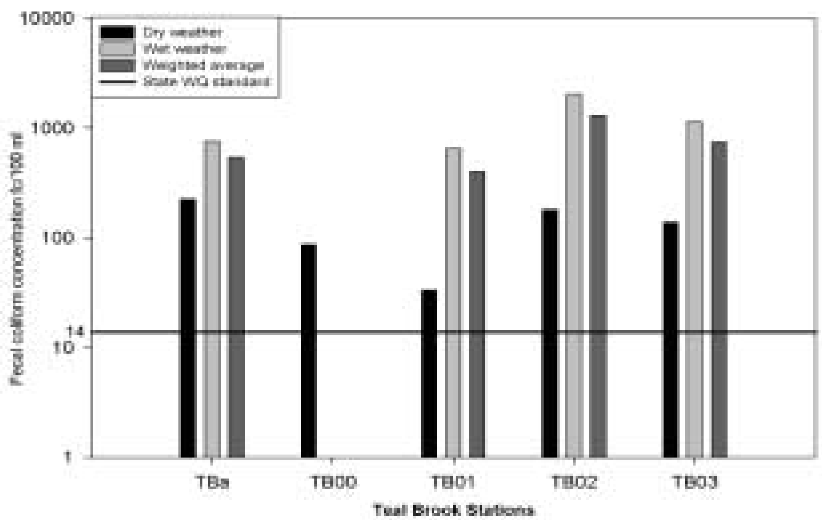
Table 4.6 Fecal coliform concentrations in storm drains and channels along Factory Pond Stream.

Storm drain name and location	Mean fecal coliform concentration fc/100ml	Number of samples
DP03 – At the intersection of Green Hill Beach Road N and Matunuck Schoolhouse Road	10,450	2
DP04 – Along Matunuck Schoolhouse Road approximately 65 meters downstream of DP03.	4300	2

Teal Pond Stream

Teal Pond Stream begins as a series of small tributaries in the Mautucket and Matunuck Schoolhouse Road area (Figure 4.2). This area is comprised of forested wetland, a pond, and a small section of residential properties. Just upstream of Matunuck Schoolhouse Road, the various tributaries merge and flow to Teal Pond, which is located in a small but densely developed residential area. Fecal coliform concentrations along Teal Pond Stream are presented in Figure 4.4. In general the sampling stations are arranged in the upstream to downstream direction except for TB01, which is located

Figure 4.4 Fecal coliform concentrations in Teal Pond Stream.



along one of the smaller tributaries that crosses Mautucket Road. Fecal coliform concentrations have no apparent trend along Teal Pond Stream. The weighted geometric mean value of 954 fc/100 ml was found at station TB02 on Matunuck Schoolhouse Road. The lowest weighted geometric mean value of 285 fc/100 ml was measured at TB01 on Mautucket Road. No storm water discharges were identified to Teal Pond Stream.

The results of bacteria source tracking conducted at TB02 and TB03 in Teal Pond Stream are presented in Table 4.5. Wildlife represented 69% of the bacteria isolates analyzed in Teal Pond Stream. Birds comprised 15% of the isolates and humans represented 10%. Half of the positively identified human isolates in the Factory Teal watershed were found at station TB02 near a known septic system failure at the time of sampling that was one of the septic systems sampled for this study. This suggests that the failing system is contributing bacteria to Teal Pond Stream. The DNA data indicate that the majority of the bacteria analyzed in Teal Pond Stream are from non-human sources including wildlife and birds, although a human influence was detected from a failing septic system.

Salt Ponds Coalition and Watershed Watch data in Northeastern Green Hill Pond
Data collected by the Salt Ponds Coalition and Watershed Watch are presented in Table 4.7. These data were collected by both organizations on different dates at stations 16G and 16T,

shown in Figure 4.2. The stations are at the end of docks. Volunteers collected the Salt Ponds Coalition data from 1996 through 2002. Sampling conducted by Watershed Watch occurred in 2001 and 2002 and was also conducted by volunteers.

The data for station 16G support the conclusion above that sources in the Northeastern section of the pond originate in the Factory and Teal Pond Stream area. Concentrations at station 16G are higher than the DEM data at GH22, which is farther out in the pond and therefore exposed to more dilution. The closer proximity of the two tributaries likely accounts for the higher value at 16G. Data for station 16T at the Twin peninsula are also consistent with the presence of a landward-based source. A number of updated septic systems have been installed in the Twin Peninsula area in the last few years. It is apparent that Salt Ponds Coalition data reflect improved water quality at station 16T because fecal coliform concentrations have decreased significantly since 1999 (station 16T – Twin Peninsula). The geometric mean fecal coliform concentration at Twin Peninsula from 1995-1999 was 183.4 fc/100 ml, while the geometric mean concentration from 2000-2002 was 7.8 fc/100 ml URI Cooperative Extension staff have indicated that one ISDS was installed in the area during 1999. The installations coincides with the change in fecal coliform concentrations at station 16T (D. Dow, pers. com.).

Table 4.7 Salt Ponds coalition and Watershed Watch Fecal coliform data.

Station	Geometric mean Fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
16G Teal Road	148	1600	2	54	540
16T Twin Peninsula	40	1600	1	48	540

Unnamed Brook 1

Unnamed Brook (UN1) is a seasonal stream that enters into Green Hill Pond in an area west of Factory and Teal Pond Streams. This stream was sampled several times in 2001. In the summer and fall of 2002, however, the stream went dry. Geometric mean values are presented in Table 4.8.

Unnamed Brook 1 originates at Indigo Point Road and flows through a forested wetland and into Green Hill Pond. It is possible, although unlikely, that the road contributes any load to the brook during dry weather. Bacterial source tracking identified birds as having contributed the majority of the isolates. However, only a small number of isolates were analyzed from UN1 and the cove. This number was most likely not sufficient to fully characterize the sources in the area.

4.2 Southeast Green Hill Pond

The southeastern portion of Green Hill Pond includes Flat Meadow Cove, and is bordered to the north by the Twin Peninsula area and to the south by a barrier beach. Only two additional stations were sampled in Flat Meadow Cove to help identify sources (Figure 4.5). Dry weather fecal coliform concentrations at these stations are presented in Table 4.9. Wet weather data were only collected at station GH19; station GH18B was added on in 2001. The weighted average geometric mean concentration at GH19 was 11 fc/10 ml and the weighted average 90th percentile concentration was 92 fc/100 ml.

Table 4.8 Unnamed Brook 1 dry weather fecal coliform concentrations.

Station	Geometric mean Fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile fc/100 ml
UN1	831*	3100	240	6	2700*

*Indicates violations of state water quality standards

Table 4.9 Dry weather fecal coliform concentrations in Southeastern Green Hill Pond.

Station	Geometric Mean fecal coliform concentration fc/100 ml (WA)	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value (WA) fc/100 ml
GH19	4.5 (11)	44	1	6	27(92)
GH18B	5	30	1	4	23

Weighted average calculations are presented in parentheses.
*Indicates violations of state water quality standards

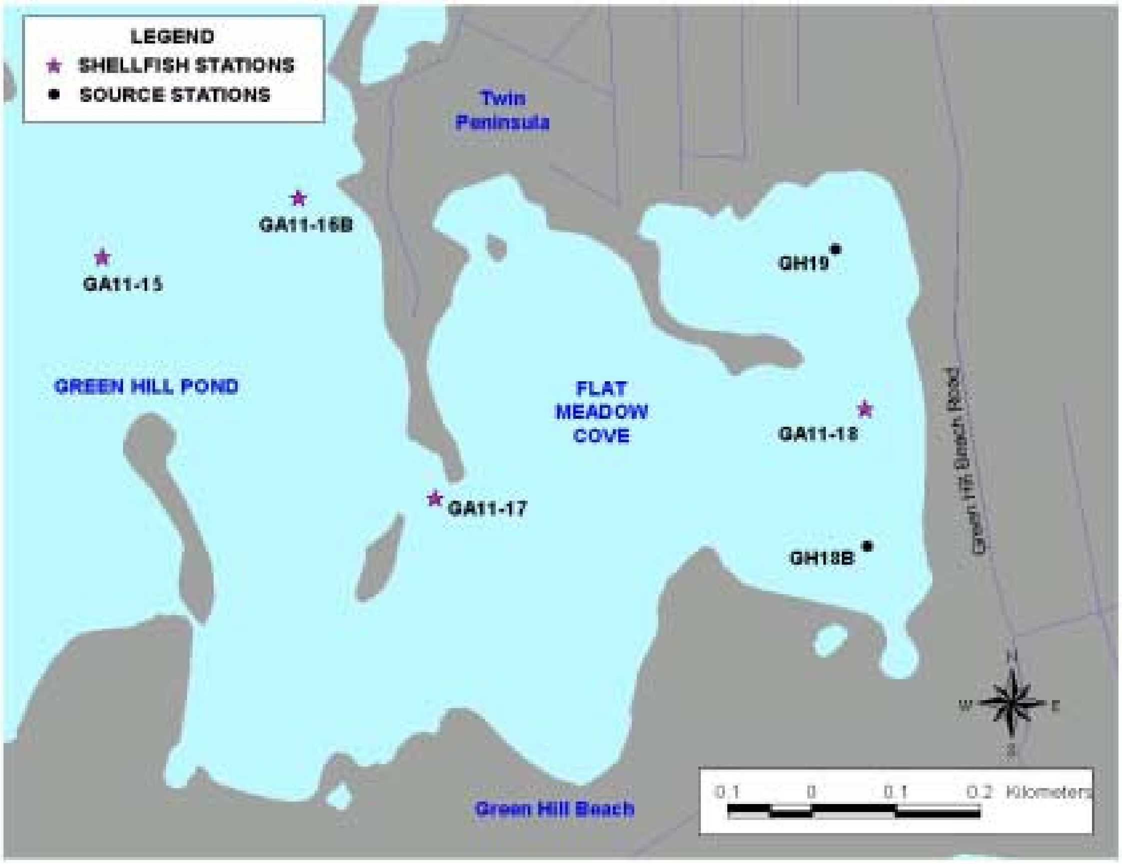
Flat Meadow Cove is very shallow with minimal flushing. Station 19 is located in a constricted cove within an already constricted area. No other source stations were sampled in this area. No streams or storm water pipes were observed in this area. It is most likely that the wet weather bacteria influences in Flat Meadow Cove are due to nonpoint sources from the Twin Peninsula area and from Green Hill Beach Road. Based on results elsewhere, possible sources include pet waste, wildlife and waterfowl. This area was not included in the bacteria source tracking study because water quality in the area sufficiently met water quality standards.

4.3 Western Green Hill Pond

The western area of Green Hill Pond includes Allen's Cove, Gooseberry Island Cove and Crab Cove. Shellfish growing area stations in this area are: GA11-14, GA11-14A, GA11-14B and GA11-15. Additional in-pond source sampling stations (GH24, GH24A, GH25, GH25A, GHCC) were sampled in order to assist in the identification of sources and problem areas. The locations of the shellfish and source sampling stations are presented in Figure 4.6. A summary of the dry weather data collected at the source sampling stations is shown in Table 4.10. The shellfish stations GA11-14 and GA11-14A violated water quality standards during both dry and wet weather conditions. Four of the five additional stations sampled in this area exceeded water quality standards. GHCC in Crab Cove was the one station that met water quality standards. Highest concentrations were found in the cove located behind Gooseberry Island at stations UN2 and GH24A, which had geometric mean fecal coliform values of 912 fc/100ml and 133 fc/100 ml, respectively.

Wet weather fecal coliform data were collected during the September 2001 storm. Sampling occurred at two of the original dry weather source sampling stations and the results are presented in Table 4.11. There was a slight increase in fecal coliform concentrations in Allen's Cove during wet weather, suggesting an additional contribution from land based sources in wet weather.

Figure 4.5 The Southeastern area of Green Hill Pond.



In Gooseberry Cove dry weather fecal coliform concentrations decreased from the mouth of Unnamed Brook 2 to GH24A and decreased further at GH24 suggesting that Unnamed Brook 2 is a source of fecal coliform bacteria to this area. However, during dry and wet weather, fecal coliform concentrations were relatively constant at station GA24 suggesting that more localized sources such as waterfowl could also be contributing to the bacteria in this area. This could include direct deposition by waterfowl and the contribution of bird waste deposited along the shore of Gooseberry Island that is washed off the sand during high tides and wet weather.

Table 4.10 Dry weather fecal coliform concentrations in Western Green Hill Pond.

Station	Geometric Mean Fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
UN2	912*	3400	40	6	3350*
GH24	21*	250	2	7	160*
GH24A	133*	2100	20	5	1400*
GH25	17*	110	1	7	86*
GH25A	42*	120	9	44	102*
GHCC	6	24	1	5	21

*Indicates violation of state water quality standards

Figure 4.6 Western Green Hill Pond.

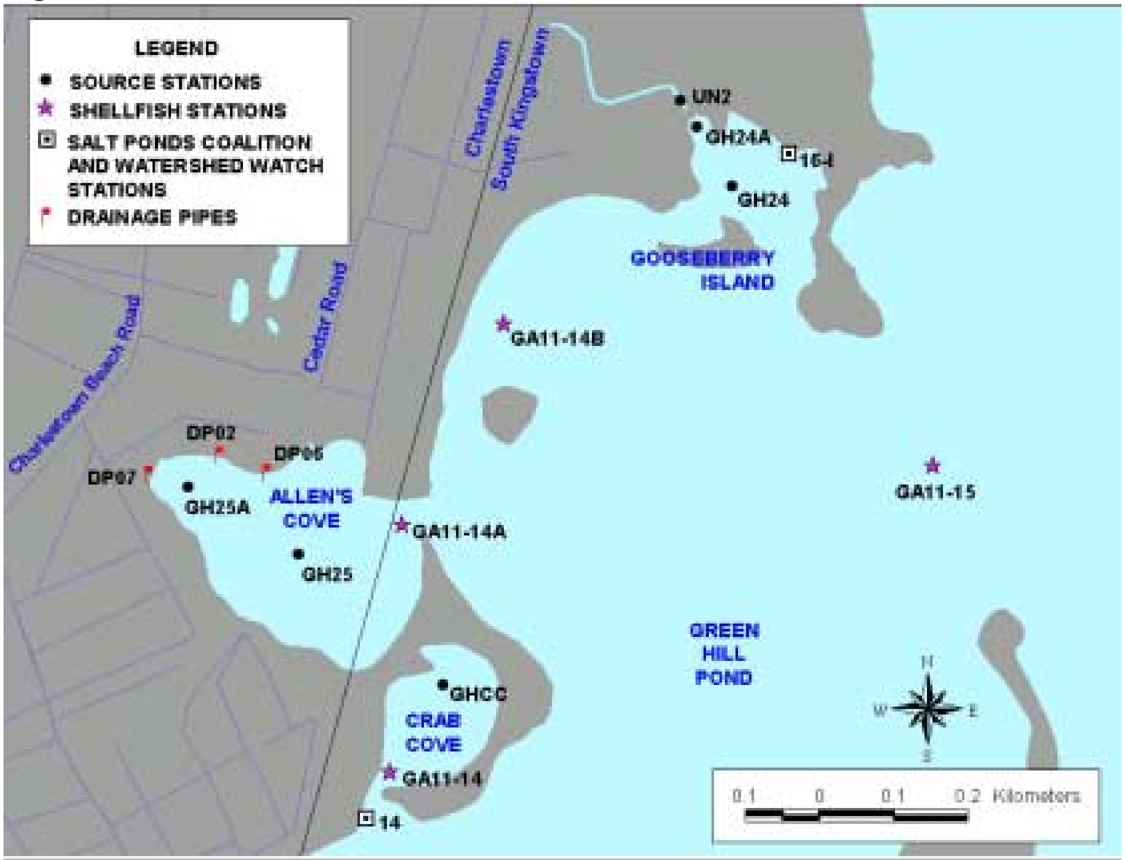


Table 4.11 Wet weather fecal coliform concentrations in Western Green Hill Pond.

Station	Geometric Mean Fecal coliform concentration fc/100 ml	Maximum fc/100 ml	Minimum fc/100 ml	Number of samples	90th percentile value fc/100 ml
GH24	18.5*	39	6	4	36.6
GH25	20.2*	820	1	3	658*

*Indicates violation of state water quality standards

Bacteria source tracking was conducted at three stations in Allen's Cove (GH25, GH25A and DP06) and four stations in the Gooseberry Island area (UN2, GH24a, GH24 and Gooseberry Island). The results of the study are presented in Table 4.12 and 4.13. In Allen's Cove

(Table 4.12) the primary source of the bacteria isolates sampled was birds (53%). Wildlife contributed about 13% of the bacteria isolated and dogs contributed 14%. Eighteen percent were unidentified. A single human isolate was identified in Allen's Cove. Allen's Cove is an ideal location for Canada geese because it is surrounded by lawns that slope down to the water. Although geese were not actually observed in the area by DEM personnel, their droppings were seen and collected in this area. Reports from residents also indicate that Canada geese are a nuisance in Allen's Cove. One of 49 isolates in Allen's Cove was human. This may suggest that bacteria from septic systems were not being conveyed in large quantities to Allen's Cove through surface water discharges or via ground water. It may also indicate that the recent repairs and upgrades of the ISDS systems in the homes surrounding the cove have reduced the human contribution to the bacterial budget of the cove.

Table 4.12 Number of positively identified isolates in Allen's Cove.

Station	Bird	Dog	Human	Wildlife	Unidentified	Total
GH25	15	5	1	1	7	29
GH25A	5	2	0	1	2	10
DP06	6	0	0	4	0	10
Percent contribution	53%	14%	2%	13%	18%	49

The Gooseberry Island area (Table 4.13) is problematic not only because of the high concentrations coming from Unnamed Brook 2 but also because there are high concentrations of waterfowl in the area, specifically mute swans. These birds congregate on a sand spit located in the northeastern section of Gooseberry Island. This sand spit is immersed at high tide and fecal matter deposited on the sand is washed into the cove. The majority of bacteria isolates (42%) analyzed from this area were from birds. Humans represented 24% of the bacteria isolates in this area and most of these were found at the mouth of Unnamed Brook 2 and in the immediate vicinity in the cove. Dogs represented 15% of the bacteria isolates, wildlife accounted for 11% and 9% were unidentified.

Table 4.13 Number of positively identified isolates in the Gooseberry Cove area.

Station	Bird	Dog	Human	Wildlife	Unidentified	Total
GH24	1	3	0	0	1	5
Gooseberry I	4	0	0	0	1	5
GH24A	5	2	6	0	1	14
UN2D	13	3	7	6	2	31
Percent Contribution	42%	15%	24%	11%	9%	55

Storm drains in the western area of Green Hill Pond were sampled during the storm event in September of 2001 described in section 3.1. Additionally, DP02 was sampled for the bacteria source tracking project on October 16, 2002 and the fecal coliform concentrations were included in calculations for Table 4.14. All of these storm drains are located in Allen's Cove. DP02 drains a portion of Charlestown Beach Road. Both DP06 and DP07 drain lots adjacent to the cove. Fecal coliform concentrations for these storm drains are presented in Table 4.14.

Table 4.14 Fecal coliform concentrations from storm drains in Allen's Cove.

Station	Fecal coliform concentration fc/100 ml	Number of samples
DP02 - A 36 inch RCP draining to Allen's Cove near station GH25a, draining a large portion of Charlestown Beach Road**.**	5150*	4
DP06 – A 6 inch pipe draining a small portion of an adjacent lot in the northern portion of Allen's Cove.	2000	1
DP07 – A 6 inch pipe draining a small portion of an adjacent lot in the western portion of Allen's Cove.	2400	1

*mean concentration value

Salt Ponds Coalition and Watershed Watch data

Data collected by the Salt Ponds Coalition and Watershed Watch were combined and are presented in Table 4.15. The two organizations collected the samples on different dates but at the same station locations (stations 14 and 16I), shown in Figure 4.6. The stations are at the end of docks. Volunteers collected the Salt Ponds Coalition data from 1996 through 2002. Sampling conducted by Watershed Watch occurred in 2001 and 2002 and was also conducted by volunteers.

Table 4.15 Salt Ponds Coalition and Watershed Watch data in Western Green Hill Pond.

Station	Geometric mean Fecal coliform concentration fc/100 ml	Maximum	Minimum	Number of samples	90^{th} percentile value
14 Sea Lea	19*	130	2	40	79*
16I Indigo Point	26*	1600	1	31	339*

*Indicates violation of state water quality standards

The high concentrations found at the Sea Lea sampling station are higher than those at nearby GA11-14 and may simply reflect different conditions considering that the 90^{th} percentile values are similar. The nearby DEM Shellfish Program sampling station GA11-14 has incidences of high concentrations in dry and wet weather, causing this station to violate the not more than 10% is 49 fc/100 ml portion of the standard. Concentrations observed at the Indigo Point Road station are in agreement with the DEM findings that high concentrations in the area behind Gooseberry Island come from sources upstream in Unnamed Brook 2 and from waterfowl that congregate in this area.

4.4. Eastern Ninigret Pond

This area of Ninigret Pond includes sections of the pond closed to shellfishing that encompass Tockwotten Cove to the Charlestown Beach Road Bridge. Shellfish stations in the area are GA11-11, GA11-12 and GA11-13. Additional in-pond sampling stations in Eastern Ninigret include N13, N14 and N15. These additional stations were sampled to assist in the identification of bacteria sources in the area. The stations sampled in Eastern Ninigret Pond are shown in Figure 4.7. Also included in this figure are stations (11A, 12A and 12B) sampled by Watershed Watch and the Salt Ponds Coalition.

Bacteria concentrations at the source sampling stations are presented in Table 4.16. The highest dry weather fecal coliform concentrations at these source stations were found at the head of Tockwotten Cove. The only other source station that had violations of water quality standards was N14 located in a small cove opposite Steven Island. This station violated the 49 fc/100 ml standard with a 90th percentile value of 71 fc/100 ml.

Figure 4.7 Sampling stations in Eastern Ninigret Pond.

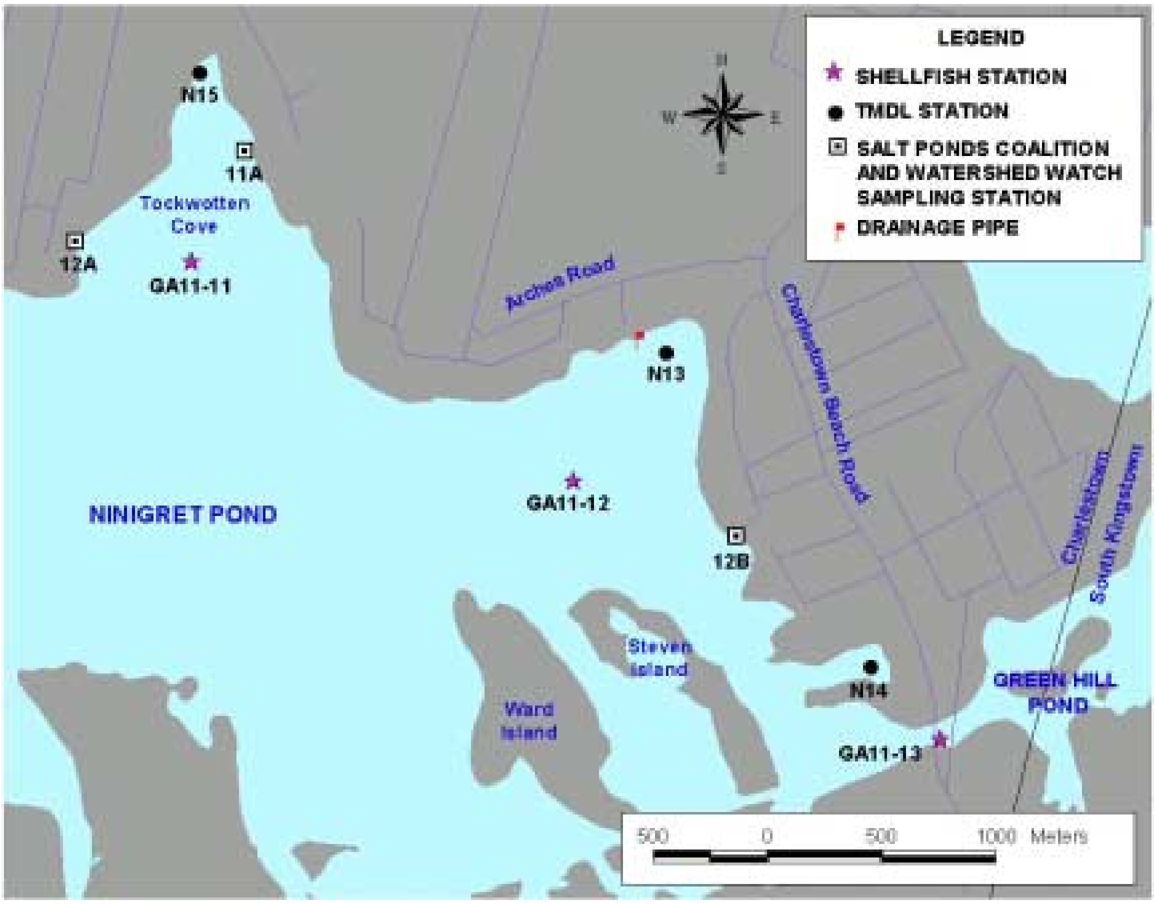


Table 4.16 Dry weather fecal coliform concentrations in Eastern Ninigret Pond.

Station	Geometric Mean Fecal coliform concentration fc/100 ml	Maximum	Minimum	Number of samples	90th percentile value
N13	9	51	2	8	34
N14	7.9	200	1	8	71*
N15	14.9*	120	1	8	106*

*Indicates violation of state water quality standards

No streams discharge to this area, however there could be some potential septic system sources surrounding the cove. Birds congregate in the coves and could contribute significantly to the bacteria in the area. The bacteria source tracking study did not extend into this area so no direct link to waterfowl can be made. However, the eastern area of Ninigret Pond is similar to Allen's Cove in Green Hill Pond, which was sampled during the bacteria source tracking study. The similarities include no direct surface water flows to the area, concentrated residential development, and small amounts of undeveloped forestland. The dry weather sources of the high concentrations in this area may include waterfowl, pet and animal waste in nonpoint source runoff, and possible failing septic systems.

Four wet weather samples were collected by DEM at each station during the September 21, 2000 storm described above. The geometric mean fecal coliform concentrations at these stations are presented in Table 4.17. Wet weather concentrations violated both parts of the water quality standards at all stations except at station N15. Station N15 met the geometric mean limit of 14 fc/100 ml during wet weather. It is assumed that the wet weather fecal coliform load in this area comes from bacteria in overland flow.

Table 4.17 Wet weather fecal coliform concentrations in Eastern Ninigret Pond.

Station	Geometric Mean Fecal coliform concentration fc/100 ml	Maximum	Minimum	Number of samples	90th percentile value
N13	28*	1100	6	4	773*
N14	18*	470	4	4	332*
N15	13	480	1	4	339*

*Indicates violation of state water quality standards

A single drainage pipe was found and sampled in the area of concern in Ninigret Pond. This pipe was located in the vicinity of N13 and was sampled during the wet weather event in September, 2001. The results presented in Table 4.18 are typically higher than the concentrations found at this pipe.

Table 4.18 Fecal coliform concentrations in storm drain in Ninigret Pond.

Station	Fecal coliform concentration fc/100 ml	Number of samples
DP01 – A 24 inch RCP located near N13, draining several lots along the shore.	1950	2

Salt Ponds Coalition and Watershed Watch data

Data collected by the Salt Ponds Coalition and Watershed Watch were combined and are presented in Table 4.19. The two organizations collected the samples on different dates but at the same locations (stations 11A, 12A and 12B), shown in Figure 4.7. All the stations are at the end of docks. Volunteers collected the Salt Ponds Coalition data from 1996 through 2002. Sampling was also conducted by Watershed Watch volunteers in 2001 and 2002.

Table 4.19 Salt Ponds Coalition and Watershed Watch data at stations in Eastern Ninigret Pond.

Station	Geometric mean Fecal coliform concentration fc/100 ml	Maximum	Minimum	Number of samples	90th percentile value
11A	31*	900	2	59	146*
12A	21*	540	2	40	79*
12B	27*	350	1	57	130*

*Indicates violation of state water quality standards

All of the stations sampled by the Salt Ponds Coalition and Watershed Watch violated water quality standards. A few of the data points included in this summary were collected during wet weather. These samples (4 at 11A, 1 at 12A and 1 at 12B) are included in the geometric mean calculation in Table 4.18 because of the disparity between the numbers of dry and wet weather data points. Since there are no specific discharges into the pond in these areas, the suspected sources are assumed to be waterfowl and wildlife. Gulls and other birds can be found congregating on private docks. These could contribute significantly to the fecal coliform concentrations at these stations, considering that the samples were collected at the ends of docks.

5.0 TMDL ANALYSIS

5.1 Establishing a numeric water quality target

MOS (Margin of Safety)

The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly allocate a portion of the TMDL as the MOS. This TMDL uses the former approach of conservative assumptions to ensure an adequate MOS. The primary sources of fecal coliform in the Green Hill Pond watershed are nonpoint in nature. Because nonpoint source loadings, especially bacteria loadings, are inherently difficult to quantify with any certainty, this TMDL uses the following implicit assumption:

- Monitoring results indicate that the pond returns to pre-storm concentrations within three days of an above average storm. For purposes of setting the % wet weather days used in calculating the weighted geometric means and 90th percentiles, it was assumed that it takes six days for the pond to return to pre-storm concentrations. As a result, the higher wet weather condition data is given proportionately greater consideration in calculating these statistical values. More specifically, use of this more conservative estimate of the recovery time resulted in an average increase of 7% in the 90th percentile values (which is the portion of the standard requiring the greatest reductions) for the four stations in the pond requiring reductions. Based upon these results, DEM also believes that these ponds recover from a typical wet weather event (0.5" rain) in much less than five days.

Antidegradation considerations

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

Seasonal variation/critical conditions

The required reductions were determined for the summer conditions when fecal coliform concentrations are typically the highest. The allocations and reductions therefore protect designated uses during all seasons.

Numeric water quality target

The water quality target for Green Hill and Ninigret Ponds is set at the state's Class SA fecal coliform standard, which is a geometric mean of 14 fc/100 ml with a 90th percentile concentration no greater than 49 fc/100 ml. It is assumed that the conservative assumptions mentioned previously will provide an adequate implicit MOS. The water quality target for Factory and Teal Pond Streams is set at the state's Class A fecal coliform standard, which is a geometric mean of 20 fc/100 ml with a 90th percentile concentration no greater than 200 fc/100 ml. It is assumed that the conservative assumptions mentioned previously will provide an adequate implicit MOS. Additionally, Factory and Teal Pond Streams must meet the more stringent Class SA fecal coliform standard at the point of discharge to Green Hill Pond.

5.2 Establishing the Allowable Loading (TMDL)

The TMDL process requires that a relationship between loadings and instream concentrations be established before loading reduction goals can be determined. For this TMDL, instream concentrations are assumed to scale linearly with concentrations in all sources to the area. Accordingly, a reduction in the averaged fecal coliform source concentrations will result in proportional instream concentration reductions. In addition, the tributaries are major sources to the ponds. If the tributaries meet water quality standards (14 fc/100 ml at mouth) it is DEM's judgment that the ponds will support designated uses.

The reduction goal for each station was determined by comparing current fecal coliform concentrations to the applicable water quality target, and then calculating the percent reduction required to reach that target. Since the water quality regulations specify both a geometric mean criterion and a 90th percent criterion, two calculations are made at each location.

Several trends emerge from the 1999-2001 RIDEM water quality data in Green Hill and Ninigret Ponds. Fecal coliform concentrations increase significantly during rainfall. Loadings to the ponds are relatively low-or non-existent during dry weather, and high during wet weather. As a result, in-stream FC concentrations are either in a low, dry weather concentration condition or a high, wet weather concentration condition throughout the year. In addition, analysis of wet weather data for Green Hill Pond show that up to 5 additional days may be required for in-pond fecal coliform concentrations to return to pre-storm levels after a significant wet weather event.

Weighted geometric mean calculation

RIDEM has developed an approach that incorporates the probability of occurrence of both dry and wet weather conditions to calculate a "weighted" statistic from the available fecal coliform dataset. The weighted geometric mean (WGM) combines elevated wet weather fecal coliform concentrations with dry weather data in a way that is more representative of the conditions specific to a waterbody. The following equation was used to calculate the WGM:

WGM (for each segment) =
(Annual % dry weather days x Dry weather geometric mean)
+ (Annual % wet weather days x Wet weather geometric mean)

Elevated bacteria concentrations in Green Hill Pond are typically the result of wet weather events and associated nonpoint loadings and these events directly affect shellfish growing beds. A daily rainfall of 0.5 inches and a recovery period of five additional days (6 days in total) were used when defining wet weather conditions. These conditions are used by the DEM Shellfish Program to define wet weather in other growing areas in the state having precipitation-derived conditional status.

The chosen recovery period is considered conservative for Green Hill and eastern Ninigret Ponds as evidenced by the observed recovery of the ponds to pre-storm levels of fecal coliform bacteria within roughly 3 days of a 1.7-inch precipitation event. Based upon these results, DEM believes that these ponds recover from a typical wet weather event in much less than five days. Historic rainfall data from T.F. Green Airport, located in Warwick, RI, shows that approximately 6.7 days on average had rainfall totals of 0.5 inches. As stated earlier, a conservative estimate of recovery is 6 days. This means that annually, wet weather conditions can be expected in the watershed approximately 40.3% (6.7 X 6) of the time, therefore the weighting formula is:

WGM (for each station) =
(0.403) x (Wet weather geometric mean) + (0.597) x (Dry weather geometric mean)

Comparison of the weighted geometric mean to the geometric mean standard
The weighted geometric mean values are compared to the first part of the Rhode Island water quality standards. For SA waters, which include Green Hill and Ninigret Ponds, the standard is a geometric mean concentration value of 14 fc/100 ml. For Teal and Factory Pond Streams and Unnamed Brook 2, the first part of the standards is a geometric mean fecal coliform concentration of 20 fc/100 ml. These streams must also meet the more stringent limit of 14 fc/100 ml where they discharge into Green Hill Pond.

The required reductions were calculated by subtracting the water quality target from the appropriate weighted value and then dividing by the same appropriate weighted value. This insures that the required reductions meet this part of the water quality standards.

Comparison of the combined dataset's 90th percentile value to the percent exceedence standard
A weighted 90th percentile value was also calculated to compare to the second part of the state water quality standards. This was calculated from the wet and dry 90th percentile values for each station the same way the geometric mean value was calculated using the formula described above. The second part of the fecal coliform standard states that, in Class SA waters, "*not more than 10% of the samples shall exceed a value of 49 MPN/100 ml*". The 90th percentile value at each station was calculated for both wet and dry weather sample results using the Percentile function in Microsoft Excel. This value was then compared to the applicable target to determine if a violation had occurred.

5.3 Calculation of required reductions

Weighted geometric mean for Green Hill and Ninigret Ponds
The weighted geometric mean values for the shellfish growing area stations in Green Hill Pond and Ninigret Pond are presented in Table 5.1. Based on a review of the source sampling data by the Shellfish Program, it was determined that water quality in the vicinity of Gooseberry Cove was not adequately represented by existing shellfish growing area stations. To address this situation, station GH24 will be added as a routine shellfish program station and data collected at station GH24 in development of this TMDL will be used to set allocations for that area of Green Hill Pond. Two stations violate the first part of the water quality standards. These stations include GA11-16 and GH24.

Table 5.1 Weighted geometric mean values for Green Hill and Ninigret Ponds.

Station	Dry Weather geometric mean fecal coliform concentration fc/100 ml	Wet weather geometric mean fecal coliform concentration fc/100 ml	Weighted geometric mean Fecal coliform concentration fc/100 ml
GA11-11	5	9	7
GA11-12	5	10	7
GA11-13	4	9	6
GA11-14	6	11	8
GA11-14A	11	8	10
GA11-14B	5	5	5
GA11-15	3	6	4
GA11-16	15*	21*	17.4*
GA11-16A	4	11	7
GA11-16B	4	6	5
GA11-17	3	6	4
GA11-18	3	7	5
GH24	21*	18.5*	20*

*Indicates violations of state water quality standard of 14 fc/100 ml

Weighted 90th percentile values for Green Hill and Ninigret Pond areas

The weighted 90th percentile values for the shellfish stations in Green Hill and Ninigret Ponds are presented in Table 5.2. Again, GH24 was included to account for sources in Gooseberry Cove. Four stations, GA11-14, GA11-14A, GA11-16 and GH24 violate the weighted 90th percentile value water quality standard.

Table 5.2 Weighted 90th percentile values for Green Hill and Ninigret Ponds.

Station	Dry Weather 90th percentile value fc/100 ml	Wet weather 90th percentile valuefc/100 ml	Weighted average 90th percentile valuefc/100 ml
GA11-11	17	43	28
GA11-12	30	12	23
GA11-13	12	41	24
GA11-14	60*	94*	74*
GA11-14A	57*	120*	82*
GA11-14B	23	23	23
GA11-15	11	27	17
GA11-16	92*	234*	149*
GA11-16A	12	79*	39
GA11-16B	12	68*	35
GA11-17	5	39	19
GA11-18	5	30	15
GH24	160*	37	110*

*Indicates violations of state water quality standard of 49 fc/100 ml

Weighted Geometric Mean for Factory and Teal Pond Streams
The weighted geometric mean values for the sampling stations in Factory and Teal Pond Streams are presented in Table 5.3. Based on the weighted geometric mean all stations except station FB01 violate water quality standards. Wet weather data were not collected at FB07 and TB00 so weighted geometric means were not calculated for these stations. The dry weather geometric mean fecal coliform concentrations at these stations exceed water quality standards.

Table 5.3 Weighted Geometric Mean values for stations in Factory and Teal Pond Streams.

Factory or Teal Pond Stream Station	Dry Weather geometric mean fecal coliform concentration fc/100 ml	Wet Weather geometric mean fecal coliform concentration fc/100 ml	Weighted Geometric Mean Fecal coliform concentration fc/100 ml
FB01	15	11	13.6
FB02	49	180*	102*
FB03	128*	1,891*	838*
FB04	104*	1,587*	702*
FB05	183*	1,241*	610*
FB06	290*	3,766*	1691*
FB07	261*	NS	-
TBa	225*	761*	441*
TB00	112*	NS	-
TB01	36*	653*	285*
TB02	212*	2,053*	954*
TB03	180*	1,150*	571*

*Indicates violations of state water quality standard of 20 fc/100 ml

Weighted 90th percentile value for Factory and Teal Pond Streams.
The weighted 90th percentile values for the sampling stations in Factory and Teal Pond Streams are presented in Table 5.4. Based on the weighted 90th percentile values geometric mean, all stations except station FB01 violate water quality standards. As in the Factory and Teal Pond Stream weighted geometric mean calculations above, two of the stations, FB07 and TB00 do not have wet weather data, so a weighted average 90th percentile value was not calculated for these stations.

5.4 Allocation of allowable loading
The required fecal coliform reductions were determined for the shellfish stations in Green Hill and Ninigret Pond and for the sampling stations in Factory and Teal Pond Streams. The weighted geometric means and weighted 90th percentile values were calculated using data collected at those specific stations. The majority of the required reductions in the pond and tributary streams are allocated to nonpoint sources. Section 4 of this report describes in detail the techniques used to identify sources of bacterial pollution in the study area.

No permitted point source discharges, other than permitted stormwater discharges, exist in the study area. ISDS contributions to the total load are assumed to be nonpoint in nature. Discharges from culverts, pipes, or other conveyances are considered to be point sources, however. Given the uncertainty in determining the stormwater load from the permitted stormwater discharges versus diffuse non-point sources, the stormwater wasteload reduction has been set for these TMDLs by estimating the percentage of the watershed that would be expected to contribute to the point source loading in each segment. The relative contributions of point sources to the total loading entering each segment of the four water bodies are assumed to be equal to the percent impervious area discharging to the segment. Therefore, the percent of the total reduction allocated to point sources in each segment and each water body will be equal to the percent imperviousness of its watershed.

Table 5.4 Weighted 90th percentile values for stations in Factory and Teal Brooks.

Factory or Teal Brook Station	Dry Weather 90th percentile values fc/100 ml	Wet Weather 90th percentile values fc/100 ml	Weighted average 90th percentile values fc/100 ml
FB01	63	14	43
FB02	264*	3,700*	1,649*
FB03	306*	10,480*	4,406*
FB04	240*	6,400*	2,723*
FB05	924*	5,450*	2,748*
FB06	578*	15,200*	6,471*
FB07	2000*	NS	-
TBa	478*	1,934*	1,065*
TB00	752*	NS	-
TB01	203*	2,500*	1,129*
TB02	530*	9,360*	4,089*
TB03	299*	4,440*	1,968*

*Indicates violations of state water quality standard of 200 fc/100 ml

Reductions needed in Green Hill and Ninigret Ponds

The weighted geometric means, weighted 90th percentile values and percent reductions for the shellfish stations in Green Hill and eastern Ninigret Pond are presented in Table 5.5. The right hand column in Table 5.5 represents the greatest percent reduction required to meet the numeric target for each station. Only station GA11-14 in Allen Cove is impacted by point source discharges. Therefore the reductions at this station will result from a combination of load and wasteload allocations.

Table 5.5 Percent reductions required in Green Hill and Ninigret Pond.

Station	Weighted geometric mean fecal coliform concentration fc/100 ml	Percent reduction needed to meet 14 fc/100 ml	Weighted average 90th percentile value fc/100 ml	Percent reduction needed to meet 14 fc/100 ml	Greatest percent reduction
GA11-11	7	0%	28	0%	0%
GA11-12	7	0%	23	0%	0%
GA11-13	6	0%	24	0%	0%
GA11-14	8	0%	74*	34%	34%
GA11-14A	10	0%	82*	40%	40%
GA11-14B	5	0%	23	0%	0%
GA11-15	4	0%	17	0%	0%
GA11-16	17.4*	20%	149*	67%	67%
GA11-16A	7	0%	39	0%	0%
GA11-16B	5	0%	35	0%	0%
GA11-17	4	0%	19	0%	0%
GA11-18	5	0%	15	0%	0%
GH24	20*	30%	110*	55%	55%

*Indicates violations of state water quality standards

Reductions needed in the tributary streams

For Factory Pond Stream and Teal Pond Stream the percent reductions for the weighted average geometric mean and weighted 90th percentile value are presented in Table 5.6. The right hand column in Table 5.6 represents the reductions required to meet the numeric target for each station.

The largest percent reduction in the mainstem of Factory Pond Stream is required at the mouth where the stream discharges to Green Hill Pond. At this location, the more stringent criteria (14 fc/100 ml), protective of Class SA waters, must be met. Therefore a single 99% reduction value at FB06 will apply to the mainstem of Factory Pond Stream. Since the mainstem is impacted by point sources, the reduction value will be comprised of both a load and wasteload allocation.

The largest percent reduction in the mainstem of Teal Pond Stream is required at the mouth where the stream discharges to Green Hill Pond. At this location, the more stringent criteria (14 fc/100 ml), protective of Class SA waters, must be met. A single 98% reduction value at TB03 will apply to the mainstem of Teal Pond Stream and because of a lack of point sources, will be comprised of a load allocation.

Table 5.6 Percent reductions required in Factory and Teal Pond Stream.

Station	Weighted geometric mean fecal coliform concentration (fc/100 ml)	Percent reduction needed to meet 20 fc/100 ml	Weighted average 90th percentile values (fc/100 ml)	Percent reduction needed to meet 200 fc/100 ml	Greatest percent reduction
FB01	13.6	0%	43	0%	0%
FB02	102*	80%	1,649*	88%	88%
FB03	838*	98%	4,406*	95%	98%
FB04	702*	97%	2,723*	93%	97%
FB05	610*	97%	2,748*	95%	97%
FB06	1691*	99%√	6,471*	99%√	99%√
FB07	290†*	93%	2000†*	90%	93%
TBa	441*	95%	1,065*	86%	95%
TB00	112†*	82%	752†*	73%	82%
TB01	285*	92%	1,129*	82%	92%
TB02	954*	98%	4,089*	95%	98%
TB03	571*	98%√	1,968*	90%√	98%√

†Indicates dry weather values only.
*Indicates violations of state water quality standards
√Indicates reductions needed to meet stricter standard of 14 fc/100ml and 49 fc/100ml.

Table 5.7 summarizes the required load and wasteload allocations for the tributary streams and ponds requiring a percent reduction. Rather than apply a reduction at each tributary station, a single reduction will be applied to the mouth. This value is conservative since these locations need to meet the more stringent Class SA fecal coliform criteria of 14 fc/100ml.

The total reduction column identifies the reductions from all point and non-point components of the total loading. The rightmost columns identify the relative contributions of point and non-point sources to the total loading. Stations/segments with no identified point sources are not given a wasteload allocation.

Table 5.7. Summary of load and wasteload contributions for stations requiring a percent reduction to meet standards.

Waterbody or Area	Station	Total Reduction (from Tables 5.5 and 5.6)	Point Source ID	Impervious area/Total area (ha)	Estimated wasteload contribution to total load (WLA)	Estimated load contribution to total load (LA)
Factory Pond Stream	FB06	99%	DP03, DP04, DP05 and other conveyances draining Green Hill Beach Road and Matunuck Schoolhouse Road	4.14 / 286	1.5%	98.5%
Teal Pond Stream	TB03	98%	No identified point sources	--	--	98%
Green Hill Pond	GA11-14	34%	No identified point sources	--	--	34%
	GA11-14A (Allens Cove)	40%	DP02, DP06, and DP07	2.63 / 38	7%	93%
	GA11-16	67%	No identified point sources	--	--	67%
	GH24 (GA11-14C)	55%	No identified point sources*	--	--	55%

* Unnamed Brook #2 identified as a nonpoint source potentially affecting GH24

5.5 Strengths and Weaknesses in the TMDL Process

Strengths:

- The TMDL is based on an extensive knowledge of land use and potential bacteria sources in the watershed.
- The TMDL incorporates the findings of several studies and utilizes data collected over several years.
- The TMDL endpoints presented in the load allocation sections allow water quality standards to be met in critical conditions.
- The phased approach allows an emphasis on mitigation strategies rather than on modeling and more complex monitoring issues to keep the focus on removing sources.
- Extensive sampling during dry weather was conducted and numerous techniques were used to differentiate the sources of pollution in the watershed.
- The TMDL is based on actual data collected in the watershed.

Weaknesses:

- Due to relatively dry seasonal conditions in the watershed, only one wet weather event was characterized.
- It can not be assumed that instream concentrations in each area can be reduced below the natural background conditions.

5.6 Supporting documentation

Recent water quality studies considered significant to this TMDL are presented in Table 5.8. These references were used to characterize the present water quality conditions or identify water quality trends.

Table 5.8 Supporting documentation.

Primary Organization or Authors	Title	Date of Report	Approximate Date of Study
RIDEM	TMDL Data report for: Green Hill Pond, Ninigret Pond, Factory Pond Stream and Teal Pond Stream	2001	1999-2001
Salt Pond Watchers	Salt Pond Watchers Water Quality Data Report		1996-2002
RIDEM	1999, 2000, 2001 EPA Approved QAPPs	1999, 2000, 2001	1999-2001
RIDEM	RIDEM Shellfish Data		Work is ongoing

6.0 IMPLEMENTATION PLANS

Earlier sections of this document identify the impairments to Green Hill and Ninigret Ponds, and to Factory and Teal Pond Streams, identify the factors that cause the impairments, and establish the scale (%) of the source reductions that will be needed to restore each water body to a condition that meets its designated uses. The two salt ponds did not meet water quality criteria, especially in wet weather. Their tributary streams were impaired under all conditions. A small number of pipes or channelized conveyances were identified as pollutant sources, including three in Allen's Cove and three along lower Factory Pond Stream. Bacterial impairments of the two ponds and their tributary streams are related largely to nonpoint sources. The DNA study identified waterfowl and wildlife as predominant animal species contributing the bacteria. Humans and domestic animals were identified as sources in some cases. Although sources not related to humans were most common, conveyances such as culverts and drainage ditches that convey bacteria of non-human origin are regulated as point sources and are considered controllable.

This section of the TMDL specifies actions that will allow water quality improvements to be made in the four water bodies. The causes of the impairments are widespread and complicated in nature. Experience has shown that the effectiveness of Best Management Practices, or BMPs that are put in place to accomplish these reductions can also vary widely. In addition, the menu of BMPs available for a given location may be limited by a number of variables, such as available space, depth to the water table, and soil types. The TMDL therefore relies on phased implementation to the reach water quality goals presented in Section 5. Phased implementation means that BMPs will be specified to move each water body toward its desired condition. After a set of BMPs is implemented, the water quality response of the water body will be measured. Additional BMPs will be required as appropriate if standards are not met after the recommended remedial measures are implemented.

Implementation recommendations are organized into those that address bacteria carried in stormwater through channelized conveyances (point sources) to the brooks and ponds and those that address bacteria conveyed as diffuse (nonpoint) form. The study results indicate that human sources of bacteria that enter the streams and ponds are largely contained in the nonpoint source category.

6.1 Point source stormwater measures

Storm water runoff is the largest controllable source of fecal coliform to Green Hill Pond and its tributaries. Storm sewers magnify the problem by rapidly collecting, concentrating, and directly routing polluted runoff to receiving waters. The storm sewer outfalls and conveyances described above in Section 4 represent the only known point sources of fecal coliform to Green Hill Pond.

A number of roadways in the watershed generate runoff that drains from roadway surfaces to the ponds and their tributaries. These sources are regulated under the RIPDES Phase II program. RIDEM has amended the existing Rhode Island Pollution Discharge Elimination System (RIPDES) Regulations to include the requirements of the EPA Phase II Storm Water Regulations that became effective in March 2002. The Phase II Program requires operators of municipal separate storm sewer systems (MS4s) in urbanized areas (UAs) to develop storm water management program plans (SWMPPs) and obtain a permit for those MS4s. MS4s include any drainage systems, catch basins, ditches, man-made channels used for collecting or conveying storm water that are located along roadways, neighborhoods, and commercial areas in the watershed. The Director of DEM (Director) additionally requires permits for MS4s in areas outside the UAs that contribute to a violation of a water quality standard, are significant contributors of pollutants to waters of the State, or that require storm water controls based on waste load allocations (WLAs) determined through a TMDL.

The SWMPP for each MS4 must describe the Best Management Practices (BMPs) for each of the following minimum control measures:

- Public education and outreach program to inform the public about the impacts of storm water on surface water bodies.
- Public involvement/participation program.
- Illicit discharge detection and elimination program.
- Construction site storm water runoff control program for sites disturbing one or more acres.
- Post construction storm water runoff control program for new development and redevelopment sites disturbing one or more acres.
- Municipal pollution prevention/good housekeeping operation and maintenance program.

The SWMPP must include the measurable goals for each control measure (narrative or numeric) that will be used to gauge the success of the program. It must also contain an implementation schedule that includes interim milestones, frequency of activities and reporting of results. In addition, the Director can require additional permit requirements based on the recommendations of a TMDL.

For the most part, areas adjacent to Green Hill and Ninigret Ponds, and Factory and Teal Pond Streams are not located in either the Urbanized Areas (UAs) or Densely Populated Areas (DPAs) that are regulated under the Phase II program. U.S. Route 1 (US-1), however, is identified as a divided highway outside of the UAs and DPAs that is regulated by the program. The areas adjacent to these water bodies discharge loadings that contribute to violations of water quality standards. Areas of Matunuck Schoolhouse Road, Mautucket Road, and Green Hill Beach Road discharge runoff to lower Factory Pond Stream. Areas along Route 1 discharge stormwater to the headwaters of Factory Pond Stream. Neighborhood roads in Charlestown that include Charlestown Beach Road contribute to pipes that empty into Allen's Cove. Bacteria concentrations along Factory Pond Stream, and in Allen's Cove to which these stormwater conveyances discharge have been observed to increase during wet weather, as documented in Section 3. Concentrations observed in the pipes are consistent with and contribute to the levels seen in the receiving waters.

Implementation of stormwater controls is therefore necessary to restore water quality. As a result, the operators of MS4s in these areas will be required to obtain a RIPDES permit (or expand coverage of an existing permit). Consistent with the goals of this TMDL, these outfalls are targeted for water quality Best Management Practices (BMPs) to mitigate pollutant loadings to the maximum extent practicable (MEP). Three outfalls, DP02 in Allen's Cove in the Town of Charlestown, and DP03 and DP04 in the Town of South Kingstown, along Factory Pond Stream should receive priority for BMP implementation, as they drain the largest impervious area of any stormwater conveyances in the watershed. The Director will require that SWMPPs for the areas outlined above contain provisions that address the identified systems and any other MS4s in the regulated area through the six minimum measures followed by monitoring to determine the need for additional measures.

Bacteria sources to Green Hill Pond are primarily non-point in nature, so RIDEM feels that significant reductions can be achieved through simple good housekeeping efforts of the municipalities and local residents. Good housekeeping measures include minimizing fertilizer applications, periodic street sweeping, policing pet waste, and discouraging waterfowl from residing in specific areas.

6.2 Improve septic system performance

Significant areas of the study area are densely settled, with year-round homes located on small lots. Many homes are relatively old. Vertical separation to the water table is low in many areas, and soils have high hydraulic conductivity, which allows waste to move rapidly through the unsaturated zone. Historic information indicates that periodic problems with nitrate and bacterial contamination have existed in the past; current information on the condition of water supplies was not completely available to characterize present conditions. Visual surveys of septic system performance in the densely developed neighborhoods, such as the 1994 DEM survey indicated that a significant number of failed systems were present in the Sea Lea area. A review of the complaints documenting the failures indicates that a majority of the failures were related to improper sewage disposal configurations. The disposal of gray water via separate lines was a frequent factor. Overflowing systems were seen in a third of the 44 failures identified by DEM. This information leads to the conclusion that a principal shortcoming in sewage disposal practices is related to the ability of the ground to absorb hydraulic loads. This is most likely due to inadequate separation to groundwater, which is probably prevalent during the spring season. A significant percentage of the systems currently in operation predate the ISDS standards and are therefore not designed to accept the loadings to which they are presently subjected. As a result, a number of homeowners have resorted to sending a portion of their wastewater, such as gray water discharges from washing machines, to ground surface discharges or to dry wells.

The 2002 DEM bacterial source tracking study associated a majority of bacterial isolates in pond and tributary waters with non-human sources. This statement, however, has significant exceptions. First, bacteria associated with human sources were a significant contributor to the impairment of Teal Pond Stream at the Matunuck Schoolhouse Road crossing. This location is a short distance downstream of a failing system that has been identified and is being upgraded by the URI Cooperative Extension Water Quality Program. A second upgraded system has apparently contributed to a significant water quality improvement at the Pond Watchers/URI Watershed Watch Station 21 on the Twin Peninsulas. Finally, bacteria associated with human sources also appears to be a significant contributor to bacteria elevations observed at Unnamed Brook 2 which flows into the Gooseberry Cove area of Green Hill Pond. So while humans may not be the predominant source of bacteria contributing to water quality impairments, they have been found to contribute to impairments in some cases. Improvements to sewage disposal practices in the watershed should therefore be continued to minimize the exposure of local residents to bacterial and viral agents of human origin.

On October 16, 2001, the Town of South Kingstown voted to approve a Wastewater Management Ordinance. The ordinance, drafted in accordance with and under the authority of the State of Rhode Island General Laws, will require the replacement of all cesspools, as well as the inspection and, if necessary, repair of all systems deemed substandard by the State. The Wastewater Management Ordinance is available online at:
http://www.uri.edu/ce/wq/owtc/South%20Kingstown/Pages/home.htm

SAFEWATER is a project that was developed by the Towns of South Kingstown, Charlestown and New Shoreham and the University of Rhode Island Cooperative Extension. The project was designed to address concerns about the effect of failing septic systems on local ground and surface waters and received a $3,000,000 grant from the Environmental Protection Agency. All three participating communities have developed wastewater treatment standards and have required mandatory septic system inspections for all homeowners. Since the inception of the program roughly 300 innovative/ alternative septic systems have been installed in these areas. According to URI Cooperative Extension, 2161 septic systems were altered, repaired or newly installed between 1986 and 2001.

6.3 Control of nonpoint source loadings

Fecal coliform bacteria are found in the intestinal tracts of warm-blooded animals, and as such, are present in the natural environment. Documented waterfowl and wildlife sources of fecal coliform bacteria in rural watersheds are raccoons, rats, beaver, gulls, geese, ducks, and pigeons (CWP, 1999). The bacterial source tracking study conducted during this TMDL found that wildlife and waterfowl accounted for 75% of the bacterial isolates in the water samples collected. The control of waterfowl and wildlife is therefore an important element of water quality restoration.

Mitigation of these types of sources is addressed by the application of nonstructural BMPs or "good housekeeping" measures. Ninigret and Green Hill Pond residents can adopt similar measures taken by the Narrow River Preservation Association, which has an ongoing informational program designed to inform local residents about how to live responsibly in the watershed. The Southern Rhode Island Conservation District has also implemented a watershed-wide educational program in the Narrow River watershed. The focus of this program is to organize a watershed action team comprised of local residents who will identify effective measures to minimize nonpoint sources of pollution to the river.

A similar program could and should be developed for Green Hill Pond by its residents. The Salt Ponds Coalition is a dedicated nonprofit organization that was developed to help preserve nine ponds along the south coast of Rhode Island. This is an ideal group to spearhead a program to address many of the nonpoint source pollution issues in the Green Hill and Ninigret Pond watersheds.

Obvious measures to limit pollutant loadings from non-human sources include policing pet wastes, minimizing fertilizer applications, and minimizing impervious cover. Pet wastes should be disposed of in trash receptacles and away from the ponds, tributary streams and all storm water conveyances. In common or public areas such as beaches or boat ramps the installation and use of pet waste bags and trash receptacles is encouraged. Impervious surfaces in the watershed should be minimized to decrease the volume of runoff generated during storm events. (These issues should be covered under the SWMPPs submitted by Charlestown, South Kingstown and RI Department of Transportation).

Residents have a number of options to minimize bird-related impacts. They can allow tall, coarse vegetation to grow along waterfront in areas frequented by waterfowl. Waterfowl, especially grazers like geese, desire easy access from the water to the lush lawns along the shore. Leaving an uncut vegetated buffer will make the habitat less desirable to geese and encourage migration. As an alternative, residents along the waterfront can also install commercially available fencing specifically designed for this purpose. Residents should also stop feeding birds. Eliminating this practice should also help to decrease summer bird populations and make the area less attractive to the year-round residence of migratory birds.

DEM's Division of Fish and Wildlife has had a mute swan egg-addling program in place since 1978. Connecticut and Massachusetts do not have a population control program for mute swans at this time. Birds from these neighboring states often move into Rhode Island and as a result Rhode Island DEM is considering discontinuing the egg-addling program in 2003. The 2002 Mute Swan census in Rhode Island identified 1400 birds in the state; an increase from 880 in 1986 (Charles Allin, pers. com.). Even with an egg-addling program, the state's mute swan population continues to grow at a 5.6% annual rate, meaning that it will double itself in 10 to 12 years. The egg-addling program only controls that portion of the population that has the highest mortality rate and is therefore not sufficient enough to properly reduce or control the adult portion of the mute swan population. Continuation of the mute swan egg-addling program, although helpful in maintaining water quality and health of a pond, will not eliminate future fecal coliform loading by this species as the population increases. TMDL recommends that DEM's Division of Fish and Wildlife continue the practice of addling mute swan eggs. Additionally, DEM needs to develop a mute swan management plan incorporating objectives and strategies developed in the Atlantic Flyway Mute Swan Management Plan (2003). Objectives to reduce the Rhode Island population might require considering the strategy of implementing a hunting season on mute swan.

During the 1970s, the DFW estimated a resident population of Canada geese at 500 birds. In 2002 the resident population was estimated to be approximately 4500 geese and possible stabilized (Charles Allin, pers. com.). Rhode Island maintains 3 hunting season for Canada goose, including 2 aimed at birds of the resident population. About 1500-2000 geese are harvested annually, including migratory wintering birds. Resident birds tend to congregate on wetland adjacent to open grassy lawns. As describe above, a buffer zone along the shoreline may discourage geese from congregating in these areas.

Feeding any waterfowl encourages birds to congregate and may have a negative affect on the animal's health. Signage discouraging hand feeding of waterfowl should be developed and installed in areas where feeding happens. Areas such as beaches and public or association docks would be ideal places for these signs. Town should be encouraged to establish and enforce local ordinances prohibiting the feeding of waterfowl.

7.0 PUBLIC PARTICIPATION

The public participation associated with this TMDL had two components. An initial 'kick-off' meeting was held prior to TMDL development, which included all interested public, private, and governmental entities. The meeting was held on August 29th, 2000 at the Cross Mills Library in Charlestown and was well attended by area residents, Salt Ponds Coalition members, as well as town officials from South Kingstown and Charlestown. The purpose of the meeting was to disseminate information regarding the TMDL issues in the watershed as well as to solicit input regarding pollution sources and/or other concerns.

EPA comments on the 2002 draft TMDL and the comment response summary prepared by RIDEM can be found in Appendix A.

DEM presented the draft TMDL plan to stakeholders and the general public on June 26th 2004. The public meeting began the 30-day public comment period, which ended on July 27th, 2004. Letters were sent to key stakeholders in advance of this meeting. In addition, the meeting was publicized in a press release, public notices, and by contacting the Salt Ponds Coalition. The meeting was held at the Cross Mills Library in Charlestown and was well attended by area residents and Salt Ponds Coalition members. DEM received no comments during the public comment period. Meeting notes are presented in Appendix B.

Additionally, the Salt Ponds Coalition hosted two informational seminars in 2003. On June 10, 2003, a presentation was given by DEM staff that described the Bacteria Source Tracking study conducted in Green Hill Pond in the Fall of 2002. Another talk by the Director of DEM was presented on July 8, 2003, on the most recent DEM projects in the Salt Ponds.

8.0 COMPLIANCE MONITORING

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

In accordance with National Shellfish Sanitation Program (NSSP) requirements, the RIDEM Shellfish Monitoring Program will monitor water quality and conduct shoreline surveys. RIDEM will ensure that ambient sampling stations are located adjacent to point sources and effectively evaluate all nonpoint sources of pollution, including the addition and/or modification of sampling locations, as necessary. As discussed previously in the report, based on a review of the source sampling data, the Shellfish Program has decided to add a new sampling station in the vicinity of Gooseberry Island in Green Hill Pond (referred to in this study as station GH24) to the routine shellfish monitoring surveys. Shoreline surveys entail the evaluation of the effect of each actual and potential source of pollution on shellfish waters including as necessary, the collection of ambient water quality samples. In addition, non-shellfish program data (such as information on potential sources, beach and volunteer monitoring) will be considered and followed up with confirmatory monitoring by RIDEM, following NSSP approved methods, as appropriate.

The continued water quality monitoring and future shoreline surveys will be used to help evaluate the effectiveness of the recommendations of the TMDL in restoring designated uses and attaining water quality standards. Ultimately, attainment of the designated shell fishing use requires compliance with the Rhode Island water quality standards including ambient water quality criteria and all NSSP requirements (including evaluation of non-shellfish program data/surveys, special sampling site data, beach and volunteer monitoring, as appropriate).

RIDEM expects BMPs to be implemented on a voluntary basis by the responsible parties. However, if this does not occur, RIDEM may use its permitting authority, or other enforceable means, to require implementation. RIDEM will work with the Town of South Kingstown and the Coastal Resources Management Council (CRMC) to identify funding sources and to evaluate locations and designs for stormwater control BMPs throughout the watershed.

9.0 REFERENCES

Allen, J. 1997. *Fecal coliform bacteria in the salt ponds*. Salt Ponds Newsletter. 28:1-6.

Allen, J. 1998. *Fecal coliform bacteria in the salt ponds*. Salt Ponds Newsletter. 28:1, 5-11.

Allin, C. 2003 Personal communication. Rhode Island Department of Environmental Management, Division of Fish and Wildlife.

Atlantic Flyway Council, Snow Goose, Brant and Swan Committee. July, 2003. Atlantic Flyway Mute Swan Management Plan. Boiling Springs, Pennsylvania.

Damon, C.. 1996. *Fecal coliform bacteria in the salt ponds*. Salt Ponds Newsletter. 26:1-9.

Dow, D. 2003. Personal communication. URI Cooperative Extension Water Quality Program.

Minopoli, R. 2002. *2001 Pond Watcher monitoring results*. Salt Ponds Coalition Newsletter. 39:5-8.

Nixon, S., B. N. Furnas, R. Chinman, S. Granger and S. Heffernan. 1982. *Nutrient inputs to Rhode Island coastal lagoons and salt ponds.* Final Report to Rhode Island Statewide Planning, Providence Rhode Island. 38pp.

Rector. 1981. Soil Survey of Rhode Island. USDA-SCS.

Rhode Island Department of Health. 1996-1972. *Well water survey*. Charlestown, Rhode Island. Providence, Rhode Island.

Rhode Island Programs for the Environment. 1982. Water and wastewater practices in Charlestown Beach, Rhode Island. 18pp.

Rhode Island Department of Environmental Management. 2000. *State of Rhode Island and Providence Plantations Water quality Regulations*. Providence, RI: Rhode Island Department of Environmental Management, Office of Water Resources.

Rhode Island Department of Environmental Management. 2001. *Quality Assurance Project Plan: Dry and wet weather water quality sampling of Green Hill Pond, Ninigret Pond, Factory Pond Stream and Teal Pond Stream*. Providence, RI: Rhode Island Department of Environmental Management, Office of Water Resources.

Rhode Island Department of Environmental Management. 2002. *TMDL Data report for: Green Hill Pond, Ninigret Pond, Factory Pond Stream and Teal Pond Stream*. Providence, RI: Rhode Island Department of Environmental Management, Office of Water Resources.

APPENDIX A: Comment Response Summary
Green Hill - Ninigret Pond bacteria TMDL

EPA Comment #1:
Comments on unnamed streams 1 and 2 taken from three places in the document are summarized below:

Item 1, Description of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking: As a note, the tributaries to Green Hill Pond are identified on the 303(d) list as Factory Pond Stream and Teal Pond Stream. In the TMDL they are identified as Factory Brook and Teal Brook. This discrepancy in waterbody names should be addressed in a subsequent draft of the TMDL. Unnamed brooks 1 and 2, which are not listed as impaired on RI's 303(d) list, appear to be contributing significant loadings of bacteria that are not addressed in the draft TMDL. As the data collected in the brooks likely support their inclusion on subsequent State 303(d) lists, DEM should consider expanding the scope of the TMDL to include these waters. In any event, as discussed in Section 5, below, these brooks should be identified as sources of bacteria and receive loading allocations.

Item 2, Description of the Applicable Water Quality Standards and Numeric Water Quality Target: Further, as noted above, unnamed brooks 1 and 2 appear to be contributing significant loadings of bacteria. Allocations for these brooks and any other tributaries contributing bacteria loadings should be established to assure that these sources do not cause or contribute to bacteria criteria violations in the ponds.

Item 5, Wasteload Allocations (WLAs): While unnamed brooks 1 and 2 are additional tributaries entering Green Hill Pond and identified as sources of bacteria, they are not assigned allocations in Sec 5 of the TMDL. As unnamed brooks 1 and 2 are clearly contributing to the loadings of Green Hill Pond, they should be assigned allocations.

Response:
Unnamed brooks 1 and 2 are not shown as streams on the USGS 7.5' quad maps (1:24,000 scale) of the area. Both streams are considered to be manifestations of water transport to the pond through its fringing wetland areas. EPA guidance strongly recommends that states use the National Hydrography Dataset (NHD) geo-referencing scheme in assessing their waters. Despite that fact that NHD is based on a 1:100,000 scale, RIDEM has chosen to assess the state's waters at the 1:24,000 scale. It is DEM's opinion that since EPA does not require that states assess waters not visible below the 1:100,000 scale, that EPA should allow states flexibility in evaluating whether to establish separate allocations for waters not visible at the 1:24,000 scale, such as Unnamed Brook 1 and 2.

Unnamed Brook 1 conveys water toward Green Hill Pond intermittently during the year. The brook did not discharge surface water to the pond during the 2002 wet weather studies, and DEM found no defined channel for the brook in the vicinity of the pond. Unnamed Brook 1 is therefore considered a nonpoint source that may convey water overland during some periods. It is not assigned an explicit load reduction, and in view of the characteristics described above, and the nature of the bacteria sources, no mitigation actions are specified for the brook.

Unnamed Brook 2 does have a defined bed at its point of entry to Green Hill Pond. As a source influencing the impairment at station GH-24 in the pond, it would be targeted for a 55% reduction, and has been identified for further source identification monitoring in the implementation section. It is DEM's opinion that any BMPs necessary to achieve the 55% reduction will not only mitigate the impact of Unnamed Brook 2 on Green Hill Pond, but also result in Unnamed Brook meeting applicable water quality standards.

EPA Comment #2:
The Study Area is narratively described in Sections 1 and 2 as the waters of Green Hill and Ninigret Ponds that are closed to shellfishing, Factory and Teal Brooks and a number of unnamed streams that discharge to Green Hill Pond. This description would be strengthened by the inclusion of a map that better illustrates the geographic extent of the impaired waters. This may be addressed in Figure 1.1, which is missing, or through modifications to Figures 2.2 or 2.3.

Section 2 of the TMDL document contains a reasonably detailed description of the waterbody and watershed, including a land-use map (Figure 2.3) that provides information regarding land use, population densities and other relevant information. This map provides the land uses for only the area adjacent to the closed portion of Ninigret Pond, suggesting that water quality in eastern Ninigret Pond is not affected by the land uses in rest of the Ninigret Pond watershed. As the TMDL document only identifies a single source of contamination in the eastern portion of Ninigret Pond, evaluating land-uses throughout the watershed may be useful, if only to justify the focus on the near scale.

Response:
The reference to Figure 1.1 has been removed. A shellfish closure line is visible in Figure 2.3. In regard to Figure 2.3, RIDEM investigations are referenced that revealed the potential bacteria sources to eastern Ninigret to include waterfowl, pet and animal waste in nonpoint source runoff, and possible failing septic systems. One point source was located and sample results are reported in the document. It is DEM's opinion that the land use map shown in Figure 2.3 is sufficient to categorize potential sources of fecal contamination within that area of the pond.

EPA Comment #3:
No explicit allocation is provided for NPS. The required reductions for all sources of bacteria (point and nonpoint) are calculated from observed concentrations at instream stations and the TMDL includes the LA for NPSs in its discussion of the WLA. This is discussed in more detail below.

Response:
Table 5.7 has been modified to more clearly summarize both point and nonpoint source allocations and reductions. As the heading in the second column from the right indicates, reductions for point and nonpoint sources are set at identical values.

EPA Comment #4:
As we have discussed in the context of other TMDLs, further discussions regarding the appropriateness of DEM weighing the 90^{th} percentile data are necessary.

Response:
DEM believes that the approach used to establish 90th percentile concentrations is appropriate. Justification for DEM's approach to quantifying upper percentile values for fecal coliform TMDLs is provided in a memo from Chris Turner to Steve Silva (dated 12 July, 2004).

EPA Comment #5:
In its efforts to identify sources, in addition to the shellfish monitoring stations, DEM evaluated data collected at a number of monitoring locations within the ponds. For Ninigret Pond there are no reductions or allocations proposed, though data collected at non-shellfish stations and a drainage pipe during wet weather demonstrate violations of the bacteria criteria. For Green Hill Pond, the proposed reductions are generally based on the State's shellfish monitoring stations. With the exception of GH24, which was used to set the reduction goal for Gooseberry Cove, it is not clear why non-shellfish stations were not used to set the reduction targets. In a number of pond segments, non-shellfish stations appear to be more representative of the water quality impacts associated with shoreline sources than the shellfish stations that were used to set the reduction goals.

The TMDL should be revised to use data collected at the non-shellfish stations, additional shoreline survey data that are collected as part of the State shellfish monitoring program, and other appropriate near shore data along with the ambient shellfish monitoring stations to assess the water quality conditions of these segments.

………. Future monitoring at shellfish stations and GH24 is discussed in the report (page 58). As discussed above, EPA believes that a more robust monitoring plan that also considers shoreline data collected under the shellfish monitoring program and additional monitoring at a number of the non-shellfishing stations utilized in the TMDL development to identify sources is warranted.

Response:

In response to EPA's comments, Section 8.0 Compliance monitoring has been revised as follows:

> This is a phased TMDL. Additional monitoring is required to ensure that water quality standards are met as remedial actions are accomplished. Monitoring by RIDEM will be the principle method of obtaining the data necessary to track water quality conditions in the watershed. Also, as proposed BMPs are installed in the watershed, post construction influent and effluent sampling may be required to assess the effectiveness of the selected technology.
>
> In accordance with National Shellfish Sanitation Program (NSSP) requirements, the RIDEM Shellfish Monitoring Program will monitor water quality and conduct shoreline surveys. RIDEM will ensure that ambient sampling stations are located adjacent to point sources and effectively evaluate all nonpoint sources of pollution, including the addition and/or modification of sampling locations, as necessary. As discussed previously in the report, based on a review of the source sampling data, the Shellfish Program has decided to add a new sampling station in the vicinity of Gooseberry Island in Green Hill Pond (referred to in this study as station GH24) to the routine shellfish monitoring surveys. Shoreline surveys entail the evaluation of the effect of each actual and potential source of pollution on shellfish waters including as necessary, the collection of ambient water quality samples. In addition, non-shellfish program data (such as information on potential sources, beach and volunteer monitoring) will be considered and followed up with confirmatory monitoring by RIDEM, following NSSP approved methods, as appropriate.

The continued water quality monitoring and future shoreline surveys will be used to help evaluate the effectiveness of the recommendations of the TMDL in restoring designated uses and attaining water quality standards. Ultimately, attainment of the designated shell fishing use requires compliance with the Rhode Island water quality standards including ambient water quality criteria and all NSSP requirements (including evaluation of non-shellfish program data/surveys, special sampling site data, beach and volunteer monitoring, as appropriate).

RIDEM expects BMPs to be implemented on a voluntary basis by the responsible parties. However, if this does not occur, RIDEM may use its permitting authority, or other enforceable means, to require implementation. RIDEM will work with the Town of South Kingstown and the Coastal Resources Management Council (CRMC) to identify funding sources and to evaluate locations and designs for stormwater control BMPs throughout the watershed.

EPA Comment #6:
MOS presented on page 42 of the TMDL report as follows:

- The watershed was evaluated during the critical summer conditions when bacteria pollution contamination is most problematic.
- No allowances were made for bacteria decay.
- Conservative estimates of the amount of rainfall needed to produce runoff and recovery of the watershed were used in the weighted geometric mean calculations.

The first and second bullets are not considered MOS. The last bullet is acceptable as implicit MOS for this TMDL.

Response:
The first two bullets have been removed

EPA Comment #7 - Errata:
1. Abstract and Sec 1.2 on p. 11 should be updated to reference 2002 303(d) list.
2. Section 2.2 (p.16), TB and FB flow into north*east* corner of Green Hill Pond.
3. Wet weather survey was in 9/00 (sec 3.1.1, p. 18) or 9/01 (sec 3.1.3, p. 20)?
4. The "<" symbol or the phrase "no more than" in Sec 3.1.4 (P. 21) should be deleted.
5. Distinction, if any, between data presented for mouths of Teal and Factory Brooks in Table 4.4 (p. 29) and data in tables 3.4 and 3.5 (pp. 21 - 22).
6. Sec 4.3 (p. 36), source tracking conducted at station DP06 or at DP02, as indicated on p. 37?
7. Table 4.17 Maximum reported density for N13 may be a typo as it is less than the 90th percentile value reported at this station.
8. Reference to Table 4.18 in section titled "Salt Ponds Coalition and Watershed Watch Data" should likely be for Table 4.19

9. Table 5.7 and last two sentences in Sec 5.3.2 regarding allocations of reductions is confusing and should be clarified.

Response:
Comments 1-9 have been addressed in the TMDL.

APPENDIX B: RIDEM Final Public Meeting Response to Comments

Notes of the June 26, 2004 Public Meeting for the Green Hill Pond and Ninigret Pond TMDL held at the Cross Mills Public Library in Charlestown, Rhode Island.

<u>Liz Scott (Deputy Chief) in the Office of Water Resources opened the meeting and presented an overview of the meeting agenda (7:30pm)</u>:

- This meeting represents the start of the 30-day public comment period, which closes on July 23, 2004.
- Comments regarding the TMDL document or this meeting can be sent via email, regular mail, or by phone. DEM will respond to all comments either in a written format, attached to the final TMDL, or verbally to the individual or organization.
- Tonight's meeting will focus on TMDL study, final data analysis, pollution sources, implementation measures, and other work currently being done within the watershed by DEM and URI staff. Following the presentation, Ms. Scott will discuss DEM's Watershed Restoration Plan for the Green Hill-Ninigret Pond area.

<u>Brian Zalewsky presentation:</u>

- Brian began with a brief overview of the study including the geographic area, applicable water quality standards for shellfishing and swimming, sources of data, and a summary of current water quality conditions.

- Water quality standards for shellfishing use are not being met in several areas of the pond. Standards for swimming are met, however DEM recommends that individuals not swim or recreate in the ponds during and for 2 to 3 days after a rain event.

- Brian explained which stations in the ponds met water quality standards and which did not. Brian then discussed pollution sources to those areas and summarized how DEM staff calculated percent reductions to meet both parts of the states water quality standards. In summary, reductions averaged 99% in the tributaries and 30%-60% in the ponds.

- The major sources of pollution to the ponds and freshwater tributaries include wildlife, waterfowl, septic effluent, and stormwater runoff.

- Brian began discussing implementation strategies for mitigating pollution. Several members of the audience had questions regarding "what is going to be done". They are as follows:

    1. A member of the audience asked about whether hurricanes could impact ISDS and cause massive failures near the ponds shoreline. Chris Turner responded that it was DEM's opinion that these events were very infrequent and that extended closures would occur in any event. These events fell outside the range of circumstances that we were planning for.

    2. A member of the audience wanted to know if DEM has bird (goose and swan) control programs and mentioned that there were too many geese and swans in the ponds. Chris responded that there is a regulation prohibiting individuals from feeding geese at any time and that they were exploring options regarding other removal and/or techniques to discourage geese and swans from living in the area. Chris mentioned that the towns could play a role in educating people regarding water quality impacts from resident waterfowl.

3. A member of the audience asked if bacteria in the ponds feed on the nutrients present. Brian answered that the bacteria live in the intestinal tracts of animals and humans and that once in an environment unlike their own, tend to die off. Survival of bacteria has been documented in warm conditions. Under those conditions, fecal coliform bacteria may utilize nutrients in the water, however the relationship is not well-understood.

4. A member of the audience asked if RIPDES will enforce stormwater permits. Liz Scott answered that the towns and DOT include tasks and schedules in their Stormwater Management Programs Plans (SWMPPs) that are submitted with their permit applications. The tasks must address specific recommendations included in this TMDL, and the completion of these tasks would be reviewed by the RIPDES Program.

5. A member of the audience asked why DEM did not conduct "critical condition" sampling. Brian explained that DEM conducted both wet and dry weather monitoring and that the Shellfish Program monitored the ponds during wet and dry weather. DEM targeted stormwater outfalls during storm events. Brian explained that wet weather is a critical condition in the pond and felt that DEM had indeed captured "critical conditions"

6. A member of the audience asked if dredging will affect bacteria levels in the ponds. Chris Turner responded that dredging would have a small impact on flushing, particularly in Green Hill Pond. As a result, the impact of the dredging project on bacteria levels in Green Hill Pond would be negligible. There could be ephemeral impacts due to resuspension of bacteria in bottom sediments in the immediate area of the dredging.

7. A member of the audience asked if DEM manages fields surrounding the portion of Ninigret Pond currently open to shellfishing to attract geese. Brian Zalewsky responded that to his knowledge, they do not.

Brian concluded his presentation and mentioned again that the public comment period would end on July 23rd and that comment would be accepted up to that point. Brian stated that Liz Scott had additional information regarding the South Shore Salt Ponds Watershed Action Plan.

<u>Liz Scott- RIDEM</u>

- Liz explained that funds are available to further pursue restoration via "South Shore Salt Ponds Watershed Restoration Plan". This proposed project will take stock of where we currently are in terms of fecal coliform and nitrogen pollution in the watershed and examine technical and planning approaches to addressing specific stormwater outfalls (which were identified in the TMDL). A project manager consultant will be hired to develop a comprehensive watershed action plan that clearly presents specific implementation activities and best management practices to clean up existing and prevent subsequent sources of bacteria and nitrogen to both Green Hill and Ninigret Ponds.

- Specific strategies to address stormwater would include:
    - Reducing runoff volumes by infiltration in the upper catchment.
    - Distributing treatment within catchment.
    - Evaluate use of "Smart Sponge" technology. Smart Sponge media is a non-toxic, fully recyclable filtration system that destroys bacteria at the street level. Smart Sponge media also removes up to 95% of oil and grease in stormwater runoff.

- The consultant has not yet been selected, however the final selection should take place by the end of July.

- Vic Divorak, executive director of the Salt Ponds Coalition, stated that they hope to have a project manager for next month's Salt Pond Watchers meeting.

- There were several questions and comments at this point in the presentation:

    1. A member of the audience asked if there were plans for a centralized wastewater system. Liz Scott replied that there were not and that she was not sure how beneficial this would be. Another member of the audience stated that that alternative had been explored in the past and that it had been determined that it was cost prohibitive and would bring unwanted development to the area.

    2. A member of the audience stated that development within the pond areas seems piecemeal and without any organization or regulations. The individual wanted to know if there is any centralized process or regulations for development. The individual also wanted to know when and how denials and variances are issued. Liz Scott replied that there is a coordinated process between DEM, CRMC, and the towns for addressing variances. Liz said that Russ Chateauneuf, Chief of Wetlands and ISDS at DEM would be the best person to explain the variance process. Liz suggested arranging for Russ to host a question-and-answer forum for Pond Watchers and other members of the community to explain the process and how it has factored into recent permitting decisions in the Green Hill Pond area. Russ Chateauneuf agreed to host a forum should one be organized.

    3. A member of the audience asked if a TMDL for nitrogen is planned. Liz Scott replied that there would not and that the nitrogen issue will be addressed in the Watershed Action Plan, which would be a “TMDL equivalent”.

- Lorraine Joubert from the University of Rhode Island Cooperative Extension Program spoke near the end of the meeting on nitrogen and water quality in the Salt Ponds.

- Lorraine stated that URI is pleased to see that the TMDL is completed and agrees with the recommendations made in the TMDL. She said that they will look forward to working with RIDEM on these recommendations and that URI is moving forward on nitrogen mitigation techniques.

- Lorraine gave some background information on the nitrogen cycle, typical levels in groundwater within low and high-density developments, and water quality impacts from increases in nitrogen inputs to the coastal ponds.

- Lorraine summarized the ISDS inspection results, stating that they had 97% compliance in Charlestown and South Kingstown. 30% of the non-compliant systems were in need of immediate repair. 7-17% of ISDS in the watershed were cesspools. Lorraine then showed a slide with a simple calculation showing how one failing system can pollute the pond.

- Lorraine further stated that nitrate levels in area wells averaged 3 ppm with a few greater than 5 ppm. Lorraine then outlined the current wastewater programs for South Kingstown and

Charlestown and talked about some of the advanced wastewater treatment systems that had been installed in the area.

Liz Scott then asked if there were any additional questions or comments. There were none. The meeting was adjourned at approximately 9:15pm.