Preliminary
Bacteria Source Identification Summary
for New Hampshire Coastal Beach Watersheds

Submitted to

The Beach Program

New Hampshire Department of Environmental Services

Submitted by

FB Environmental

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1.0 Introduction

The New Hampshire Beach Program is currently conducting a bacteria source characterization and modeling project in eight coastal beach watersheds. As part of this project, we are tasked with estimating bacteria loads from various watershed sources and assessing their relative contributions to ambient bacteria concentrations observed at seacoast beaches. Obtaining and carefully reviewing available bacteria source information from a variety of sources is an important step in the source characterization process.

This document provides a preliminary summary of known and potential sources of bacteria in the subject watersheds. The summary is based on information and data from several sources including:

- NHDES Beach Program Annual Beach Monitoring Reports
- NHDES Shellfish Program Sanitary Surveys and other Investigations
- NHDES and UNH Microbial Source Tracking Investigations
- NHDES TMDL Reports
- NHDES Land Cover Maps

A bibliography of reports was compiled as part of this investigation is attached in Appendix A. Dr. Steve Jones, lead microbial source tracking (MST) investigator at the University of New Hampshire, is working with us on this project and has written a summary of the beach watersheds from an MST perspective. Dr. Jones's MST summary (Jones 2008) is provided in Appendix B and is referenced throughout this summary.

We have reviewed bacteria-related data and reports of each type above and have talked with investigators with each of these programs. The summary below represents a preliminary attempt to integrate this information.

2.0 Watershed Source Identification Summaries

The New Hampshire beaches included in this investigation are shown in Figure 1 and listed in Table 1. The figure also shows the contributing watersheds to each beach and the seacoast towns. The table compiles beach watershed information, such as town, watershed size, and adjacent creeks. The summary is organized by watershed, starting at the northernmost beach watershed, New Castle Town Beach, proceeding southerly, as follows:

1. New Castle Town Beach
2. Wallis Sands, Pirates Cove, and Foss Beaches
3. Jenness and Cable Beaches
4. Sawyer Beach
5. Bass Beach
6. State Beach and Northside Park
7. North Beach
8. Seabrook Harbor, Seabrook Beach, and Hampton Beach.

A section is provided for each beach watershed and includes GIS-based maps and brief summaries of bacteria source information.

#	Beach Name(s)	Beach Watershed Town(s)	Area (sq. miles)	Adjacent Creeks or Outfalls
1	New Castle Town Beach	New Castle	0.08	pipe outfall
2	Wallis Sands, Pirates Cove, & Foss Beaches	Rye	2.3	Parsons Creek
3	Jenness and Cable Beach	Rye	0.2	
4	Sawyer Beach	Rye, North Hampton	2.5	Eel Pond
5	Bass Beach	North Hampton, Rye	1.3	Bass Brook & Chapel Brook
6	State Beach and Northside Park	N. Hampton, Hampton, Rye	7.7	Little River
7	North Beach	Hampton	2.5	
8	Seabrook Harbor, Seabrook Beach, and Hampton Beach	Hampton, Seabrook	46	Numerous

Table 1. New Hampshire Coastal Beach Watersheds with towns, sizes, and adjacent creeks.

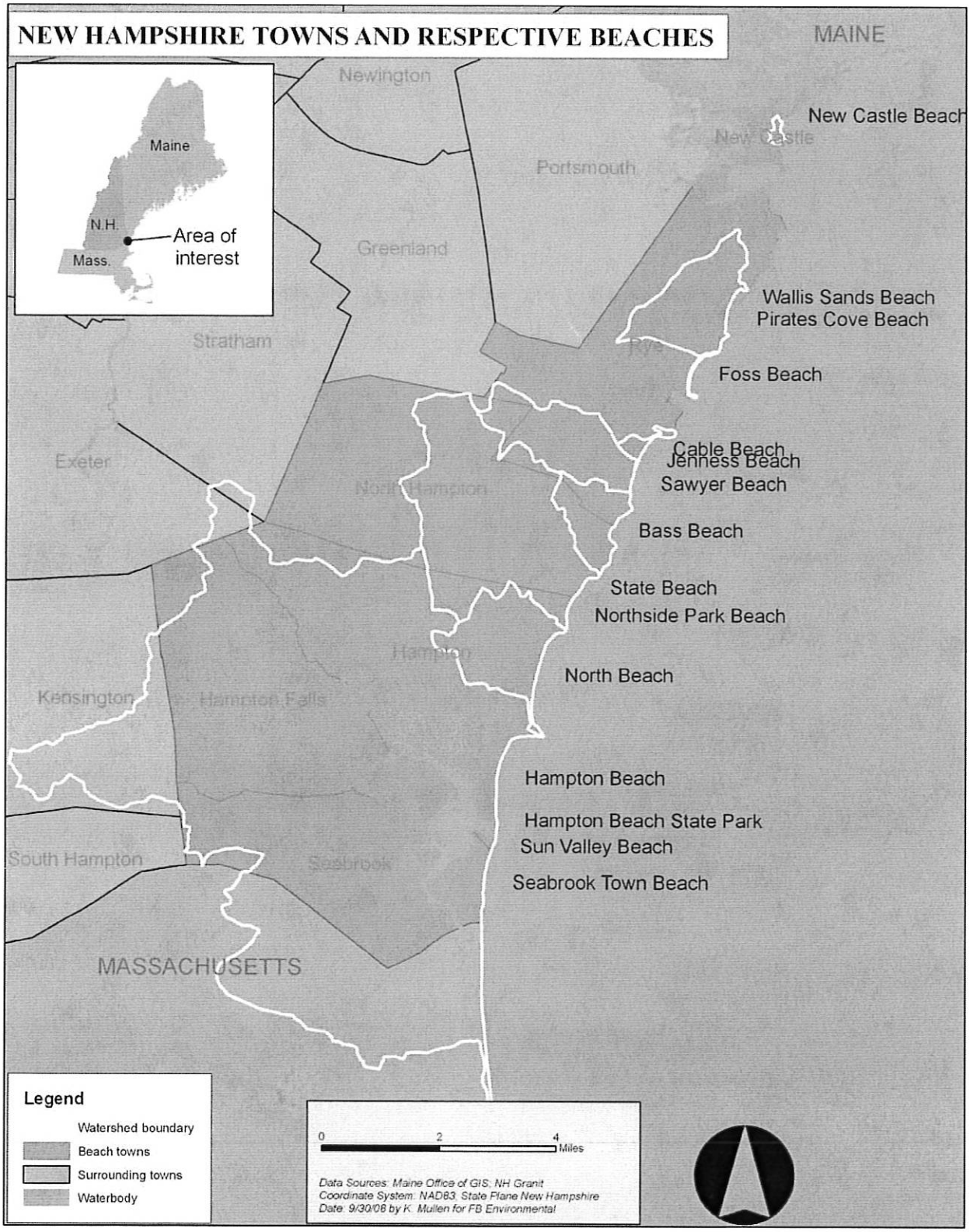

Figure 1. New Hampshire Coastal Beaches with Contributing Watersheds and Towns Indicated.

2.1 New Castle Town Beach Watershed

New Castle Town Beach, New Castle, NH, and its contributing watershed are shown in Figure 2. The figure also shows the locations of bacteria sampling locations, including three beach locations and two pipe outfall locations. There are several types of sampling conducted in this area including beach program monitoring (denoted in purple circles) and special project sampling locations (in red). The contributing watershed for New Castle Town Beach is small, 48 acres (0.08 square miles) in area, and is primarily developed, glassland, and forested. Land cover information for the watershed is shown in Figure 3. Note that New Hampshire categorizes developed land as "disturbed".

Bacteria sources to New Castle Town Beach include:

- Discharge pipes – One pipe is situated at the northern end of the beach and identified as "BCHNWCHWCPIPE" in Figures 2 and 3. Bacteria were measured at the pipe outfall from 2004 through 2007 and the bacteria standard of Enterococci 104 counts/100 ml was exceeded on numerous occasions. The pipe discharges from a small, wet detention pond. The pond is situated in the residential areas adjacent to the beach and has not been delineated. A second pipe was historically situated to the south of sampling location New Castle TB –Right (Figure 2). We are not aware of the current condition of this pipe.
- Storm drains and runoff – An MST study was conducted in 2006 and found that the highest bacteria levels were recorded during a wet weather event (Jones 2008). Several high wet weather bacteria levels were also measured as part of beach program sampling.
- Wildlife – The 2006 MST investigation found sea gulls, deer, and other wild animals as bacteria sources. The study's overall source species identification rate was relatively low (48%) indicating that some significant source species may not have been identified. Gulls, cormorants, and ducks have been frequently observed on and near the town beach.
- Septic systems – There are reportedly only 20 septic systems in use on the island of New Castle. The New Castle Town Beach watershed represents a relatively small and less developed part of the island. The 2006 MST study found wastewater to be a source at the beach, however, and the town beach has its own sanitary facility using a septic system. We do not know that septic systems are a source of bacteria to the beach, but it is possible.
- People at the beach – The 2006 MST study found humans to be a source of bacteria at the beach and many people visit the beach each year. Thus, it is likely that beach visitors are sources of bacteria. To minimize adverse impacts, the beach is cleaned and raked every morning in the summer.
- Pets – The 2006 MST study identified dogs as a bacteria source. Dogs are allowed on the town beach and have been observed. To minimize adverse impacts, the beach is cleaned and raked every morning in the summer.

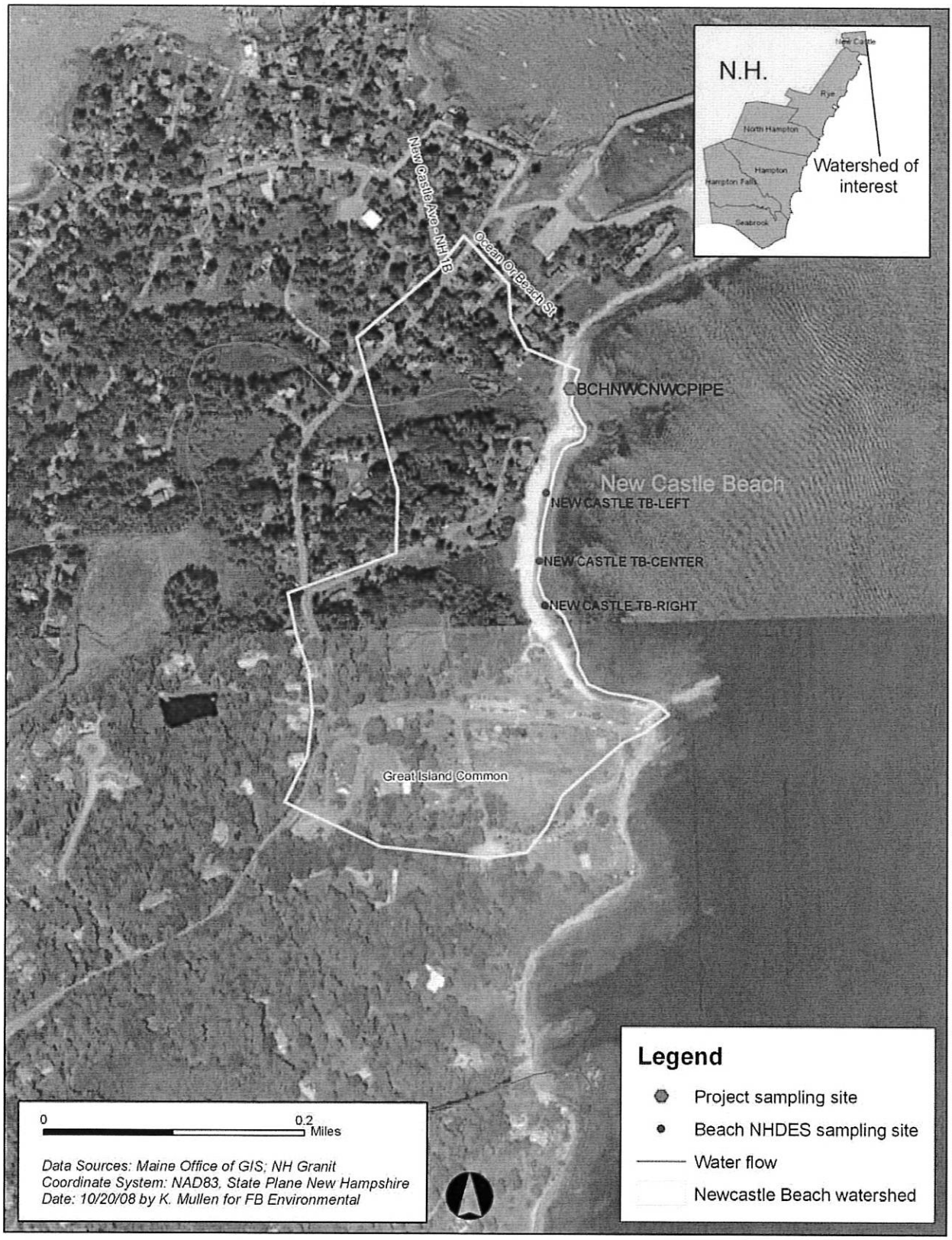

Figure 2. New Castle Town Beach Watershed with Bacteria Sampling Locations Indicated.

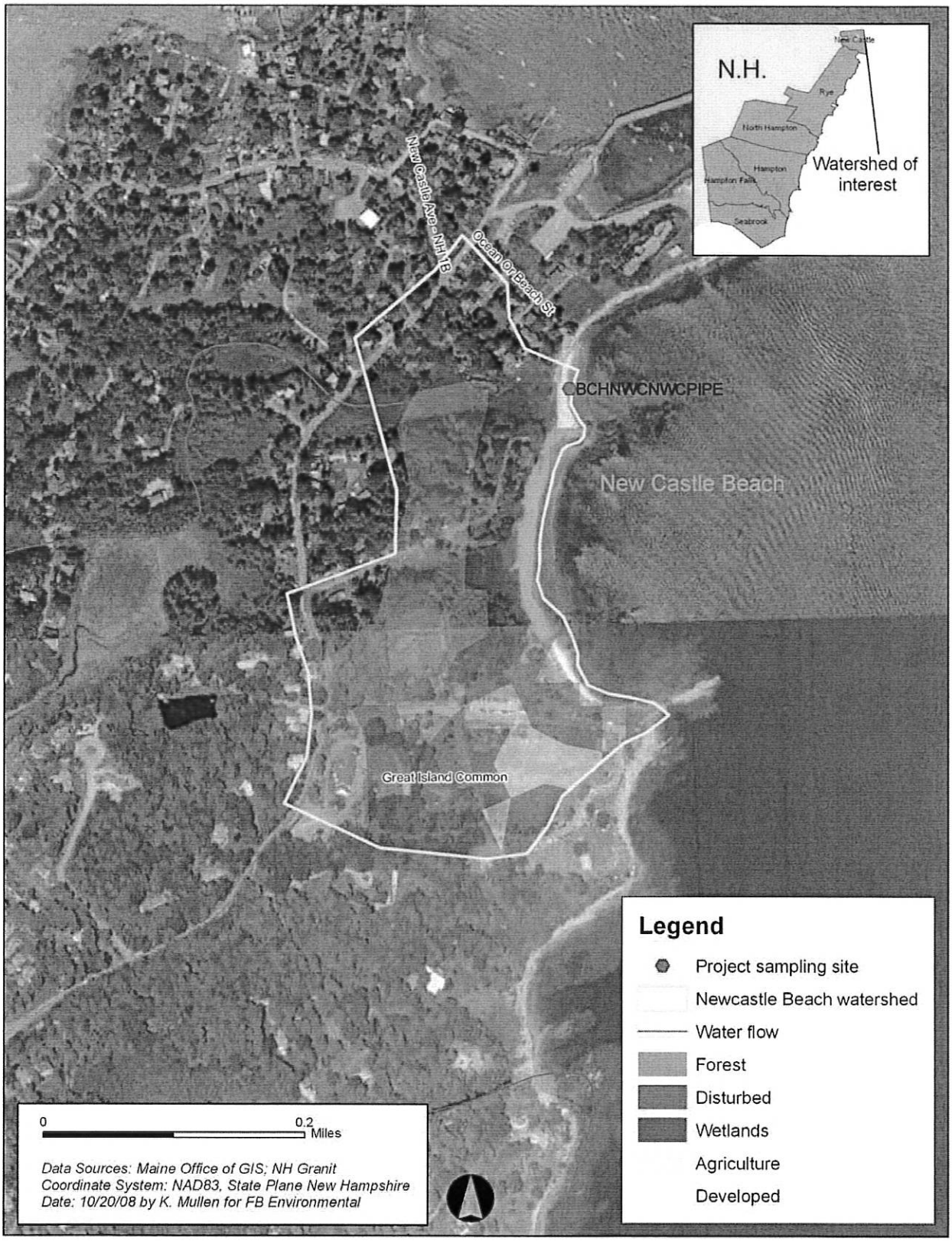

Figure 3. New Castle Town Beach Watershed with Land Cover Indicated.

- Sand and Beach Wrack – Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – New Castle Island is situated near Portsmouth Harbor and the mouth of the Piscataqua River. The Portsmouth WWTF and other major point source discharges are situated relatively nearby. The 2006 MST study found that wastewater was a source of bacteria to the beach. This wastewater may be carried by the coastal currents to New Castle Town Beach from a nearby WWFT or other sources.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the town beach, although the magnitude of this potential source is largely unknown.

2.2 Wallis Sands, Pirates Cove, and Foss Beach Watersheds

Wallis Sands, Pirates Cove, and Foss Beach and their contributing watersheds are situated in Rye, NH, are shown in Figure 4. The figure also shows the locations of bacteria sampling locations. There are several types of sampling conducted in this area including beach program monitoring (denoted in purple circles), shellfish program sampling (in black triangles), and special project sampling (in red). The contributing watershed (Figure 5) covers 2.3 square miles and is primarily developed, forested, and wetland. The most developed areas are along the seashore and along the major roadways in the watershed.

Bacteria sources to Wallis Sands, Pirates Cove, and Foss Beach Watersheds include:

- Parsons Creek – The mouth of Parsons Creek is situated just south of Pirates Cove (Figure 4) and has been observed to be a source of bacteria during many surveys. Parsons Creek flows southerly on the landward side of the heavily developed Route 1A (Ocean Rd) corridor. Historically, bacteria loads were believed to have entered Parsons Creek from developed areas and been transported by the Creek to the nearby coastal beaches. Parsons Creek also drains a marsh area to the west of its mouth.

  A sanitary survey conducted by the Shellfish Program in 2000 (NHDES 2000) found several active straight pipes and failing septic systems providing major bacteria loads to Parsons Creek. Parsons Creek is believed to be the primary source of bacteria to Pirates Cove Beach and may also be a significant source to the other beaches. Based on high bacteria counts, the Shellfish Program established a prohibited zone at the mouth of Parsons Creek in 2000.

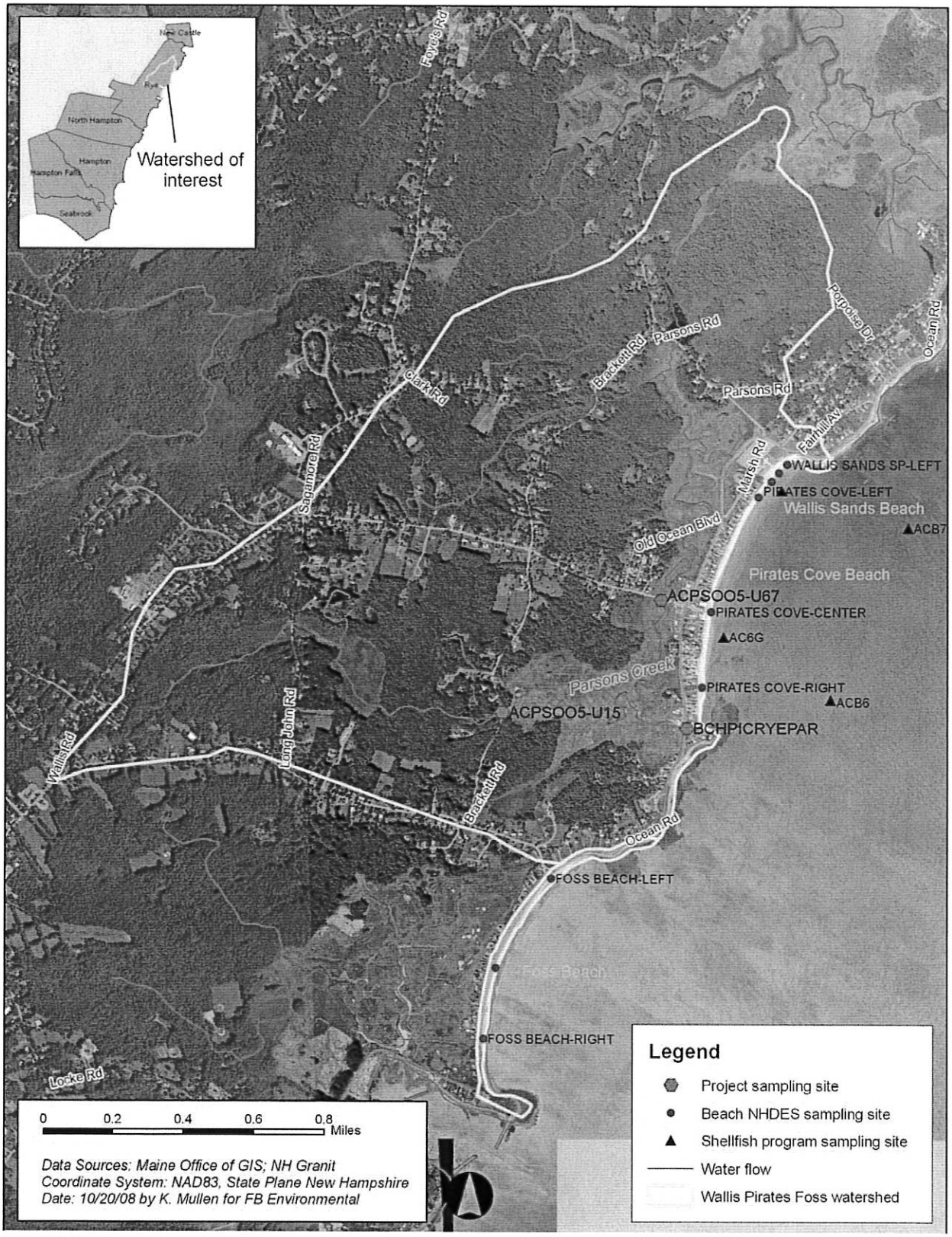

Figure 4. Wallis Sands, Pirates Cove, and Foss Beach Watersheds with Bacteria Sampling Locations

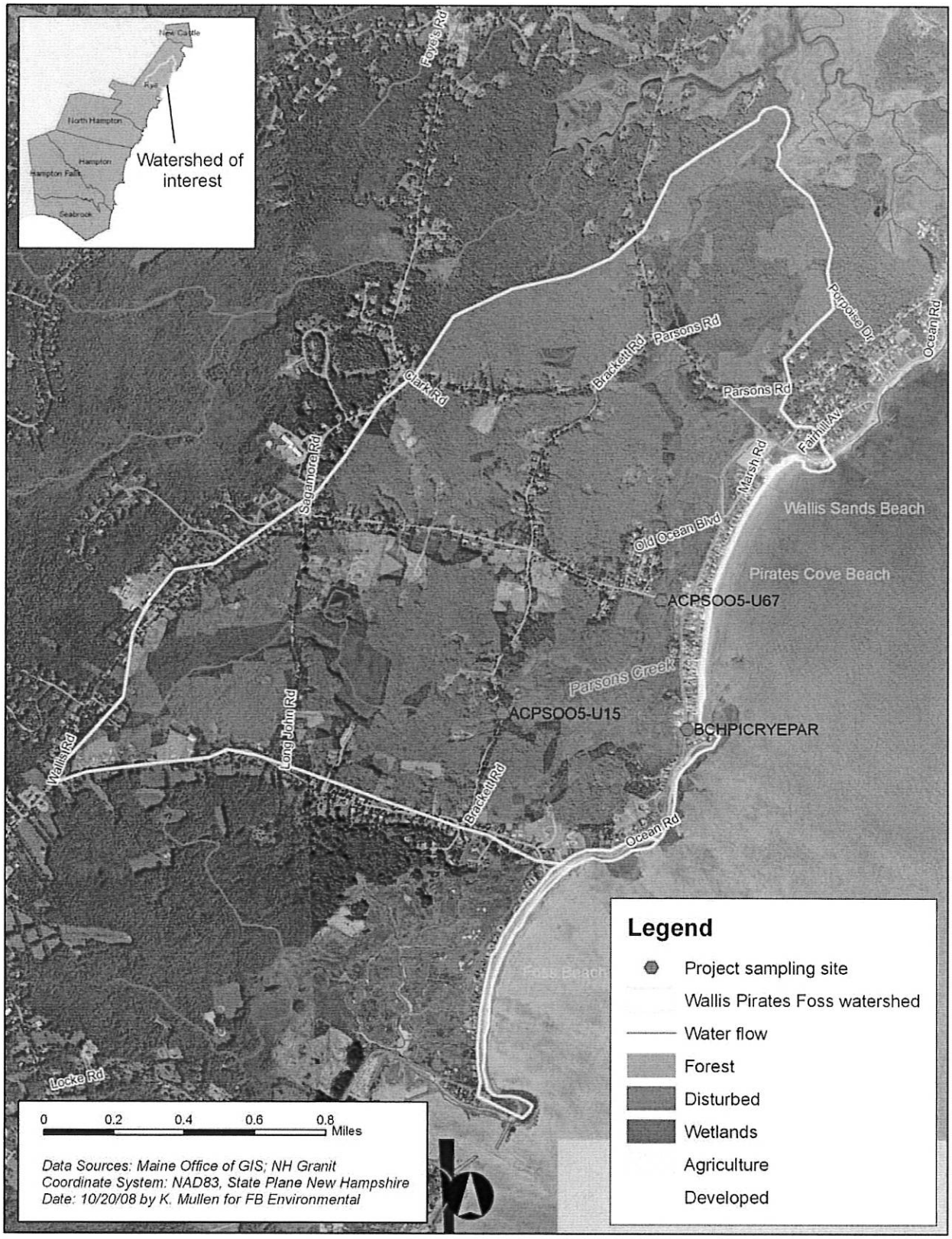

Figure 5. Wallis Sands, Pirates Cove, and Foss Beach Watersheds with Land Cover Indicated.

- WWTF – Wallis Sands Beach has a small package plant treating wastewater and grey water from its onsite facility. The plant's design flow is 0.006 MGD and it discharges directly to the Atlantic Ocean just north of Wallis Sands Beach. Secondary treatment is achieved using a large sand filter, underlain by a collection box, which is then followed by UV disinfection. In recent years, bacteria levels from the Wallis Sands WWTF have been very low. In 2008, Chris Nash and the Shellfish Program team conducted a dye study to evaluate transport of wastewater leaving the package plant.
- Storm drains and runoff – High wet weather bacteria levels have been measured as part of beach program sampling. Storm event runoff has been observed to carry large bacteria loads directly to the beaches and also to the seacoast via Parsons Creek.
- Wildlife – MST surveys were conducted in Parsons Creek during 2001, 2002, and 2003. The primary sources of bacteria were found to be human, but otters, deer, and seagulls (Jones 2008). Sea gulls, tern and other birds have been observed at the beaches.
- Septic systems – There are reportedly as hundreds of septic systems in the watersheds contributing to these beaches. The MST surveys (2001-2003) conducting in Parsons Creek, which drains much of the contributing area, found that human waste was the primary source of bacteria. Based on this information, septic systems appear likely to be significant sources of bacteria in these watersheds.
- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.
- Pets – The MST surveys (2001-2003) identified dogs as a bacteria source. Dog are not allowed at Wallis Sands Beach at any time and are forbidden from Pirates Cove and Foss Beaches during beach hours (9-5).
- Sand and Beach Wrack – Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacteria loads may be carried by the coastal currents to these beaches from a nearby WWTF or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past these beaches.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown.

2.3 Cable and Jenness Beach Watersheds

Cable and Jenness Beaches and their contributing watersheds are situated in Rye, NH, are shown in Figure 6. The figure also shows bacteria sampling locations. The contributing watershed (Figure 7) covers 118 acres (0.2 square miles) and is primarily residentially developed.

Bacteria sources to Cable and Jenness Beach Watersheds include:

- Storm drains and runoff – High wet weather bacteria levels have been measured as part of beach program sampling. Storm event runoff has been observed to carry large bacteria loads.
- Wildlife – Wildlife sources are a concern at these beaches. Sea gulls, plovers, and terns are frequently observed.
- Septic systems – There are reportedly relatively few septic systems in the Cable and Jenness Beach watershed.
- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.
- Pets – Dog are not allowed at Jenness Beach at any time and are forbidden from Cable Beach during beach hours (9-5).
- Sand and Beach Wrack– Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacteria loads may be carried by the coastal currents to these beaches from a nearby WWTF or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past these beaches.
- Eel Pond outlet – The outlet of Eel Pond is situated at Sawyer Beach, to the south of Cable and Jenness Beaches (Figure 6). Eel Pond has been observed to have high bacteria concentrations that could potentially be transported to Cable and Jenness Beaches. A description of Eel Pond outlet as a potential bacteria source is provided under the Sawyer Beach watershed description below.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown.

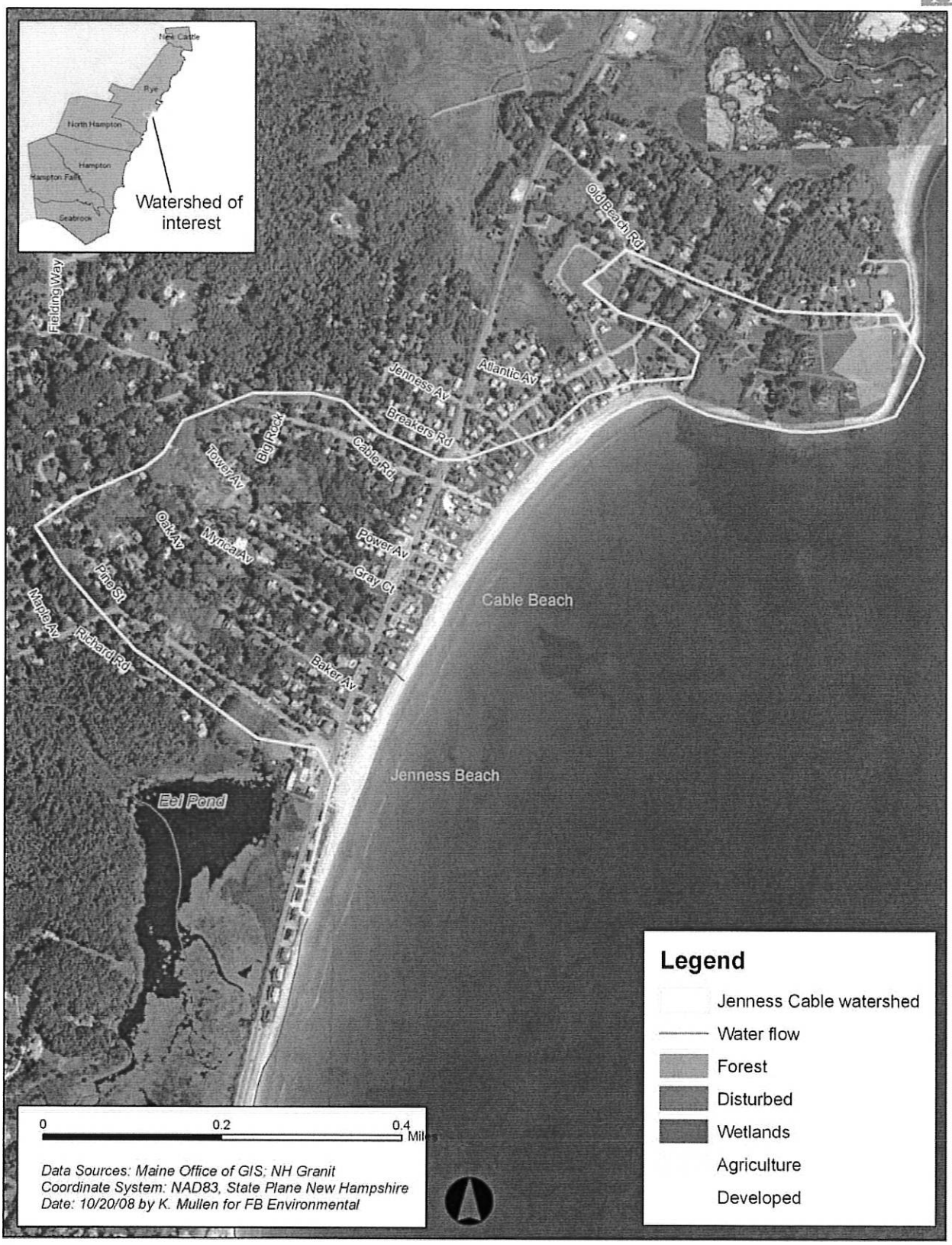

Figure 7. Cable and Jenness Beach Watersheds with Land Cover Indicated.

2.4 Sawyer Beach Watershed

Sawyer Beach and its contributing watershed are primarily situated in Rye with a westerly portion of the watershed in North Hampton. Figure 8 shows the Sawyer Beach watershed and the locations of bacteria sampling stations. The contributing watershed (Figure 9) covers 2.5 square miles and is primarily forested, with residential development along several roads. Eel Pond is situated directly landward of the beach and is discussed below.

Bacteria sources to Sawyer Beach Watersheds include:

- Eel Pond outlet – The outlet of Eel Pond is situated at the southern end of Sawyer Beach (Figure 8) and has been observed to be a source of bacteria. Eel Pond is in the Sawyer Beach watershed. The Sanitary Survey of 2000 (NHDES 2000) reported that the Eel Pond outlet travels under Route 1A through a double culvert and discharges directly on Sawyer Beach to the south. The sanitary survey also stated; "Eel Pond itself does not appear to be a source of concern; however, large flocks of seagulls tend to congregate on the beach between the culvert discharge and the Atlantic Ocean." The Shellfish Program established a prohibited zone at the mouth of Parsons Creek based on high bacteria counts at this location.
- Storm drains and runoff– High wet weather bacteria levels have been measured as part of beach program sampling. Storm event runoff has been observed to carry large bacteria loads.
- Wildlife – Wildlife sources are a concern at these beaches. Sea gulls and plovers are frequently observed. As noted above, large populations of sea gulls have been observed in the Eel Pond outlet area.
- Septic systems – We do not presently have information regarding septic systems in the Sawyer Beach watershed.
- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.
- Pets – Dogs are not allowed at Sawyer Beach during beach hours (9-5), but are allowed during other hours. Dogs have been observed on the beach and are likely a source of bacteria.
- Sand and Beach Wrack – Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacteria loads may be carried by the coastal currents to these beaches from a nearby WWTF or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past the beach.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown.

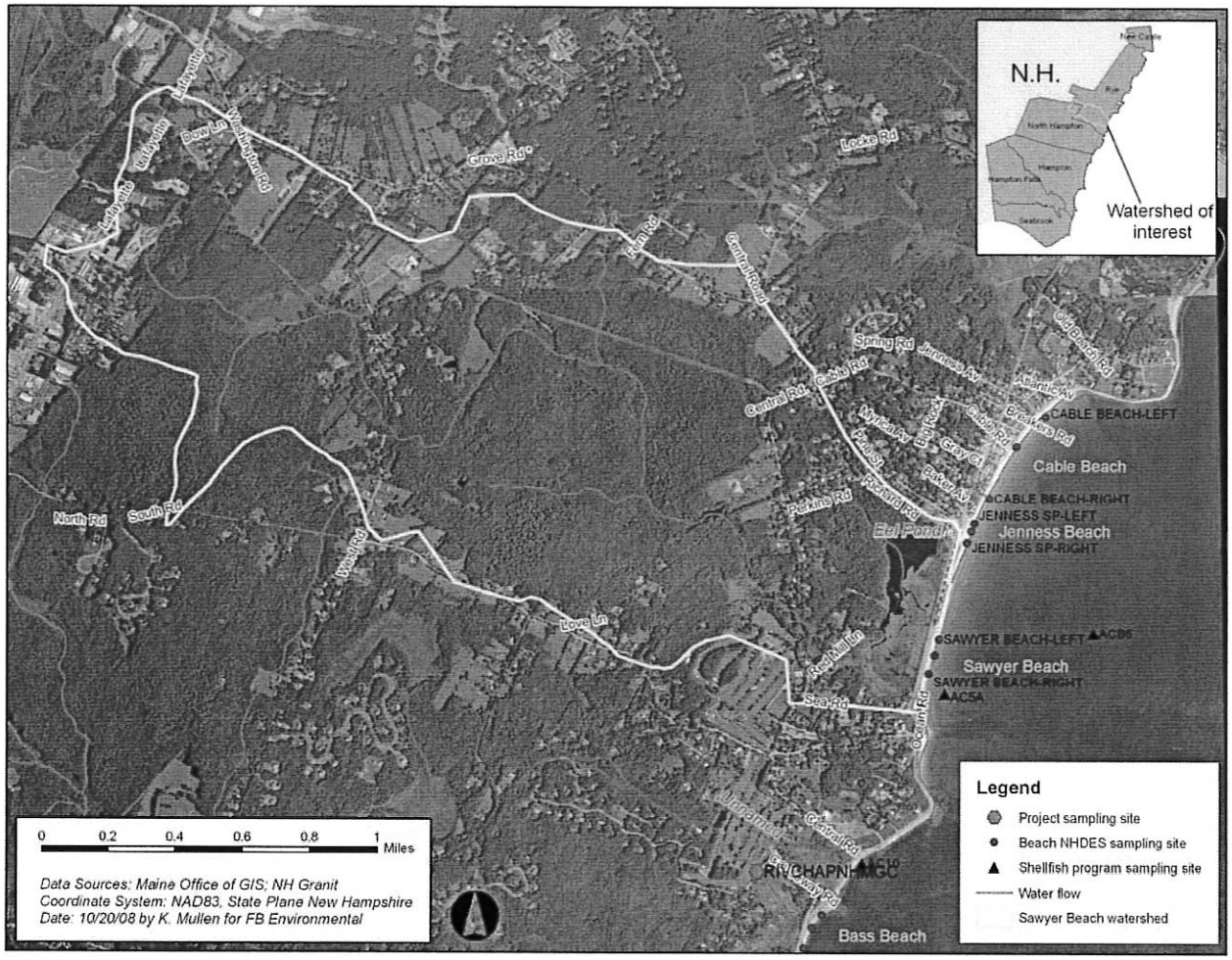

Figure 8. Sawyer Beach Watershed with Bacteria Sampling Locations Indicated.

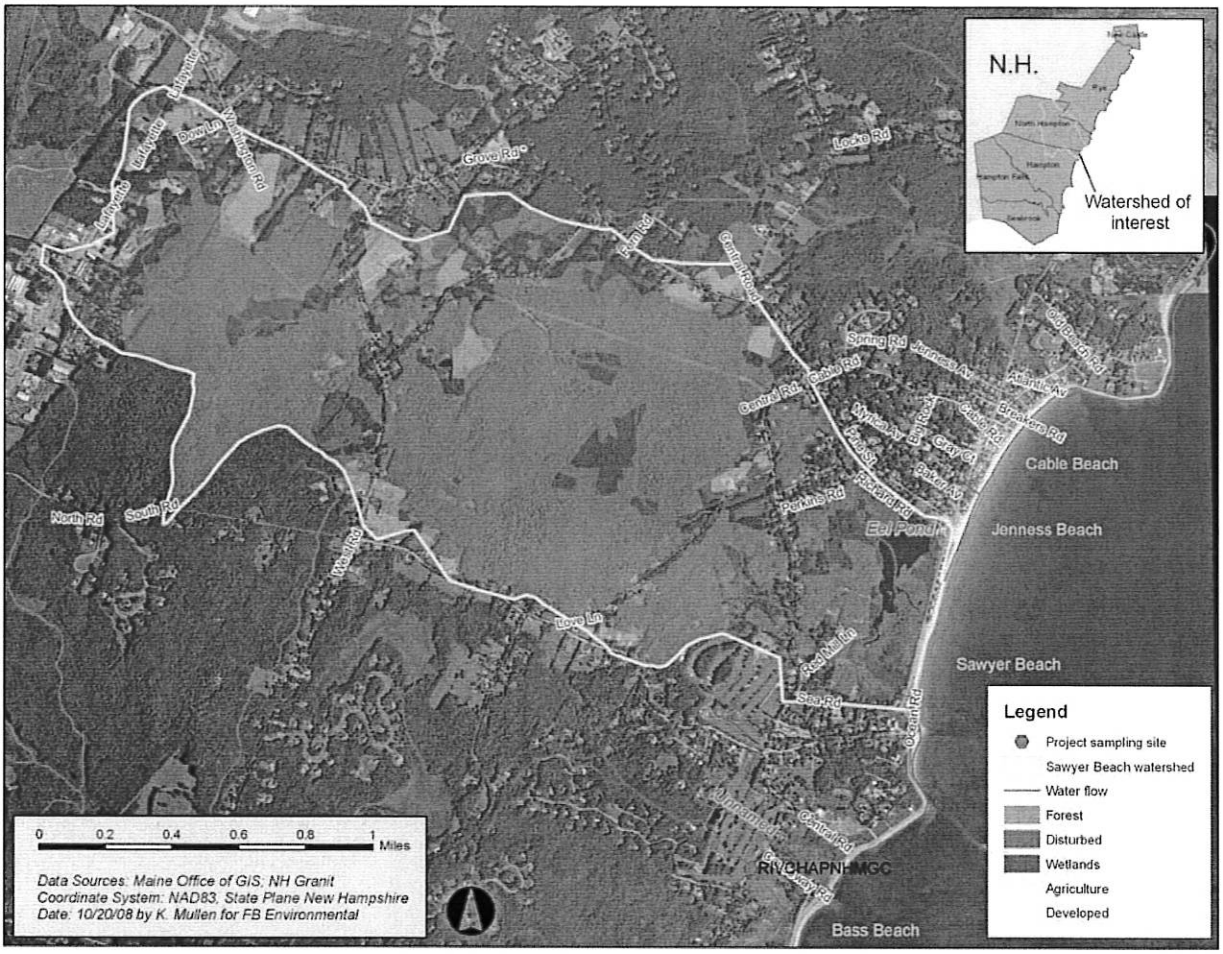

Figure 9. Sawyer Beach Watershed with Land Cover Indicated.

2.5 Bass Beach Watershed

Bass Beach and its contributing watershed are situated in Rye and North Hampton and are shown in Figure 10. The contributing watershed (Figure 11) covers 1.3 square miles and includes residential, roadways, a golf course, forests, and wetlands.

Bacteria sources to the Bass Beach Watershed include:

- Bass Beach Brook and Chapel Brook – Bass Beach Brook, previously referred to as "Unnamed Brook" (NHDES 2000), drains the Bass Beach Marsh and its contributing area. The Bass Beach Brook outlet is situated in the northern part of Bass Beach and has been observed to carry high bacteria counts. As a result, the Shellfish Program established a prohibited zone at the mouth of Bass Beach Brook in 2000.

  Chapel Brook drains Philbrick Pond, Chapel Pond and their contributing area. Chapel Brook's outlet is situated just south of Bass Beach and has been observed to carry large bacteria counts. As a result, the Shellfish Program established a prohibited zone at the mouth of Bass Beach Brook in 2000.

  Bass Brook and Chapel Brook are believed to be the main sources of bacterial contamination for Bass Beach. Microbial source tracking (MST) investigations have been conducted in each of these brooks. In 2001 and 2002, MST surveys of Bass Beach Brook found a wide range of sources including wild animals, livestock, dogs, and humans. In 2003, wet weather MST surveys were conducted in Chapel Brook and found wild animals and humans to be the most common bacteria source.

- Storm drains and runoff– High wet weather bacteria levels have been measured as part of beach program sampling and special surveys of Chapel Brook and Bass Beach Brook. In 2003, storm event runoff has been observed to carry large bacteria counts (e.g., *E.coli* 784/100 ml), while dry weather samples were relatively low (e.g., *E.coli* 18/100 ml). Thus, stormwater runoff, particularly via tidal brooks, is believed to be a significant source at Bass Beach.

- Wildlife – Wildlife sources are a concern at these beaches. MST surveys have identified sea gulls, plovers, otter, and other wild animals. Wildlife was observed to be the largest source in MST surveys conducted in 2001 and 2002.

- Septic systems – There are approximately 200 septic systems within 1 mile of Bass Beach. MST surveys have identified septic systems as a source of bacteria in this watershed.

- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.

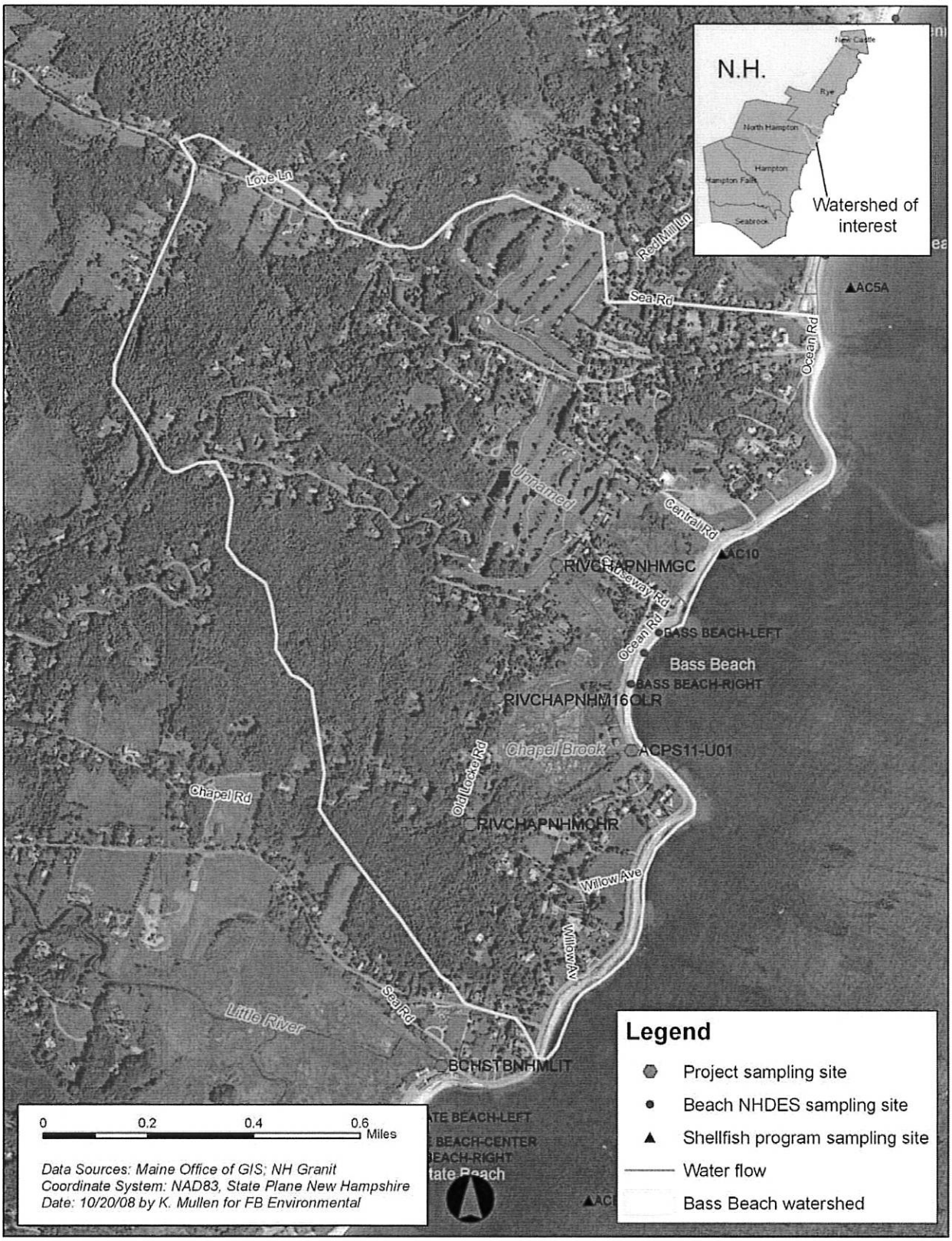

Figure 10. Bass Beach Watershed with Bacteria Sampling Locations Indicated.

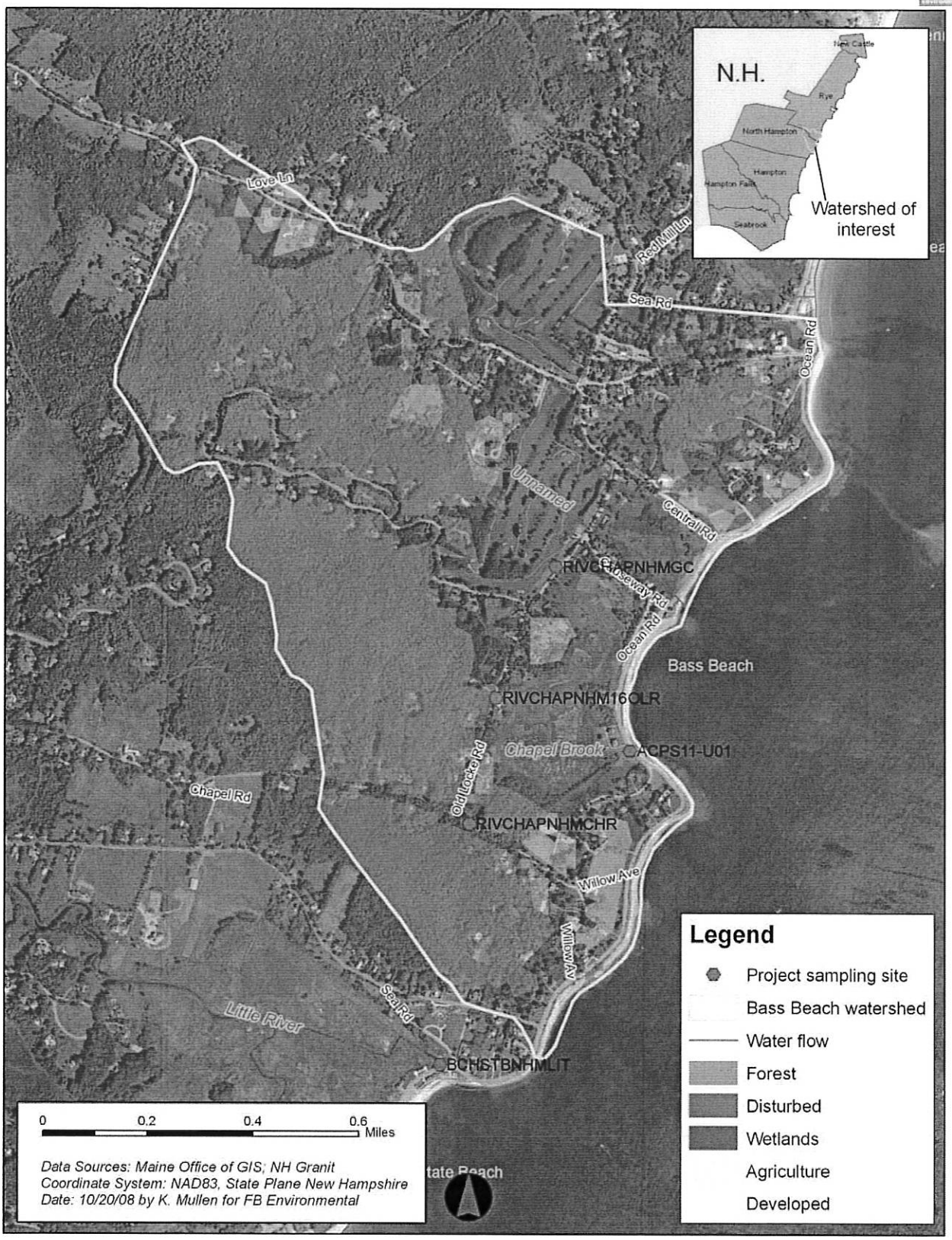

Figure 11. Bass Beach Watershed with Land Cover Indicated.

- Pets – Dogs are not allowed at Bass Beach from May 30th through October 1st each year. MST surveys have observed dogs as a source of bacteria in the watershed.
- Sand and Beach Wrack although the magnitude of this potential source is largely unknown.– Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacteria loads may be carried by the coastal currents to these beaches from a nearby WWTF or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past the beach.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown.

2.6 State and Northside Park Beach Watershed

State Beach, Northside Park Beach and their contributing watershed are situated in North Hampton, Hampton and Rye and is shown in Figure 12. The contributing watershed (Figure 13) covers 7.7 square miles, primarily in North Hampton, and includes forest, wetlands, residential, and roadway areas and is primarily located in North Hampton. The Little River Swamp is situated landward of the beaches and is discussed below.

Bacteria sources to State and Northside Park Beaches include:

- Little River – The Little River outlet is in the northern part of State Beach and drains the Little River Swamp and its contributing area (Figure 12). The Little River has been observed to carry high bacteria counts. As a result, the Shellfish Program established a prohibited zone at the mouth of the Little River in 2000. Several MST surveys were conducted in the Little River during the 2001-2003 time period. These investigations found wild animals, including otters and birds, to be the largest bacteria source. Humans were also identified as significant sources of bacteria to the Little River. Little River is believed to be a significant source of bacterial contamination for both State Beach and Northside Park Beach.
- Storm drains and runoff – High wet weather bacteria levels have been measured as part of beach program sampling. Storm event runoff has been observed to carry large bacteria counts , while dry weather samples were typically below the water quality standard. Thus, stormwater runoff, particularly via Little River, is believed to be a significant source at these beaches.
- Wildlife – Wildlife sources are a concern at these beaches. MST surveys have identified otters, sea gulls, and other wild animals. Wildlife was observed to be the largest source in MST surveys conducted in 2001-2003.

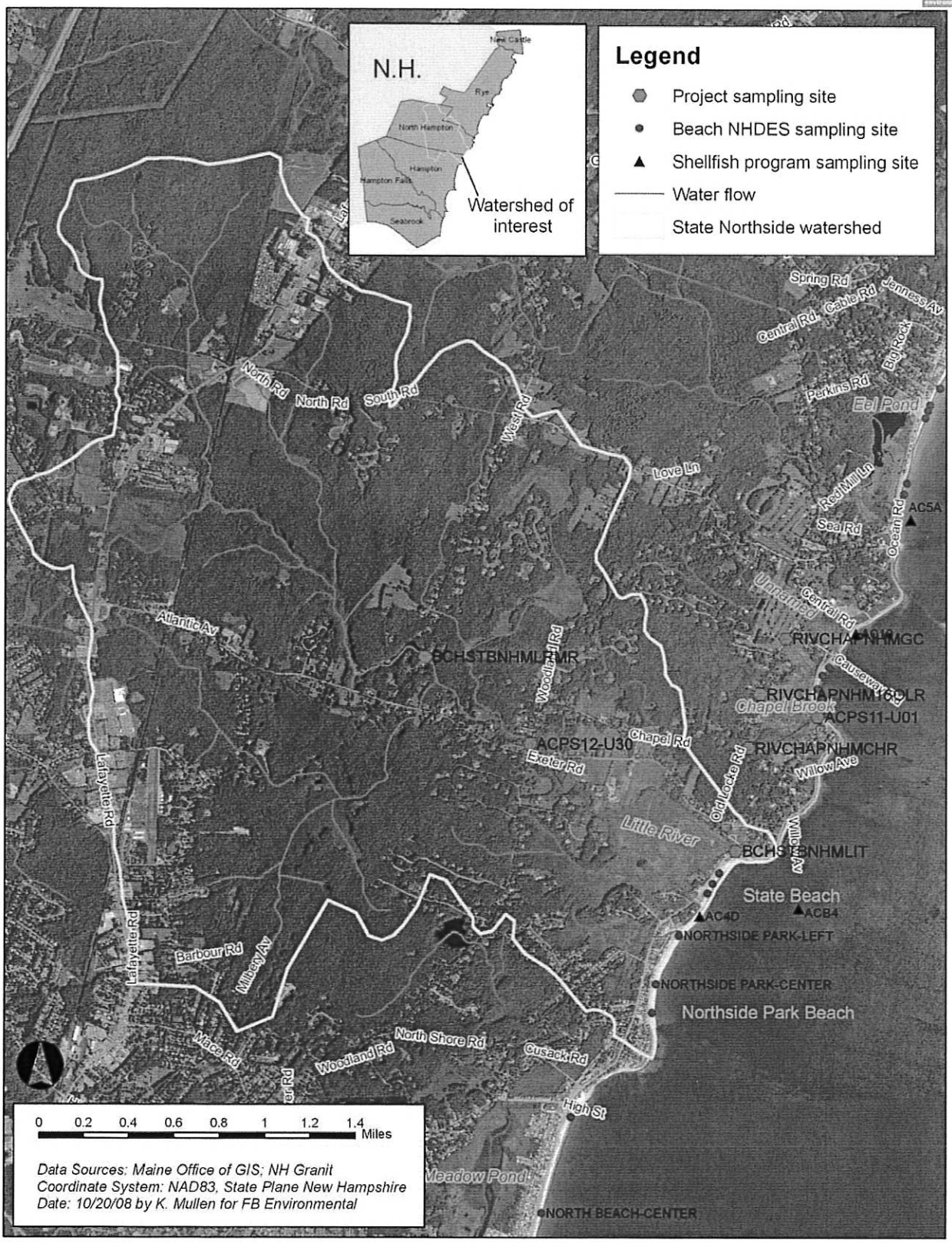

Figure 12. State and Northside Park Beach Watersheds with Bacteria Sampling Locations Indicated.

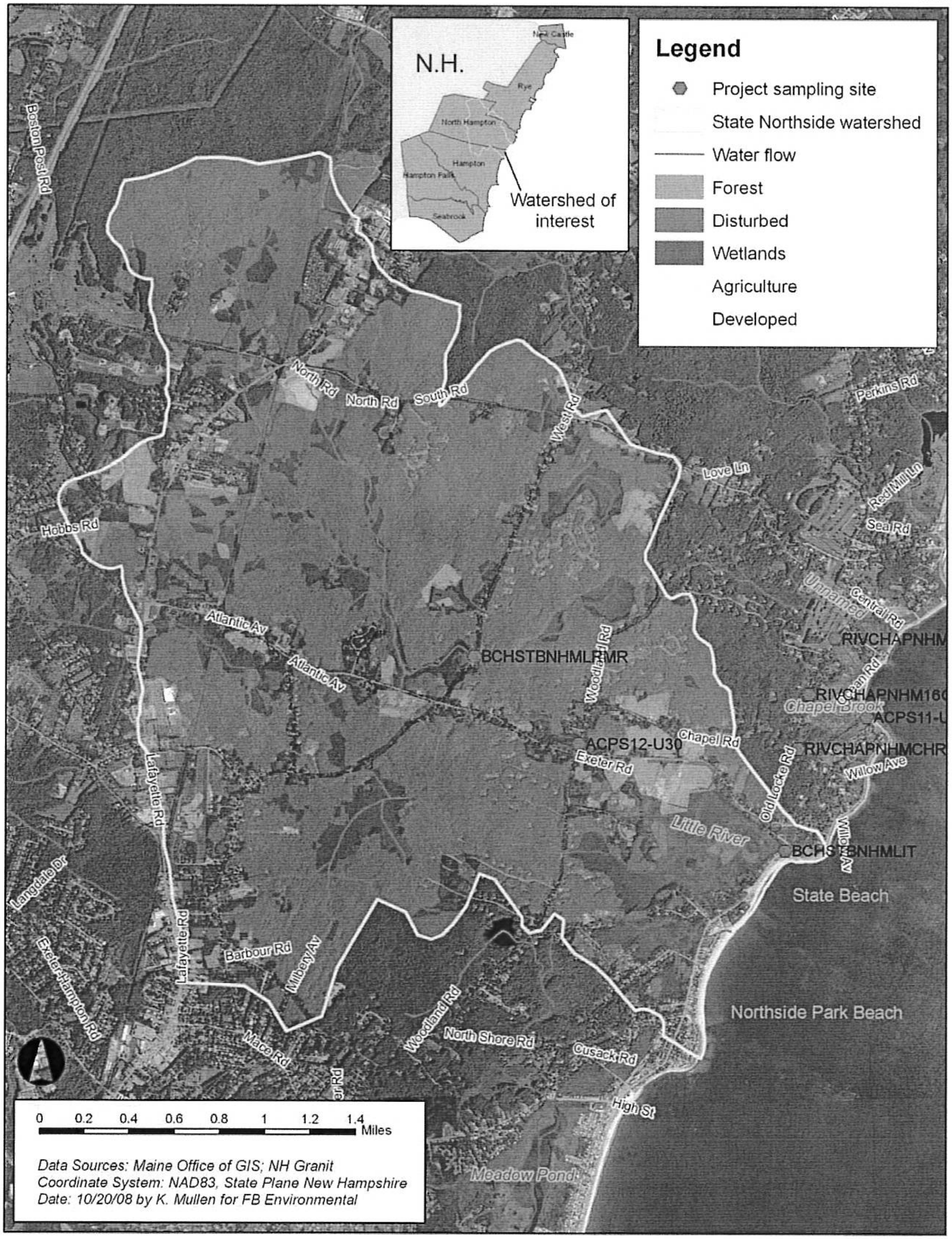

Figure 13. State and Northside Park Beach Watersheds with Land Cover Indicated.

- Septic systems – Septic systems are not believed to be present in the contributing watershed. State Beach, however, reportedly has a sanitary system consisting of a 1,000 gallon tank with no leach field. We do not have information on the performance of this system.
- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.
- Pets – Dogs are not allowed on State Beach. Dogs are allowed by ordinance on Northside Park Beach before 8 am and after 8 pm and fecal matter must be removed.
- Sand and Beach Wrack – Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacteria loads may be carried by the coastal currents to these beaches from a nearby WWTF or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past the beach.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown.

2.7 North Beach Watershed

North Beach and its contributing watershed are situated in Hampton, as shown in Figure 14. The contributing watershed (Figure 15) covers 2.5 square miles. The North Beach watershed is highly developed particularly along the coastline and to the south and southwest. Meadow Pond is a large wetland marsh area situated landward to North Beach. Meadow Pond appears to drain to Tide Mill Creek to the south, raising questions about the true watershed delineation of this area.

Bacteria sources to North Beach include:

- Storm drains and runoff – Modest increases in bacteria counts have been observed during beach monitoring. No Enterococci samples collected at North Beach from 2004 to 2007 have exceeded the water quality standard. This observation suggests that large bacteria sources, associated with storm events or dry weather conditions, do not appear to be having an adverse impact.
- Wildlife – Seagulls, plovers, ducks and other wildlife have been observed at North Beach.
- Septic systems – Septic systems are not believed to be present in the contributing watershed.
- People at the beach – Many people visit these beaches each year. Thus, it is likely that beach visitors are sources of bacteria.
- Pets – Dogs are not allowed on North Beach.

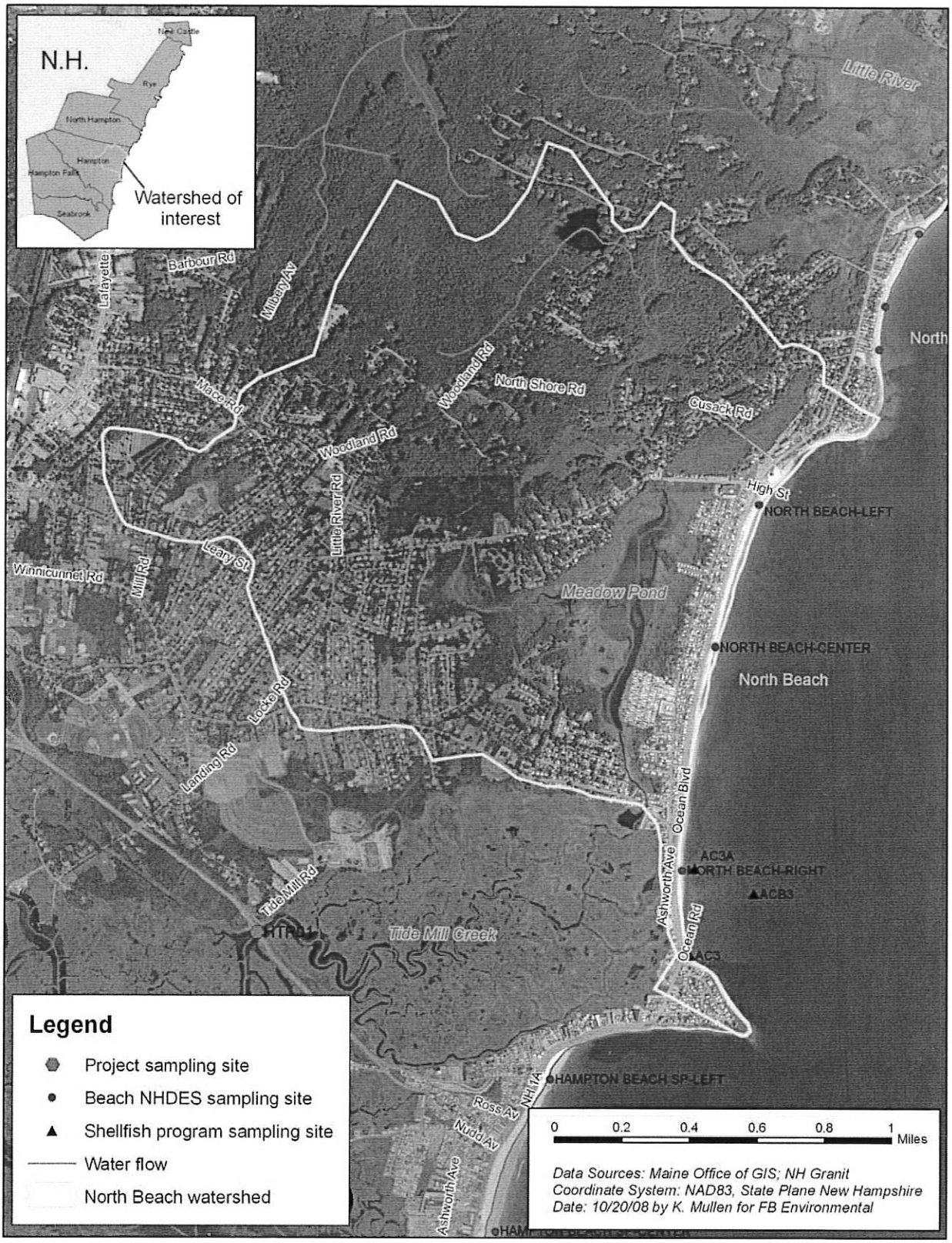

Figure 14. North Beach Watersheds with Bacteria Sampling Locations Indicated.

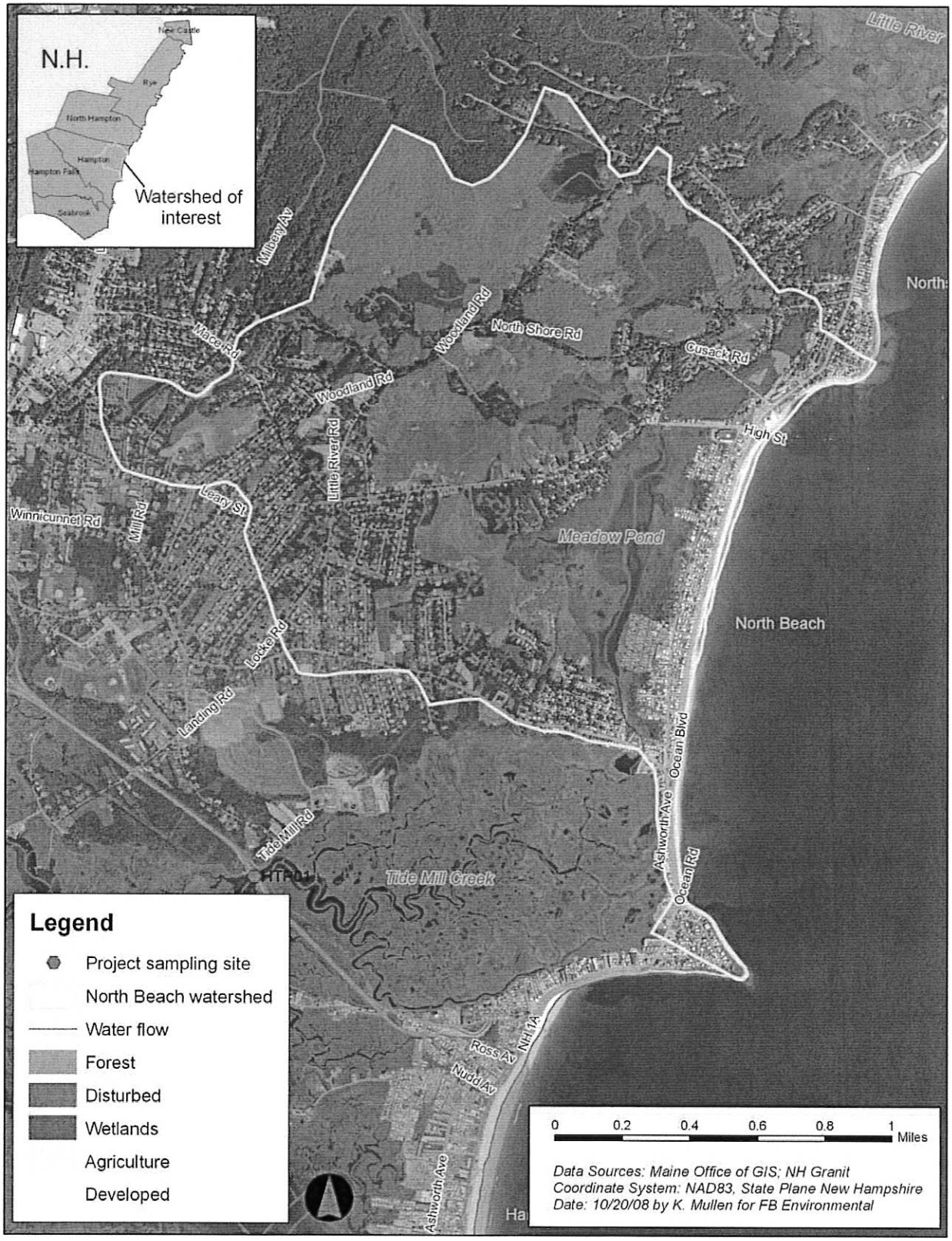

Figure 15. North Beach Watersheds with Land Cover Indicated.

- Sand and Beach Wrack – Wet sand and seaweed have been sampled as part of MST investigations at several New Hampshire coastal beaches (Jones 2008). Beach wrack and underlying sand were consistently observed to have very high Enterococci counts and appear to be significant sources of bacteria.
- Remotely located wastewater discharges and other remote sources – Bacterial loads may be carried by the coastal currents to these beaches from a nearby WWFT or other sources. The shellfish program measures bacteria at significant levels at distances of over 1000 feet from shore. As a result, we know that bacteria are present in the currents that travel past the beach.
- Boats – Vessels situated both immediately adjacent and remotely are potential sources of bacteria to the beach, although the magnitude of this potential source is largely unknown..

2.8 Seabrook Harbor, Seabrook Beach, and Hampton Beach Watersheds

Seabrook Harbor, Seabrook Beach, Hampton Beach and their contributing watershed are situated primarily in Hampton and Seabrook, as shown in Figure 16. The watershed also extends into parts of Hampton Falls, Kensington, Exeter, and Stratham (Figure 1). Figure 16 also shows the locations of bacteria sampling locations. The contributing watershed (Figure 17) covers 46 square miles and is very large compared to the other study area watersheds. The Hampton/Seabrook area is highly developed with very dense residential and commercial development along the seashore. Seabrook Harbor is lies landward of the seashore and drains a network of tidal creeks. Several of these creeks have historically been observed to carry high bacteria counts and have been investigated. Several major investigations have been conducted in this watershed including the following:

- Nash, C., M. Wood. 2006. Sanitary Report for Hampton/Seabrook Harbor, Shellfish Program, New Hampshire. NH Department of Environmental Services. Concord, NH. Document R-WD-07-27. December 2006
- Jones. S.H. and C. Edwards. 2007. Management of Non-Human Sources of Bacterial Pollution in Hampton/Seabrook Harbor. Final report. New Hampshire Department of Environmental Services, Concord, NH.
- Jones. S.H., N. Landry and C. Edwards. 2005. Tracking Bacterial Pollution Sources in the Mill Creek Watershed, Seabrook, NH. A Final Report to the U.S. Environmental Protection Agency. New Hampshire Department of Environmental Services, Concord, NH.
- Trowbridge, P. 2004. Total Maximum Daily Load (TMDL) Study for bacteria in Hampton/Seabrook Harbor. NHDES-R-WD-03-32. New Hampshire Department of Environmental Services, Concord, NH.

The reader is encouraged to review the referenced documents to obtain a description of known and potential bacteria sources in this watershed.

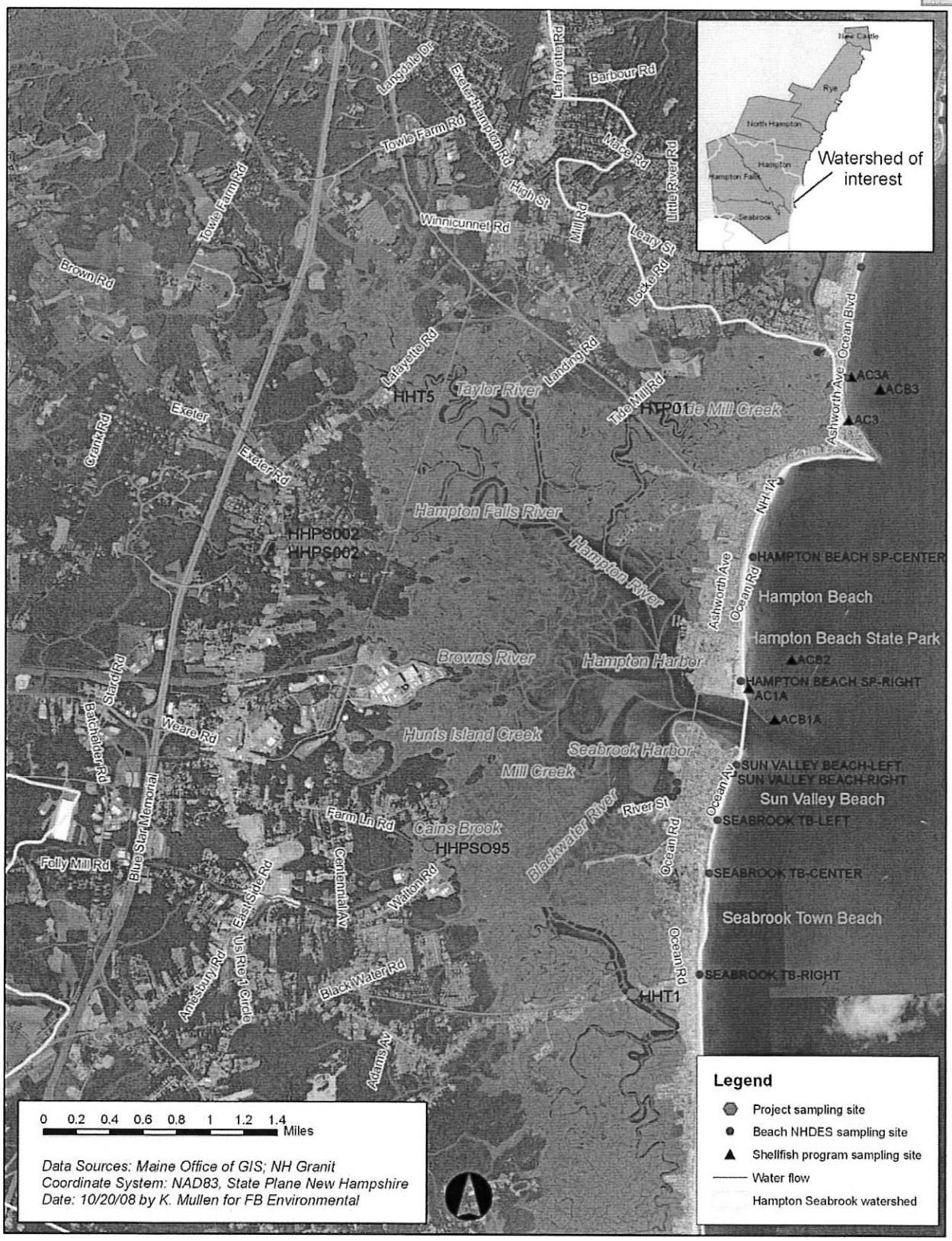

Figure 16. Seabrook and Hampton Area Beach Watersheds with Bacteria Sampling Locations Indicated.

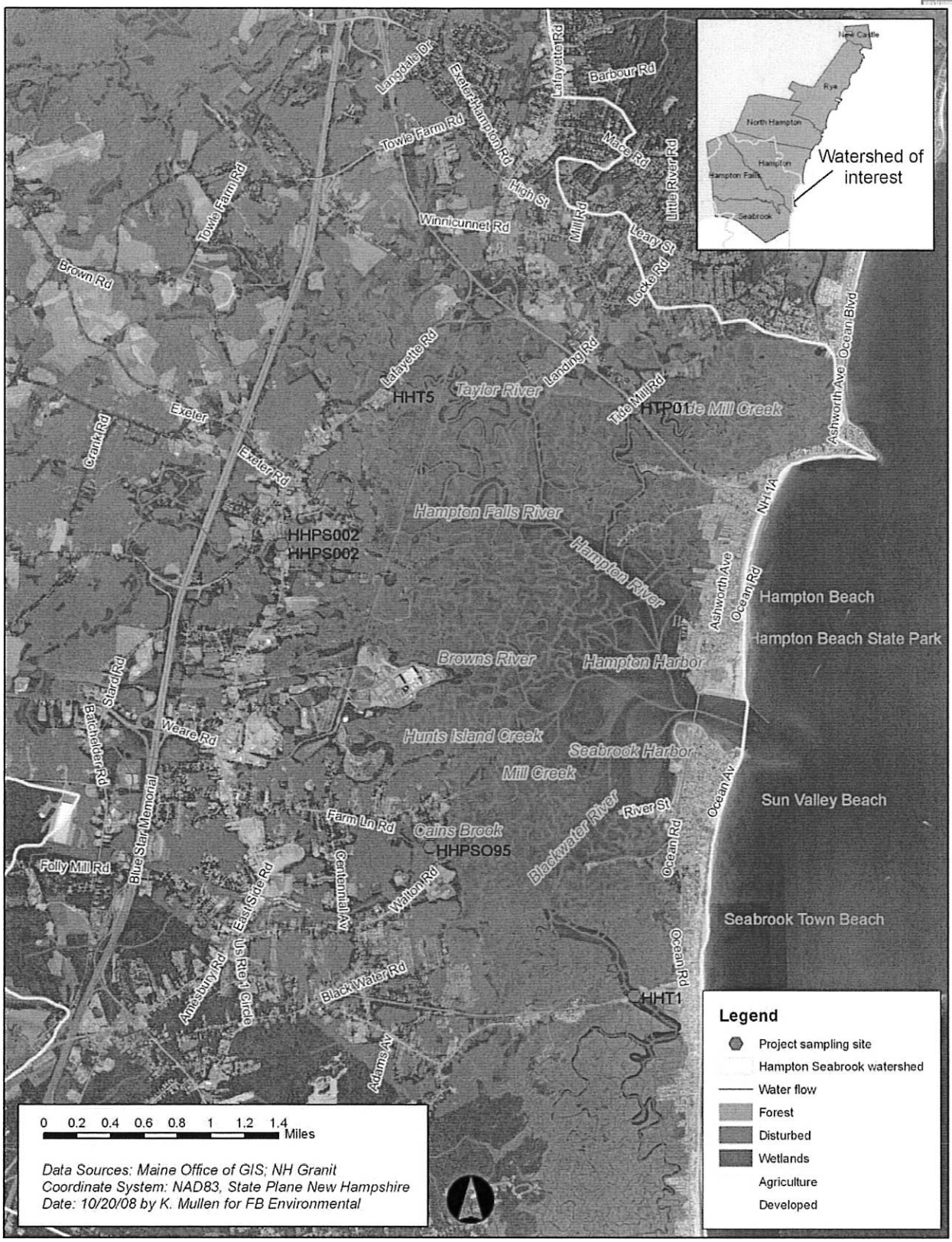

Figure 17. Seabrook and Hampton Area Beach Watersheds with Land Cover Indicated.

3.0 References (also see Appendix A)

Annual Beach Program monitoring program reports, Shellfish Program reports, and Special Investigation Reports were reviewed in preparing this summary. A list of these reports is organized by watershed and provided in Appendix A. Several sources, listed below, were particularly useful and frequently referenced:

Jones, S. 2008. *Summary of Fecal-Borne Pollution Sources and Bacterial Data in Nine New Hampshire Coastal Beach Watersheds.* September 8, 2008. Attached as Appendix B.

Nash, C., A. Chapman. 2000. *Sanitary Survey Report for the Altantic Coast, Gulf of Maine, New Hampshire.* NH Department of Environmental Services. Concord, NH. Document R-WD-01-03. December 2000.

NHDES 2008. Excel spreadsheet table entitled " Source info by Beach" and containing a tabulation of dog ordinances and sanitary system information for each beach.

Appendix A

Bibliography of Available Reports
New Hampshire Beach Bacteria Modeling Project
August 28, 2008

The bibliography below provides a compilation of reports related to bacteria at New Hamphire beaches and associated watersheds. Reports are organized by nine New Hampshire coastal watersheds, arranged from north to south as follows:

1. New Castle Town Beach watershed
2. Wallis Sands Beach and Pirates Cove Beach watershed
3. Foss Beach watershed
4. Jenness and Cable Beach watershed
5. Sawyer Beach watershed
6. Bass Beach watershed
7. State Beach and Northside Park Beach watershed
8. North Beach watershed
9. Seabrook Harbor, Seabrook Beach and Hampton Beach watershed

Following the watershed summaries below, general reports on New Hamphire beaches (but not specifically for any one beach) and general reports on bacterial impairment are listed.

New Castle Town Beach Watershed

- *Size*: 48 acres (.08 square miles)
- *Town*: New Castle
- *Tributaries*: none; pipe outfall (north)

Annual Beach Bacteria Monitoring Reports

Merrifield, C., A. Carlson. 2008. *New Castle Town Beach, New Castle: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *New Castle Town Beach, New Castle: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *New Castle Town Beach, New Castle: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *New Castle Town Beach, New Castle: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Other Reports

Jones, S. H. 2007. *Microbial Pollution Source Tracking at New Castle Beach.* Final Report to the New Hampshire Department of Environmental Services, Concord, NH.

Wallis Sands and Pirates Cove Beach Watershed

- *Size:* 2.3 square miles
- *Town*: Rye
- *Tributaries*: Parsons Creek (south)

Annual Beach Bacteria Monitoring Reports

Wallis Sands Beach

Merrifield, C., A. Carlson. 2008. *Wallis Sands State Park, Rye: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Wallis Sands State Park, Rye: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Wallis Sands State Park, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Pirates Cove Beach

Merrifield, C., A. Carlson. 2008. *Pirates Cove Beach, Rye: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Pirates Cove Beach, Rye: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Pirates Cove Beach, Rye: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Pirates Cove Beach, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Foss Beach Watershed

- *Size*: 19 acres (.03 square miles)
- *Town*: Rye
- *Tributaries*: Rye Harbor (south)

Annual Beach Bacteria Monitoring Reports

Merrifield, C., A. Carlson. 2008. *Foss Beach, Rye Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Foss Beach, Rye: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Foss Beach, Rye: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Foss Beach, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Jenness and Cable Beach Watershed

- *Size*: 118 acres (0.2 square miles)
- *Town*: Rye
- *Tributaries*: Eel Pond outlet (south)

Annual Beach Bacteria Monitoring Reports

Cable Beach

Merrifield, C., A. Carlson. 2008. *Cable Beach, Rye Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Cable Beach, Rye: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Cable Beach, Rye: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Cable Beach, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Jenness Beach

Merrifield, C., A. Carlson. 2008. *Jenness Beach State Park, Rye: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Jenness Beach, Rye: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Jenness Beach State Park, Rye: Beach Water Quality Report Summer 2005*. Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Jenness Beach State Park, Rye: Beach Water Quality Report Summer 2004*. Report for the New Hampshire Department of Environmental Services, Concord, NH.

Sawyer Beach

- 2.5 square miles
- *Size*: 19 acres (.03 square miles)
- *Town*: Rye
- *Tributaries*: Eel Pond outlet (south)

Annual Beach Bacteria Monitoring Reports

Merrifield, C., A. Carlson. 2008. *Sawyer Beach, Rye: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Sawyer Beach, Rye: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Sawyer Beach, Rye: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Sawyer Beach, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bass Beach

- *Size:* 1.3 square miles
- *Town:* North Hampton
- *Tributaries*: Chapel Brook (south)

Annual Beach Bacteria Monitoring Reports

Merrifield, C., A. Carlson. 2008. *Bass Beach, North Hampton Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Bass Beach, North Hampton: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Bass Beach, North Hampton: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Bass Beach, North Hampton: Beach Water Quality Report Summer 2004*. Report for the New Hampshire Department of Environmental Services, Concord, NH.

Other Reports

Carlson, A., S. Sumner, J. Connor. 2008. *Chapel Brook Special Study North Hampton, NH May to September 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

State Beach and Northside Park

- *Size*: 7.7 square miles
- *Town*: North Hampton
- *Tributaries*: Little River (north)

Annual Beach Bacteria Monitoring Reports

State Beach

Merrifield, C., A. Carlson. 2008. *State Beach, North Hampton: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *State Beach, North Hampton: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *State Beach, North Hampton: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *State Beach, North Hampton: Beach Water Quality Report Summer 2004*. Report for the New Hampshire Department of Environmental Services, Concord, NH.

Northside Park Beach

Merrifield, C., A. Carlson. 2008. *Northside Park, Hampton: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Northside Park, Hampton: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Northside Park, Hampton: Beach Water Quality Report Summer 2005*. Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Northside Park, Hampton: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

North Beach

- *Size*: 2.5 square miles
- *Town*: Hampton
- *Tributaries*: none

Annual Beach Bacteria Monitoring Reports

Merrifield, C., A. Carlson. 2008. *North Beach, Hampton: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *North Beach, Hampton: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *North Beach, Hampton: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *North Beach, Hampton: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH

Seabrook Harbor, Seabrook Beach and Hampton Beach

- *Size*: 46 square miles
- *Town*: Hampton and Seabrook
- *Tributaries*: Mill Creek, Cains Brook, and several others by way of Seabrook Harbor

Annual Beach Bacteria Monitoring Reports

Hampton Beach State Park Flagship Beach

Merrifield, C., A. Carlson. 2008. *Hampton Beach State Park Flagship Beach Report 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2004. *Hampton Beach State Park Flagship Beach Report.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2005. *Hampton Beach State Park Flagship Beach Report.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Hampton Beach State Park Flagship Beach Report.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Hampton Harbor Beach

Merrifield, C., A. Carlson. 2008. *Hampton Harbor Beach, Hampton Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Seabrook Harbor Beach

Merrifield, C., A. Carlson. 2008. *Seabrook Harbor Beach, Seabrook: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Seabrook Harbor Beach, Seabrook: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

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Carlson, A., S. Sumner. 2005. *Seabrook Harbor Beach, Seabrook: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Seabrook Town Beach

Merrifield, C., A. Carlson. 2008. *Seabrook Town Beach, Seabrook: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Seabrook Town Beach, Seabrook: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Seabrook Town Beach, Seabrook: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Seabrook Town Beach, Seabrook: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Sun Valley Beach

Merrifield, C., A. Carlson. 2008. *Sun Valley Beach, Hampton: Water Quality Report Summer 2007.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bouthiette, E., S. Sumner. 2007. *Sun Valley Beach, Hampton: Beach Water Quality Report Summer 2006.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

New Hampshire Department of Environmental Services: Beach Inspection Program. 2006. *Sun Valley Beach, Hampton: Beach Water Quality Report Summer 2005.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Sun Valley Beach, Hampton: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Other Reports

Jones. S.H. and C. Edwards. 2007. *Management of Non-Human Sources of Bacterial Pollution in Hampton/Seabrook Harbor. Final report.* New Hampshire Department of Environmental Services, Concord, NH.

Jones. S.H., N. Landry and C. Edwards. 2005. *Tracking Bacterial Pollution Sources in the Mill Creek Watershed, Seabrook, NH.* A Final Report to the U.S. Environmental Protection Agency. New Hampshire Department of Environmental Services, Concord, NH.

Trowbridge, P. 2004. *Total Maximum Daily Load (TMDL) Study for bacteria in Hampton/Seabrook Harbor.* NHDES-R-WD-03-32. New Hampshire Department of Environmental Services, Concord, NH.

Nolan, S., S.H. Jones and N. Landry. 2004. *Evaluating the stormwater treatment performance of AbTech industries Smart Sponge ® Plus in Seabrook, New Hampshire*. Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H. and N. Landry. 2003. *Tracking bacterial pollution sources in Hampton Harbor*. Final report. New Hampshire Estuaries Project, Portsmouth, NH.

Other New Hampshire Beach Area Reports

Jones, S.H., S. Sumner, N. Landry and J. Connor. 2006. *Pollution source tracking at New Hampshire (USA) ocean beaches.* Pp. 107-114, In, Micallef, A., A. Vassallo and M. Cassar (Eds.) Proceedings of the Second International Conference on the Management of Coastal Recreational Resources-Beaches, Yachting and Coastal Ecotourism. 25-27 October, 2006. Gozo, Malta. Euro-Mediterranean Centre on Insular Coastal Dynamics, Foundation for International Studies, Valletta, Malta.

Jones, S.H., S. Summer and J. Connor. 2004. *Identify and Mitigate Bacterial Sources at Public Beaches Using Microbial Source Tracking.* Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones SH. 2008. *Environmental Sources of Microbial Contaminants in Shellfish and Their Public Health Significance.* J. Foodservice 19:238-244.

Jones, S.H. 2003. *Tracking Bacterial Pollution Sources in Stormwater Pipes.* Final Report. New Hampshire Estuaries Project, Portsmouth, NH.

Trowbridge, P. 2006. *Total Maximum Daily Load (TMDL) Study for bacteria in Little Harbor.* NHDES-R-WD-05-25. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H. 2004. *Microbial Source Tracking in Little Harbor and Tributaries using Escherichia coli Ribotyping.* Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H. and N. Landry. 2004. *Tracking Bacterial Pollution Sources in Little Harbor and the New Hampshire Atlantic Coast Tributaries.* Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H. 1999. *Public health significance of storm water-borne microorganisms*. Final report. NH Department of Environmental Services, Concord, NH. 10 pp.

Bolster, C.H., J. M. Bromley, and S. H. Jones. 2005. *Recovery of Chlorine-Exposed Escherichia coli in Estuarine Microcosms.* Environ. Sci. Technol. 39: 3083-3089.

Jones. S.H., N. Landry and R. Ruszenas. 2006 *Tracking Bacterial Pollution Sources in the Berry Brook Watershed.* A Final Report to the U.S. Environmental Protection Agency. New Hampshire Department of Environmental Services, Concord, NH.

Carlson, A., S. Sumner. 2005. *Star Island Beach, Rye: Beach Water Quality Report Summer 2004.* Report for the New Hampshire Department of Environmental Services, Concord, NH.

Bacteria-related reports

Chaopeng, S. et. al. 2008. *Evaluating Bacteriophage P22 as a Tracer in a Complex Surface Water System: The Grand River, Michigan.* Environ. Sci. Technol. 42,2426-2431.

Clean Beaches Council. 2005. *2005 State of the Beach Report: Bacteria and Sand, A National Call to Action.* Report for the Clean Beaches Council www.cleanbeaches.org.

Dorfman, M., N. Stoner. 2007. *Testing the Waters: A Guide to Water Quality at Vacation Beaches* 17th edition. Report for the Natural Resources Defense Council.

Hartel et al. 2007. *Improving Fluorometry as a Source Tracking Method to Detect Human Fecal Contamination.* Estuaries and Coasts Vol. 30, No. 3, p. 551-561.

Ishii, S., K. P. Meyer, M. J. Sadowsky. 2007. *Relationship Between Phylogenetic Groups, Genotypic Clusters, and Virulence Gene Profiles of Escherichia coli Strains from Diverse Human and Animal Sources.* Applied Environmental Microbiology, Vol. 73, No. 18, p. 5703-5710.

Pond, K. 2005. *Water Recreation and Disease: Plausibility of Associated Infections: Acute Effects, Sequelae and Mortality.* A report for the World Health Organization.

Sampson, R.W. et al. 2006. *The Effects of Rainfall on Escherichia coli and Total Coliform Levels at 15 Lake Superior Recreational Beaches.* Water Resources Management 20: 151-159.

World Health Organization. 2003. *Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Freshwaters.* A report for the World Health Organization.

World Health Organization. 2000. *Who Monitoring Bathing Waters- A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes.* A report for the World Health Organization

Wymer, L. J., K. P. Brenner, J. W. Martinson, W. R. Schaub, S. A. Schaub, A. P, Dufour. 2005. *The EMPACT Beaches Project: Results from a Study on Microbiological Monitoring in Recreational Waters.* Report for the U.S. Environmental Protection Agency, Office of Research and Development, National Exposure Research laboratory, Cincinnati, OH.

Moore, D. F., J. A. Guzman, C. McGee. 2008. *Species Distribution and Antimicrobial Resistance of Enterococci Isolated from Surface and Ocean Water.* Journal of Applied Microbiology ISSN 1364-5072.

Appendix B

Summary of Fecal-Borne Pollution Sources and Bacterial Data in Nine New Hampshire Coastal Beach Watersheds

Stephen Jones

September 8, 2008

INTRODUCTION

The NHDES has delineated nine watersheds bordering Atlantic Coast beaches that include Tier 1-Impaired, Tier 1, Tier, 2 and Tier 3 beaches, based on the NHDES Beach Program Risk-Based evaluation ranking system. There exists some information on actual and potential sources of fecal-borne bacterial contamination in these watersheds, and there are several aspects of water contamination that are common to most of these beaches. One is the conveyance of elevated bacterial loading during rainstorm runoff events. The focus of the present report is to inform storm water modeling efforts for the targeted watersheds by summarizing what is known about concentrations and sources of fecal indicator bacteria and the dynamics of bacterial concentrations relative to environmental, human and other influences.

This report is organized by watershed, with brief summaries of existing knowledge, data and sources of information for each of the nine watersheds. Pollution sources that are considered to be "identified" are based on the ribotyping analysis conducted as part of the MST studies, whereas those considered as "potential" sources are based on observations of the animal presence or its feces on or near the beach. In general, pollution sources as discussed here are humans or animal species, though other types of sources like wastewater effluent, boats, beach sand, and others are also noted.

WATERSHED: New Castle Town Beach

MST REPORTS: (1)

Jones, S.H. 2008. Microbial Pollution Source Tracking at New Castle Beach. Final report. New Hampshire Department of Environmental Services, Concord, NH.

NHDES BEACH REPORTS: (5)- 2003, 2004, 2005, 2006, 2007

OTHER INFORMATION: None

All of the studies at this beach have used four sampling sites: three along the beach and one at a pipe that discharges into the small rocky beach area north of the recognized town beach area. The pipe discharges from what appears to be a small wet detention pond in the residential area adjacent to the beach. The pond watershed, however, has yet to be delineated. Sampling in the pond showed elevated levels of PAHs and asbestos above State standards, as reported in the 2004 Beach Report (Carlson and Sumner 2005).

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites ranged from a total of 42 to 101 samples per year from 2004 to 2007, and at the pipe from three to 13 samples per year. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml at least one time each year from 2004 to 2007.

Identified Sources of Fecal Contamination: *sea gulls, cormorants, ducks, geese, dogs, deer, unidentified wild animal, rabbits, coyotes, raccoons, wastewater (human)*

The overall level of source species identification (48%) in the MST study (Jones 2008) conducted in 2006 was relatively low, suggesting the possibility that the some significant source species were not included in the analysis. The most commonly identified source species was sea gull (14 isolates), followed by unidentified wild animals (7), deer (6), wastewater/human (4), dog and unidentified livestock (3), rabbit, duck and goose (2), with single isolates identified as coming from coyote and raccoon. The number of different species identified as sources at each site was seven for the pipe, six for the left side of the beach (NWCLF), three for the center of the beach (NWCCR) and five for right side of the beach (NWCRT) (Table 8). The number of isolates identified for each source species was relatively even for the beach sites, but was dominated by sea gulls (7/19 isolates) at the pipe. Sea gulls were the only source species identified at each site; dog and unidentified wild animals were identified at three sites, while several species were identified at two sites (wastewater, deer, and duck). For all ribotyped isolates, and according to type of source species identified, birds were the most prevalent (20%) source species type, followed by wild animals (18%), humans (4%), and pets and livestock (3%).

Potential Sources of Fecal Contamination: *sea gulls, cormorants, dogs, deer, unidentified wild animal*

The NHDES Beach Reports for New Castle Town Beach included observations of the presence of animals on or near the beach during sampling visits. The most common were birds, particularly sea gulls and cormorants, though ducks were also observed, and all were observed in low numbers on each occasion. The Beach reports also included observations of turbid water and suspected sand re-suspension occurring, especially at the 'right' sample site, and suggested re-suspended sand may also be a source of bacterial contamination.

As part of the MST study (Jones 2008), NHDES Beach Program personnel collected feces from around the beach watershed to be used as a local source species database. The feces were identified as coming from sea gulls, dogs, deer, and a sample from an unidentified wild animal, containing *E. coli* concentrations of 1.1×10^2 to 2.8×10^{10}.

Evidence Of Storm Event Runoff Influence: YES

Jones (2008) showed that the highest recorded levels of *E. coli* occurred during the one wet weather sampling event at the pipe and at the 'right' beach sampling site, which is most distant from the pipe. *E. coli* levels exceeded the state standard (104 cfu/100 ml) only in these samples, and on all other occasions and sites levels were much lower.

WATERSHED: Wallis Sands and Pirates Cove

MST REPORTS: (2)

Jones, S.H. and N. Landry. 2004. Tracking Bacterial Pollution Sources in Little Harbor and the New Hampshire Atlantic Coast Tributaries. Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H., S. Summer and J. Connor. 2004. Identify and Mitigate Bacterial Sources at Public Beaches Using Microbial Source Tracking. . Final report. New Hampshire Department of Environmental Services, Concord, NH.

NHDES BEACH REPORTS: (8)- 2004, 2005, 2006, 2007 for each beach

OTHER INFORMATION: (1)

Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

The annual investigations by NHDES at this beach have used three sampling sites along Wallis Sands beach, three sites along Pirates Cove beach and one at Parsons Creek where it discharges into the southern tip of the Pirates Cove beach area. Parsons Creek drains the marsh area behind these two beaches, and the NHDES sample site designation is ACPS 5, the same site and designation used in the two referenced MST studies.

Bacterial Concentrations in Water Samples:

Sampling at the three Wallis Sands beach sites ranged from a total of 39 to 45 samples per year from 2004 to 2007, from 42 to 45 at the three Pirates Cove beach sites, and at Parsons Creek from eight to 13 samples per year. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml at least one time each year from 2004 to 2007 in Parsons Creek, and on two consecutive dates during July 2006 at Pirates Cove beach.

The NH Shellfish Program also sampled at Wallis Sands and Pirates Cove beaches during 2005 (Nash and Wood 2006). Three monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from 1.8 to 13 MPN/100 ml at Wallis Sands and from <2 to 170 MPN/100 ml at Pirates Cove; the high value was recorded in June.

Identified Sources of Fecal Contamination: *humans, otters, sea gulls, deer, cat, fox, raccoon, cow, horse, sparrow*

Parsons Creek is the main source of contamination for Pirates Cove beach. *E. coli* concentrations in seven water samples collected from ACPS 5 during dry weather from June 2001 to September 2002 ranged from 34 to 200 cfu/100 ml (Jones and Landry 2004). The date on which the highest *E. coli* concentration occurred was considered a wet weather date because of the ~1.0 in of rain that fell in the two days prior to sampling. *E. coli* isolates from five water samples were ribotyped and source species identified for 16

of 23 isolates, a success rate of 70%. By far the most significant source was humans (10/16 isolates), followed by otter (2) then 1 isolate each for cat, deer, fox, and sea gull. For all ribotyped isolates, and according to type of source species identified, humans were the most prevalent (20%) source species type, followed by wild animals (17%), then pets and birds (4% each).

NHDES conducted a follow-up MST investigation at Parsons Creek, focusing on two storm events during August and September 2003 (Jones et al. 2004). *E. coli* concentrations ranged from 80 to 600 cfu/100 ml, which is higher compared to the previous MST study conducted during mostly dry weather. *E. coli* isolates from four water samples collected during post-peak or end of storm conditions were ribotyped and source species identified for 21 of 35 isolates, a success rate of 60%. The most significant source was humans (6 isolates), followed by deer (5), fox and raccoon (3), cow (2) then 1 isolate each for horse and sparrow. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (31%) source species type, followed by humans (17%), then livestock (9%) and birds (3% each).

Potential Sources of Fecal Contamination: *sea gulls, dogs, WWTF effluent, bathers, seaweed, red fox, otters, ducks, deer, skunks, raccoons*

The NHDES Beach Reports for Wallis Sands beach included observations of the presence of a few birds on or near the beach during sampling visits. The fact that the WWTF outfall pipe discharges to the beach area is also a potential source, though the degree of treatment and record of no detection of bacteria in the effluent mitigates that concern. The high number and density of bathers, and the high volume of seaweed that is frequently present at this beach are also potential sources of contamination. At Pirates Cove beach, reports of sea gulls, terns, dogs and dog feces were reported.

As part of the MST study conducted during 2002 (Jones and Landry 2004), NHDES Beach Program personnel collected feces from the Parsons Creek watershed to be included as local sources in the source species databases. The feces were identified as coming from red fox, otter, duck, deer, skunk and raccoon.

Evidence Of Storm Event Runoff Influence: YES

The results from the two MST studies provide an opportunity to compare differences for wet compared to dry weather conditions, even though the studies were conducted in different time periods. The geometric mean *E. coli* concentration was much higher in Parsons Creek during wet (273/100 ml) compared to dry (51/100 ml) weather conditions. There was also an apparent difference in occurrence for some types of sources species, with a higher incidence of livestock sources during wet weather and a higher occurrence of human sources during dry weather.

WATERSHED: Foss Beach

MST REPORTS: None

NHDES BEACH REPORTS: (4)- 2004, 2005, 2006, 2007

OTHER INFORMATION: None

All of the studies at this beach have used three sampling sites along the beach.

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites ranged from a total of 21 to 42 samples per year from 2004 to 2007. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml once in August 2004.

Identified Sources of Fecal Contamination: *Not kknown*

Potential Sources of Fecal Contamination: *sea gulls, dogs, crows*

The NHDES Beach Reports for New Castle Town Beach included observations of the presence of animals on or near the beach during sampling visits. The most common were sea gulls and dogs.

Evidence Of Storm Event Runoff Influence: YES

The one sample in August 2004 that exceeded the State standard occurred on a day when ~4 inches of rain fell in the previous three days, suggesting runoff contributed to the elevated bacterial concentrations.

WATERSHED: Jenness and Cable Beaches

MST REPORTS: None

NHDES BEACH REPORTS: (8)- 2004, 2005, 2006*, 2007 for each beach
*The file on the NHDES Beach Program website for the Jenness Beach 2006 report could not be opened

OTHER INFORMATION: None

All of the studies at this beach have used three sampling sites along the beach.

Bacterial Concentrations in Water Samples:

Sampling at the three Cable Beach sites ranged from a total of 42 to 81 samples per year from 2004 to 2007. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml twice in 2004, and in single events in 2006 and 2007.

Sampling at the three Jenness Beach sites ranged from a total of 42 to 45 samples per year from 2004 to 2007, although the 2006 report could not be opened from the Beach Program web site. Enterococci concentrations did not exceed the state standard of 104 cfu/100 ml, although elevated levels were observed on July 12, 2006 when there was an exceedence at Cable Beach.

Identified Sources of Fecal Contamination: *Not known*

Potential Sources of Fecal Contamination: *sea gulls, dogs, plovers, terns, horses*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common were sea gulls and dogs, with plovers observed at both beaches. Terns were also reported at Jenness Beach, and horse feces was observed once at Cable Beach.

Evidence Of Storm Event Runoff Influence: YES

The sample in July 2006 that exceeded the State standard at Cable Beach occurred on a day prior to which >1.5 inches of rain fell. The report suggested runoff contributed to the elevated bacterial concentrations at both beaches.

WATERSHED: Sawyer Beach

MST REPORTS: None

NHDES BEACH REPORTS: (4)- 2004, 2005, 2006, 2007*
*The report on the NHDES Beach Program website was incomplete.

OTHER INFORMATION: (1)
Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

All of the studies at this beach have used three sampling sites along the beach and an added site at the mouth of the beach outlet of Eel Pond.

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites ranged from a total of 39 to 84 samples per year from 2004 to 2007, and from 12 to 19 per year at Eel Pond. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml twice in 2004 and 2006, and once in 2007 at the beach sites, while Eel Pond samples exceeded the State standard each year at least twice, though this information was not available in the incomplete report for 2007.

The NH Shellfish Program also sampled at Sawyer Beach during 2005 (Nash and Wood 2006). Four monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from <2 to 17 MPN/100 ml.

Identified Sources of Fecal Contamination: *Not known*

Potential Sources of Fecal Contamination: *sea gulls, dogs, plovers, rabbits, ducks, raccoons*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common were the highly numerous sea gulls, especially in Eel Pond. Dogs and plovers were also observed, and a dying seal was on the beach one day in 2005. Other waterfowl frequent Eel Pond, and these are also potential sources of contamination to Sawyer Beach.

As part of the MST study conducted during 2002 (Jones and Landry 2004), NHDES Beach Program personnel collected feces from Eel Pond to be included as local sources in the source species databases. The feces were identified as coming from rabbit, duck and raccoon.

Evidence Of Storm Event Runoff Influence: YES

Sample with elevated enterococci levels in 2006 and 2007 were described in the beach Reports as probably due to rainfall and associated runoff, especially as it affected Eel Pond. Elevated levels at the beach during rainfall-affected conditions were also coincident with elevated enterococci levels at the Eel Pond outlet site.

WATERSHED: Bass Beach

MST REPORTS: (2)

Jones, S.H. and N. Landry. 2004. Tracking Bacterial Pollution Sources in Little Harbor and the New Hampshire Atlantic Coast Tributaries. Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H., S. Summer and J. Connor. 2004. Identify and Mitigate Bacterial Sources at Public Beaches Using Microbial Source Tracking. . Final report. New Hampshire Department of Environmental Services, Concord, NH.

NHDES BEACH REPORTS: (4)- 2004, 2005, 2006, 2007

OTHER INFORMATION: (2)

NHDES. 2008. Chapel Brook Special Study North Hampton, NH: May to September 2006. R-WD-07-45. NH Department of Environmental services, Concord, NH.

Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

The annual investigations by NHDES at this beach have used three sampling sites along Bass Beach, one at Bass Beach Brook at the northern part of the beach and one at Chapel Creek where it discharges into the southern tip of the beach area. Bass Beach Brook drains the Bass beach Marsh area behind the northern part of the beach, and the NHDES sample site designation is ACPS 10, the same site and designation used in the two referenced MST studies. Chapel Brook drains the Philbrick Pond and Marsh, Chapel Pond and smaller associated tributaries behind much of the beach. The NHDES sample site designation is ACPS 11, the same site and designation used in the two referenced MST studies for Chapel Brook.

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites ranged from a total of 39 to 84 samples per year from 2004 to 2007, once at Bass Beach Brook in 2005, and from 7 to 21 per year at Chapel Brook. Enterococci concentrations at the three beach sample sites exceeded the state standard of 104 cfu/100 ml once in both 2004 and 2006. Chapel Brook samples exceeded the State standard at least twice and up to eight times each year, and the one sample collected from Bass Beach brook also exceeded the standard.

The special study at Chapel Brook in 2005 involved sampling from five stations in the Chapel Brook watershed from May to September 2005 (NHDES 2008). Sampling at each site occurred from a minimum of three to 14 times, with a total of 52 samples collected from the watershed. *E. coli* concentrations ranged from 9 to 5100 cfu/100 ml. The "Pond" site had consistently high *E. coli* levels and had the highest concentration (5100 cfu/100 ml). The other four sites had varying levels of *E. coli* present.

The NH Shellfish Program also sampled at Bass Beach Brook (ACPS 10) during 2005 (Nash and Wood 2006). Four monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from <2 to 6.8 MPN/100 ml.

Identified Sources of Fecal Contamination: *humans, geese, ducks, sea gulls, raccoons, coyotes, deer, skunks, otters, rabbits, cows, sheep and dogs*

Chapel and Bass Beach brooks are the main sources of bacterial contamination for Bass Beach.

E. coli concentrations in six water samples collected from Bass Beach Brook (ACPS 10) during dry weather from June 2001 to September 2002 ranged from 30 to 360 cfu/100 ml (Jones and Landry 2004). *E. coli* isolates from four water samples were ribotyped and source species were identified for 9 of 18 isolates, a success rate of 50%. There was no most significant source as single isolates were identified for raccoon, cow, coyote, dog, human, otter, sea gull, sheep and skunk. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (22%) source species type, followed by livestock (11%), then pets, humans and birds (6% each).

At Chapel Brook (ACPS 11), *E. coli* concentrations in six water samples ranged from 6 to 380 cfu/100 ml (Jones and Landry 2004). *E. coli* isolates from five water samples were ribotyped and were source species identified for 8 of 17 isolates, a success rate of 47%. There was no truly significant source as two isolates were identified as being from both geese and rabbits, while single isolates were identified for deer, ducks, humans and otters. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (24%) source species type, followed by birds (18%) and humans (5%).

NHDES conducted a follow-up MST investigation at Chapel Brook, focusing on two storm events during August and September 2003 (Jones et al. 2004). *E. coli* concentrations ranged from 370 to 1410 cfu/100 ml, which is much higher compared to the previous MST study conducted during mostly dry weather. *E. coli* isolates from four water samples collected during peak, post-peak or end of storm conditions were ribotyped and source species identified for 21 of 37 isolates, a success rate of 57%. The most significant source was humans (7 isolates), followed by geese and raccoons (4), coyotes and deer (2), then 1 isolate each for cows and otters. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (24%) source species type, followed by humans (19%), then birds (11%) and livestock (3%).

Potential Sources of Fecal Contamination: *sea gulls, dogs, plovers, septic system, seaweed, otter, deer*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common were the highly numerous dogs, sea gulls and terns. There was also a suspected failed septic system on

Bass Beach Brook in 2004, and turbid water combined with large amounts of seaweed were also considered as potential sources. There is also a concern about the impacts of marsh restorations and their apparent negative impact on indicator bacteria levels in the marsh creeks.

As part of the MST study conducted during 2002 (Jones and Landry 2004), NHDES Beach Program personnel collected feces from Bass Beach Brook (ACPS 10) to be included as local sources in the source species databases. The feces were identified as coming from otter and deer.

Evidence Of Storm Event Runoff Influence: YES

Samples with elevated enterococci levels were described in the Beach Reports as probably due to rainfall and associated runoff, especially as it affected Chapel Brook. Elevated levels at the beach during rainfall-affected conditions were often coincident with elevated enterococci levels at the Chapel Brook outlet site.

The results from the two MST studies provide an opportunity to compare differences for wet compared to dry weather conditions, even though the studies were conducted in different time periods. The geometric mean *E. coli* concentration was much higher during wet (784/100 ml) compared to dry (18/100 ml) weather conditions. There was also an apparent difference in occurrence for some types of sources species, with a higher incidence of livestock sources during wet weather and a higher occurrence of human sources during dry weather.

WATERSHED: State Beach and Northside Park Beach

MST REPORTS: (2)

Jones, S.H. and N. Landry. 2004. Tracking Bacterial Pollution Sources in Little Harbor and the New Hampshire Atlantic Coast Tributaries. Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, S.H., S. Summer and J. Connor. 2004. Identify and Mitigate Bacterial Sources at Public Beaches Using Microbial Source Tracking. . Final report. New Hampshire Department of Environmental Services, Concord, NH.

NHDES BEACH REPORTS: (8)- 2004, 2005, 2006, 2007 for each beach

OTHER INFORMATION: (2)

Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

Jones S.H., S. Sumner, N. Landry and J. Connor. 2006. Pollution source tracking at New Hampshire (USA) ocean beaches. Pp. 107-114, In, Micallef, A., A. Vassallo and M. Cassar (Eds.) Proceedings of the Second International Conference on the Management of Coastal Recreational Resources-Beaches, Yachting and Coastal Ecotourism. 25-27 October, 2006. Gozo, Malta. Euro-Mediterranean Centre on Insular Coastal Dynamics, Foundation for International Studies, Valletta, Malta.

The annual investigations by NHDES at this beach have used three sampling sites along both Northside Park and State beaches, and one at Little River at the southern part of the State Beach that drains the Little River Swamp. The NHDES sample site designation is ACPS 12, the same site and designation used in the two referenced MST studies.

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites for Northside Park Beach ranged from a total of 21 to 42 samples per year from 2004 to 2007. Enterococci concentrations at the three beach sample sites never exceeded the state standard of 104 cfu/100 ml once from 2004 to 2007.

At State Beach, sampling occurred 39 to 124 times each year and from 11 to 18 times per year at Little River. Enterococci concentrations at the three beach sample sites exceeded the state standard of 104 cfu/100 ml between one to four times in 2004, 2006 and 2007, but not in 2005. Little River samples exceeded the State standard at least four times and up to eleven times each year.

The NH Shellfish Program also sampled along State Beach during 2005 (Nash and Wood 2006). Four monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from <2 to 13 MPN/100 ml.

Identified Sources of Fecal Contamination: *humans, geese, sea gulls, otters!!,*

raccoons, coyotes, foxes, muskrats, rabbits, horses, alpacas and dogs

The Little River is considered a significant source of bacterial contamination for both Northside Park and State beaches.

E. coli concentrations in six water samples collected from Little River (ACPS 12) during dry weather from June 2001 to September 2002 ranged from 10 to 184 cfu/100 ml (Jones and Landry 2004). *E. coli* isolates from four water samples were ribotyped and were source species identified for 13 of 19 isolates, a success rate of 68%. The most significant source species identified was otters (5 isolates), followed by humans (3), rabbits (2), and single isolates identified for raccoons, geese and muskrat. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (47%) source species type, followed by humans (16%) and birds (5%).

NHDES conducted a follow-up MST investigation at Little River, focusing on two storm events during August and September 2003 (Jones et al. 2004). *E. coli* concentrations ranged from 1280 to 2210 cfu/100 ml, which is much higher compared to the previous MST study conducted during mostly dry weather. *E. coli* isolates from five water samples collected during peak, post-peak, seep or end of storm conditions were ribotyped and source species identified for 21 of 38 isolates, a success rate of 55%. The most significant source was otters (9 isolates), followed by humans (3), fox and raccoons (2), then 1 isolate each for alpacas, coyotes, dog, sea gulls and horses. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (37%) source species type, followed by humans (8%), livestock (5%) then birds and pets (3%).

Potential Sources of Fecal Contamination: *sea gulls, dogs, seaweed, beach sand*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common were sea gulls and dogs. Seaweed was also mentioned as a potential source at State Beach.

Bacterial pollution sources that may not be from the Little River discharges have also been a concern. A small study was conducted by UNH/JEL on enterococci concentrations in water, beach sand and seaweed wrack near ACPS 12 at North Hampton State Beach (Jones et al. 2006). Seaweed wrack was collected monthly from the wrack line before high tide in the afternoon from June to August, 2004. Beach sand was also collected from below the wrack, midway in the intertidal zone and at 0.5 m water depth, where a water sample was also collected. Enterococci were detected in water at levels less than the single sample maximum of 104/100 ml except during July. Enterococci concentrations in intertidal and submerged beach sand were also relatively low, with a geometric mean of 42 MPN/g dry weight. Consistently high enterococci levels were harbored in beach wrack ($2.0\pm0.9 \times 10^5$/g DW) and underlying sand ($6.0\pm9.5 \times 10^3$/g DW). The high enterococci concentrations in the wrack and underlying sand suggest that washing of the wrack at high tide could impact water quality.

Evidence Of Storm Event Runoff Influence: YES

Samples with elevated enterococci levels at State Beach were described in the Beach Reports as probably due to rainfall and associated runoff, especially as it affected the Little River. Elevated levels at the beach during rainfall-affected conditions were often coincident with elevated enterococci levels at the Little River outlet site at both beaches.

The results from the two MST studies provide an opportunity to compare differences for wet compared to dry weather conditions, even though the studies were conducted in different time periods. The geometric mean *E. coli* concentration was much higher during wet (993/100 ml) compared to dry (31/100 ml) weather conditions. There was also an apparent difference in occurrence for some types of sources species, with a higher incidence of livestock sources during wet weather and a higher occurrence of human sources during dry weather.

WATERSHED: North Beach

MST REPORTS: None

NHDES BEACH REPORTS: (4)- 2004, 2005, 2006, 2007

OTHER INFORMATION: (1)
Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

All of the studies at this beach have used three sampling sites along the beach.

Bacterial Concentrations in Water Samples:

Sampling at the three beach sites ranged from a total of 36 to 42 samples per year from 2004 to 2007. Enterococci concentrations never exceeded the state standard of 104 cfu/100 ml from 2004 to 2007.

The NH Shellfish Program also sampled at North Beach during 2005 (Nash and Wood 2006). Four monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from <2 to 4.5 MPN/100 ml.

Identified Sources of Fecal Contamination: *Not known*

Potential Sources of Fecal Contamination: *sea gulls, dogs, plovers, ducks, seals*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common were sea gulls and dogs, though plovers, ducks and a seal were also observed and can be considered as potential sources.

Evidence Of Storm Event Runoff Influence: YES

Two samples with slightly elevated enterococci levels (50-60 cfu/100 ml) in 2006 were described in the Beach Report as probably due to rainfall and associated runoff, especially as it affected the whole coastline on that day.

WATERSHED: Hampton Beach State Park, Hampton Harbor, Seabrook Harbor, Sun Valley and Seabrook Town Beaches

MST REPORTS: (5)

Jones, S.H. and N. Landry. 2003. Tracking bacterial pollution sources in Hampton Harbor. Final report. New Hampshire Estuaries Project, Portsmouth, NH.

Jones, S.H. 2003. Tracking Bacterial Pollution Sources in Stormwater Pipes. Final Report. New Hampshire Estuaries Project, Portsmouth, NH.

Jones. S.H., N. Landry and C. Edwards. 2005. Tracking Bacterial Pollution Sources in the Mill Creek Watershed, Seabrook, NH. A Final Report to the U.S. Environmental Protection Agency. New Hampshire Department of Environmental Services, Concord, NH.

Jones. S.H. and C. Edwards. 2007. Management of Non-Human Sources of Bacterial Pollution in Hampton/Seabrook Harbor. Final report. New Hampshire Department of Environmental Services, Concord, NH.

Jones, SH, N Landry, C Edwards. In press. Enhanced Use of *Escherichia coli* Ribotyping for Tracking Bacterial Pollution Sources in Coastal New Hampshire, USA. Proceedings of the 6th International Conference in Molluscan Shellfish Safety. 18 to 23 March, 2007, Blenheim, New Zealand.

NHDES BEACH REPORTS: (17)- 2004, 2005, 2006, 2007 for all beaches except Hampton Harbor Beach, for which there is only a 2007 Beach Report

OTHER INFORMATION: (3)

Nolan, S., S.H. Jones and N. Landry. 2004. Evaluating the stormwater treatment performance of AbTech industries Smart Sponge ® Plus in Seabrook, New Hampshire.

Trowbridge, P. 2004. Total Maximum Daily Load (TMDL) Study for bacteria in Hampton/Seabrook Harbor. NHDES-R-WD-03-32. New Hampshire Department of Environmental Services, Concord, NH.

Nash, C. and M. Wood. 2006. NH Department of Environmental Services Shellfish Program Activities, January 2005 - December 2005. Final Report. NH Estuaries Project, Durham, NH.

The annual investigations by NHDES at these beaches have used the same established sampling sites along each beach. The number of sites is five for Hampton Beach State Park (referred to as Hampton Beach hereafter), three each for Hampton Harbor, Seabrook Harbor and Seabrook Town beaches, and two for Sun Valley Beach.

Bacterial Concentrations in Water Samples:

Sampling at the five beach sites for Hampton Beach ranged from a total of 60 to 135 samples per year from 2004 to 2007. Enterococci concentrations exceeded the state standard of 104 cfu/100 ml only on two dates in May, 2004 during the pre-season. Enterococci concentrations never exceeded the standard at Hampton Harbor Beach (19 samples/y) in 2007 and at Sun Valley (14-28 samples/y) from 2004 to 2007. Enterococci concentrations did exceed the standard at Seabrook Harbor Beach (42-81 samples/y)

twice each year in 2005 and 2006, and once each year at Seabrook Town Beach (39-45 samples/y) in 2004 and 2006.

The NH Shellfish Program also sampled along Hampton Beach during 2005 (Nash and Wood 2006). Four monthly samples were collected during June to September and analyzed for fecal coliforms, which ranged from <2 to 33 MPN/100 ml.

Hampton/Seabrook Harbor has three NPDES permitted discharges, the main one being the Hampton municipal wastewater treatment facility (WWTF). The other two permitted sources for bacteria discharges, EnviroSystems, Inc. (NPDES # NH0022055) and Aquatic Research Organisms, Inc. (NPDES # NH0022985), are considered negligible sources (Trowbridge 2004). Estimated fecal coliform (FC) loads from the Hampton WWTF were based on Discharge Monitoring Reports from 1989 to 2001 and conversion of data for total coliform concentrations in the effluent. The geometric mean loading rate from the WWTF decreased from ~0.8 billion FC/d in 1989 TO 0.3 billion FC/d in 2001. In addition, MS4 stormdrains discharged an estimated average of ~3500-6100 FC/100 ml in July and October 2002, with a range of 50 to 14,200 FC/100 ml. This translated to a loading of 120 to 630 billion FC/d during the July and October storm events, respectively. This is much higher than the calculated loading from the Hampton WWTF, though, of course, it only occurs during storm events.

Mill Creek is considered to be a chronic source of fecal-borne bacteria to Hampton/Seabrook Harbor. *E. coli* concentrations from 104 water samples collected from 8 study sites in the Cains Brook/Mill Creek watershed on 13 dates during June to November 2004 ranged from 1 to 12,100 *E. coli*/100 ml (Jones et al. 2005). Concentrations increased at sites going downstream and the highest geometric mean concentration was at the most downstream site closest to the harbor. This is consistent with Trowbridge (2004) where the only harbor site that did not meet the shellfish geometric mean standard was the site at the mouth of Mill Creek.

Identified Sources of Fecal Contamination: *humans: boat discharges, wastewater effluent (Hampton WWTF), deer, coyote, fox, raccoon, otter, rabbit, skunk, muskrat, horse, cow, goat, chicken, dog, cat, cormorant, goose, sea gull, duck, pigeon, robin, wild turkey, dry weather nonpoint and tributary storm sources*

An early MST study was conducted on the whole Hampton/Seabrook Estuary to address shellfish harvesting concerns. Fecal coliform concentrations in 310 water samples collected from ten sampling sites in Hampton/Seabrook Harbor during dry and wet weather from August 200 to October 2001 ranged from <1 to 168 cfu/100 ml (Jones and Landry 2003). *E. coli* isolates from water samples collected from all sites and 30 of the sample dates were ribotyped and source species were identified for 236 of 391 isolates, a success rate of 60%. The most significant source species identified was humans (102 isolates), followed by deer (29), coyote (23), horse (20), dog (14), goose (11), sea gull (10), cow and fox (8), duck (5), chicken (4), and single isolates identified for pigeon and robin. For all ribotyped isolates, and according to type of source species identified, humans were the most prevalent (26%) source species type, followed by wild animals

(15%) livestock (8%), birds (7%) and pets (4%). Little difference in source types was observed for isolates collected during wet compared to dry weather or for autumn (September-November) compared to the rest of the year.

Trowbridge (2004) reported the results of a TMDL for Hampton/Seabrook Harbor. The TMDL was focused on shellfish harvesting impairments, and recognizes that contact recreation (swimming) impairments were not evident at the time of the study for this area. As a result, the data analysis excludes data during June-August, the primary recreation period. Nonetheless, the information on pollution sources is useful for this report. Overall, the percent of annual bacterial loading was estimated to be 7% for boat discharges, 52% for dry weather non-point sources and 41% for stormwater loading, with 0% for the Hampton WWTF. Some of the stormwater loading also came from tributaries.

As part of the Hampton/Seabrook Harbor TMDL, NHDES collected samples from two stormwater sources and these were also used for ribotyping analysis (Jones 2003). The pipes included HHPS069 in Hampton, which drains multiple catch basins along Ashworth Avenue, and HHPS182 in Seabrook, which receives stormwater runoff via the River Street pump station. Five samples from each source were collected at hourly intervals during a large rainstorm on October 16, 2002. Birds (cormorants> geese> sea gull> pigeon) were the largest relative source of bacteria for both pipes, accounting for 21 (36%) of the total 59 ribotyped isolates. Humans accounted for 20% of the isolates, followed by wild animals (15%; fox, raccoon, coyote) and pets (7%; cat, dog). Sources were identified for 78% of the isolates, leaving 22% unidentified. These results are somewhat different from the relative source strengths determined by Jones and Landry (2003), probably due to the obvious differences in timing, duration and spatial extent of the two studies. The data from the two pipes is still useful for designing remediation plans for these two sources and, importantly, for identifying the presence of human-sourced bacteria in storm water.

A more spatially focused MST study took place during 2004 in the Cains Brook and Mill Creek watersheds (Jones et al. 2005) of Seabrook, NH and Salisbury, MA. *E. coli* isolates from 32 water samples collected from 7 of the 8 study sites on 10 of the 13 sample dates were ribotyped. Source species identified for 151 of 283 isolates, a success rate of 53%. The most significant source species identified was chickens (25 isolates), followed by human (22), horse (16), cow (12), deer and dog (10), cat, coyote and unidentified wild animals (8), goose and raccoon (7), otter and sea gull (3), rabbit (2) and single isolates identified for fox, unidentified livestock, skunk and wild turkey. For all ribotyped isolates, and according to type of source species identified, livestock/chickens were the most prevalent (19%) source species type, followed by wild animals (12%), humans (8%), pets (6%) and birds (4%). Distinct difference in source types were observed for isolates collected in areas characterized by different land uses.

Yet another MST study focused on identifying non-human sources of pollution at two sites, including the HHPS069 pipe (Jones 2003), in Hampton during 2005 (Jones and Edwards 2007). *E. coli* isolates from 24 of 61 total water samples collected from the 7 study sites on 9 of the 10 sample dates were ribotyped. Source species identified for 95 of

189 isolates, a success rate of 50%. The most significant source species identified was humans (26 isolates), followed by unidentified wild animal(s) (14), raccoons (14), deer and geese (7), horses (6), cats (5), sea gulls (4), foxes and dogs (3), ducks, cows and goats (2) and single isolates identified for muskrats and otters. For all ribotyped isolates, and according to type of source species identified, wild animals were the most prevalent (20%) source species type, followed by humans (14%), birds (7%), livestock (5%) and pets (4%). A high prevalence of human-borne bacteria was observed at the HHPS069 pipe (42%) whereas wild animals were more prevalent in the study area on the outskirts of downtown Hampton.

Potential Sources of Fecal Contamination: *sea gulls, dogs> seaweed, plovers, terns, cats, bathers, moored boats, fish, marinas*

The NHDES Beach Reports for both beaches included observations of the presence of animals on or near the beach during sampling visits. The most common sources, observed at all five beaches, were the typical sea gulls and dogs. A variety of other potential sources were also observed, including seaweed, plovers, terns and cats. High density and numbers of bathers were cited as a potential source at Hampton Beach, while moored boats and fish from fishing were considered to be potentially significant sources at Seabrook Harbor Beach and dredged sediments at Seabrook Town Beach. The influence of spring tides on bacterial contamination was mentioned for Seabrook Harbor Beach.

In two of the MST studies, feces samples were collected in the study areas to provide local source material for building source species databases. For the Mill Creek/Cains Brook study, *E. coli* was isolated from wastewater, and the feces of dogs, chickens, horses and geese found in the watershed, and these were included in the source species database (Jones et al. 2005). Jones and Edwards (2007) included isolates from raccoons, muskrats and an unidentified wild animal in the source species database for that study. All of these were identified as sources in MST studies, so they are already listed as identified sources for this watershed.

Evidence Of Storm Event Runoff Influence: YES

Samples with elevated enterococci levels at Hampton Beach were described in the Beach Reports as possibly associated with rainfall and associated runoff. Little other mention of runoff as a factor was made for the other four beaches, though the close proximity to urbanized areas and impervious surfaces is obviously a consideration.

Trowbridge (2004) reported an analysis of long-term fecal coliform data for sites in Hampton/Seabrook Harbor showed an increase with increasing size (rainfall amount) of storms. In addition, the prevalence of elevated 90th percentile values for fecal coliforms in harbor sites suggests unacceptably high variability in FC due to periodic spikes from wet weather runoff. The estimated FC loading based on modelling during different size storms ranged from ~1600 billion FC/d for storms of 0.02-0.5 in to ~29,000 billion FC/d for storms >1 in for the harbor.

Jones et al. (2005) reported little difference on geometric mean *E. coli* concentrations at 8 sites in the Cains Brook/Mill Creek watersheds. The geometric mean for dry weather was 102/100 ml, and that for wet weather was 99/100 ml. There were marked differences, however, for the incidence of the different types of source species under wet and dry weather. Considering only identified isolates, the incidence of wild animals was much higher during dry (31%) compared to wet (13%) weather, while the incidence of birds was much higher during wet (21%) compared to dry (6%) weather (Jones et al. In press). There was little to no difference in the incidence of other source types for wet and dry weather.

A detailed study was conducted in the HHPS069 stormwater pipe (Jones 2003) to evaluate the pollutant removal efficiencies of a commercial material installed in an existing stormwater treatment system to remove bacterial from stormwater runoff (Nolan et al. 2004). The technology tested was AbTech Smart Sponge® Plus material installed into the main stormwater drain pipe upstream of HHPS069 outfall and the River St. pump station. Enterococci concentrations ranged from 150 to 50,000 cfu/100 ml in the influent and effluent stormwater from September 2003 to May 2004. The overall load reductions for the bacterial indicators were 50.3% for fecal coliforms, 51.3% for *E. coli* and 43.2% for enterococci, suggesting that post-treatment stormwater would still result in discharge of elevated bacterial levels that would continue to limit uses in receiving waters.

REFERENCES

MST REPORTS: (8)

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