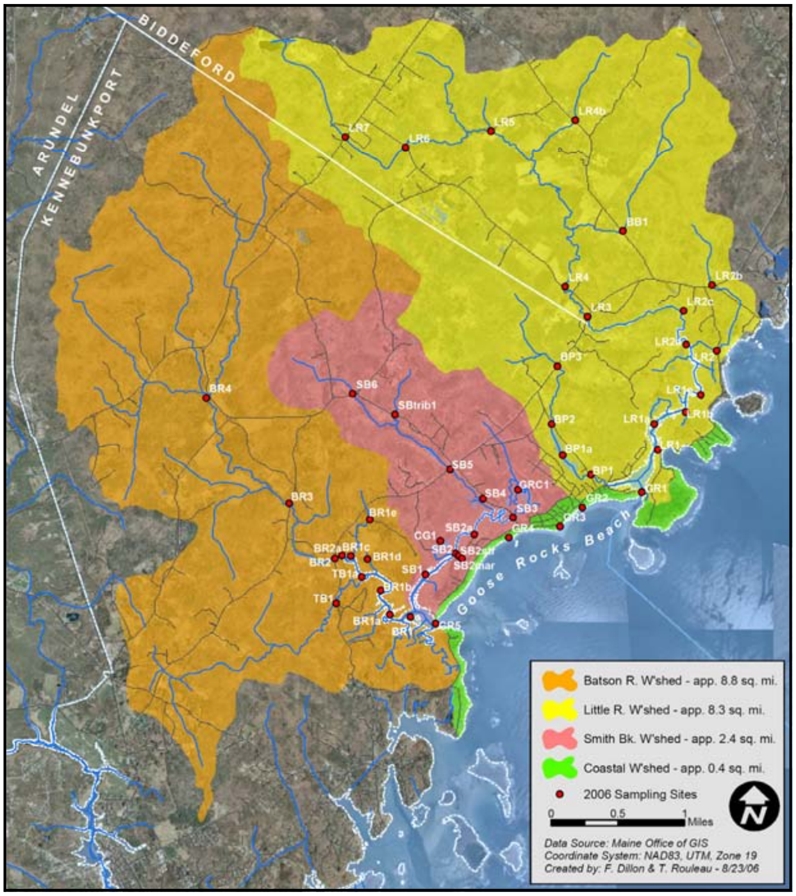
Summer 2006 Goose Rocks Beach Water Quality Monitoring Project

FINAL REPORT - November 2006



FB Environmental
Hillier & Associates
Jackson Estuarine Laboratory

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PROJECT TEAM MEMBERS

FB Environmental: Forrest Bell, Tim Bennett, Fred Dillon, Jennifer Jespersen and Tricia Rouleau
(207) 650-7597; email: info@fbenvironmental.com

Hillier & Associates: Jim Hillier and Brad Tirone
(207) 626-0613; email: jhillier@hillierinc.com

Jackson Estuarine Lab: Steve Jones and Colin Edwards
(603) 862-5124; email: shj@cisunix.unh.edu

Executive Summary

Based on the bacterial and fluorescence results, it appears that certain areas in the watersheds surrounding Goose Rocks Beach may be impacted by human sewage contamination. This conclusion is based mostly on the bacterial levels being elevated because the fluorescence measurement results gave no unequivocal evidence of the presence of optical brighteners. The widespread interference by dissolved organic compounds with fluorescence measurements greatly complicated interpretation of the results. Despite this, some of the water samples with elevated (>104 enterococci/100 mL) bacterial concentrations had elevated fluorescence readings and diminished interference from UV-absorbing organic constituents. Further, the fact that almost all incidences of possible optical brightener detection occurred during the storm event sampling suggests that the presence of optical brighteners may be more prevalent in the area around Goose Rocks Beach under conditions of higher flow of freshwater compared to dry, low-flow conditions like those experienced during the study period in August 2006.

1. Introduction

The Project Team was hired by the Town of Kennebunkport in mid July of 2006 and employed a suite of investigative analytical tools in order to determine the potential sources of bacterial contamination affecting Goose Rocks Beach (hereafter referred to as "GRB"). Specific tasks included:

1) Conduct watershed ground-truthing and preliminary "hotspots" identification using Geographic Information Systems (GIS) modeling approach;
2) Conduct intensive estuarine and riverine sampling during the months of July and August;
3) Complete report including data analysis and recommendations for remediation of bacteria sources and potential need for future work; and
4) Research availability and assist with procurement of funding for implementation of management recommendations and potential research-based investigations to further identify bacterial sources.

1.1 Project Background

In **2005**, FB Environmental was hired by the Town of Kennebunkport in cooperation with the Maine Healthy Beaches Program to conduct estuarine and riverine water sampling in three watersheds that contribute to GRB. Sample timing coincided with outgoing tides, as well as scheduled spring and neap high tides during the months of August, October, and November of 2005. Data were collected over a span of time that included at least three days past the spring high tide, and incorporated samples from several storm events. Initial results revealed high enterococci bacteria counts in the Little River, Batson River (including Smith Brook), and Beaver Pond Brook. The highest counts generally occurred during August, and during or shortly after storm events. Additional monitoring conducted by the Maine Geological Survey determined that beachfront currents from the Batson River affect the entire stretch of GRB. Flow from the Little River has an impact on the beachfront, but to a lesser extent than the Batson. Following these findings, the Town of Kennebunkport worked cooperatively with the Maine Healthy Beaches Program to preliminarily assess potential sources of bacteria. These potential sources included the Town sewer system, local septic systems, a local agricultural operation, and wildlife.

In February of **2006** the Town of Kennebunkport issued a request for proposals for assistance with analyzing water quality data, locating sources of contamination, and finding solutions to mitigate contamination as it relates to providing safe swimming opportunities at GRB. In June of 2006 FB Environmental was hired to conduct additional water testing, GIS analysis, ground-truthing, provide recommendations, and attempt to secure funds for future work related to the recommendations of this report and the staff and residents of the Town of Kennebunkport.

1.2 Problem Definition

The Town of Kennebunkport is a partner in the Maine Healthy Beaches Program and has been experiencing high levels of Enterococci bacteria at GRB leading to the posting of swimming advisories. In an effort to determine the potential sources of contamination, the Little River, Smith Brook, and Batson River watersheds were monitored for enterococci bacteria, optical brighteners, and other parameters including water temperature, salinity, and dissolved oxygen.

2. Description of Study Area

Goose Rocks is an approximately 2 mile long beach located in the town of Kennebunkport in York County, Maine. The Goose Rocks Beach watershed covers 19.8 square miles (approx. 12,600 ac.) within the towns of Kennebunkport (69%) and Biddeford (31%). The watershed is part of a larger coastal drainage system extending from Biddeford pool to the Kennebunkport River.

The GRB watershed is comprised of three smaller subwatersheds: the Batson River watershed, the Smith Brook watershed, and the Little River watershed (Figure 1). The Batson River originates in the northwest corner of the GRB watershed and flows for approximately 20 miles before reaching the southwestern end of GRB. The Batson has a drainage area of ~ 8.8 square miles (5,606 ac.). Smith Brook, with a drainage area of ~ 2.4 square miles (1,539 ac.), is almost 9 miles long and meets up with the Batson before reaching GRB. The Little River drainage area covers ~ 8.3 square miles (5,328 ac.). The 24 mile long River originates in Biddeford and flows to the northeastern end of GRB. A smaller stream, Beaver Pond Brook is located to the west of the Little River and flows through Beaver Pond before meeting up with the Little River at GRB.

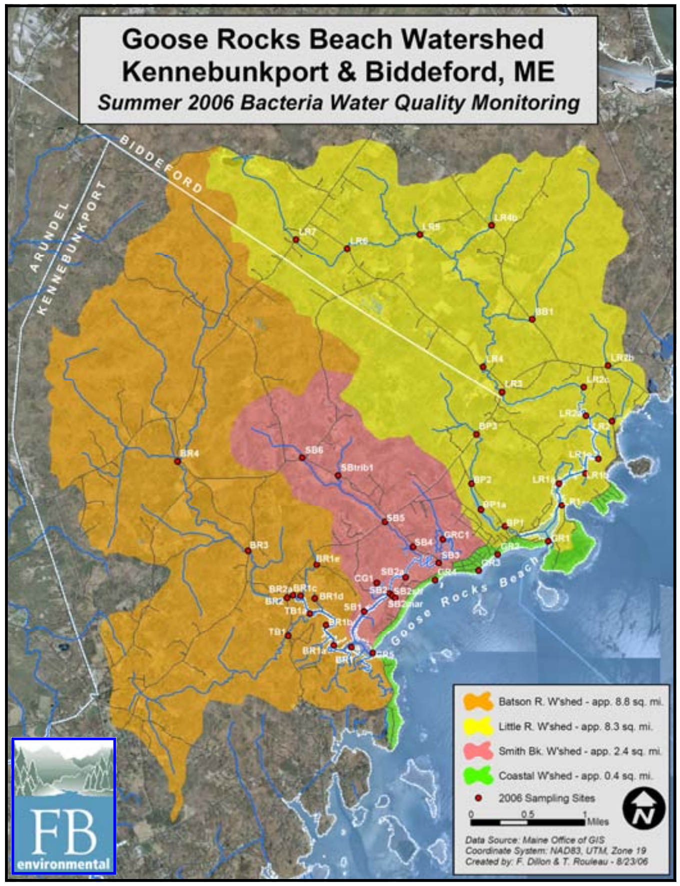


Figure 1: *Goose Rocks Beach subwatersheds and sampling sites for summer 2006 water quality monitoring project.*

2.1 Bedrock Geology

The bedrock structural setting together with the extent and type of glacial and marine soil deposits dictate the physiographic character of the project's shoreline and inland areas. The bedrock of the project area has been mapped primarily as granite rocks of the Biddeford Pluton, thought to have been formed about 354 million years before present. This pluton intrudes a much older Pre-Cambrian formation of metamorphic rocks known as the Kittery Formation. While the Kittery Formation is extensive in Southern Maine's coastal region, only remnant portions are present within the project area, and are found on the eastern shore of Timber Island in Biddeford (Hussey 1985).

2.2 Topography

Topography associated with the Biddeford Pluton dominates the drainage pattern of the area. The

Saco River skirts its northeastern flanks, and the Batson and Little Rivers drain its eastern and southern uplands. Based on observation of glacial melt-water sediments, some previous geologic investigators suggest that the Saco River may have once been diverted south by the Biddeford Pluton, and flowed to the ocean via the present Kennebunk River channel (Caldwell and others, 1985).

Coastal Maine has experienced numerous glaciations and its surface contours and character have been extensively shaped by erosion and deposition related to both glacial action and sea level change. Having been submerged by the weight of glacial ice during maximum glacial advance and subsequent glacial retreat (17,000 to 13,000 years before present), Maine's coast was inundated by marine waters for several thousand years. Within the project area, marine submergence reached an estimated 190 feet during maximum marine transgression (Clinch and O'Toole, 1999).

Slopes in the GRB watershed generally range between 0 and 5%, but may be as steep as 54%. The steepest slopes in the watershed are located in an area of rocky outcrops above Goose Rocks Rd. and Guinea Road. Smaller areas of relatively steep slopes and rocky outcrops are located along the Little River near the intersection of West St. and Route 9 and along the Batson River near the intersection of Beachwood St., Stone Rd., and Route 9.

2.3 Surficial Geology

Glacially derived soils found in the project area consist mainly of lodgement till which varies in thickness throughout the area. Lodgement till was deposited beneath the ice sheet and formed a blanket of coarse soil over bedrock. It is generally composed of varying portions of boulders, gravel, sands and silts. Younger materials, deposited during and after glacial melting, typically overly this coarse soil layer.

Silty and sandy glacial-marine sediments that were deposited into the glaciomarine environment in this area are known as the Presumpscot Formation. These sediments formed a discontinuous cover over the older till deposits and bedrock at low elevations throughout the region, including the mid- to-lower watershed portions of the project area. Some sandy and gravelly "stratified" deposits were also deposited beneath and inter-layered with the finer grained Presumpscot Formation. These materials apparently washed from glacially derived sources, i.e. till, and were reworked in near-shore or shoreline environments during the marine transgression. Having been deposited during the Pleistocene age these are referred to as Pleistocene – marine shoreline deposits (Pms in mapping notation) while the Presumpscot Formation is referred to as Pleistocene presumpscot or (Pp in map notation). Deposits of the most recent age, Holocene, include modern stream deposits, wetlands, and current marine shoreline beaches and dunes (Hildreth, 1999).

2.4 Soils

The majority of the soils of the Goose Rocks Beach watershed area have formed on two parent materials: glacial till and glaciomarine sediments. Marshes with organic parent materials are also scattered throughout the watershed and beach deposits are located along the shoreline. Soils in the watershed are dominated by two general soil associations (Appendix B): Lyman-Tunbridge-Abram (61%) and Scantic-Buxton-Lamoine (26%). Lyman-Tunbridge-Abram soils are formed in glacial till. Stones and boulders are common in these well drained to excessively well-drained soils. Scantic-Buxton-Lamoine soils are moderately well to poorly drained clayey and loamy soils formed in glaciomarine sediments.

The dominant soil series in the watershed are the Lyman fine sandy loam, the Lyman-Rock outcrop complex, and the Scantic silt loam. Lyman soils are located on the tops of till ridges and hills and consist of gently sloping to very steep, somewhat excessively drained, mixed with areas of exposed bedrock. These soils have a surface layer of fine sandy loam and are shallow to bedrock. Scantic soils are found in low-lying areas of the watershed that receive runoff from adjacent, higher areas.

These soils are deep, level, and poorly drained, with a substratum of silty clay (Flewelling and Lisante, 1982).

Due to factors such as texture, depth to bedrock, slope, and drainage, over 60% of the soils in the GRB watershed have a low or very low suitability for low density development, and 35% of the soils have a medium suitability (Figure 2, and Appendix B). According to the Natural Resources Conservation Service (NRCS), the definition for low-density development used in this designation is as follows:

> "LDD is defined as 3-bedroom single-family unit residence with basement and comparable buildings covering 2,000 sq. ft. and subsurface wastewater disposal system, with or without on-site source of water. Paved roads in development are also included. Residences may be a single-unit or a cluster of units in a development."

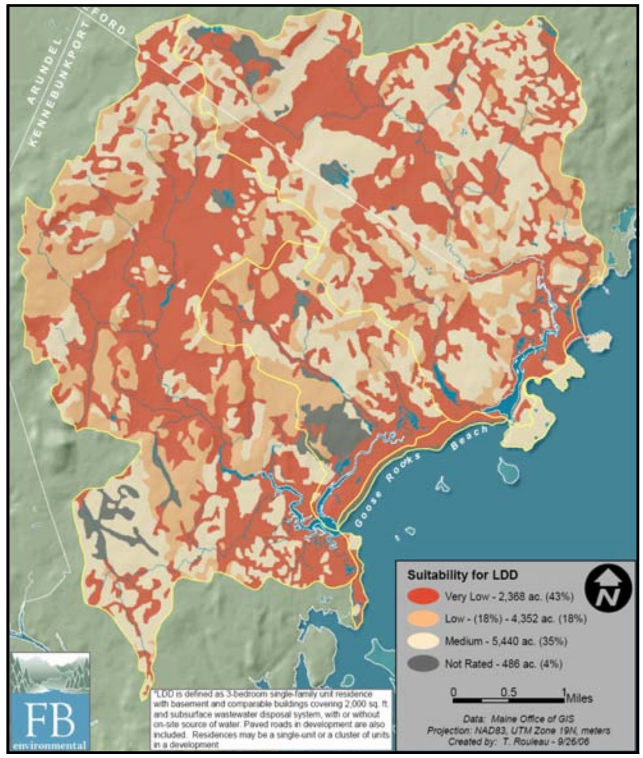


Figure 2: *Soil suitability for low density development*

2.5 Landcover

Land uses in the GRB watershed were determined from the Maine Land Cover Data (MeLCD) set recently developed by various Maine state agencies. Satellite imagery from the early spring, summer and early fall for the years 1999-2004 was collected at spatial resolutions of 30 m and 5 m. Landcover information is important because certain water quality problems may be associated with particular land uses. According to the MeLCD, there are 20 different landcover types in the GRB watershed. For the sake of clarity, these were grouped into eight more general classifications (Figure 3 and Appendix B). Landcover in the GRB watershed is dominated by mixed and deciduous forest (~66% of total land area) interspersed with areas of wetlands (~16%), pasture and cultivated land (~8%), residential development (~4%), grasslands (~2%), roads (~2%), and shoreland (~1%). Residential land uses in the GRB watershed includes two areas of dense development: one along Guinea Rd. in the northern section of the watershed and one along Kings Highway in the southern section of the watershed.

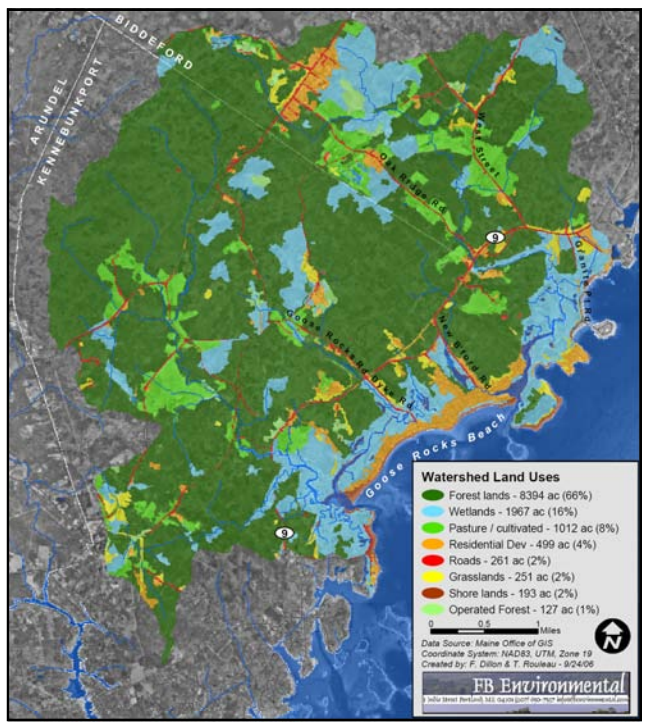


Figure 3: *Landcover / land uses in the GRB watershed.*

2.6 Beach and Marshes

Goose Rocks Beach, like most beaches in southern Maine, exhibits an arcuate-embayment shoreline where sand sources, consisting of glaciomarine sediments and other glacial deposits, were sufficient to build barriers between bedrock headlands (FitzGerald et al. 1989). Although the drainage systems developed behind these protected barrier beaches are referred to as rivers, i.e. the Little River and Batson River, they are more accurately described as ocean inlets and tributary streams as they normally have relatively little fresh water discharge. Tidal action is the main factor affecting flow dynamics below the head of tide in this area, and tidal sea water is the main component of its water discharge.

Tide height plays a major role in the dynamic of the beach, inlet, and marsh system in the project area. The orientation of the southern Maine coast relative to the Gulf of Maine and the Atlantic Ocean, among other factors, results in a mean tidal range of about 2.7 meters. During spring tide conditions, the range increases to about 3.5 meters. Tidal action together with wind direction, wave energy and the geometry of the shoreline in Goosefare Bay create a dynamic environment that maintains the sediment balance on Goose Rocks Beach as well as the inlets, marshes, and tidal creeks located behind it.

Near the mouths of the Little River and Batson River, sand is transported onshore and behind the beach barrier system by dominant flood tidal currents, resulting in the formation of flood-stage deltas above the inlets and behind the beach barrier (onshore). These flood stage deltas exceed the volume of deltas formed in front of the barrier by ebb tide deltas (offshore).

The duration of flood and ebb phases of each tide cycle help to illustrate the forces associated with tidal flows into the Little River and Batson River inlets. " The tide curve at these small inlets is characterized by a steeply rising tide followed by a less steeply falling tide with an extended period of slack water. The following cycle begins abruptly. Low water occurs later in the inlet and bay than for the ocean tide, whereas the time of high tide is nearly synchronous with the forcing ocean tide…a simple conservation of mass argument can be used to explain the observed flood current dominance: because there is a shorter period of time to fill the back barrier than to empty it, flood current velocities must exceed ebb current velocities" (FitzGerald and others, 1989). Tide gauging conducted by these previous authors at the Little River found that the mean ebb tide duration exceeded the flood tide duration by an average of 2 hours and 10 minutes. Similarly, at the Batson River, mean ebb duration exceeded flood duration 1 hour and 45 minutes.

Recurring flooding of the local marshes during high tides sustains the balance of sediment migration into the marsh and creek environment and maintains much of the broad flat floodplains that encompass the lower drainages of the Little River, Batson River, and Smith Creek. Along with the sandy sediment deposited there, flora and fauna from both the marine and estuarine environment are distributed across much of the vegetated marsh environment. This regularly occurring influx of organic material provides the marsh environment with nutrients that support a richly diverse ecosystem including fish, crabs and birds, as well as large mammals such as beaver and deer.

3. Study Design

Determination of the number of sample sites and their locations, the sampling period and frequency, and the conditions under which the sampling would occur were based on a variety of considerations. These included a preliminary "hotspots" identification that identified potential bacterial source threats to surface waters in the GRB watershed; field reconnaissance based on the hotspots estimation and recent DEP septic system evaluations; and consultation with local, state and federal government officials.

3.1 Preliminary Hotspots Identification

The basis for the preliminary hotspots Identification derived from a study in California (Reid et al, 2001) that used a variety of criteria to identify the relative risks for potential human sources of bacterial contamination. The GRB watershed study used similar criteria that was readily available in GIS

GIS Layer	Criteria	Score
OBD	*Parcels with overboard discharges*	OBD = 1, all others = 0
Problem Sites	*Parcels identified by DEP's John Glowa as having septic issues that need to be addressed*	problem sites = 1, all other = 0
Hydrobuff	*Buffer of 250 feet for freshwater waters and 500 feet for tidal waters.*	hydrobuff = 1, all others = 0
Riparian Residential	*Residential land uses within the riparian zone (defined by the hydrobuff layer).*	riparian residential = 1, all others = 0
SFHA	*Special flood hazard areas (defined by FEMA).*	sfha = 1, all others = 0
Soils	*Soils with low or very low suitability for low density development (house, septic & driveway).*	low suitability = 1, very low suitability = 2, all others = 0
Significant Wetlands	*Hydrologically connected wetlands.*	sig. wetlands = 1, all other = 0
Slope	*Areas with a slope greater that 20%.*	slope >20% = 1, all others = 0
Non-Sewered	*Parcels that are not on public sewer (based maps provided by town of Kennebunkport).*	non-sewered = 1, all others = 0

Table 1: *GIS data and criteria scoring system used for GRB watershed bacterial hotspots evaluation.*

format (Table 1). The Town of Kennebunkport provided parcel data, sewer line location data and a compilation of recent septic system survey results conducted by the Maine DEP (courtesy of the City of Biddeford). Additional data for hydrology, flood hazard areas, soils, wetlands and slope were obtained from the Maine Office of Geographic Information Systems (MEGIS).

The GIS model determined relative risks from potential human sources by assigning scores (as indicated in Table 1) to the criteria in each data layer. The rationale used for scoring each criterion was as follows:

- **OBDs:** overboard discharges are licensed by the State to release treated effluent into adjacent surface waters. Since the level of treatment provided by OBDs in the GRB watershed is somewhat suspect, the DEP has recommended their removal. Parcels with OBDs were assigned a risk score of 1 because they were assumed to be more likely sources of potential bacterial contamination.

- **Problems Sites:** identified by the DEP's recent survey as having potential problems with adequately functioning septic systems. Problem parcels were assigned a risk score of 1 because they were assumed to be more likely sources of potential bacterial contamination.

- **Hydrobuff:** derived from significant and hydrologically connected surface water features in the GRB watershed. Freshwater streams were buffered at 250' and tidal waters were buffered at 500'. These distances were selected based on the increased potential for bacterial contamination due to stormwater runoff and astronomically high tides. The areas falling inside the buffers were assigned a risk score of 1.

- **Riparian Residential:** included non-sewered residential land uses (from MeLCD) within the

Hydrobuff area based on the assumption that greater potential bacterial contamination risks exist under certain conditions (e.g., storm events and astronomically high tides). All parcels within the riparian residential zone were assigned a risk score of 1.

- **Special Flood Hazard Areas:** also known as the 100-year floodplain, areas within the SFHA were assigned a risk score of 1 based on the assumption that bacterial contamination would be more likely during significant storm events.

- **Soils:** as discussed previously, the Natural Resources Conservation Service (NRCS) established a soil suitability rating for low density development (i.e., residences with septic systems). Soils rated with a low suitability for septic systems were assigned a risk score of 1 while those with rated with a very low suitability were assigned a risk score of 2. These soil types were assumed to pose a greater potential risk due to the increased possibility of bacterial contamination from inadequately functioning septic systems.

- **Significant Wetlands:** wetlands in the GRB watershed that are hydrologically connected to perennial streams or tidal waters were assigned a risk score of 1 based on the assumption that bacterial contamination in these areas would be more likely to reach nearby surface waters during storm events or astronomically high tides.

- **Slope:** all areas with slopes greater than 20% were assigned a risk score of 1 and assumed to pose a greater potential bacterial contamination risk due to increased runoff potential.

- **Non-Sewered Parcels:** all developed parcels that were not on public sewer were assumed to pose a greater potential risk due to the possibility of inadequately functioning septic systems. All such parcels were assigned a risk score of 1.

After assigning risk scores, all data layers were overlayed (Figure 4) to create a composite risk map. Risk scores for overlapping criteria were summed to create a single risk factor for each area of intersection. Final risk factors ranged from 0 to 7 with 7 representing the greatest potential risk (Figure 5 - next page). Since the majority of soils in the GRB watershed are not well suited for septic systems, the primary determinant in identifying the greatest risk potential from bacterial contamination was proximity to freshwater streams, estuaries, wetlands and flood hazard areas (Most of the problem parcels identified by the recent DEP septic system survey are also located in these areas). Additionally, areas with steep slopes pose greater potential risks due to the increased possibility of contaminated runoff.

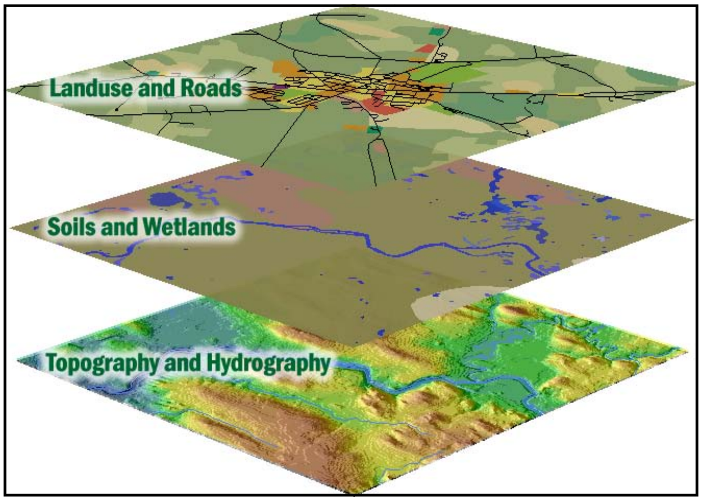
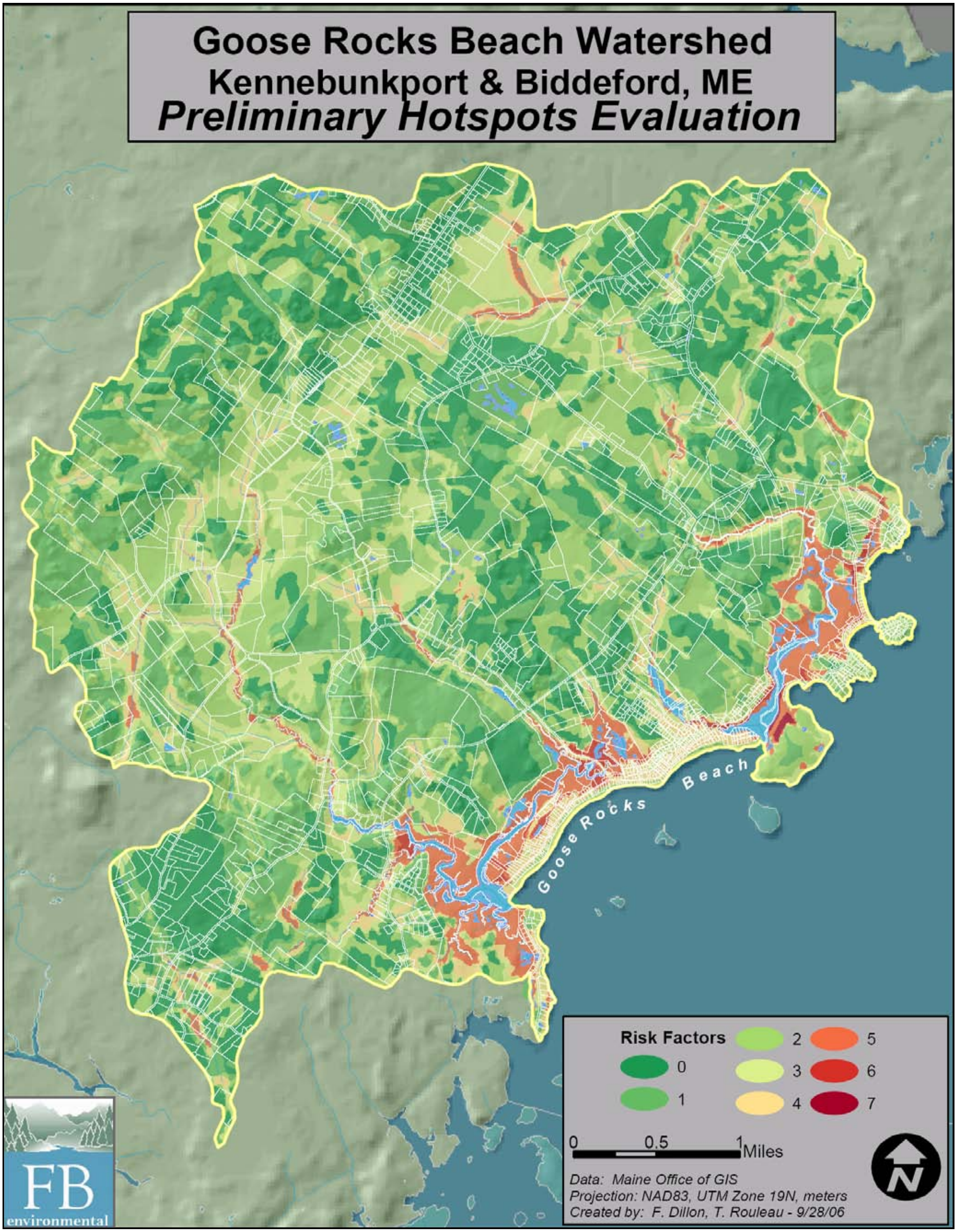


Figure 4: *GIS overlay technique (Courtesy of St. Lawrence University GIS Libraries: www.stlawu.edu/gis/whatisgis.html)*

Figure 5: *Preliminary hotspots evaluation. (Lowest potential risk = 0; highest potential risk = 7)*



3.2 Field Reconnaissance

A field reconnaissance of the GRB watershed was conducted on July 26, 2006 based on several criteria: results from the 2005 water quality monitoring season (FB Environmental, 2005); a recent sanitary survey by Maine DEP (Glowa, 2006); a preliminary hot spots identification (section 3.1, above); and local input from the Town of Kennebunkport officials. The intent of this initial reconnaissance was to locate potential sampling sites that were not included in the 2005 GRB study (FB Environmental, 2005), but showed potential for bacterial contamination based on past results.

The recent data from Maine DEP listed sanitary survey results for more than 100 individual parcels in both Kennebunkport and Biddeford. The purpose of the study was to identify illegal discharges to waters of the State and to identify malfunctioning septic systems (Glowa, 2006). Specific parcels of land that were deemed potential problems for bacterial contamination were mapped by FB Environmental using GIS software, and then combined with high priority sites determined from the Hot Spot Analysis.

Two project teams spent the day visiting sites throughout the watershed. One team focused on visiting sites that were both high priority from the preliminary hot spots identification <u>and</u> listed as potential problems from the sanitary survey. The second team visited several 2005 sampling sites while collecting water quality samples, scoped out practical boat access locations, and identified new sampling locations based on local input from the town, and results from the 2005 study.

3.3 Sampling Regime

The sampling regime was agreed upon after consultation with project partners including the Town of Kennebunkport, State representatives of the Maine Healthy Beaches Program, and the US EPA.

Sample Locations: FB Environmental and partners defined sample stations based on the following considerations:

1. Sites with historical data
2. Geographic location (e.g. confluence of tributary)
3. GIS based preliminary hotspots identification
4. Results of field reconnaissance
5. Input from partners

The initial sampling efforts covered 43 sites in the three major watersheds and was eventually expanded to as many as 54 sites. The expansion of sites was usually undertaken in order to investigate new potential sources of Enterococci bacteria.

Note: Sample sites were chosen at both tidal and freshwater sites in order to determine the potential upstream inputs.

Sample Timing: All samples were taken approximately 1 – 4 hours after peak high tide in order to ensure consistency of results with previous sampling and in order to make the 2006 water sampling data set comparable. All samples were taken during daylight hours in order to accommodate the laboratory selected for the work. The sampling was conducted on the following dates:

1. **July 26 –** preliminary sampling for bacteria only.
2. **August 3rd –** full sampling of selected sites during Neap Tide.
3. **August 10th –** full sampling of selected sites during Spring Tide.
4. **August 17th –** full sampling of selected sites during dry weather with additional sampling with a

field fluorometer in the Little River watershed.
5. **August 20th** – storm event sampling (first major rain event during project study period). Two samples were collected at each site approximately 1 – 11/2 hours apart. A reduced number of sites were sampled due to time restrictions due to tidal considerations. According to local records, Kennebunkport received just over 1 inch of rain during this storm event.
6. **August 24th** – sample collections at beachfront sites and field fluorometer analysis in the Little River watershed.
7. **August 31st** – field fluorometry analysis in the Smith Brook watershed & field reconnaissance in the Little River watershed.

Sampling Team: Each full sample event required that at least six people participate in order to cover the full suite of sites within the 3 ½ hour window within the outgoing tide. Field staff included trained professional staff from FB Environmental Associates (Forrest Bell, Fred Dillon, Jennifer Jespersen, Tricia Rouleau, and Tim Bennett), Hillier Associates (Jim Hillier and Brad Tirone), the Jackson Estuarine Lab (Steve Jones and Colin Edwards), and Maine Healthy Beaches staff (Sarah Mosley and Keri Lindberg). Werner Gilliam (Town of Kennebunkport) assisted with one dry weather sampling event.

Teams of two samplers were assigned to specific watersheds or select geographic areas (e.g. inland sites, beach sites, etc.). Each sample event was designed so that at least one individual was familiar with the exact sample locations. At least three canoes were used during dry weather sample events in order to access sites not easily accessible by foot. All staff were briefed by Forrest Bell and Fred Dillon on quality assurance/quality control measures for this sampling project.

The Maine Healthy Beaches Program provided a Turner Designs field fluorometer (Model 10-AU) to assist with optical brightener analysis. Field fluorometry required that three people ride in a canoe - one to steer the boat, one to hold the fluorometer probe, and one to read and record the data.

Laboratory Analysis: All enterococci samples were delivered by courier to Nelson Laboratories in Springvale, Maine. Nelson Laboratories is the certified Maine Healthy Beaches lab for southern Maine and provides analysis using the Enterolert method developed by Idexx laboratories in Westbrook, ME. Nelson laboratories provided courier service of samples from Kennebunkport to Springvale. FB Environmental paid for lab analysis of all sites with the exception of sites GR1-GR5 which were paid for by the Maine Healthy Beaches program. All optical brightener samples were delivered to the Jackson Estuarine Laboratory (JEL) in Durham, NH. Analysis of samples at JEL was completed by Colin Edwards and Steve Jones.

4. Field Sampling

4.1 Water Quality Monitoring

Water quality parameters measured included present weather conditions, water temperature, air temperature, salinity, dissolved oxygen, and sample collection of water for lab analysis of enterococci and optical brightener levels.

Methods: Sampling collection methods for enterococci followed the Quality Assurance Project Plan for Maine Coastal Swim Beach Monitoring for Indicator Bacteria prepared by Esperanza Stancioff, University of Maine Cooperative Extension and Sea Grant, November 22, 2002. The detection limit for enterococci bacteria was 10 MPN/100mL. Results were reported by Nelson Laboratories within a measurement range of less than 10 MPN/100mL to greater than 24,190 MPN/100mL. The precision for enterococci lab and field duplicates was +/- 10% (95% confidence limit) with a Relative Percent

Difference (RPD) of ≤ 50%. Water samples for enterococci were collected using sample tongs and sterile Whirlpak bags and were kept in a cooler between 4 and 10 degrees C. All samples were analyzed within 6 hours of sample collection.

Sample collection for optical brighteners followed Jackson Estuarine Lab protocol (see Section 4.3, Laboratory Methods). In order to compare enterococci and optical brightener levels at each site, samples for enterococci were first collected in sterile Whirlpak bags. The optical brightener water sample was then poured from the Whirlpak into a sterile 250 mL plastic bottle. Water samples for optical brighteners were kept in a cooler between 4 and 10 degrees C. For both enterococci and optical brighteners, one duplicate sample was collected for approximately every ten samples collected.

Dissolved oxygen levels were measured with either a YSI 85 meter or a YSI DO 200 meter (both meters were calibrated according to manufacturer's instructions). Salinity levels were measured with either a YSI 85 meter or a field refractometer. All water quality samples were collected by trained professionals (members of the sampling team).

4.2 Field Observations

A variety of field observations were recorded throughout the sampling period which may help link significant water quality results with probable causes of pollution.

At each sampling event, water quality monitors were directed to make notes about wildlife occurrences including animal sightings, tracks, scat, or any other general wildlife observations. Presence of domesticated animals such as dogs, sheep and horses was also noted. Other notable observations included: water that had a colored appearance (brown, yellow, rust-colored); water with suspended sediments or high levels of turbidity; stagnant or mucky water; low flows; pipes flowing to channel; stream channel alteration; unpleasant odors; presence of algae, and oily sheens or other forms of visible pollution including corroding culverts. Any unusual water quality readings such as low dissolved oxygen, high conductivity, or fluctuations in salinity were also noted.

- **Animals:** A majority of the wildlife/animal observations were related to the presence of birds including gulls at Goose Rocks sites and geese in the Batson River. Deer and deer tracks were sighted in both the Batson and Little River watersheds, as well as scat at marsh sites in the Smith Brook watershed. Domestic animal observations included a dog on the marsh and the beach, sheep, and a horse farm.

- **Iron Bacteria:** Iron bacteria was present at four sites including SB6 in Smith Brook; BR3 and BR4 in the Batson River, and LR7 in the Little River watershed. However this presence was associated with sampling at or near a culvert at all four sites.

- **Algae:** Algae in a stream may indicate excessive nutrient inputs, and may be elevated in areas of low flow. The presence of algae was noted at two sites in the Little River (LR4b and LR4c), and one site in the Batson River (BR3). Both Little River sites were affected by channelization/ ditching and stagnant water. A possible septic problem was noted at LR4b.

- **Turbidity:** Turbid water, or water that has high amounts of suspended sediment and debris is to be expected during rain events when large volumes of water are flushed downstream. Turbid water was noted at three sites (in the Little River watershed on two different sampling dates (8/17 and 8/20/06) and at one site in the Batson River watershed (BR3) during the storm event on the 8/20/06.

4.3 Fluorometric Assessment

Laboratory Methods

Fluorometry of water samples collected by the Project Team was conducted using a Turner Model TD700 fluorometer located at the UNH Jackson Estuarine Laboratory in Durham, NH. To detect optical brighteners, the excitation wavelength was 360 nm and the emission wavelength was either 410-610 nm or 436 nm. Fluorometry was conducted on water samples that had been refrigerated in the dark following collection, and readings were made within 48 hours. Each sample was analyzed in the 'direct concentration' mode within 30 seconds to avoid overheating by the UV lamp. Readings were made on discreet sub-samples first at 410-610 nm, for all samples, then at 436 nm with fresh sub-samples. The fluorometer was calibrated using 50 mg of Tide/L set at 100 fluorometer units, with the machine-adjusted sensitivity at 15-16%. For readings at 436 nm, the machine-adjusted sensitivity was 25-26%. This calibration was similar to what was used by Hartel et al. (in review) in Puerto Rico, where organic matter was much lower than what was found in Georgia. The optical density reading of concern in both places was either >30 fluorometric units (Puerto Rico) or >100 (Georgia).

UV-Absorbing Organic Constituents in Water

To help quantify organic matter present in water samples, UV-absorbing organic constituents were measured as a surrogate for some dissolved organic matter (APHA 1998). Many common organic compounds found naturally in water strongly absorb UV radiation. These aromatic organic compounds include humic substances, tannin and lignin. Method 5910 B. was used on samples stored for up to one month as an estimate of dissolved UV-absorbing organic matter; the long storage time and the non-processed nature of the samples precluded other measures of organic matter. The relative concentration of UV-absorbing organic constituents in the supernatant of each settled water sample was determined by measuring the absorption at 253.7 nm in a Shimadzu UV-1601PC UV-visible spectrophotometer using deionized water as a blank. The data were used along with observed color of the water to help gauge how much interference organic matter may have had with the fluorometric measurements for optical brighteners.

Field Measurements

On August 17th at approximately 2 PM, Project Team members paddled on the Little River by canoe with the Turner 10-AU field fluorometer to investigate the possible presence of optical brighteners (Figure 6). The instrument was outfitted with a flow-cell and sample probe to continuously monitor for fluorescence. Before the field survey, the fluorometer was calibrated with a 500 µg/L fluorescent dye solution (as suggested by EPA's Tim Bridges) and blanked with seawater obtained from sample site GR2 on Goose Rocks Beach. The blank location was selected based on low to negligible fluorometric values from water quality samples analyzed by JEL earlier in the month. Meter readings were expressed in µg/L. On August 31st at approximately 07:30, project team members paddled ~500 m upstream from the Dyke Road crossing and set the fluorometer to begin measuring before proceeding slowly back downstream (Figure 7). Calibration procedures were identical to those used on 8/17/06.

Fluorometer readings on August 17th (Figure 8) were greatest at the furthest upstream sampling point of the tidal estuary and steadily declined as the survey crew proceeded down stream to the canoe take-out location (adjacent to GR1). On August 31st, as in the Little River, a declining trend in fluorometry readings was also observed on Smith Brook. Initial fluorometer readings were close to 700 µg/L and decreased steadily to around 250 µg/L at the downstream take-out location (Figure 9). Readings above the confluence of a small tidal tributary behind the Town's sewage pumping station

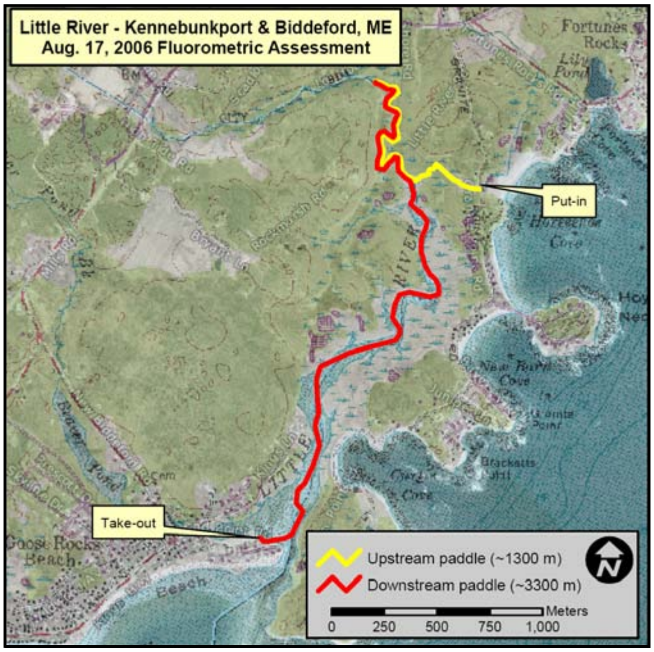


Figure 6: *Little R. 8/17/06 fluorometric field assessment.*

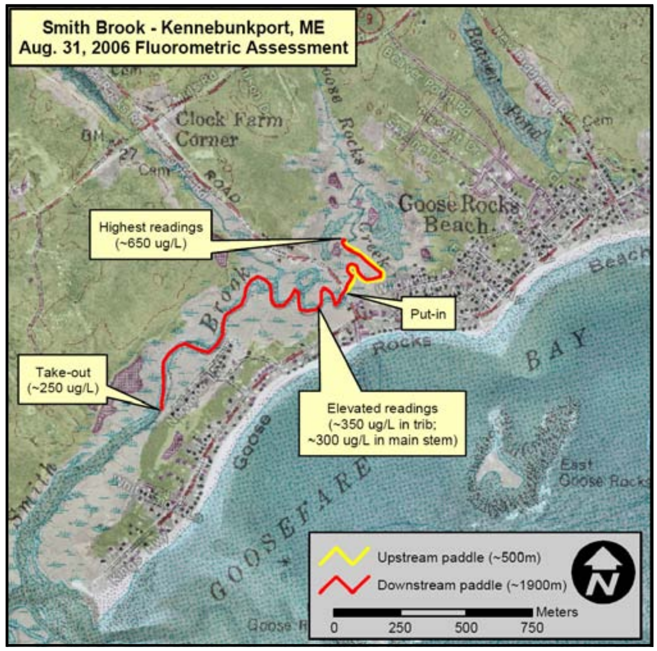


Figure 7: *Smith Br. 8/31/06 fluorometric field assessment.*

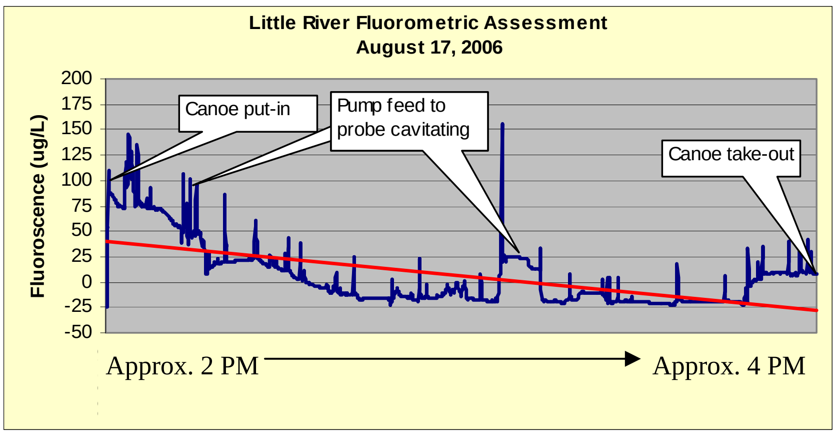


Figure 8: *Little R. 8/17/06 field fluorometry results*

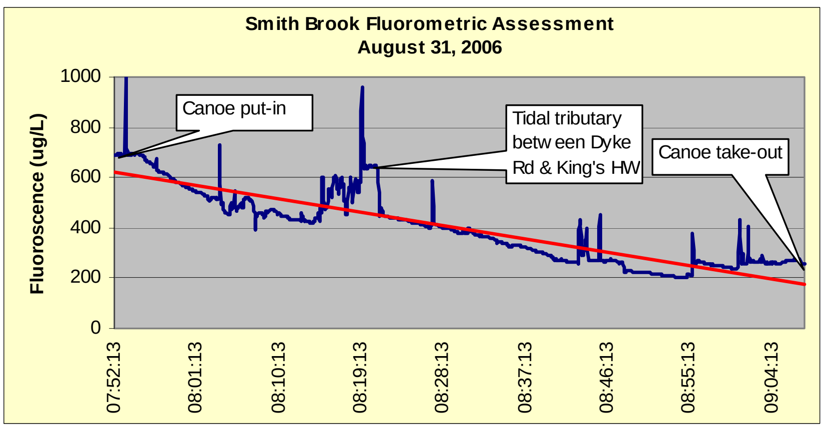


Figure 9: *Smith Brook 8/31/06 field fluorometry results.*

on King's Highway were somewhat higher than the main stem of Smith Brook (~ 350 µg/L in the tributary as compared to ~300 µg/L in the main stem). However, the most significant factor influencing fluorometric readings seemed to be water color (i.e., organic matter). The survey crew noticed a gradual increase in water clarity as they floated further downstream and fluorometric readings decreased correspondingly.

5. Results

5.1 Enterococci

Enterococci is an indicator organism used to determine the potential for contamination from fecal matter. Although these organisms do not cause illness directly, enterococci identifies where fecal contamination may have occurred and indicates the potential presence of other harmful pathogens. The EPA recommended criterion for fresh and marine recreational waters are as follows:

- ***Marine water:*** Enterococci samples should not exceed a criterion of 104 colonies per 100 ml for a single sample or a geometric mean of 35 colonies per 100 ml based on 5 or more samples collected within a 30-day period (EPA, 1986).

- ***Freshwater:*** Enterococci samples should not exceed a criterion of 61 colonies per 100 ml for a single sample or a geometric mean of 31 colonies per 100 ml based on 5 or more samples collected within a 30-day period
  Source: "Ambient Water Quality for Bacteria" (EPA, 1986).

Summary of Exceedances: A total of 206 enterococci samples were collected at 49 sites in the GRB watershed during July and August of 2006 (Table 2). Of the sites sampled, 16 sites were sampled five or more times within a 30-day period AND had an enterococci geometric mean in exceedance of the EPA criteria. Geometric mean exceedances are listed below by watershed (Figure 10, p.16; see also Appendix C, p.45):

- ***Batson River watershed:*** BR3, TB1, TB1a, BR1c
- ***Little River watershed:*** LR2a, LR2c, LR3, LR4b, LR4c, LR6, LR7, BB1
- ***Smith Brook watershed:*** SB2str, SB3, SB4, SB5

Over the sampling period, 16 sites exceeded the single sample enterococci criteria >50% of the time and 8 sites exceeded the single sample criteria 100% of the time.

Neap and Spring Tide Results: Enterococci samples were collected on a 7.3 foot Neap tide on August 3, 2006. Spring tide enterococci samples were collected on a 10.6 foot tide on August 10, 2006. Of the tidally influenced sites, only 3 sites exceeded the single sample enterococci criteria during the Neap tide. This is in contrast to 10 single sample exceedances recorded at tidally influenced sites during the Spring tide sampling event. (see also Appendix C, p.49-50; Appendix B, p. 35-36)

Dry Weather Results: Dry weather, or base, sampling was conducted during five sampling days in July and August: 7/26, 8/3, 8/10, 8/17, and 8/24. Dry weather averages, in general, show lower enterococci levels at sites closer to GRB during dry weather. Over the sampling period, 23 sites exceeded the single sample enterococci criteria at least once. Of these sites, 11 sites had 2 or more exceedances. (see also Appendix C, p.47; Appendix B, p.33)

Wet Weather Results: Wet weather enterococci sampling was conducted two times at 30 sites on August 20, 2006. According to local records, approximately 1 inch of rain fell in Kennebunkport during this storm event. Of the sites sampled on this date, all but one site exceeded the sample enterococci criteria at least once, and 13 sites exceeded the EPA criteria twice. (see also Appendix C, p.48; Appendix B, p.34)

Statistical Analyses

Statistical analyses were conducted in Systat Version 11 (Systat software Inc, 2004).

Wet vs. Dry Sampling

Hypothesis: Significant rain events result in higher Enterococci levels than dry weather sampling. A paired t-test was used to test for differences between geometric mean Enterococci results from dry season and storm sampling events across the entire GRB watershed**. Results of the analysis reveal that bacteria levels are significantly higher ($p < 0.01$) during rain events than during dry weather sampling.**

Neap vs. Spring Tides-(whole watershed)

Hypothesis: Spring tides result in higher Enterococci levels than neap tide samples.
A paired t-test was used to test for differences between Enterococci results from samples collected during the spring tide and the neap tide across the entire GRB watershed. **Results of the analysis reveal that there were no significant differences ($p > 0.05$) between Enterococci levels for the spring vs. neap tide samples watershed wide.**

Neap vs. Spring Tides-(tidally influences sites only)

Hypothesis: Spring tides result in higher Enterococci levels than neap tide samples at tidally influenced sites. A paired t-test was used to test for differences between Enterococci results from samples collected during the spring tide and the neap tide across the entire GRB watershed. **Results of the analysis reveal that bacteria levels during the spring tide were significantly higher ($p < 0.05$) than levels during the neap tide for the tidally influenced sites.**

Differences across Watersheds (Batson vs. Little River)

Hypothesis: Bacteria levels of samples collected in the Batson River Watershed are significantly different from bacteria levels in the Little River watershed. A two sample (independent) t-test was used to test for differences between the geometric mean Enterococci concentrations for all sites in the Batson River Watershed (including sites in the Smith Brook watershed), and geometric mean bacteria concentrations for all sites in the Little River watershed. **Results of the analyses reveal that bacteria levels in the Batson River watershed were not significantly different ($p > 0.05$) than bacteria levels in the Little River watershed.**

Differences across Watersheds (Little River vs. Smith Brook vs. Batson River)

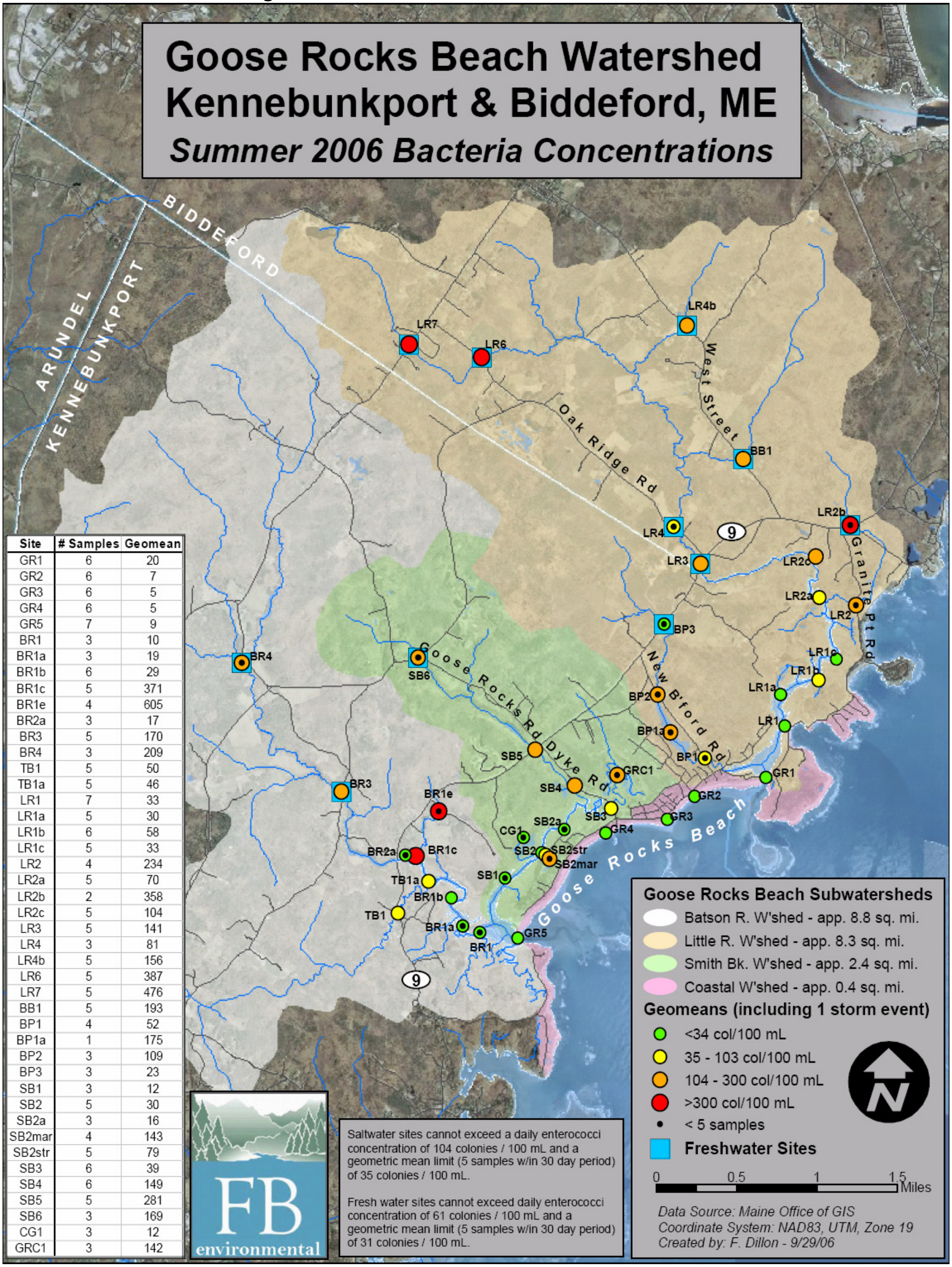
Hypothesis: Bacteria levels of samples collected across three different watersheds will differ by watershed. A one-way ANOVA was used to test for differences between the geometric mean Enterococci concentrations for all sites in the Little River watershed, Smith Brook watershed and Batson River watershed. An α of 0.05 corrected using the Bonferroni correction factor was used to correct p-values for the increased probability of Type I errors. **Results of the analyses reveal that bacteria levels do not differ significantly ($p > 0.05$) across the three watersheds.**
Note: While there were no significant differences across the watersheds, these results showed that the geometric mean of Smith Brook sites was generally lower than either the Little River and the Batson River. The two larger watersheds had practically identical means.

Table 2: *Goose Rocks Beach Watershed Summary of Instantaneous Enterococci Exceedances*

	At Least One Dry Weather Exceedance	At least One Wet Weather Exceedance	Exceeded on > 50% of Sampling Dates	Exceeded on 100% of Sampling Dates
SITE				
GR1	X	X		
GR2				
GR3				
GR4				
GR5				
BR1		N/S		
BR1a		N/S		
BR1b		X		
BR1c		X	X	
BR1e	X^+	X		X
BR2a		N/S		
BR3	X^+	X^+	X	
BR4	X^+	N/S		X
TB1		X^+		
TB1a		X^+		
SB1		N/S		
SB2		X		
SB2a		N/S		
SB2marsh	X	X^+	X	
SB2str	X	X^+	X	
SB3		X		
SB4	X	X^+	X	
SB5	X	X^+	X	
SB6	X^+	N/S		X
CG1		N/S		
GRC1	X^+	N/S		X
LR1		X^+		
LR1a	X	N/S		
LR1a-a	X	N/S	X	
LR1b	X	X^+	X	
LR1c		X		
LR2		X^+	X	
LR2-pool				
LR2a		X^+		
LR2b	X^+	N/S		X
LR2c	X	X^+	X	
LR2c-a		N/S		
LR3	X^+	X^+	X	
LR4	X^+	N/S		X
LR4b	X	X	X	
LR4c		X	X	
LR5		N/S		
LR6	X^+	X	X	
LR7	X^+	X		X
BB1	X	X	X	
BP1	X	N/S		
BP1a		N/S		X
BP2	X^+	N/S	X	
BP3		N/S		

x^+ *= 2 or more exceedances.*
N/S = *No storm sample collected.*

Figure 10: *Summer 2006 Bacteria Concentrations*



Site	# Samples	Geomean
GR1	6	20
GR2	6	7
GR3	6	5
GR4	6	5
GR5	7	9
BR1	3	10
BR1a	3	19
BR1b	6	29
BR1c	5	371
BR1e	4	605
BR2a	3	17
BR3	5	170
BR4	3	209
TB1	5	50
TB1a	5	46
LR1	7	33
LR1a	5	30
LR1b	6	58
LR1c	5	33
LR2	4	234
LR2a	5	70
LR2b	2	358
LR2c	5	104
LR3	5	141
LR4	3	81
LR4b	5	156
LR6	5	387
LR7	5	476
BB1	5	193
BP1	4	52
BP1a	1	175
BP2	3	109
BP3	3	23
SB1	3	12
SB2	5	30
SB2a	3	16
SB2mar	4	143
SB2str	5	79
SB3	6	39
SB4	6	149
SB5	5	281
SB6	3	169
CG1	3	12
GRC1	3	142

5.2 Fluorometry

Based on the bacterial and fluorescence results, it appears that certain areas in the watersheds surrounding Goose Rocks Beach may be impacted by human sewage contamination. This conclusion is based mostly on the bacterial levels being elevated because the fluorescence measurement results gave no unequivocal evidence of the presence of optical brighteners. The widespread interference by dissolved organic compounds with fluorescence measurements greatly complicated interpretation of the results. Despite this, some of the water samples with elevated (>104 enterococci/100 mL) bacterial concentrations had elevated fluorescence readings and diminished interference from UV-absorbing organic constituents. Further, the fact that almost all incidences of possible optical brightener detection occurred during the storm event sampling suggests that the presence of optical brighteners may be more prevalent in the area around GRB under conditions of higher flow of freshwater compared to dry, low-flow conditions like in August 2006.

Fluorescence Measurements for Detection of Optical Brighteners

Fluorescence measurements at both 410-610 nm and 436 nm were made on 208 water samples collected in the GRB watershed on August 3, 10, 17, 20 & 24, 2006. The range of values was from 2.3 to 192.1 for 410-610 nm readings, and from 1.0 to 105.6 for 436 nm readings. Of the 208 fluorometry readings, only 30 (14%) were above 100 units using 410-610 nm. The only sample with a fluorometry reading >100 using 436 nm was at LR4c on August 10 where the enterococci concentration was 63/100 mL. All of the samples with readings of >100 fluorometric units had discernable light brown or brown coloring from dissolved organic matter. The sites where fluorometer readings exceeded 100 units (410-610 nm) included LR2, 2b, 3, 4b, 4c; BB1; BP2, 3; BR1e, 3; GRC1; SB5; TB1. All sites except BP3 and TB1 had enterococci levels >104/100 mL in at least one sample with a fluorometer reading >100 units, and all these samples were collected on August 3 or 20, 2006. However, all samples had observable color (brown/light-brown), indicating the presence of dissolved organic matter and possible interference with fluorescence readings.

Hartel et al. (in review) showed relatively low concentrations of dissolved organic matter increase fluorometer readings in water samples for readings to a greater extent at 410-610 nm than at 436 nm, whereas with no organic matter present, fluorometric readings for several concentrations of *Tide* laundry detergent in distilled water were the same for measurements made at both wavelengths. For all fluorescence measurements in this study, the difference between the 410-610 nm and the 436 nm readings was ~50%, with 436 nm readings always lower than the 410-610 nm readings. These findings suggest that the GRB water sample fluorometry measurements were all affected to some degree by background interference from natural organic matter, which was confirmed by detection of UV-absorbing organic constituents even in samples with low fluorometry unit readings.

Because of the possibility that dilution of the optical brightener fluorescence signal may occur in surface water, especially where impacted by tidal action, the fluorescence data were further scrutinized for any evidence of possible presence of optical brighteners. Several sites (pink dots on Figure 11, next page) had elevated (>104/100 mL) enterococci concentrations and somewhat elevated fluorescence readings (>50 fluorescence units) with diminished organic matter interference. These were as follows:

- Little River watershed (5 sites): **LR1c, LR2, LR4b, BB1, BP2**
- Smith Brook watershed (2 sites): **SB2, SB3**
- Batson River watershed (1 site): **BR1c**

Of these 8 occurrences of elevated fluorescence and bacterial concentrations, 7 of them were in samples collected on August 20th, with the BP2 sample collected on August 17th. This suggests that the presence of optical brighteners may be more prevalent under higher flowing conditions for fresh-water than what occurred during the dry month of August, 2006. Figure 11 also indicates those sites that exceeded water quality standards for bacteria on every single sampling event (orange dots).

5.3 Discussion of Human-Nonhuman Sources

The detection of bacterial indicators of fecal contamination in surface waters is a warning that disease-causing pathogenic microorganisms may be present. The threat of human disease caused by exposure to pathogens is a concern that has caused limitations or warnings about the consumption of shellfish and use of freshwater and marine swimming areas, including GRB.

Most diseases associated with exposure to contaminated water are probably from human-borne viruses, though non-human fecal sources may also contain pathogens of concern to humans. From a pollution management viewpoint, it is desirable to assess the relative contributions to pollution from human and non-human sources to enable judicious use of limited resources to eliminate pollution sources and public health threats. Simply measuring bacterial concentrations tells little of where they came from. Current monitoring schemes and new technologies go beyond this simple approach and are now being used to provide for more definitive identification of pollution sources.

The scope of the present study included a spatially- and temporally-intensive assessment of bacterial (enterococci) concentrations throughout the surface waters that may affect water quality at GRB. The sampling was designed to capture possible problematic conditions (neap/spring tides; storm events) as well as to bracket areas where suspected sources of fecal contamination are present. The latter part of the design was intended to help identify actual pollution sources, including animal farms, non-sewered areas and overboard discharges. To enhance the interpretation of these results, fluorescence readings were also made on water samples to detect optical brighteners, because these substances are present in most human sewage sources and would be coincident with elevated bacterial concentrations. Thus, detection of optical brighteners helps to differentiate sources of fecal pollution as human or non-human. Follow up studies can then be pursued to identify and eliminate the specific pollution source(s).

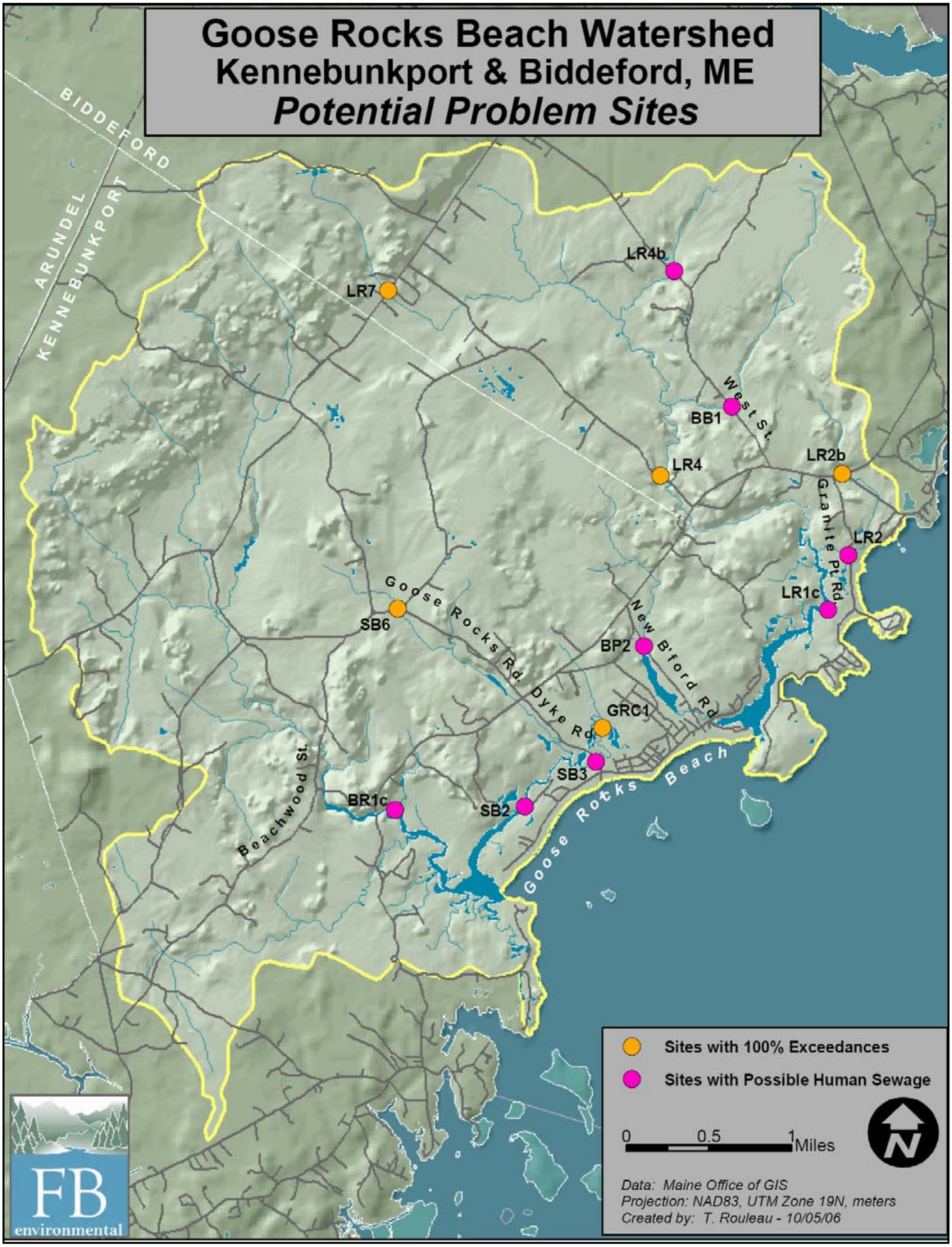
Use of more sophisticated methods should be considered as a possible add on to even more focused sampling under problem conditions for identifying specific sources of pollution. A final point that should be mentioned is that enterococci and other bacterial indicators have limitations, and in some cases may not be accurate indicators of fecal pollution. On the one hand, many human pathogens can out-survive some indicator bacteria. In other cases, the indicator bacteria may grow in the environment and thus give a false impression of elevated pollution levels. Despite these shortcomings, it is well accepted that any water body with elevated levels of indicator bacteria is not a pristine water body and probably reflects some human disturbance of the natural ecosystem.

6. Recommendations

6.1 Strategies for Additional Characterization of Potential Bacteria Sources in the Goose Rocks Beach Watershed:

A. Continued and Expanded Comprehensive Estuarine and Riverine Sampling: The project team recommends that bacteria sampling be continued in the watersheds contributing flow to the GRB area. Water sampling could be conducted by professional staff and/or trained volunteers. The study design should be developed by properly trained professionals. The purpose of expanded comprehensive estuarine and riverine sampling would be to track bacteria levels during dry and wet weather periods during various tidal cycles over a broad geographic area. This sampling will allow

Figure 11: *Summer 2006 Potential Problem Sites*



for useful information regarding future beach postings and tracking the success of treatment measures in the watershed over time.

B. Additional Storm Sampling: The project team recommends that bacteria and optical brightener sampling be conducted for at least one more storm event in 2006. The purpose of this storm event would be to track the flow of bacteria from select upstream sources to the beachfront locations (GR 1 – GR5) before, during, and after the storm event. The samples should be collected at regular intervals for at least 48 hours following a rain event of 0.5 inches or more in order to assist the Town of Kennebunkport with the posting of advisories in the river outlets (GR1 and GR5) and the beachfront locations (GR2, 3, and 4).

C. Continued Analysis of Potential Bacteria Sources in the Watersheds: The project team recommends that the Towns and partners continue to monitor septic issues in all contributing watersheds. The following questions (adapted from the CWP, Article 31) should be definitively answered where applicable:

1. How many septic systems are present in the watershed? How old are they?
2. Under what feasibility, setback, and design standards were they built?
3. What proportion of the watershed is not suitable or marginal for septic treatment?
4. Are septic systems clustered near receiving waters (along shorelines or streams)?
5. Are livestock or hobby farms present?
6. Are wildlife populations dense in water or riparian areas (beaver, gulls, geese)?

D. Microbial Source Tracking: There have been many recent applications of Microbial Source Tracking (MST) methods that have been shown to enable identification of bacterial and viral pathogens, the source species for indicator and pathogenic microorganisms, or to differentiate between human-borne and non-human sources of microorganisms and/or sewage. In many cases, especially in more recent studies, the best approach for identifying sources of pollution involves multiple tools. For example, a recent study in the Charles River in Massachusetts employed fluorescence detection of optical brighteners and enterococci concentrations as in this study, as well as caffeine, human-specific genes in *Enterococcus facium*, human specific genes in *Bacteriodes* bacteria, HPLC detection of specific optical brightening chemicals and detection of pharmaceuticals (O. Pancorbo, personal communication). The detection of more than one of these indicators helps to provide confidence in determining the presence of human-borne sewage pollution.

As for non-human sources of fecal pollution, many studies have been conducted in the coastal areas of southern Maine, New Hampshire and northern Massachusetts using several MST approaches that identify the source species for bacteria detected in water samples. The approach used in New Hampshire is ribotyping of *Escherichia coli*. The results of many studies in coastal areas of Maine and New Hampshire have shown non-human sources of fecal pollution to be significant and in some cases to be the dominant sources. At some NH beaches, otters, raccoons and horses have been significant sources. At Wells, ME, feral cats were suspected to be significant sources in the upper portions of some watersheds. Sea gulls, deer, fox, cormorants, geese, ducks, dogs, cows and cats have also been determined to be significant in different studies in this region, in addition to human sources (untreated wastewater, septage, direct human discharges).

6.2 Management Strategies

While differentiating between human and non-human fecal pollution sources is important, management strategies can be developed before more sophisticated methods are used to make this distinction. Pet waste, livestock grazing, animal feedlots and other non-human sources should also be managed to more effectively reduce pollution to surface waters. Many of these management strategies are relatively low cost and can provide meaningful involvement for watershed residents as active participants and stakeholders in this process. The present study has served to help the municipalities surrounding GRB to focus future efforts on eliminating bacterial pollution.

The Town of Kennebunkport and partners have invested considerable time and resources to address the bacteria issues at GRB. In order to maintain momentum and move ahead in a timely manner, management of existing bacteria sources should continue. Tom Schueler (Center for Watershed Protection, 2000) provides this general advice:

> *"The success of a low density (watershed) strategy stands or falls on the ability to prevent septic system failure…Key prevention strategies in low density watersheds are to prevent residential septic systems from failing (maintain failure rate close to 0)"*

The GRB watershed has a calculated impervious area of approximately 5%, which classifies it as a low density watershed. Based on the substantial area of watershed soils that are unsuitable for low density development and septic treatment, Schueler's advice may well pertain to the Batson, Smith Brook, and Little River Watersheds. Other treatment options should be investigated and implemented as appropriate. The following general Action Items present a logical plan of action for the Town of Kennebunkport and partners to use as a guide:

Action Item #1: Form a Goose Rocks Beach Management Committee

A sound management strategy greatly depends on having a vehicle for implementing treatment measures. Forming a GRB Management Committee (GRBMC) would be necessary to ensure that all groups are working together to properly address bacteria issues impacting the beach. This management committee should include town staff and selectmen/city councilors from Kennebunkport and Biddeford. The committee should also include local citizens, State Agency and Maine Healthy Beaches representatives, and consulting scientists/watershed managers. Additionally, regional expertise (e.g. Wells National Estuarine Research Reserve, York County Soil and Water Conservation District, Southern Maine Regional Planning Commission) could provide valuable input to the committee.

Action Item #2: Develop a List of Preferred Additional Research Measures

Before implementing measures in the watershed the GRBMC should prioritize additional assessment and research options. Some suggested measures are outlined in the previous sections. The GRBMC should develop a list of additional assessment and research questions that they would like to see answered while keeping in mind that definitive answers are often difficult to come by. The GRBMC should seek input from FB Environmental and partners on potential methods and funding sources that may help to address these questions.

Action Item #3: Continue to Target Human Sources of Pathogens

The GRBMC should consider focusing on less expensive management options first, until funding becomes available for more costly measures. The information provided in this report on potential trouble spots should provide some necessary guidance on geographic areas to focus on. Specific recommendations include:

Action Item 3A: ***Rehabilitate Existing Septic Systems*** **–** The GRBMC should utilize the assistance of the Maine DEP to test systems that may be impacting the rivers and streams draining to GRB. Outdated or failing systems should be replaced and State funding programs should be utilized whenever possible.

Action Item 3B: ***Connect Failing Systems to Sewer*** – In some cases, there may be a cluster of failing systems that are contributing high bacteria counts to the rivers and streams draining to GRB. Where feasible, systems could be connected to existing sewer systems in the area.

Action Item 3C: ***Increase Septic System Clean Outs*** – This management measure may be necessary in several locations throughout the watershed. Watershed residents should be educated regarding the need for frequent septic clean outs, especially in areas where high bacteria counts are prevalent. Frequency of clean outs will depend on site characteristics and the functionality of individual septic systems.

Action Item 3D: ***Develop Conservation Plans for Farms*** – The GRBMC should work with watershed farms and hobby farms to develop conservation plans that reduce bacteria loading from agricultural sources. Example management options include fencing of livestock, relocating animals further from waterways, and manure management. The Natural Resources Conservation Service (Alfred, Maine) and Maine Department of Agriculture have funding and free technical assistance available to assist with Conservation Plans.

Action Item 3E: ***Develop Pet Waste Management Programs*** – The GRBMC should provide pet waste management outreach to citizens and visitors to GRB and its watershed . The posting of signs prohibiting domestic animal waste near waterbodies is an example of a widely-used management measure.

Action Item 3F: ***Consider Wildlife Management Measures*** – Specific recommendations are not provided for this task because the extent and location of wildlife impacts are still unknown. However, the GRBMC should consider management options if/when more information is learned regarding wildlife impacts.

Action Item #4: Prevent or Treat Future Bacteria Sources

The GRBMC should consider the treatment of future sources as a priority. As this low density watershed becomes more developed, the chances for further human related sources of bacteria will likely increase. Special consideration should be give to areas unsuitable for low density development. Increased set back distances of septic systems from waterbodies is an example of a future management measure that will help to ensure that bacteria levels do not increase. Education and outreach programs are good examples of low-cost measures that can help stifle the increased bacteria loads. Education of local decision makers and the public on the basic functions of septic systems and need for pet waste management are two good examples of programs that have been successful in other communities. The GIS data layers (e.g. low density development, soil classifications) developed for the watershed by FB Environmental and partners should aid the GRBMC in making future planning decisions.

Action Item #5 Keep Informed Regarding Current Research on Related Issues

GRB is just one of many US beaches that has experienced high bacteria levels. At present, there are substantial national and international efforts to improve identification, monitoring, beach posting, and implementation measures relating to bacteria issues impacting beaches. Additionally, extensive epidemiological research is being undertaken to attempt to quantify health issues relating to bacteria counts at beaches. The GRBMC should keep informed on the current research that may provide more efficient and economical measures to be utilized in the future.

6.3 Potential Funding Sources for Additional Work

FB Environmental and partners will be researching potential funding sources throughout the month of October 2006 and will send a report to the Town in November of 2007. Forrest Bell, Fred Dillon, and Jim Hillier will be attending the National Beaches Conference from October 11 – 13th to learn more about federal grant programs. Dr. Steven Jones will be attending the International Conference on Management of Coastal Recreational Resources in Gozo, Malta in late October.

I. Characterizing Potential Bacteria Sources in a Watershed:

- Cooperative Institute for Coastal Estuarine and Environmental Technology (CICEET) - Environmental Technology Development Program for FY 2007. Competitive application due December 18, 2006.

- Maine Department of Environmental Protection Section 319 Funds - Competitive application due in May of 2007. Statewide funding is usually about $500,000 - $600,000.

II. Implementation of Practices to Prevent or Treat Future Bacteria Sources:

- Maine Department of Agriculture - Nutrient Management Grant Program - Phase II Supplemental. Competitive application due November 17, 2006

- Maine Department of Environmental Protection Small Community Grant Program -

- Maine Department of Environmental Protection Section 319 Funds - Competitive application due in May of 2007. Statewide funding is usually about $500,000 - $600,000.

- Environmental Protection Agency (EPA) - Clean New England Beaches Initiative for FY 2007. (Funding for Maine Healthy Beaches Program in 2006).

References

American Public Health Association (APHA). 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association, Washington, DC.

Caldwell, D.W., Hanson, L.S., and Thompson, W.B., 1985, Styles of deglaciation in central Maine, in Borns, H.W., Jr., LaSalle, P., and Thompson, W.B. (eds.) Late Pleistocene history of northeastern New England and adjacent Quebec: Geologic Society of America, Special Paper 197, p. 45-58.

Clinch, J.M., and O'Toole, P.B., 1999, Surficial Geology of the York Harbor 7.5 minute Quadrangle, Maine: Maine Geological Survey, Open-File Report 99-138, 6p.

Ferwerda, J., LaFlamme, K., Kalloch, N., and Rourke, R. 1997. The Soils of Maine. Maine Agricultural and Forest Experiment Station, University of Maine, Orono, Maine.

FitzGerald, D.M., Lincoln, J.M., Fink, L.K., and Caldwell, D.W. 1989, Maine Geological Survey, Studies in Maine Geology: volume 5, p. 67-96.

Flewelling, L.R. and Lisante, R.H. 1982. Soil Survey of York County, Maine. National Cooperative Soil Survey.

Hartel, P.G., McDonald, J.L., Genit, L.C., Rogers, K., Smith, K.L., Hemmings, S.N.J., Belcher, C.N., Kuntz, R.L., Rivera-Torres, Y., Otero, E. and Schroder, E.C. In review. Improving fluorometry as a source tracking method to detect human fecal contamination.

Hildreth, C.T., 1999, Surficial Geology of the Biddeford Harbor 7.5 minute Quadrangle, Maine: Maine Geological Survey, Open-File Report 99-109, 5p.

Hussey, A.M.II, Bedrock Geology of the Bath and Portland 2o Map Sheets, Maine: Maine geological Survey, Open-file Report 85-87, 82p., 2 plates, scale 1:250,000.

Reid, D., Just, E., Krauss, G., and Robinson, J. 2000. Clean Beaches - Using GIS to Help Remedy Shoreline Contamination. ESRI International User Conference, June 27, 2000. Retrieved from internet February 2006; URL: http://gis.esri.com/library/userconf/proc00/professional/papers/PAP546/p546.htm

Schueler, Thomas, 2000. The Practice of Watershed Protection: Techniques for Protecting our Nation's Streams, Lakes, Rivers, and Estuaries. Article 31: Microbes in Urban Watersheds: Implications for Watershed Managers. Pp 183-192. Center for Watershed Protection, Ellicott City, MD.

USDA/NRCS and MEGIS, 2005. United States Department of Agriculture/Natural Resources Conservation Service and Maine Office of Geographic Information Systems. Soil Survey Geographic (SSURGO). Maine Office of Geographic Information Systems. Augusta, ME.

APPENDICES