SUMMARY REPORT OF ENHANCED MONITORING AND POLLUTION SOURCE TRACKING EFFORTS IN THE GOOSE ROCKS BEACH WATERSHED, KENNEBUNKPORT, ME

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Photo: Noah Sargent

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ACRONYMS

BMP - Best Management Practice
CCTV - Closed Circuit Television Video
ENT - Enterococci Bacteria
EPA - Environmental Protection Agency
FIB - Fecal Indicator Bacteria
GRB - Goose Rocks Beach
LID - Low Impact Development
MHB - Maine Healthy Beaches
MPN - Most Probable Number
MST - Microbial Source Tracking
OB - Optical Brightener
OBD - Overboard Discharge
PCR - Polymerase Chain Reaction
PPCP - Pharmaceuticals and Personal Care Products
qPCR - Quantitative Polymerase Chain Reaction
UNH JEL - University of New Hampshire, Jackson Estuarine Laboratory
ME DEP - Maine Department of Environmental Protection

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The Goose Rocks Beach (GRB) watershed (approximately 19.8 square miles) located in the Town of Kennebunkport and the City of Biddeford is comprised of three primary subwatersheds (Batson River, Smith Brook, Little River) that ultimately discharge into popular downstream swim beach areas. Persistently elevated levels of enterococci (ENT) bacteria, particularly in the river mouths (Batson River and Little River) at each end of GRB, have resulted in beach advisory notifications and public concern regarding potentially unsafe swimming conditions. In response, the Maine Healthy Beaches (MHB) program has supported Kennebunkport's efforts to improve water quality at the beach and throughout the surrounding watershed by building local capacity to address pollution sources. This support includes the implementation of a multi-year pollution source-tracking study and the technical expertise of MHB program staff and partners.

In 2018, MHB and Kennebunkport initiated a pollution source monitoring plan aimed at assessing ongoing water quality issues at GRB, addressing watershed-wide recommendations from prior source-tracking work, and assisting Kennebunkport with the identification and elimination of possible fecal contamination sources. These efforts have focused primarily on the collection of water samples throughout the three subwatersheds, including GRB swim beaches at the mouths of the Batson and Little Rivers, for ENT, optical brightener (OB), and microbial source tracking (MST) DNA source-specific analyses. Through these efforts, several bacteria hot spots were identified, and priority areas were further investigated using source-specific methods.

Elevated fecal bacteria concentrations were observed throughout all GRB subwatersheds, particularly the Smith Brook and Little River subwatersheds. DNA detections varied distinctly by source type with mammal DNA detected in 100% of submitted samples, human DNA in 20%, canine DNA in 46%, bird DNA in 93%, gull DNA in 100%, and ruminant DNA in 0%. Sample sizes among source marker tests were not equal. These results suggest that fecal contamination in the GRB watershed is likely a product of a diverse set of host sources including a combination of human, wild, and domestic animal waste. Overall, elevated bacteria results and human-specific DNA detections were more common during wet weather monitoring events, suggesting stormwater runoff may play a significant role in the mobilization of fecal sources in the watershed. However, dry weather monitoring efforts also revealed impaired water quality in portions of the watershed, suggesting possible issues with nearby wastewater disposal systems. Monitoring sites with elevated/positive results for multiple measured parameters were prioritized as locations warranting follow up investigative efforts by Kennebunkport.

To address water quality impairments in the GRB watershed, Kennebunkport has investigated, identified, and removed sources of human wastewater discharges, continued to assess wastewater and stormwater infrastructure, expanded local public education and outreach initiatives, and hired interns to support these efforts. Ongoing human fecal contamination issues underscore the importance of continuing investigative efforts to ensure the integrity of wastewater disposal systems and continuing education/outreach efforts to improve water quality throughout the watershed and better protect public health at GRB.

1. BACKGROUND

Goose Rocks Beach (GRB) in Kennebunkport, ME is a popular summer destination for locals as well as thousands of seasonal visitors each year, and Kennebunkport's coastal beaches, including GRB, are an economic asset to the town. In 2017, Kennebunkport's estimated year-round population of approximately 3,500 more than tripled to an estimated seasonal population of over 12,000. Additionally, housing occupancy trends over the last decade show an increase in homes used for seasonal/recreational use from 34% in 2000 to 40% in 2017. In 2019, over 8,000 Goose Rocks Beach use stickers were sold (1-2).

Since 2005[1], Kennebunkport has partnered with the Maine Healthy Beaches (MHB) program and local volunteers to perform water quality monitoring and public notification of unsafe swimming conditions at GRB and Colony Beach (Figures 1-2). When bacteria monitoring results are elevated, Town staff post a Contamination Advisory at the beach near public entrances, the Town Office, the Police Department, the Goose Rocks Beach General Store (GRB only), and on Town and MHB websites. Beach monitoring locations are chosen based on where people swim as well as the location of freshwater inputs (rivers, streams, storm drains), high-risk features, wildlife areas, etc. Participation in the MHB program is voluntary and coastal water quality monitoring for swimming and other water contact is the responsibility of local jurisdictions.


Figures 1-2. Water quality monitoring volunteers for the Town of Kennebunkport.

Over the past 15 years, persistently elevated fecal bacteria levels have been observed at GRB, particularly at monitoring locations located at the mouths of the Batson River (GR-5) and Little River (GR-1) at low tide and following moderate-heavy rainfall. For most of that time, elevated bacteria levels have been observed less frequently at monitoring sites located near the central portion of GRB (GR-2, GR-3, GR-4) compared to river mouth monitoring sites (Figure 3; Appendix A, Figure A1, Table A1). For all monitoring years, the percent of GRB samples (data combined for all sites) exceeding Maine's single sample safety threshold[2] was greater than the MHB program-wide exceedance rate. This program exceedance rate encompasses monitoring results for all participating beaches. Elevated bacteria levels contribute to increased numbers of beach advisories, threaten public health, and degrade ecosystems. These advisories can negatively impact local economies that benefit from the tourism industry, like Kennebunkport's (3-4).

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[1] Initial monitoring conducted in 2004. Town officially joined the program in 2005.

[2] The percent of samples that exceed Maine's single sample safety threshold of 104 MPN/100mL is referred to as the exceedance rate. It is calculated by dividing the number of samples ≥ 104 MPN by the total number of samples.

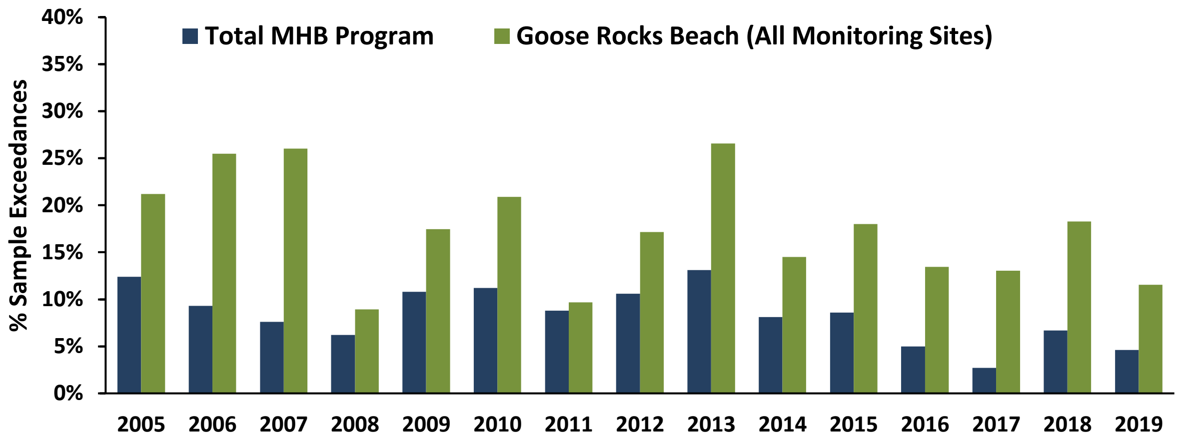

Figure 3. 2005-2019 percent sample exceedances of Maine's single-sample enterococci (ENT) threshold (104 MPN/100mL) for Goose Rocks Beach (GRB) (river mouth sites (GR-1, GR-5) and main beach sites (GR-2, GR-3, GR-4) combined) and total MHB program (all beach sites monitored through the MHB program) (See Appendix A, Figure A1 and Table A1 for sample sizes and site-specific exceedances).

1.1 Study Area

Goose Rocks Beach is located in Goosefare Bay and extends approximately two miles from the Batson River, northeast to the Little River. The surrounding watershed has an area of approximately 19.8 square miles and comprises the Batson River, Little River, and Smith Brook subwatersheds. The GRB watershed is primarily located within the Town of Kennebunkport, although a portion of the Little River subwatershed is within the City of Biddeford (Figure 4).

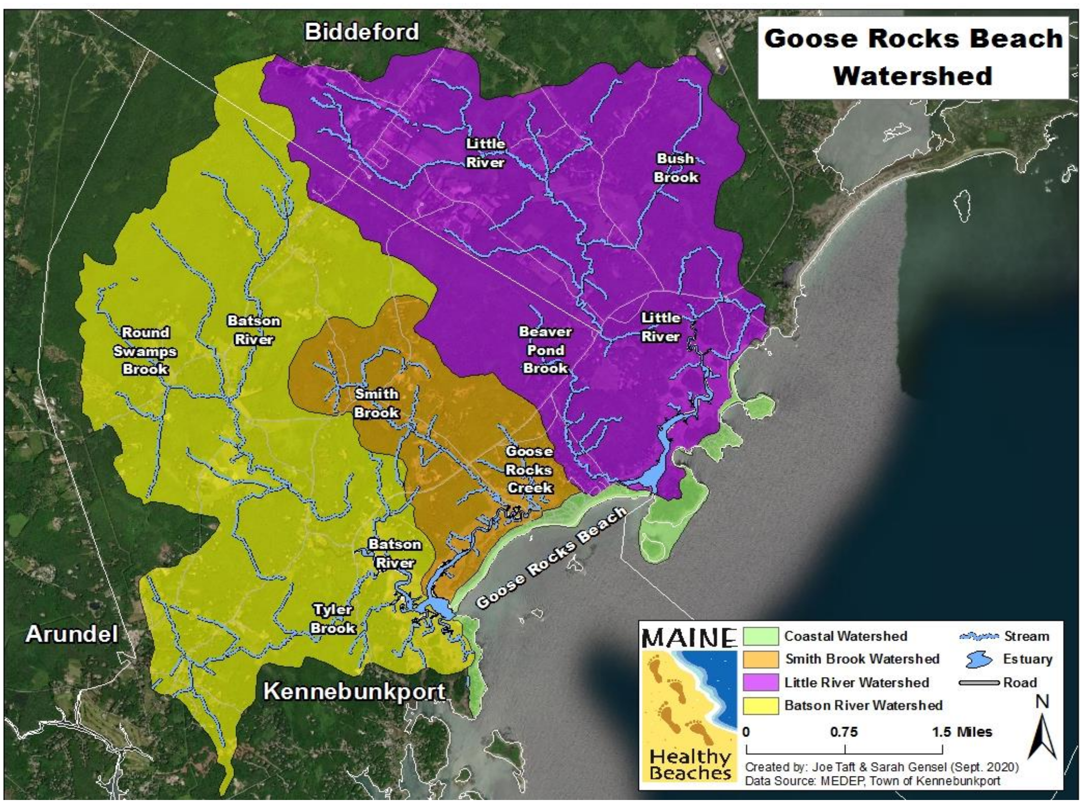

Figure 4. Goose Rocks Beach (GRB) watershed including three major subwatersheds (Batson River, Smith Brook, and Little River).

Within each of the three subwatersheds, a number of smaller tributaries/creeks combine and discharge to downstream GRB swim beach sites via the mouths of the Batson and Little Rivers. Coastal wetlands comprise the lower reaches of each subwatershed and, below head of tide, flushing is largely dependent on tidal inundation. The Batson River subwatershed is the largest subwatershed and includes Tyler Brook to the west of the Batson's main stem and Round Swamps Brook in the northwestern portion of the subwatershed. The Smith Brook subwatershed, located between the Batson and Little River subwatersheds, is the smallest of the three. It includes Goose Rocks Creek and discharges into the Batson River before reaching downstream GRB. The Little River subwatershed is shared by both Kennebunkport and Biddeford and includes Bush Brook in the northeastern region and Beaver Pond Brook to the west of the Little River's main stem (Figure 4).

Forest is the primary landcover type in the GRB watershed, followed by wetland areas that are dispersed throughout each of the three subwatersheds, particularly in the coastal regions. Residential development makes up a small proportion of watershed land cover and is located primarily along Kennebunkport's GRB shoreline (Kings Highway) and in Biddeford, in the northern portion of the Little River subwatershed along Guinea Rd. Additionally, there are two campgrounds located within the GRB watershed, the Shamrock Campground in the upper portion of the Little River subwatershed (Biddeford) and the Sandy Pines Campground in the lower reaches of the Smith Brook subwatershed (Kennebunkport) (Figure 5). For additional information regarding bedrock geology, topography, surficial geology, and soils see FB Environmental's 2006 Water quality report (5).

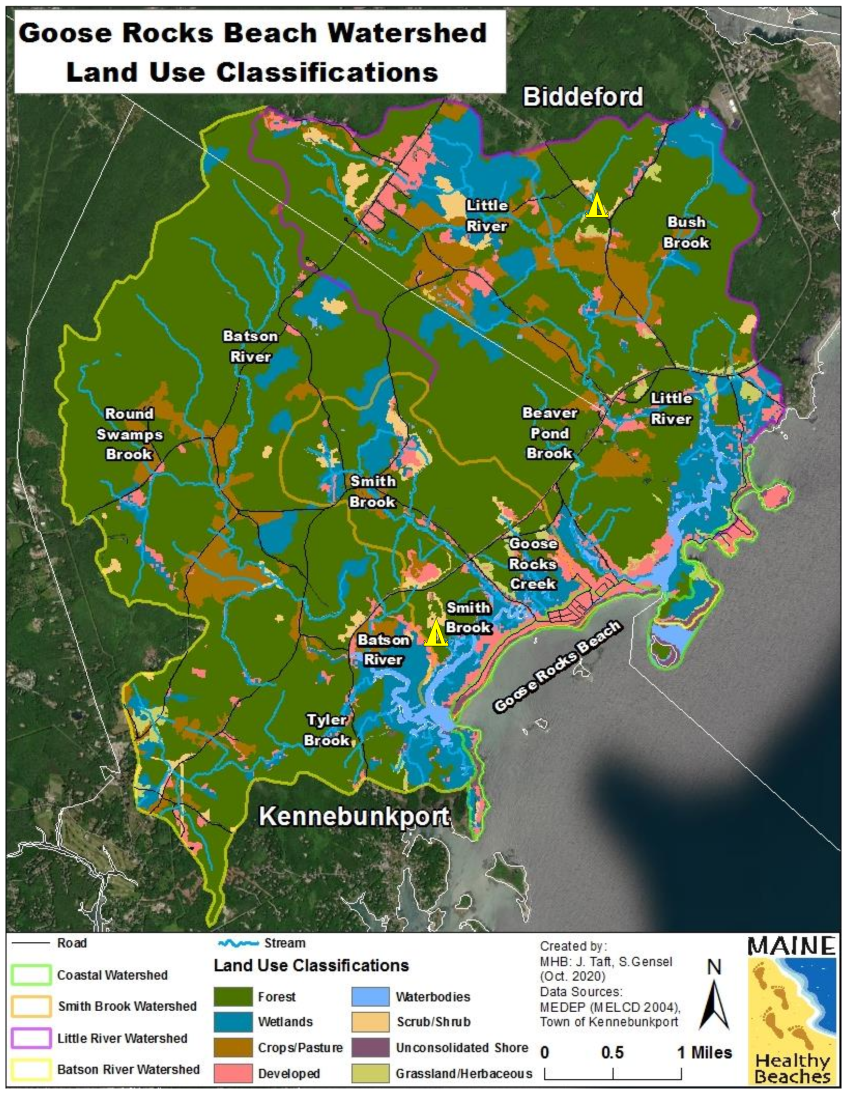

Figure 5. Land use classifications for the Goose Rocks Beach (GRB) watershed (derived from the 2004 Maine Land Cover Data (MELDC) data set). Land covers grouped into like types to aid with visualization. Campgrounds shown as yellow tent symbol.

Municipal sewer services portions of the GRB watershed, specifically properties located along Kings Hwy., Sand Point Rd., and a portion of the lower reaches of Dyke Rd. and New Biddeford Rd. (up to Binnacle Ln.). A majority of parcels in the watershed are not tied into the municipal sewer system and rely on individually maintained subsurface wastewater disposal systems. Historically, threats to water quality in the GRB watershed were thought to be largely due to malfunctioning septic and overboard discharge (OBD)[3] systems (2, 5-6). Sewer extensions to the GRB area have resulted in the removal of many of those systems, particularly in the Batson River subwatershed. Presently, all but four OBDs in the watershed have been removed and those properties have connected to municipal sewer. The remaining four OBD systems are located in Biddeford's portion of the GRB watershed and discharge into the ocean north of GRB, in the Granite Point region (Figure 6).

Kennebunkport's stormwater collection system for the GRB watershed south of Rt. 9 consists of shallow catch basins located predominantly along Kings Hwy., Crescent Ave., Proctor Ave., and the lower section of New Biddeford Rd. Stormwater runoff from these structures is collected and discharged into adjacent tidal marshes, primarily to Goose Rocks Creek and Beaver Pond Brook. Above Rt. 9, stormwater is primarily managed via open ditches with cross culverts (Figure 6).

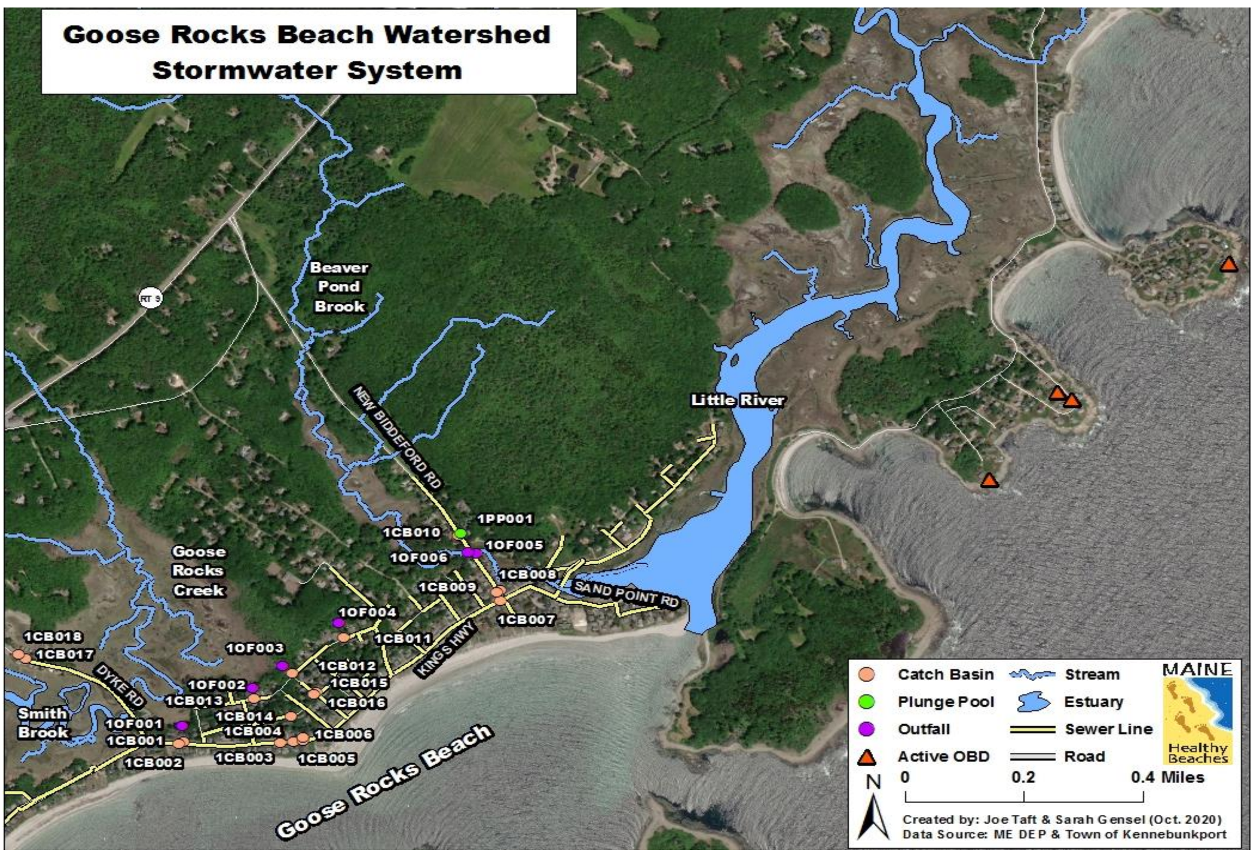

Figure 6. Municipal wastewater (sewer lines only) infrastructure, stormwater infrastructure (including catch basins, plunge pools, and outfalls), and active overboard discharge (OBD) systems (Biddeford) for the Goose Rocks Beach (GRB) watershed. See Appendix E, Figures E1-E2 for additional detail.

[3] An overboard discharge (OBD) is a discharge to surface waters of the State of domestic pollutants (sanitary wastes or wastewater from household activities generated at residential or commercial locations) that are not conveyed to municipal or quasi-municipal sewage treatment facilities. https://www11.maine.gov/dep/water/wd/OBD/ip_obd.pdf

The Maine Department of Marine Resources (Maine DMR) has performed monitoring in the GRB watershed for over 50 years to evaluate the safety of shellfish consumption and the health of their growing waters. All shellfish growing areas in Maine are evaluated according to standards set by the National Shellfish Sanitation Program (NSSP). Classifications are determined based on a sanitary survey, which includes water quality monitoring of fecal coliform[4] bacteria among other criteria[5]. Growing areas can be given one of five classifications including Approved, Conditionally Approved, Restricted, Conditionally Restricted, or Prohibited. Data has been collected since the late 1960s documenting specific areas within the GRB watershed as being unsuitable for shellfish harvesting, but digital records of this water quality information do not exist prior to 1997.[6] Since the late 1990s, portions of each GRB subwatershed have been classified by DMR as Restricted or Prohibited to shellfish harvesting due to impaired water quality.

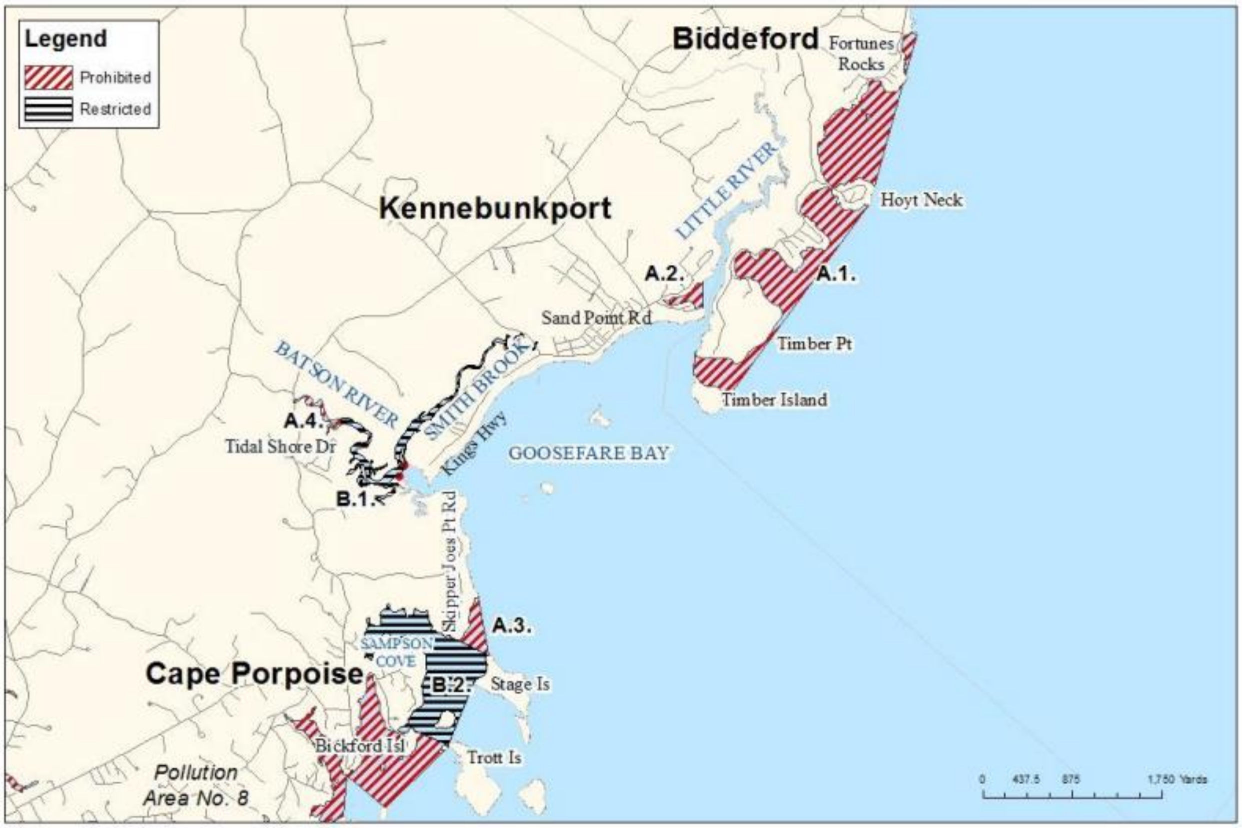

Figure 7. Maine Department of Marine Resources (DMR) Pollution Area No. 9, Sampson Cove to Fortunes Rocks.

Current classifications for each subwatershed include (Figure 7; Appendix B):

- **Little River:** A portion of the Little River subwatershed (A.2.) where the Beaver Pond Brook discharges to the Little River has been classified as Prohibited since at least 1997. The main portion of the Little River has been classified as Approved since 2009. Prior to 2009, this area was Conditionally Approved based on season (1997-2009).

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[4] Fecal coliforms are a fecal indicator bacteria (FIB) used as an indicator of fecal contamination from warm-blooded animals and the possible presence of disease-causing pathogens.

[5] https://www.maine.gov/dmr/shellfish-sanitation-management/programs/growingareas/index.html

[6] Maine DMR's digital records date to 1997, but Kennebunkport's 2012 Comprehensive Plan (2) details closures back to at least 1967. Classification records dating beyond 1997 are not available.

- **Batson River:** The entire Batson River was classified as Restricted from 1997 to 2014 when the upper portion of the river (A.4. - from Tidal Shore Drive to northern the northern most portion of the river) was reclassified as Prohibited. The lower portion of the Batson River (B. 1. below Tidal Shore Drive) remains Restricted to harvesting.
- **Smith Brook:** Smith Brook was classified as Restricted from 1997 to 2006 when it was reclassified as Prohibited. From 2006-2009, the classification alternated between Prohibited and Restricted until it was classified as Approved in 2009. In 2020, Smith Brook was reclassified from Approved to Restricted.

These restrictions aren't unique to Kennebunkport's shellfish resources. Restrictions on shellfish harvesting are prevalent along the coast of Maine, typically as a result of persistent elevated fecal bacteria levels and the presence of point source pollution, such as wastewater treatment plant discharges. No such municipal wastewater discharges currently occur at GRB. Monitoring of these Kennebunkport waterbodies by Maine DMR is ongoing.

1.2 2005-2006 Water Quality Efforts

During the last 15 years, Kennebunkport has worked to identify and address possible sources of bacterial pollution in the GRB watershed. In 2005 and 2006, Kennebunkport hired FB Environmental to perform comprehensive water quality monitoring throughout the GRB watershed, determine possible sources of bacterial contamination, and provide recommendations, including potential funding opportunities for addressing fecal contamination to improve water quality and ensure safe recreation at downstream GRB (5, 7).

Monitoring efforts specifically targeted conditions most likely to produce poor water quality results (e.g. large tidal fluctuations and rain events) in order to best capture water quality issues and bracket problematic sites for additional fecal source investigations. GIS techniques were used to perform a preliminary "hotspots" analysis to identify areas with a greater likelihood of human-sourced pollution and help inform the design of the sampling regime. Monitoring primarily involved the collection of enterococci bacteria and optical brighter samples[7]. Results of those efforts indicated widespread bacterial contamination and elevated fluorometry readings throughout each subwatershed, with specific priority areas identified as those suspected to be impacted by human fecal contamination.

These results were used to prioritize recommendations for future source identification work, help inform management strategies, and inform acquisition of funding to support ongoing efforts. A few key recommendations/actions items from that report include:

- Perform ongoing water quality sampling and source tracking efforts throughout the watershed including microbial source tracking[8] to target human-sourced contamination
- Continue evaluations of the integrity of septic systems and provide support and education to the public regarding septic system maintenance
- Consider additional measures to prevent future bacteria sources, including the use of GIS to help with resource management and establishment of education and outreach programs

[7] See page 10 for definitions of enterococci and optical brighteners.
[8] See page 11 for definition of microbial source tracking.

- Secure funding to support continued efforts in the watershed

Results from a 2005 circulation study by the Maine Geological Survey suggested elevated bacteria at Goose Rocks Beach was likely, at least in part, a result of non-point source bacterial pollution originating from coastal wetlands during spring tide conditions (8). Unlike point-source pollution (i.e. pollution originating from a single identifiable source such as discharge pipes from wastewater treatment plants), non-point source pollution originates from many diffuse sources and is transported via runoff, particularly during rainfall, to waterbodies such as rivers, streams, lakes, and coastal waters. In the case of coastal wetlands like those comprising the Goose Rocks Beach watershed, tidal inundation, particularly during spring tides, can also contribute to the transport of these pollutants downstream on an ebbing tide and upstream during a flood tide (9-15). During the 2005 circulation study, the authors also noted greater bacteria concentrations during flood tidal conditions compared to ebb, particularly at the mouth of the Little River, indicating a possible retainment of contaminants from an ebbing tide in the area that are then brought back to the beach on a flood tide. Further compounding bacteria issues at the Little River, authors suggested that the Little River beach monitoring site may also receive contaminants from the Batson, as the data demonstrated a potential for the transport of Batson River flow along the GRB shore and reaching the mouth of the Little River under flood tide conditions (8) (See Appendix C for more information).

1.3 2018-2019 Source Tracking Efforts (MHB & Kennebunkport)

For the last several years, ongoing bacteria issues at the mouths of the Little and Batson Rivers (Fig 8, sites GR-1 and GR-5) have remained. To address these issues, Kennebunkport requested support from MHB to reestablish baseline monitoring of the watershed to determine if hot-spots have changed over the last decade and to address specific recommendations from the 2006 report, particularly the implementation of additional source tracking tools to better understand specific sources of bacterial contamination. Monitoring efforts focused on previously identified priority locations within the three subwatersheds, prioritizing areas in the lower reaches of the watershed where human fecal contamination sources were suspected.

To pinpoint human fecal sources, MHB uses the pollution source tracking toolbox approach. This method includes the use of multiple parameters and typically, as the number of parameters that exceed a threshold (or detectable) limit increases, so does the confidence that human sources are impacting water quality (Table 1). Human sources of bacterial pollution may include, but are not limited to, faulty sewer lines, cross-connections between sewer and stormwater infrastructure, and malfunctioning septic systems. For the GRB watershed, toolbox parameters varied for each monitoring season as their utilization was largely dependent on staff and funding availability.

The EPA recommends using the fecal indicator bacteria (FIB) enterococci (ENT) as an indicator of fecal contamination for marine waters. ENT are intestinal bacteria that, when detected in surface water, indicate the presence of fecal contamination from warm-blooded animals and, thus, the possible presence of disease-causing pathogens (16-17). FIB like ENT do not differentiate the source(s) of bacterial pollution and have been found to persist and regrow in sand, seaweed, and sediment (9, 16, 18-26). As a result, using FIB alone to assess public health risks from water contact is limited, as their ability to persist and grow in the environment means FIB may not always provide a useful indication of the presence and concentration of actual fecal waste. Since FIB do not differentiate sources of fecal waste, they provide limited management direction for addressing causes of FIB contamination. This is particularly problematic from a public health perspective, as they do not give any information about whether waste of human origin is present (24, 27-28).

Research confirms human sources of fecal waste present the greatest human health risk, particularly for children, due to the host-specificity of associated pathogens compared to non-human fecal sources (28-30). This underscores the need for the incorporation of human-specific test methods into water quality assessment efforts when possible. Several parameters targeting human sources have been incorporated into source tracking efforts in the GRB watershed, each with varying levels of cost/required expertise, usefulness for water quality management, and method limitations (Table 1).

Table 1. Source tracking toolbox parameters utilized in the Goose Rocks Beach watershed (excluding canine detection) by MHB and partners.

Parameter	Method	Source Target	Cost/Expertise
Enterococci (ENT)	Grab sample; IDEXX Enterolert	Warm blooded animals	Low/Low
Optical brighteners (OBs)	Grab sample; fluorometry	Human	Low/Low
Ammonia, Surfactants, Total Chlorine	Grab sample; Field test kit	Human	Low/Low
Pharmaceuticals and personal care products (PPCPs)	Grab sample; metabolite analysis	Human	High/High
Canine detection	ENT grab sample in tandem with canines	Human	Low/Med
Microbial source tracking (MST) (DNA source markers)	Grab sample; PCR/qPCR	Human and non-human	High/High

Optical brighteners (OBs) are compounds commonly used in commercial/retail products such as clothing detergents, dishwashing agents, and personal care products to brighten the whiteness of materials. OBs are typically flushed down the drain and can be used to track human sources of wastewater. When concentrations are found in surface waters, it can be indicative of an illicit discharge. Canine detection involves the deployment of dogs trained to detect human feces (presence/absence). FIB monitoring is typically conducted alongside canine detection to verify and quantify suspected contamination (31-32). Canine detection was not used as part of this study.

The presence of ammonia, surfactants, and total chlorine in surface water may indicate a nearby sanitary, municipal, or industrial discharge, as these are common compounds used by treatment facilities, homes, and industry. For this reason, these parameters are commonly used as indicators of human-sourced discharges. Ammonia is considered the best indicator of the three for sanitary discharges, while surfactants and total chlorine are used to detect non-sanitary sources of human pollution (e.g. soaps, oils, disinfectants). Results from these screening tests are often used to prioritize more conclusive test methods (e.g. pharmaceuticals and personal care products (PPCPs) testing and MST). PPCPs represent a suite of compounds that are predominately used by humans, but also to care for domesticated animals and in livestock and poultry operations. These compounds are considered as contaminants of emerging concern due to their demonstrated persistence in wastewater effluent and now widespread presence in the natural environment. Because PPCPs can be indicative of wastewater pollution, monitoring for these compounds can be useful when trying to identify potential illicit human sources of fecal pollution. These compounds were monitored for in a limited capacity as part of this study.

Microbial source tracking (MST) methods are used to complement traditional FIB monitoring because they can be used to identify actual fecal pollution and can discriminate between sources (both human and non-human) of fecal pollution by targeting host-specific DNA markers from different host-specific strains of certain species of fecal-borne bacteria (33-38). In the case of this study, PCR/qPCR-based methods were used to discern sources of fecal contamination that are possibly contributing to persistently elevated FIB levels in the GRB watershed. These markers provide host specificity, allowing for the identification (PCR)[9] and quantification (qPCR)[10] of a variety of specific host sources from one sample. Using qPCR, a relative quantitative amount of source-specific fecal contamination can be determined. This method provides a copy number for the DNA of targeted genes that can be used to gain a sense of the relative pollution contribution from human waste and other sources (rather than just a presence/absence conclusion) which aids in efforts to assess relative loading levels and to track source(s).

In contrast to FIB, the host-specific bacteria targeted for MST assays are unable to proliferate in the environment. Once outside their host, these organisms do not grow and can be consumed by other organisms or begin to die off over time. Therefore, detection of source-specific genetic markers is usually indicative of a recent contamination event (35, 38-41). This is particularly useful in the GRB watershed due to the potential for FIB to persist in low-lying marsh regions and complicate FIB source identification.

2. PROJECT METHODS

Monitoring sites for this study were selected based on “hot spots” (i.e. areas with consistently elevated bacteria levels) identified through historical water quality monitoring efforts, field investigations, accessibility considerations, and local knowledge from municipal staff and residents[11]. When possible, an adaptive monitoring approach was used to prioritize resources toward targeting suspected pollution hot spots. As a result, monitoring locations and sampling frequencies have varied over time.

Since 2018, a total of 16 stream sites have been routinely sampled including two sites at the mouths of the Batson and Little Rivers that have also been monitored 2x per week during the summer sampling season through MHB’s swim monitoring program (Figure 8). Several of the sites monitored in 2018 were discontinued in 2019, primarily as a result of access limitations or minimal stream flow. Additional samples were collected at several supplemental (FYI) stream sites, as well as a limited number of stormwater structures to further bracket problematic sites and investigate

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[9] PCR: Polymerase chain reaction. A method used to detect and amplify segments of DNA resulting in presence/absence determinations for specific source targets.

[10] qPCR: Quantitative polymerase chain reaction. A method used to detect, amplify, and quantify segments of DNA resulting in a relative copy number for the DNA of targeted genes for specific source targets.

[11] Best efforts were made were made to use the same naming scheme as prior monitoring activities for consistent data comparisons; however, not all site names from prior reports (3, 5) are consistent with those used in this report.

suspected pollution sources contributing to elevated FIB results. Stormwater monitoring was incorporated in 2019, after 2018 monitoring and investigative efforts identified stormwater runoff as a potential source of bacterial pollution, particularly to the Smith Brook and Little River (Beaver Pond Brook) subwatersheds. Prior to monitoring site selection, Kennebunkport worked with MHB to identify and map stormwater structures (outfalls and basins). Stormwater monitoring was limited in scope as these efforts were primarily wet weather dependent.

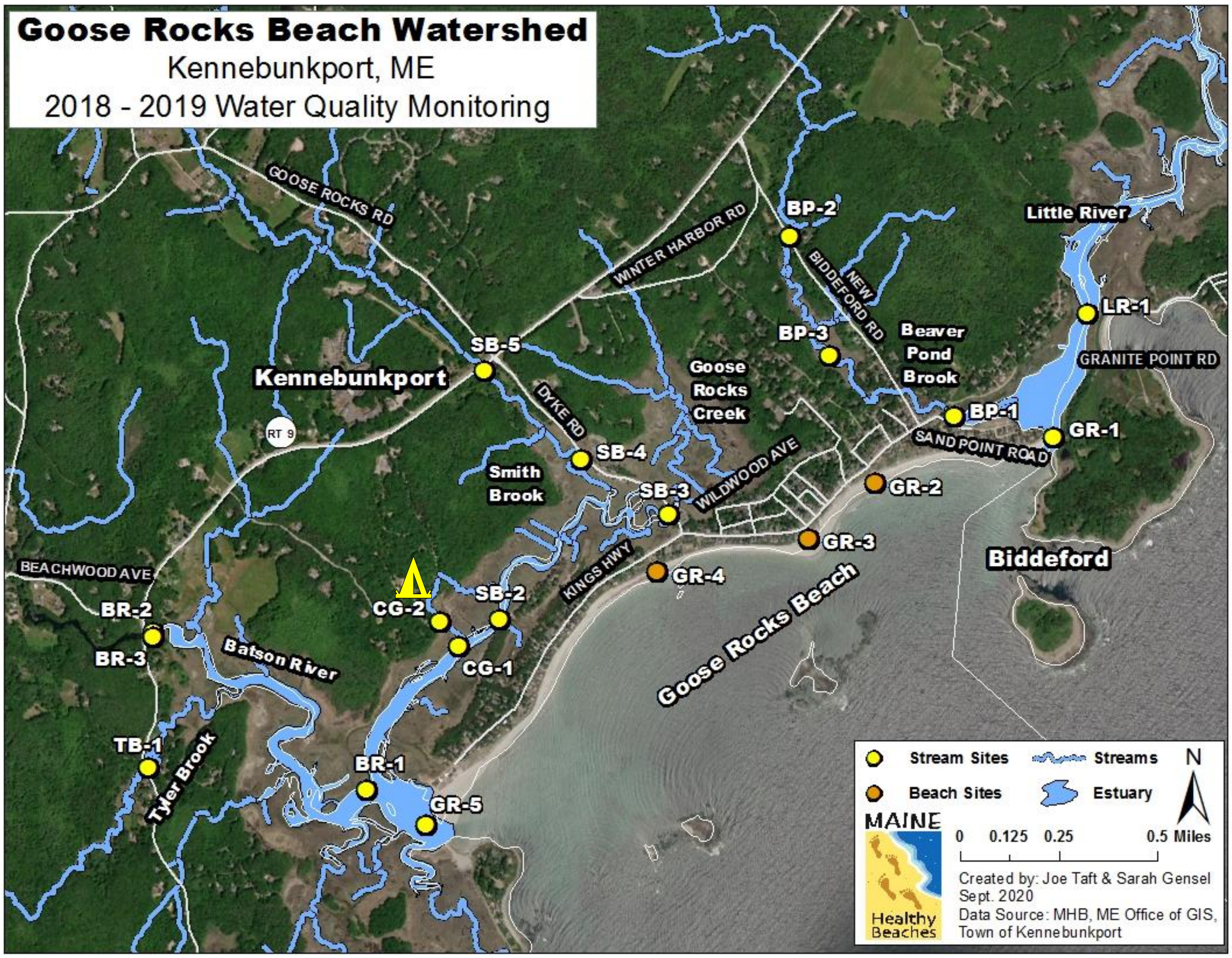

Figure 8. 2018-2019 Goose Rocks Beach watershed stream and beach monitoring sites (FYI and stormwater monitoring sites not included). Yellow tent symbol = Sandy Pines Campground.

Stream monitoring sites included a mix of tidal (saltwater) and freshwater sites, with the majority of sites being tidally influenced. Monitoring was conducted during a mix of dry and wet weather events on an outgoing tide. Monitoring events typically began 2-2.5 hours before peak low tide to ensure all samples were collected prior to the incoming high tide (Appendix A, Table A2)[12]. Monitoring was performed during outgoing tides to capture potential impacts of upstream tributary flushing on downstream water quality, including possible inputs from wildlife, domestic animals, agriculture/hobby farms, and subsurface wastewater disposal systems. The MHB program is most concerned with potential point sources of human fecal pollution (e.g. malfunctioning septic systems, compromised sewer infrastructure). Monitoring for FIB during dry weather conditions

[12] Exceptions: 9/24/2018 & 7/11/2019. Monitoring began 1-3 hours after peak high tide due to scheduling constraints.

can assist with identifying these types of pollution sources. During wet weather, multiple human and non-human sources can act together and result in extremely elevated FIB that often do not provide insight as to the location and host source(s) of contamination issues.

In 2018-2019, water samples were collected for ENT, OB, and MST analyses. MST analyses were made possible through a partnership with Dr. Steve Jones and his research lab at the University of New Hampshire's Jackson Estuarine Laboratory (UNH JEL). In 2019, MHB and Kennebunkport partnered with staff from the EPA to incorporate additional source tracking parameters to target human sanitary sources including PPCPs and field screening toolkit parameters (ammonia, surfactants, and total chlorine). Monitoring for these parameters was limited (1-3 monitoring events depending on the parameter). Additional parameters collected for each site/date included current weather conditions, air and water temperature, salinity, tidal stage, 48-hour preceding rainfall, and any field conditions/observations (Appendix A, Table A2).

2.1 Enterococci and Optical Brighteners

ENT samples were analyzed according to MHB's EPA-approved Quality Assurance Project Plan (QAPP) by a Maine-certified laboratory[13] using the IDEXX Enterolert ® Most Probable Number (MPN) enumeration method. The relative concentration (µg/L) of OBs were determined by Maine DEP staff using a Turner Designs field fluorometer (Model 10-AU-005-CE)[14]. This is considered a semi-quantitative method because the large variety of OBs used in the industry results in varying fluorescence intensities among products. Additionally, for this study, it was not possible to account for potential interference from organic matter on observed measurements. MHB recommends the collection of OB samples in conjunction with bacteria sampling and other co-indicators. Although OB results were considered, ENT results were the primary parameter used to prioritize subsequent MST source marker analyses.

Samples were collected and analyzed for ENT and OBs for 20 monitoring events (2018, 10 events from late June to mid-October; 2019, 10 events from late May to early October) at stream sites stratified throughout the Smith Brook, Little River, and Batson River subwatersheds. Paired ENT and OB stream samples (254 total) were collected at 14 routine sites in 2018 and 13 in 2019 during 13 dry and seven wet weather events (2018: 5 dry, 5 wet; 2019: 8 dry, 2 wet[15]) (Figure 8; Appendix A, Table A2).

Stormwater monitoring included 26 samples from 12 total catch basins in the Smith Brook and Little River subwatersheds for four monitoring events in 2019 (7/23, 8/1, 9/12, 9/18). Sample sizes for each site (1-4 samples per structure) varied due to limited wet weather events and scheduling constraints that made it difficult to monitor in conjunction with wet weather. As a result, many catch basins were dry at the time of monitoring. No outfalls were monitored in 2019 due to lack of flow (Appendix A, Table A2).

[13] Nelson Analytical in Kennebunk, ME for 2018 and Maine Environmental Laboratory in Yarmouth, ME for 2019.
[14] The fluorescence of the compounds were excited at 360 – 365 nm and measured at 436 nm emission wavelength.
[15] Wet weather criteria: ≥0.1 inches of precipitation in the prior 24 hours or ≥0.25 inches in the prior 48 hours. Best efforts were made to monitor during a mix of dry and wet weather events, but wet weather monitoring events were limited due to scheduling constraints and timing of precipitation.

2.2 Ammonia, Total Chlorine, and Surfactants

EPA staff supported analyses for ammonia, total chlorine, and surfactants using in-situ field test kits for three 2019 sampling events (7/24/2019, 8/24/2019, 9/4/2020) at 10 stream monitoring locations. Timing constraints prevented monitoring at BR-1 for the 7/24/2019 event. Surfactants were only analyzed in samples with low salinity levels due to the possibility of false positive results from samples with a salinity greater than 1 part per thousand. For each sample collected, measurements of salinity, specific conductivity, and temperature were also performed (Appendix A, Table A2).

2.3 Pharmaceuticals and Personal Care Products

In 2019, EPA supported the analysis of samples for eight PPCPs for one sampling event (9/4/2019) at 10 monitoring locations (Table 2). PPCP analyses were conducted at EPA's Region 1 Laboratory (North Chelmsford, MA) (Appendix A, Table A2).[16]

Table 2. Pharmaceutical and Personal Care Products (PPCPs) analyzed for in the Goose Rocks Beach (GRB) watershed (2019).

PPCP	Description
Acetaminophen	Pain killer
Atenolol	Control high blood pressure
Caffeine	Stimulant
Carbamazepine	Control seizures
Cotinine	Metabolite of nicotine
1,7-Dimethylxanthine	Metabolite of caffeine
Diphenhydramine	Antihistamine
Metoprolol	Controls high blood pressure

2.4 Microbial Source Tracking

Recommendations from the 2006 water quality study conducted by FB Environmental included the incorporation of source-specific test methods into future water quality assessments at sites suspected to be impacted by human fecal contamination. Since that report, the field of MST has rapidly evolved, including the development of a variety of reliable and field-tested source-specific test methods. Advancements in these techniques has made these tools more readily available to municipalities for pollution source tracking work.

As part of this study, a subset of GRB water quality samples have been analyzed using PCR and qPCR MST assays for six host source markers including mammals, humans, birds, gulls, canines, and ruminants (e.g. deer, sheep, cows) (Figure 9, Appendix A, Table A9). For mammal, human, and bird source assessments, qPCR analyses were conducted. This qPCR analysis provides a relative quantification of source-specific fecal contamination present in each sample (results are communicated as a target gene copy number). For all other source markers (gulls, canines, and ruminants), PCR analyses were used to determine presence/absence of source-specific fecal contamination. All DNA analyses were performed by trained personnel in Dr. Jones's research lab at the UNH JEL in Durham, New Hampshire.

MST analyses are costly and require a greater level of expertise than traditionally used methods (ENT and OBs). Analyses were prioritized for human and mammal source targets to verify the

[16] For more information see Appendix D.

presence/absence of recent human and/or other mammalian fecal sources at identified contamination hot spots. Sample sizes among source marker tests were not equal. Beach monitoring locations at the mouths of the Little and Batson Rivers (GR-1 and GR-5) were prioritized for DNA source testing because of their frequent use for recreational water contact activities. For remaining sites, ENT results and preliminary DNA results were used to prioritize suspect locations for additional human-specific DNA testing.

Additional source-specific analyses (canine, bird, gull, and ruminant) were prioritized for areas with high ENT concentrations, mammalian DNA detections, and infrequent or no human DNA detections. This was done to assist with the identification of possible non-human fecal sources contributing to elevated ENT concentrations. To assess consistent mammalian DNA detections in the absence of consistent human DNA detections, follow-up ruminant and canine DNA assessments were performed for sites suspected to be impacted by wildlife and/or canine feces. Select samples were tested for bird and gull specific DNA, particularly samples from downstream sites at or near coastal beach areas.

MST sample sizes differed distinctly between 2018 and 2019 due to contracting delays during the 2018 season. Samples were collected during three sampling events from late September to mid-October at 12 sites in 2018 and during 11 sampling events from late May to early October at 13 stream sites in 2019. The late start for MST sample collections in 2018 resulted in samples from fewer dates analyzed and a smaller sample size for 2018 stream samples compared to 2019 (2018:17 samples analyzed for two dates; 2019: 48 samples analyzed for seven dates). A limited number of stormwater structures (6) were monitored (one sample per structure) in 2019 during one monitoring event in mid-September (Figure 9; Appendix A, Tables A2, A9). All samples submitted for DNA analyses were tested for mammal and human DNA source targets.

Although stream sites were sampled during a mix of dry and wet monitoring events, the majority of samples submitted for DNA analyses were collected under dry weather conditions. In 2018, DNA samples were submitted for two dates that included one wet weather and one dry weather event. For 2019, samples were submitted for seven stream monitoring events and included two wet weather and five dry weather dates.[17]

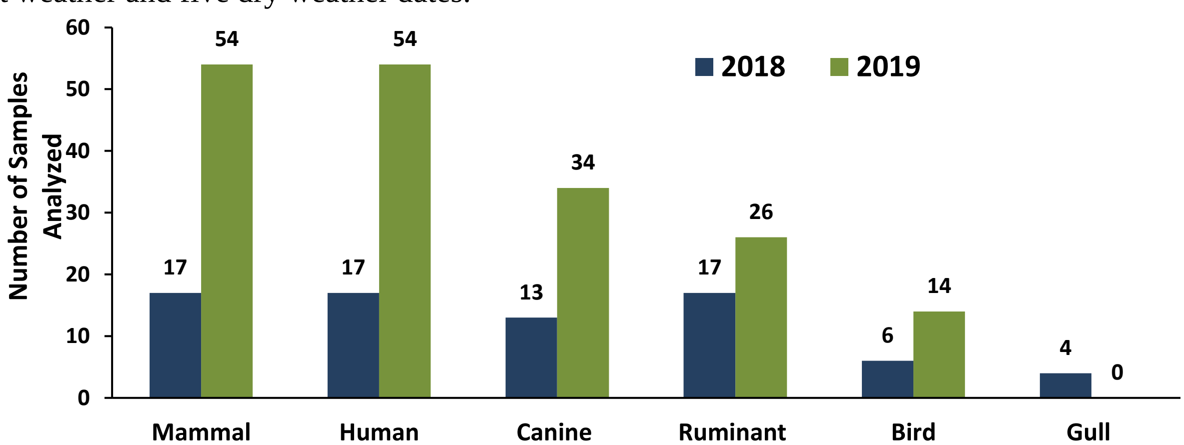

Figure 9. Number of Goose Rocks Beach (GRB) watershed samples (stream and stormwater) submitted for DNA analysis per source marker in 2018 and 2019.

[17] Wet weather is defined as ≥0.1 inches of precipitation in the prior 24 hours or ≥0.25 inches within 48 hours prior to monitoring: 10/3/2018 (0.99), 6/24/2019 (0.50), and 7/24/2019 (1.90).

3. RESULTS

3.1 Enterococci and Optical Brighteners

3.1.1 Enterococci Exceedances

Maine's EPA-approved single sample safety criteria for ENT is 104 MPN/100mL and EPA recommended ENT geometric mean (geomean)[18] for five or more samples collected within a 30-day period is 35 MPN/100mL. Of the 253 stream samples collected (2018-2019)[19] at 16 routinely monitored sites, 33% (83) exceeded the 104 MPN/100ML threshold. Of those 83 exceedances, over half (53%) were associated with wet weather 24 or 48 hours prior to sample collection. Percent sample exceedances of ENT single sample criteria varied considerably between sites and among monitoring years with just five sites (BP-1, BP-2, SB-3, SB-4, SB-5) accounting for 61% of all observed single sample exceedances (Figure 9; Appendix A, Table A3, Figures A2-A3).

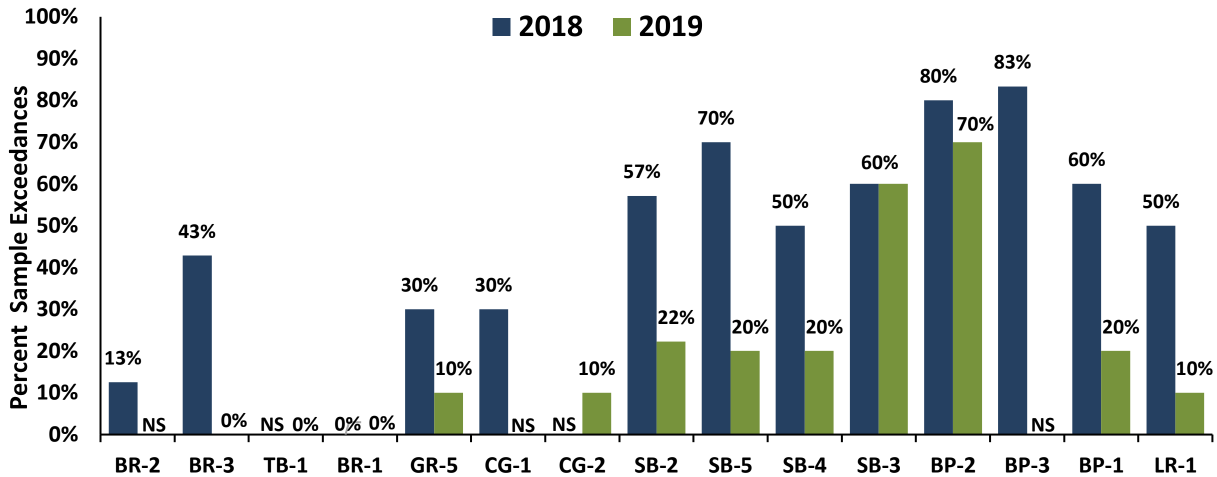

Figure 10. Percent sample exceedances of Maine's single-sample enterococci (ENT) threshold (104 MPN/100mL) for Goose Rocks Beach (GRB) watershed stream monitoring sites for 2018 and 2019 (See Table A3 for sample sizes).

In 2018, single sample ENT values ranged from <10 to 4,611 MPN/100mL[20] and 47% (59) of samples exceeded Maine's single sample safety threshold. Exceedances were observed for all but one site (BR-1). Eight of 14 sites (57%) had single sample values that exceeded 104 MPN/100mL ≥50% of the time, including two sites (BP-2 and BP-3) that exceeded the single sample threshold >80% of the time. A greater number of wet weather exceedances (63%) occurred compared to dry weather (37%). In 2018, wet weather exceedances occurred at 13 sites, and for all of these sites, exceedances were associated with wet weather ≥50% of the time. Monitoring sites BR-2 and BP-3 had the greatest percent of exceedances associated with wet weather (100% and 80% respectively). Exceedances were associated with wet weather 67% of the time for monitoring sites BR-3, GR-5, GR-1, CG-1, and SB-3 (Figure 10; Appendix A, Figures A2-A3, Table A4).

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[18] A measure of central tendency used to account for large fluctuations (common for bacteria data) by putting less weight on outliers in a data set. Geometric means (geomeans) are calculated using the product of a set of values rather than the sum, as is used to calculate the arithmetic mean (average). Any ENT results of <10 MPN/100mL were considered 5 MPN/100mL for calculations.

[19] Excludes FYI sites and field/lab duplicates.

[20] The IDEXX Enterolert ® method requires a 1:10 dilution for marine samples; therefore, the detection limit is 10 MPN/100 ml of sample water. Results with a 1:10 dilution test can reach a maximum value of >24,196 MPN/100mL.

In 2019, single sample ENT values ranged from <10 to 959 MPN/100 mL with fewer exceedances overall (19%) compared to 2018. Exceedances were observed for nine of 13 total sites and a greater number of exceedances occurred during dry compared to wet weather monitoring events with just 29% of the 24 total exceedances associated with wet weather.[21] Two sites (SB-3 and BP-2) accounted for the majority of 2019 observed exceedances as these sites exceeded the single sample criteria ≥50% of the time. These sites were also among those that exceeded ENT single sample criteria ≥50% of the time in 2018. Samples collected for the remaining 11 sites exceeded the safety criteria 25% or less of the time and no exceedances were observed for four sites (BR-3, TB-1, BR-1, GR-1) under any weather conditions. Wet weather exceedances occurred at six sites, and for five of these sites, exceedances associated with wet weather were observed ≤50% of the time. Sites CG-2, SB-2, and GR-5 exhibited dry weather exceedances, but no wet weather exceedances in 2019 (Figure 10; Appendix A, Figures A2-A3, Table A4).

3.1.2 Enterococci Geomeans

Sites exceeding the ENT geomean criteria in 2018 were dispersed throughout each of the three subwatersheds, while most sites exceeding in 2019 were located in the Smith Brook subwatershed (one Little River subwatershed site). ENT geomean values varied widely between stream sites, particularly for 2018. Site specific geomeans ranged from 24.6 to 539.3 MPN/100mL in 2018 and from 10.7 to 161.8 MPN/100mL in 2019. Geomean values exceeded the recommended 35 MPN/100mL criteria for a greater number of stream sites in 2018 (79%: 11 out of 14) compared to 2019 (31%: 4 out of 13). Of the 11 monitoring sites consistently sampled for both years, 36% (4 sites) exceeded the 35 MPN/100mL threshold for both years; those sites include SB-5, SB-4, SB-3, and BP-2. Four sites (GR-5, LR-1, GR-1, SB-2) exceeded the geomean threshold in 2018 but did not exceed in 2019.[22] The highest one-year ENT geomean was observed for the site with the smallest sample size (BP-3, n=6) (Figures 11-12; Table 3; Appendix A, Table A3, Figures A2-A3).

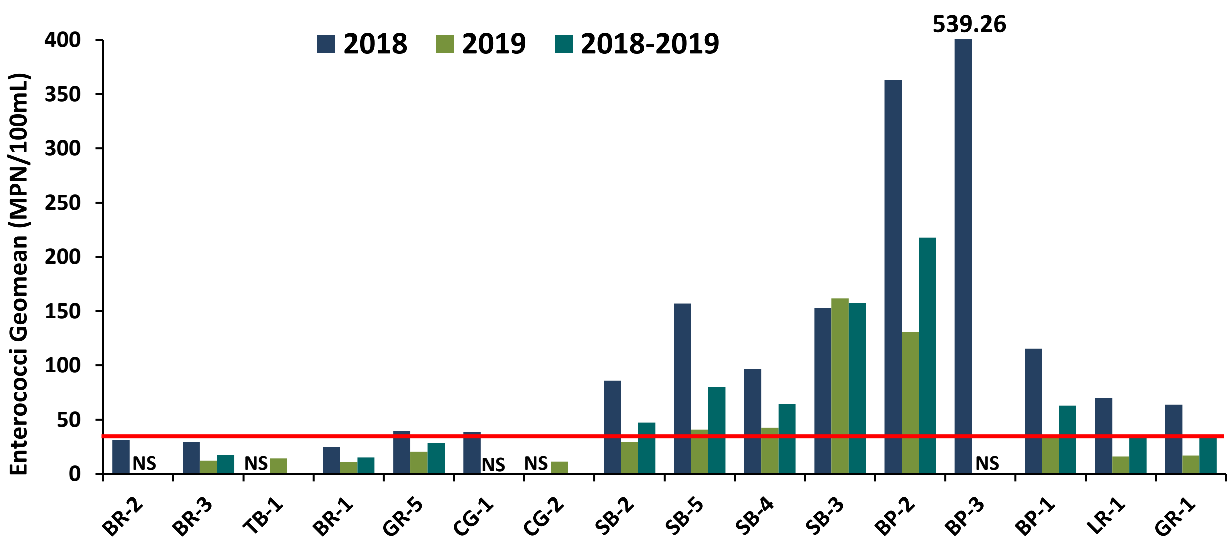


Figure 11. Enterococci (ENT) geomean (MPN/100mL) for Goose Rocks Beach (GRB) watershed stream monitoring sites for 2018, 2019, and 2018-2019 combined data (See Table A3 for sample sizes). Red line represents EPA recommended ENT geomean threshold (35 MPN/100mL). 2018-2019 geomeans not calculated for sites monitored for one season only.

[21] Limited wet weather monitoring dates for 2019 (2 out of 10).

[22] 2019 geomean for BP-1 nearly exceeded 35 MPN/100mL at 34.3 MPN/100mL.

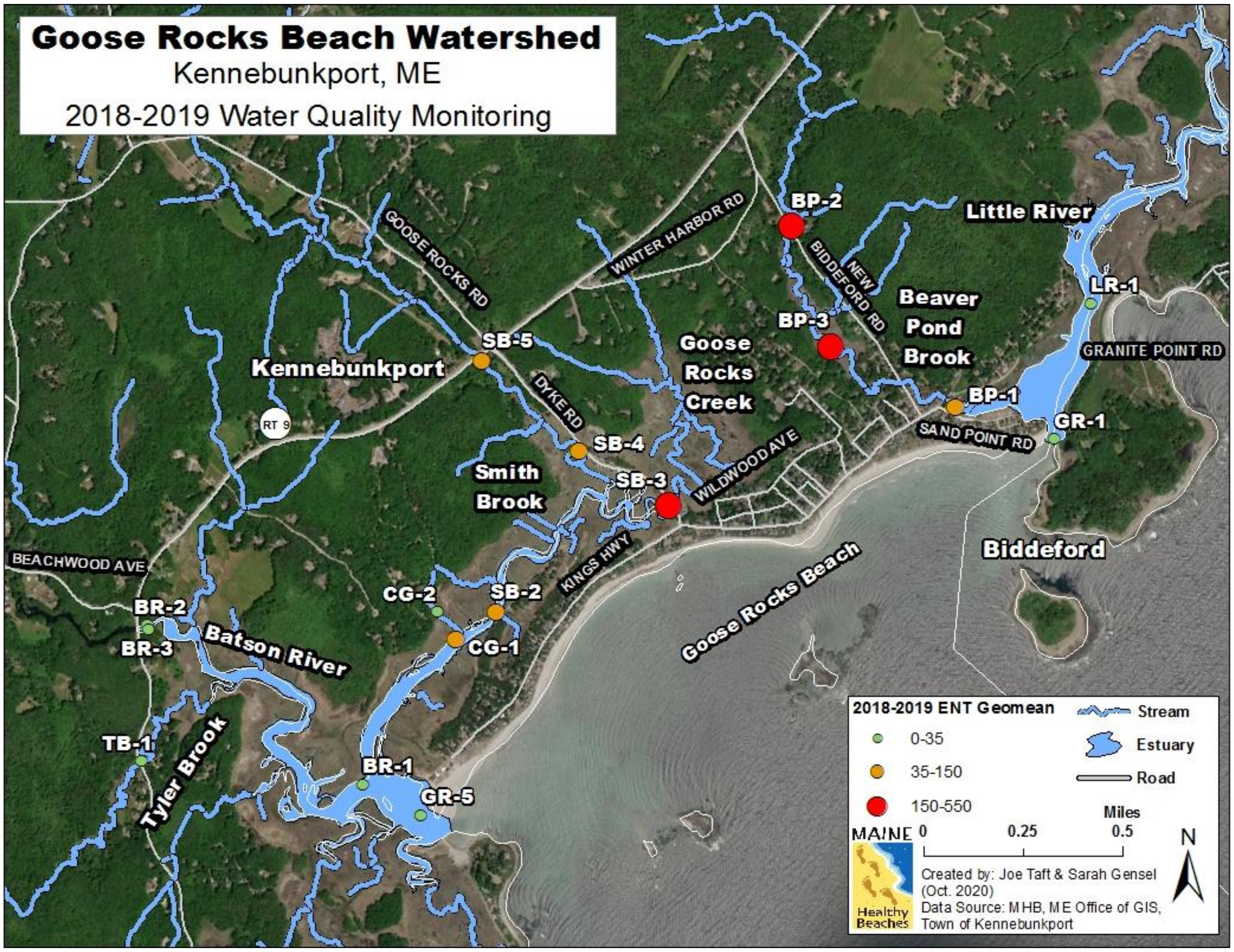


Figure 12. Combined 2018-19 enterococci (ENT) geomean (MPN/100mL) for Goose Rocks Beach (GRB) watershed stream monitoring sites (See Table A3 for sample sizes).

For the majority of stream monitoring sites, wet weather geomeans were > dry weather geomeans during both monitoring seasons.[23] Wet weather geomeans exceeded the ENT geomean criteria for all but two sites in 2018 (BR-2, BR-3) and for five of 13 sites monitored in 2019. Of the 11 monitoring sites consistently sampled in 2018 and 2019, wet weather geomeans were > dry weather geomeans during both years at 64% (7) of sites. Monitoring sites with higher geomeans during dry weather compared to wet weather were located in the Batson River and Smith Brook subwatersheds. These included BR-2 and SB-2 in 2018 and GR-1, GR-5, CG-2, SB-2, and SB-3 in 2019. Geomeans for four sites exceeded the EPA recommended 35 MPN/100mL threshold during both dry and wet weather conditions (SB-4, SB-3, BP-3, and BP-2) during 2018 and 2019 (BP-3 monitored in 2018 only) (Table 3; Appendix A, Table A4).

[23] Geomeans used for data comparisons regardless of sample size. For ENT averages see Appendix A, Table A4.

Table 3. 2018 and 2019 enterococci (ENT) (MPN/100mL) geomean and sample size for Goose Rocks Beach (GRB) watershed stream monitoring locations. See Appendix A, Table A4 for full watershed results. Red bolded values indicate geomeans exceeding EPA's recommended ENT geomean value (35 MPN/100mL).

Stream Site	Subwatershed	Enterococci Geomean (MPN/100mL); Sample Size					
		2018 Total	2018 Wet	2018 Dry	2019 Total	2019 Wet	2019 Dry
BR-2	Batson River	31.21; 7	28.67; 4	34.94; 3	-	-	-
BR-3	Batson River	29.43; 7	34.83; 4	23.51; 3	12.25; 10	27.20; 2	10.03; 8
TB-1	Batson River	-	-	-	14.06; 10	21.79; 2	12.61; 8
BR-1	Batson River	24.58; 7	**39.85**; 4	12.91; 3	10.73; 10	16.12; 2	9.69; 8
GR-5	Batson River	**39.41**; 10	**73.13**; 5	21.24; 5	20.35; 10	10.00; 2	24.30; 8
CG-1	Smith Brook	**38.28**; 10	**67.92**; 5	21.57; 5	-	-	-
CG-2	Smith Brook	-	-	-	11.10; 10	7.07; 2	12.43; 8
SB-2	Smith Brook	**85.95**; 7	**75.03**; 4	**103.01**; 3	29.56; 9	20.25; 2	32.93; 7
SB-5	Smith Brook	**157.08**; 10	**198.99**; 5	**124.01**; 5	**40.62**; 10	**118.87**; 2	31.05; 8
SB-4	Smith Brook	**96.66**; 10	**126.33**; 5	**73.96**; 5	**42.63**; 10	**51.19**; 2	**40.72**; 8
SB-3	Smith Brook	**152.92**; 10	**345.22**; 5	**67.73**; 5	**161.79**; 10	**78.61**; 2	**193.79**; 8
BP-2	Little River	**362.86**; 10	**800.96**; 5	**164.39**; 5	**130.57**; 10	**431.06**; 2	**96.87**; 8
BP-3	Little River	**539.26**; 6	**646.32**; 4	**375.41**; 2	-	-	-
BP-1	Little River	**115.33**; 10	**177.94**; 5	**74.76**; 5	34.31; 10	**86.37**; 2	27.24; 8
LR-1	Little River	**69.70**; 10	**142.49**; 5	34.10; 5	15.87; 10	33.02; 2	13.21; 8
GR-1	Little River	**63.70**; 10	**105.54**; 5	**38.45**; 5	16.73; 10	12.45; 2	18.01; 8

3.1.3 Enterococci - Spring and Neap Tides

Historical water quality monitoring in the GRB watershed demonstrated greater fecal bacteria concentrations during spring tide conditions compared to neap tides, when tidal portions of the watershed experience less inundation (5, 7-8). For this study, monitoring dates did not specifically target spring and neap tidal conditions as they were selected primarily based on volunteer and laboratory availability. Of the 20 monitoring dates, one was performed during a spring tide (9/24/2018) and the remaining 19 during neap tides (11)[24]. Therefore, a comparison of water quality conditions during spring vs. neap tidal stages was outside of the scope of this project.

Although sampling efforts did not sufficiently coincide with spring tidal conditions for a comparison of ENT concentrations during spring and neap tidal conditions, samples were collected over a variety of tidal ranges spanning 5.6 ft. to 10.3 ft. Dry weather ENT geomeans[25] were compared for tidal ranges > 9 ft. and < 9 ft. at all tidally influenced sites. Of the sites monitored, 13 sites corresponded to locations (approximately) monitored under spring/neap tidal conditions in the 2006 study (See Appendix A, Table A6 for full watershed results) (5).

For the two most tidally influenced sites located at the mouths of the Little River (GR-1) and Batson River (GR-5), results were inconclusive or inconsistent with 2006 observations for both spring/high and

[24] Tide ranges were classified as *spring* or *neap* as defined by Boehm and Weisberg 2005 (See *References*). Monitoring dates considered to be representative of spring tide conditions included those that were 0-3, 12-18, and 26-28 days following the full moon. Monitoring dates were considered representative of neap conditions for the remaining days.
[25] Only dry weather values used for calculations to exclude confounding results due to surface water runoff. Geomeans used compare data between sites regardless of sample size. For site specific averages see Appendix A, Table A6.

Table 4. Dry weather enterococci (ENT) geomeans, sample size, and number of single sample exceedances for sites GR-1 and GR-5 for monitoring events with tidal ranges > and < 9 ft. Red values indicate geomeans exceeding EPA's recommended ENT geomean value (35 MPN/100mL).

Stream Site	Enterococci Geomean (MPN/100mL); Sample Size; Exceedances	
	Tide Range > 9 ft.	Tide Range < 9 ft.
GR-1	17.07; 4; 0	28.11; 9; 1
GR-5	**44.22**; 4; 1	17.28; 9; 1
Combined	27.48; 8; 1	22.04; 18; 2

neap/low tide conditions. For spring tide conditions, the 2006 study observed one elevated single sample ENT concentration at GR-1 (120 MPN/100mL) and no elevated samples at GR-5. For the present study, no exceedances were observed on dry weather monitoring dates with tidal heights > 9ft. for GR-1 samples, and one of four GR-5 samples was elevated on those monitoring dates (Table 4).

Under neap tide conditions, GR-1 and GR-5 did not exceed ENT single sample criteria in 2006 but exceeded for 11% (one sample) of samples for dry weather conditions with tidal heights < 9 ft. for the present study. Three exceedances were observed of the 26 total samples collected at GR-1 and GR-5 during 2018-2019 for all tidal ranges. This included one for GR-1 and GR-5 during an 8.8 ft. tidal range and one for GR-5 during a 10.3 ft. tidal range. The elevated ENT concentration at GR-5 during the 10.3 ft. tide event represented the greatest of the three exceedances (262 MPN/100mL) and contributed to that site exceeding the EPA recommended ENT geomean threshold (Table 4; Appendix A, Table A6). It should be noted that sample sizes were small, particularly for tidal ranges > 9ft. (four samples per site) compared to those < 9 ft. (nine samples per site) and comparisons between the studies were limited. Additional monitoring targeting spring and neap tidal conditions is recommended to better understand if increased ENT concentrations observed in recent years in the GRB watershed are associated with increased tidal ranges as was observed in 2005 and 2006.

3.1.4 Optical Brighteners - Exceedances

The OB single sample, or "red flag", threshold recommended by EPA New England to identify samples with the potential for human wastewater contamination is 100 µg/L. Of the 253 stream samples collected in 2018 and 2019 at 16 sites, 43% (110) exceeded 100 µg/L. Of those 110 exceedances, just less than half (46%) were associated with wet weather 24 or 48 hours prior to sample collection. Percent sample exceedances, site averages, and overall watershed averages were less varied for OB results than ENT concentrations (Figures 13-14; Appendix A, Table A3).

In 2018, single sample OB values ranged from 7.3 to 190 µg/L and 49% (61) of samples exceeded the recommended 100 µg/L "red-flag" threshold. As with ENT values, BR-1 was the only site without an OB exceedance. A greater number of wet weather exceedances (57%) were observed compared to dry weather exceedances (43%). Samples collected for half (7 out of 14) of 2018 monitoring sites exceeded the EPA recommended 100 µg/L threshold ≥ 50% of the time and four of those sites (BR-2, BR-3, BP-2, BP-3) exceeded the threshold 100% of the time. Wet weather exceedances occurred at 13 sites and, for the majority of those sites, wet weather exceedances were observed ≥50% of the time (Figure 13; Appendix A, Table A5).

In 2019, single sample OB values ranged from 12.8 to 204 µg/L, with slightly fewer exceedances (38%; 49 samples) than in 2018. In 2019, single sample exceedances were observed for fewer sites (10 out of 13) than in 2018. There were also a greater number of dry weather exceedances (67%) than wet weather exceedances (33%) in 2019. Four sites (BR-3, TB-1, SB-5, BP-2) exceeded the recommended threshold ≥70% of the time and accounted for the majority of observed exceedances in 2019. Wet weather exceedances were observed for eight sites in 2019 and occurred ≥50% of the time for four sites (Figure 13; Appendix A, Table A5).

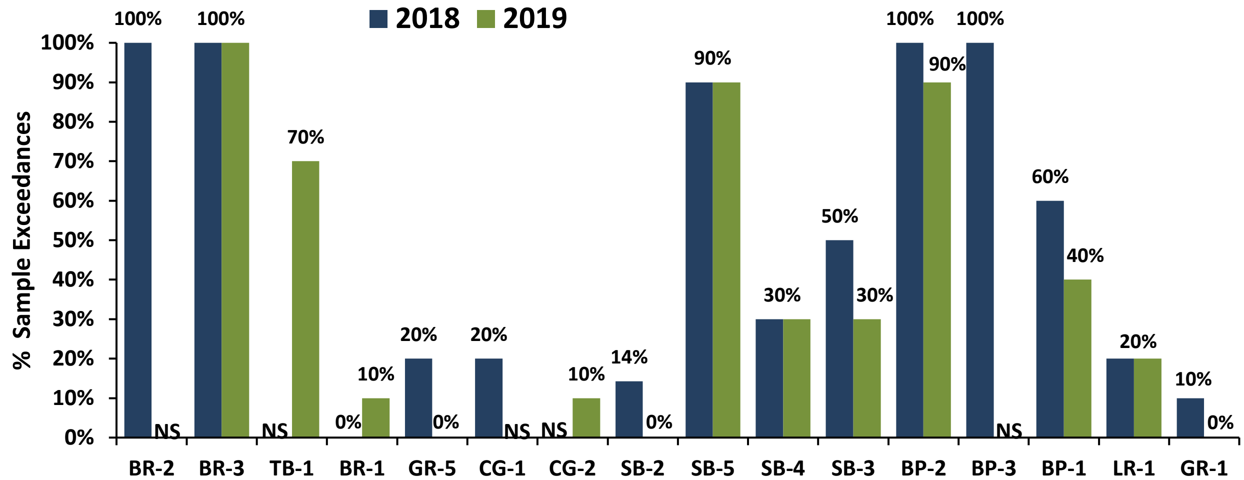


Figure 13. Percent sample exceedances of EPA New England recommended optical brightener (OB) "red-flag" threshold (100 µg/L) for Goose Rocks Beach (GRB) watershed stream monitoring sites for 2018 and 2019 (See Table A3 for sample sizes).

3.1.5 Optical Brighteners - Averages

Average OB concentrations were consistent between monitoring seasons for individual sites. All but one (BR-1) of the 11 monitoring sites consistently sampled for both years had a higher average in 2018 compared to 2019. Site specific average OB concentrations ranged from 38.9 to 172.8 µg/L in 2018 and 37.0 to 147.0 µg/L in 2019 (Figure 14; Appendix A, Table A3).

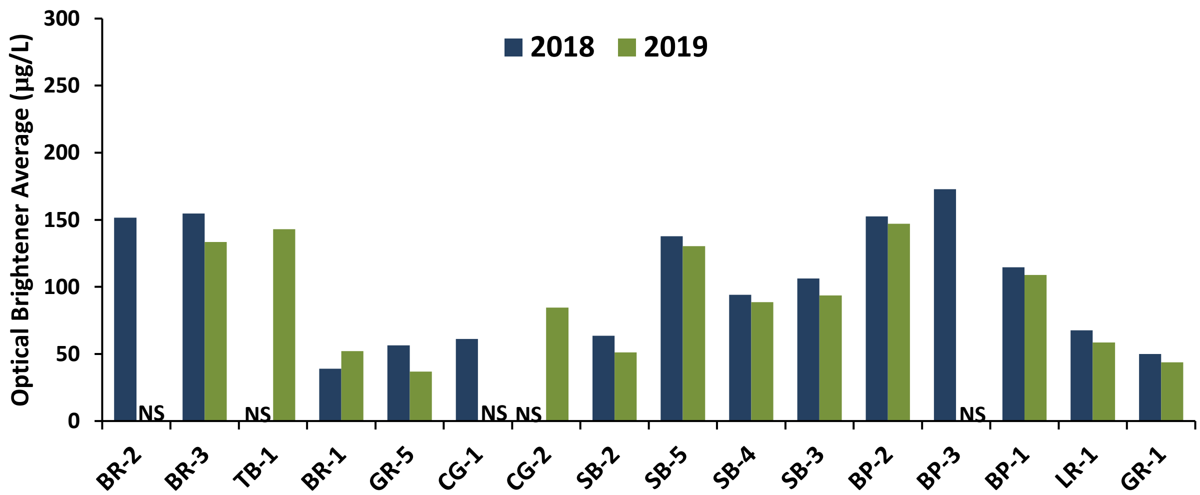


Figure 14. Optical brightener (OB) average values (µg/L) for Goose Rocks Beach (GRB) watershed stream monitoring sites per monitoring season (2018 & 2019) (See Table A3 for sample sizes).

The greatest average OB concentrations for 2018-2019 data (values exceeding >130 µg/L)[26] were observed in all three subwatersheds and included sites BR-2, BR-3, TB-1, SB-5, BP-2, and BP-3. The stream monitoring sites with the lowest average OB concentrations (< 60 µg/L) were located at the mouth

[26] For monitoring sites sampled for both years, only those with concentrations >130 µL or < 60 µL for both years were included in greatest/least average concentration summaries.

of the Little and Batson Rivers (GR-1 and GR-5) as well as just upstream of the mouth of the Batson River (BR-1 and SB-2). Wet weather average concentrations were greater than dry weather averages for the majority of sites in 2018 and for all sites in 2019. Monitoring sites with higher average concentrations during dry weather compared to wet weather for the 2018 season were located in the Batson River (BR-2) and Little River (BP-3) subwatersheds (Figure 14; Appendix A, Table A5).

OB samples collected in the GRB watershed were noted as tea-colored for the majority of monitoring locations, particularly for upstream sites where little or no tidal flushing occurred and/or there was minimal stream flow. In waterbodies where tea-colored water (an indicator of humic content) is common, the 100 µg/L threshold may not be an ideal metric for identifying human-sourced pollution due to interference from humic substances (tannins and other dissolved organic compounds) that can artificially inflate fluorescence measurements and result in a "background level" contribution to observed concentrations. It was not possible to account for this interference during this study; therefore, OB results were assessed alongside ENT results and other co-indicators.

3.1.6 Priority Stream Sites

Monitoring sites with consistently elevated results for ENT, and to a lesser extent OBs, in the GRB watershed were primarily located in the Smith Brook and Little River (Beaver Pond drainage) subwatersheds and include SB-5, SB-4, SB-3, SB-2, BP-3, BP-2, and BP-1. Of these sites, SB-4, SB-3, and BP-2 exhibited elevated ENT values exceeding a geomean of 35 MPN/100mL under dry weather conditions for both monitoring seasons. Site BP-3 also demonstrated dry weather exceedances of geomean criteria but was only monitored during 2018 (Figures 8, 10-14; Table 3; Appendix A, Figures A2-A3, Tables A3-A5). The majority of sites monitored for this study were previously monitored by FB Environmental in the 2006 study. Of the sites consistently monitored during both studies, elevated ENT results were observed for sites SB-5, SB-4, BP-3, and BP-2, while elevated OB concentrations were noted primarily for sites SB-3, BP-2, and BP-1. This information was factored into the prioritization of samples for toolkit parameters such as ammonia, surfactants, total chlorine, PPCPs, and source specific MST analyses.

3.1.7 Stormwater System Monitoring

All stormwater basins sampled as part of this study were observed to have very little or no flow at the time of sampling. Of the 26 paired ENT and OB samples collected at stormwater structures during this study, 23 ENT samples exceeded Maine's single sample criteria of 104 MPN/100mL and 23 OB samples exceeded the 100 µg/L recommended threshold. Of the seven catch basins monitored more than once, three exceeded the ENT and OB thresholds 100% of the time. Single sample values ranged from 41 to >24,196 MPN/100mL for ENT and from 71.5 to 236 µg/L for OBs. Of the four structures with results below the

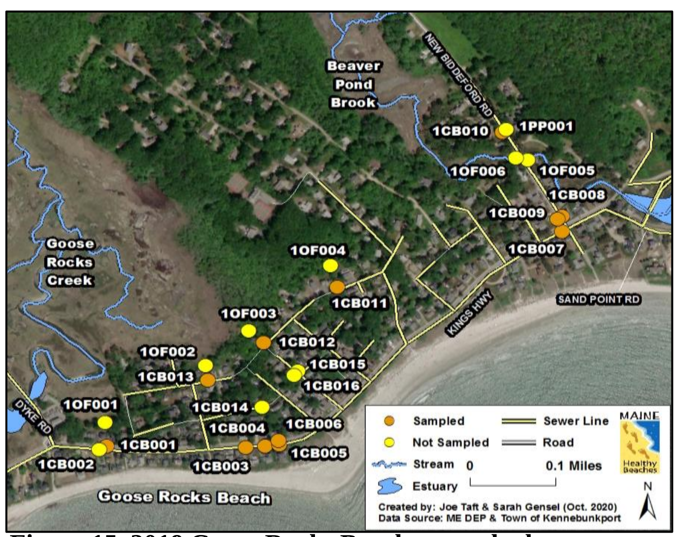


Figure 15. 2019 Goose Rocks Beach watershed stormwater monitoring structures sampled for enterococci (ENT) and optical brighteners (OB).

threshold for either parameter, samples collected on 8/1/2019 at two structures (1CB007 and 1CB008) were below both the ENT and OB thresholds, a sample collected on 9/12/2019 at structure 1CB006 was below the OB threshold, and a sample collected on 9/18/2019 at structure 1CB010 was below the ENT safety limit (Figure 15; Appendix A, Table A7).

3.2 Ammonia, Total Chlorine, and Surfactants

Concentrations of ammonia, total chlorine, and surfactants did not exceed levels of concern at any sites during 2019 sampling events (Appendix A, Table A8). The EPA recommends screening thresholds of ≥1.0 mg/L for surfactants and ≥0.5 mg/L for both total chlorine and ammonia. No samples were collected in 2018 for these parameters.

3.3 Pharmaceuticals and Personal Care Products

For all sample sites, no detectable concentrations were observed for four of the eight PPCPs tested (acetaminophen, atenolol, diphenhydramine, and metoprolol). For the remaining compounds, cotinine was detected at all sites, caffeine was detected at four sites, and carbamazepine and 1,7-dimethylxanthine were each detected at one site (separate sites) (Table 5). The EPA has not established level of concern values for PPCPs to compare these concentrations to. All detected concentrations were detected at very low levels, only slightly above the reporting limit. When using PPCPs to determine the potential for human wastewater sources, acetaminophen is considered the best indicator of sanitary sewage. This is because several of the other commonly used compounds have been shown to be ubiquitous in the aquatic environment, and their presence in the absence of acetaminophen may not be indicative of human-sourced contamination.

Table 5. Single sample concentration of pharmaceuticals and personal care products (PPCPs) for 10 Goose Rocks Beach (GRB) monitoring stations (9/4/2019). ND = non-detect, RL = reporting limit.

PPCP Compound	MONITORING STATION									
	SB-3	SB-4	SB-5	BP-1	LR-1	BP-2	BR-1	CG-1	TB-1	BR-3
Acetaminophen (RL=2.0 ng/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Atenolol (RL=2.0 ng/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Caffeine (RL=4.0 ng/L)	ND	ND	ND	ND	**5.3**	**4.1**	**5.9**	ND	ND	**6.2**
Carbamazepine (RL=0.4 ng/L)	ND	ND	**0.41**	ND	ND	ND	ND	ND	ND	ND
Cotinine (RL=0.4 ng/L)	**0.99**	**0.72**	**0.59**	**1.1**	**0.71**	**1.1**	**0.9**	**0.62**	**0.61**	**0.73**
1,7-Dimethylxanthine (RL=2.0 ng/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	**2.1**
Diphenhydramine (RL=0.4 ng/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metoprolol (RL=2.0 ng/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

3.4 Microbial Source Tracking

3.4.1 Percent Positive Detections

The percent of samples with positive detections of the six tested DNA source markers varied distinctly between years and among monitoring sites, particularly for human source markers. DNA markers for mammals, humans, birds, and canines were detected for sites throughout the GRB watershed. Of the 65 samples submitted for mammal and human analyses, all tested positive for mammal DNA (15 total sites) and 20% (13 samples at nine sites) tested positive for human DNA. Resources were prioritized for the identification of suspected human sources, and the remaining source markers were tested to a lesser extent. Nearly half (46%) of the 41 stream monitoring samples analyzed showed positive detections for canine DNA (19 samples at 9 sites). Of the 15 samples submitted for bird analyses and the four samples submitted for gull analyses, 93% (14 samples at six sites) were positive for bird DNA and 100% (4 samples at four sites) were positive for gull DNA. Gull DNA was analyzed for river mouth sites (GR-1 and GR-5) in 2018 only. Ruminant DNA was not detected in any of the 43 submitted samples (Figures 16-20; Appendix A, Table A9).

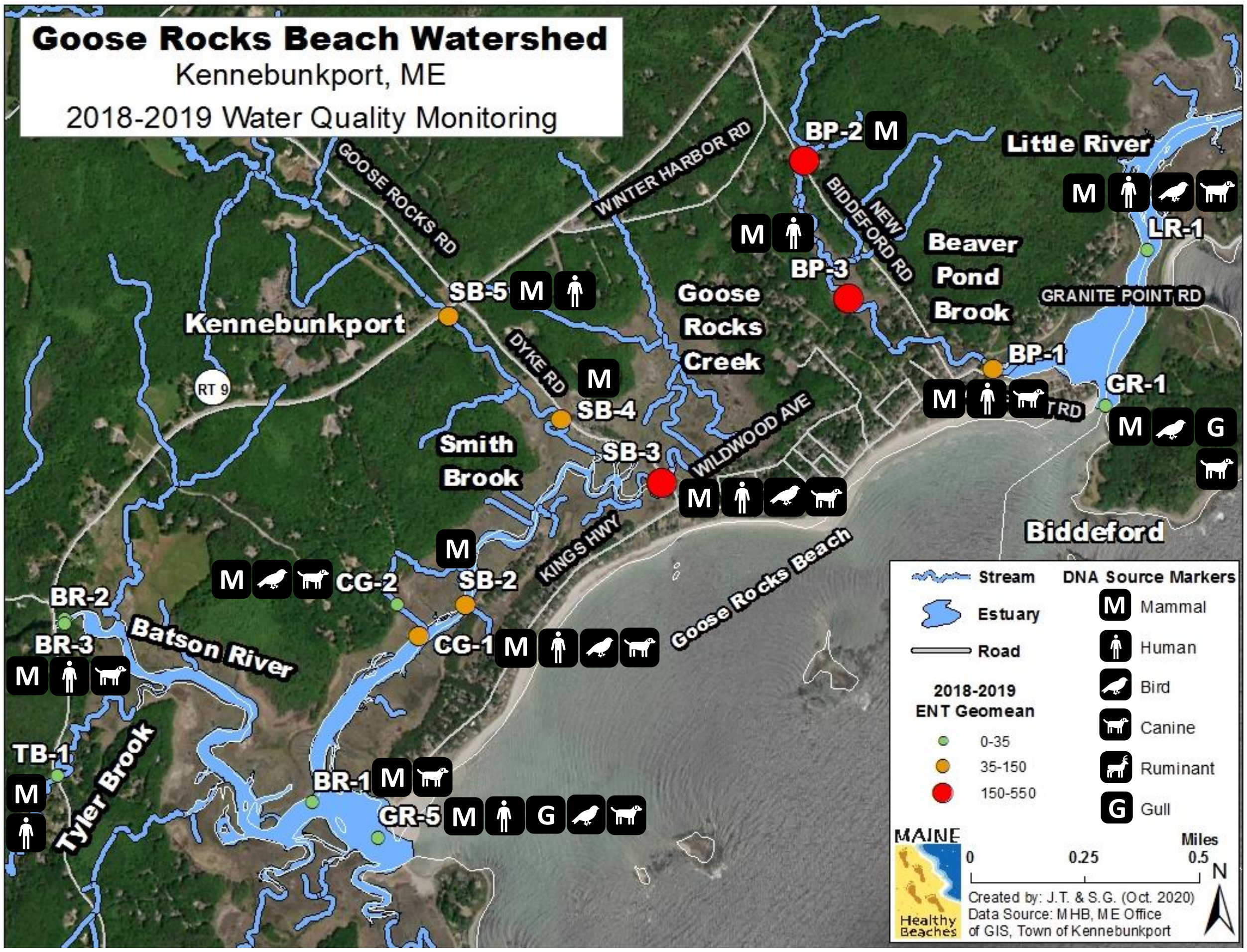
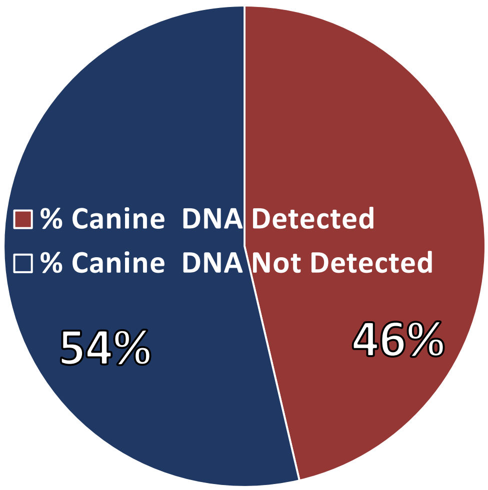


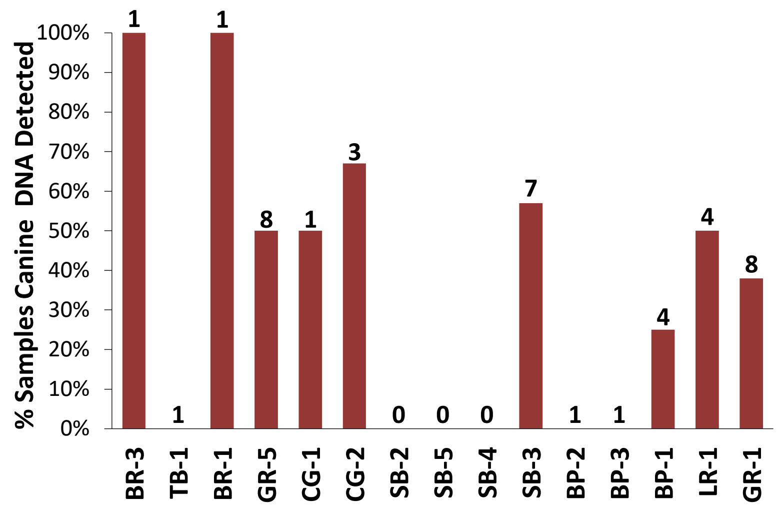
Figure 16. 2018-2019 PCR/qPCR source marker detections for Goose Rocks Beach (GRB) watershed sites. Source marker images on the map indicate that source was detected in at least one sample at that site. See Table A9 for sample sizes.

Canine

For the five sites tested most frequently for canine DNA (four or more times), the greatest percent detections (≥50% of samples positive) were observed in all of the three subwatersheds (GR-5, SB-3, and LR-1). Percent detections of canine DNA were greater in 2019 than in 2018; however, more than twice the number of samples were analyzed in 2019 (2018: 13 samples; 2019: 28 samples) (Figures17-18; Appendix A, Table A9).

In 2018, of the 13 samples collected at eight stream sites, four samples (31%) at four sites (BR-3, GR-5, LR-1, and CG-1) tested positive for canine DNA. All positive detections in 2018 were observed for samples collected during one wet weather monitoring date (10/3/2018). In 2019, of the 28 samples submitted for canine DNA analyses, 15 (54%) tested positive. These positive detections were observed throughout the 2019 monitoring season and included samples from seven of eight sites submitted for analyses (BR-1, GR-5, CG-2, SB-3, BP-1, LR-1, and GR-1). Two of the 15 detections (sites SB-3 and GR-1 on 6/24/2019) were from sites sampled during wet weather monitoring events (Figure 18; Appendix A, Table A9).





Figures 17-18. Percent of Goose Rocks Beach (GRB) watershed stream site samples (2018-2019) with canine DNA detections (PCR) for all watershed sites combined (Fig. 17) and per site (Fig. 18). Total sample size = 41, total positive samples = 19, total negative samples = 22. Sample sizes shown above bars.

Human

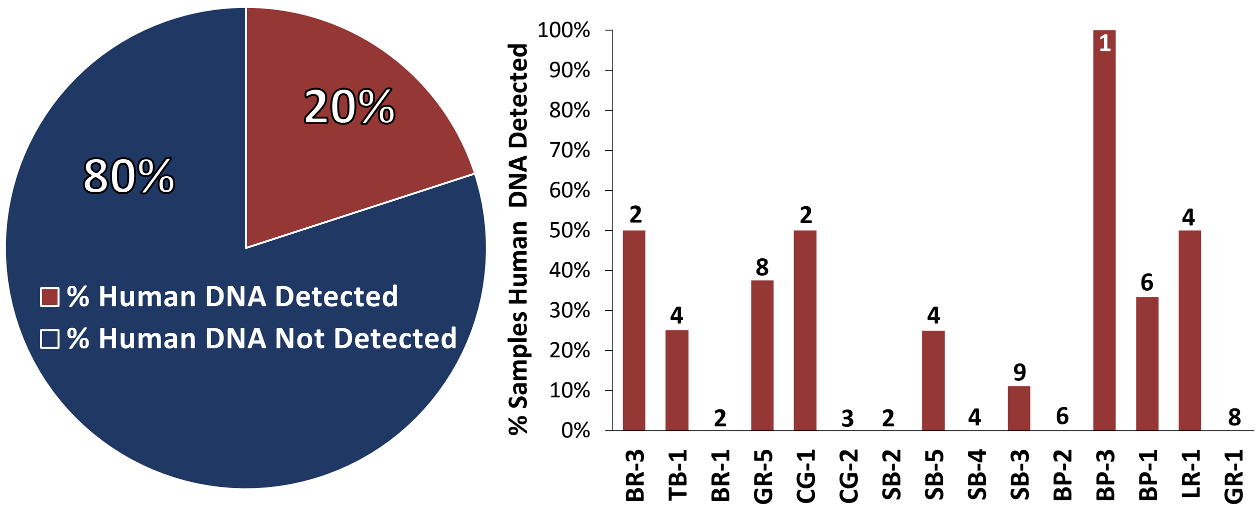
Initial DNA results from the 2018 monitoring season demonstrated the potential for widespread human-sourced fecal pollution throughout the GRB watershed, as samples from 72% of sites analyzed from 10/3/2018 (eight out of 11 sites representing all subwatersheds) tested positive for human DNA. However, fewer human detections in fewer locations (15%; two out of 13 sites) were observed for subsequent monitoring events in 2019. Twenty percent of submitted samples (2018-2019) tested positive for human DNA, with the majority of positive detections observed during 2018. Of the eight stream sites tested the most frequently (four or more times), the greatest percent detections (≥30% of samples positive) were observed at two sites in the Little River subwatershed (BP-1 and LR-1) and one in the Batson River subwatershed (GR-5) (Figures 19-20; Appendix A, Table A9).

In 2018, of the 17 samples submitted for two monitoring dates, 11 (65%) samples tested positive for human DNA. These positive samples were located at eight (BP-1, BP-3, BR-3, CG-1, GR-5, LR-1, SB-3, SB-5) of the 11 stream monitoring sites sampled. Of the six sites that were tested for human DNA on both monitoring dates (BP-1, SB-3, GR-1, GR-5, LR-1, CG-1), three tested positive for both dates, including two in the Little River subwatershed (BP-1 and LR-1) and one in the Batson River subwatershed (GR-5).[27] Eight of the 11 positive samples were collected during a wet weather monitoring event (10/3/2020 – 0.99 in. rainfall 48 hrs. prior to monitoring) and three were collected during a dry weather event (10/17/2020) (Figure 20; Appendix A, Table A9).

In 2019, 48 samples representing 13 stream monitoring sites were submitted for human DNA analyses and two of these (4%) tested positive. These two positive detections were observed during

[27] Funding constraints resulted in a limited number of Smith Brook subwatershed samples submitted for the second 2018 monitoring date (10/17/2018). Samples for DNA testing were prioritized for areas with elevated ENT results.

one wet weather monitoring event (7/24/2019 - 1.9 in. rainfall 48 hrs. prior to monitoring) at two of the 14 tested sites (TB-1 and GR-5). Three DNA samples were also submitted for another wet weather monitoring event (6/24/2019 – 0.50 in. rainfall 48 hrs. prior to monitoring), and there were no positive human detections for that date (Figure 20; Appendix A, Table A9).



Figures 19-20. Percent of Goose Rocks Beach (GRB) watershed stream site samples (2018-2019) with human DNA detections (qPCR) for all watershed sites combined (Fig. 19) and per site (Fig. 20). Total sample size = 65, total positive samples = 13, total negative samples = 52. Sample sizes shown above bars.

3.4.2 DNA Concentrations

qPCR analyses were used to determine the copy number/100mL (hereafter referred to as "concentration", "copies" or "copy numbers") for samples with positive mammal, bird, or human source marker detections. The copy number represents the relative quantification of source-specific fecal contamination and was used to assist with understanding the strength of the source marker. This information was also used to prioritize subsequent DNA testing efforts and to refine selection of monitoring sites to better track suspected fecal pollution to the source(s). DNA concentrations in the GRB watershed were put into context through comparisons to other qPCR analyses performed for similar watersheds in Maine (42-43).

Mammal fecal DNA markers were detected ubiquitously in the GRB watershed (100% detections in 65 samples); however, there was variation in the amount detected between sites and between monitoring dates. Single sample copy numbers ranged from just over 190,000 copies to over 350 million copies with an average copy number for all sites and all dates of just over 2.60 x 10^7 (26 million) copies. The greatest copy numbers were values >1.50 x 10^8 (150 million) copies and were observed for two consecutive monitoring dates (one wet and one dry) in 2019 and included all of the three sites tested on 6/24/2019 (GR-5, SB-3, GR-1) and one site (BP-1) from the seven sites tested on 7/11/2019.[28] The highest average copy numbers were values > 3.5 x 10^7 (35 million) copies and were observed for three sites including one in the Smith Brook subwatershed (SB-3) and two in the Little River subwatershed (BP-1 and GR-1) (Figure 21; Appendix A, Table A10).

[28] Wet weather in inches 48 hours prior to monitoring: 6/24/2019 (0.50). Dry weather monitoring for 7/11/2010.

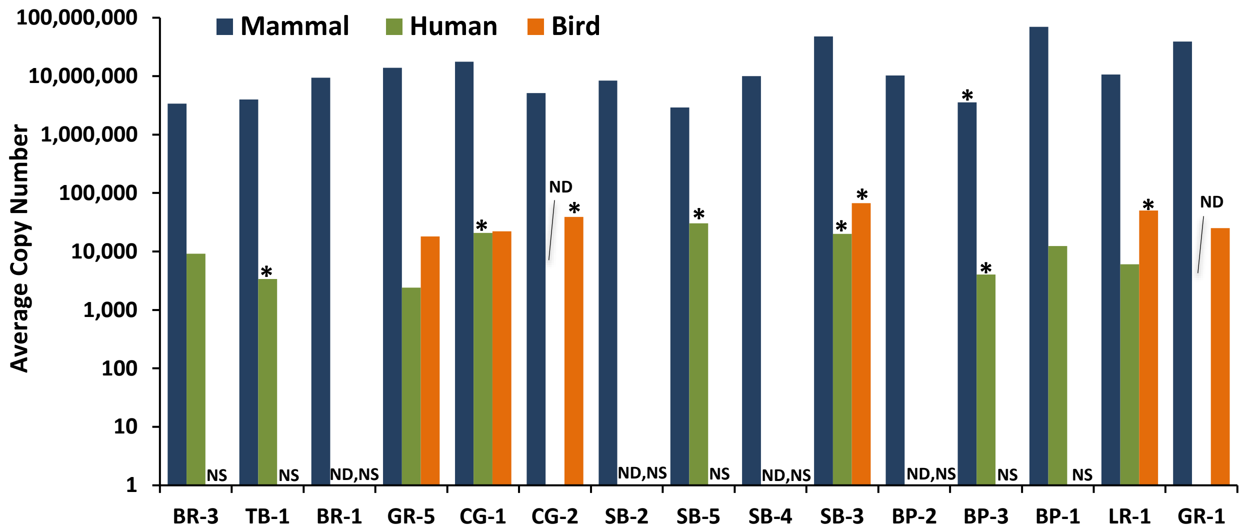


Figure 21. 2018-19 qPCR average mammal, human, and bird copy numbers (copies/100mL) for Goose Rocks Beach (GRB) stream monitoring sites. No samples submitted for site BR-2. * = single samples, ND=Not detected, NS=Not Submitted.

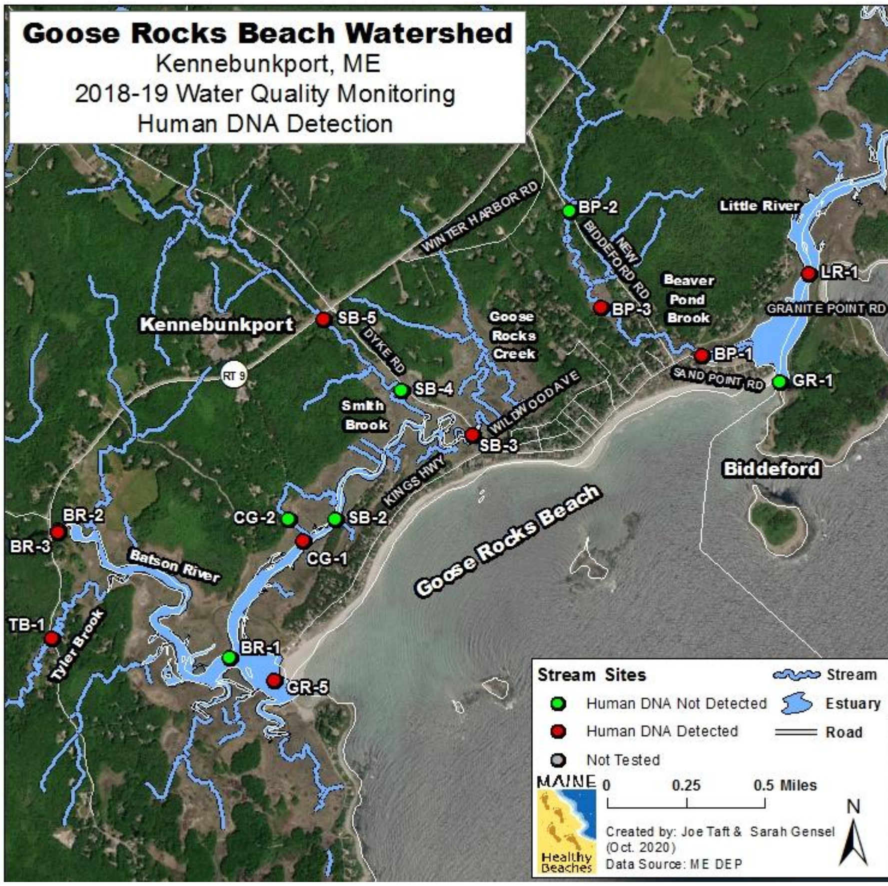
Average mammal DNA concentrations in the GRB watershed were put into context through comparisons to analyses performed for similar watersheds in Wells and Old Orchard Beach (OOB), Maine (42-43). Average mammal DNA concentrations for the majority of GRB sites appeared similar to those observed for Wells and OOB estuary and marsh monitoring sites, and the highest concentrations observed for GRB sites (SB-3, BP-1, and GR-1) were greater than many of those observed for similar Wells and OOB sites (Figure 21; Appendix A, Table A10).[29]

Fewer samples (15) were analyzed for bird qPCR source targets compared to samples for mammal and human sources (65). For three (CG-2, SB-3, and LR-1) of the six sites with positive bird DNA detections, only one sample was submitted for analysis. Single sample copy numbers ranged from <1,000 to >67,000 copies with an average copy number of just over 28,000 copies (all sites and years combined). Of the 15 samples analyzed, 14 tested positive for bird DNA. The highest bird copy numbers were values >35,000 copies and were observed for all five sites/samples tested on 8/7/2019 (CG-2, GR-5, SB-3, GR-1, and LR-1). In general, bird DNA copy numbers were similar among samples collected on the same monitoring date with more variability observed between monitoring dates than between sites (Figure 21; Appendix A, Table A10). Small sample sizes for this study limited comparisons to data observed for similar studies conducted in Wells and OOB. Bird copy numbers observed in this study were generally greater than those observed for similar Wells estuary sites, comparable to those observed for OOB estuary sites, and less than those observed for OOB marsh sites (42-43).

Of the 65 samples that were analyzed for human-sourced DNA in the GRB watershed, just 20% (13) tested positive. For six of the nine sites with positive detections (BR-3, TB-1, CG-1, SB-5, SB-3, BP-3), human DNA was detected in just one of the analyzed samples. Single sample copy numbers ranged from <1,000 copies to just over 30,000 copies with an average copy number of just over 10,000 copies (all sites and years combined). The greatest single sample human copy

[29] Comparisons were observational only. Statistical comparisons between the data sets were not performed.

numbers were values >19,000 copies and were observed from two consecutive monitoring dates (one wet and one dry) in 2018. These samples were collected from three sites monitored in the Smith Brook subwatershed on 10/3/2018 (SB-3, SB-5, and CG-1) and one site monitored in the Little River subwatershed (BP-1) on 10/17/2018 (Figures 21-22; Appendix A, Table A10).[30]



Site	Positive Samples; % Samples Detected; Average/Single Sample* Copy Number
BP-1	2; 33%; 12,341
BP-2	0; 0%; 0
BP-3	1; 100%; 4,028*
BR-1	0; 0%; 0
BR-2	Not Sampled
BR-3	1; 50%; 9,171*
CG-1	1; 50%; 20,708*
CG-2	0; 0%; 0
GR-1	0; 0%; 0
GR-5	3; 38%; 2,397
LR-1	2; 50%; 6,028
SB-2	0; 0%; 0
SB-3	1; 11%; 20,106*
SB-4	0; 0%; 0
SB-5	1; 25%; 30,193*
TB-1	1; 25%; 3,385*

Figure 22. Human DNA detection results for Goose Rocks Beach (GRB) stream sites (2018-19). Number of samples with human DNA detected, percent of total samples with positive human detections, and average/single sample copy numbers for positive samples per site shown in table. * = single samples. See Appendix A, Tables A9-A10 for full dataset.

Human DNA results were assessed using EPA's unacceptable illness rate of 30 gastrointestinal (GI) illnesses per 1,000 swimmers. For the human DNA marker used for this study, HF183, this corresponds to concentrations of 4,200 copies in recreational waters (44). Of the 13 samples that tested positive for human DNA, copy numbers for 54% (7) of those samples were greater than 4,200 (all sampled in 2018). Neither of the two samples testing positive for human DNA in 2019 exceeded 4,200 copies (Appendix A, Table A10). Comparing human DNA concentrations to those observed for similar sites in Wells and OOB, GRB results indicate similar overall human DNA concentrations in the GRB compared to OOB estuary sites and greater concentrations compared to Wells estuary and OOB marsh sites (42-43). Samples testing positive (and therefore providing a copy number for comparisons) for human DNA detections were few, and more data is needed to better understand how these monitoring locations compare to data collected in similar Maine watersheds.

[30] Wet weather in inches 48 hours prior to monitoring: 10/3/2018 (0.99). Dry weather monitoring for 10/17/2010.

MST analyses were conducted at several of the monitoring sites identified through the 2006 watershed study as sites suspected to be impacted by human fecal sources. Although sample sizes were limited, human sources were verified at Batson River subwatershed site BR-3 (just upstream of 2006 site), Smith Brook sites SB-3 and SB-2, and Little River site LR-1 (just downstream of 2006 site).[31] Although Beaver Pond site BP-2 was suspected of being influenced by human fecal pollution in 2006, human DNA was not detected in the six samples submitted for analysis from that location (primarily in 2019) for this study. However, human DNA was detected at downstream sites BP-3 (one detection) and BP-1 (two detections), which were not identified as potential problem sites in 2006.

Several other sites tested positive for human DNA sources for the present study that were not identified as those with possible human sewage sources in 2006, including Tyler Brook site TB-1, Smith Brook site SB-5, and Little River site LR-1 (Appendix A, Tables A9-A10). For LR-1, the 2006 study identified upstream sites (LR-1c and LR-2) as those with possible human sewage sources nearby, but no sites were monitored upstream of LR-1 for the present study (5). Although human DNA was detected for the sites discussed, sample sizes and human detection rates were very low for all sites, with most sites exhibiting just one positive detection. The remaining sites in the 2006 study identified as potentially impacted by human sources were not investigated in 2018-2019.

3.4.3 Stormwater System Monitoring

All stormwater basins monitored during this study were observed to have little or no flow at the time of sampling. Six stormwater basins were monitored on 9/12/2020 and submitted for qPCR (mammal, human, bird)[32] and PCR (canine) DNA source analyses. All tested positive for mammal DNA as was similarly observed for stream sites. Bird DNA was detected at four of five sampled basins (1CB003, 1CB004, 1CB005, 1CB006), one basin (1CB008) located along New Biddeford Rd. near the corner of Kings Hwy. and New Biddeford Rd. tested positive for canine DNA, and no basins tested positive for human DNA. ENT and OB grab samples were also collected at all basins at the time of DNA sample collections. ENT results were elevated above Maine's single sample safety criteria at all basins and OB results were above the 100 µg/L recommended threshold at all but one basin (1CB006). Single sample ENT values ranged from

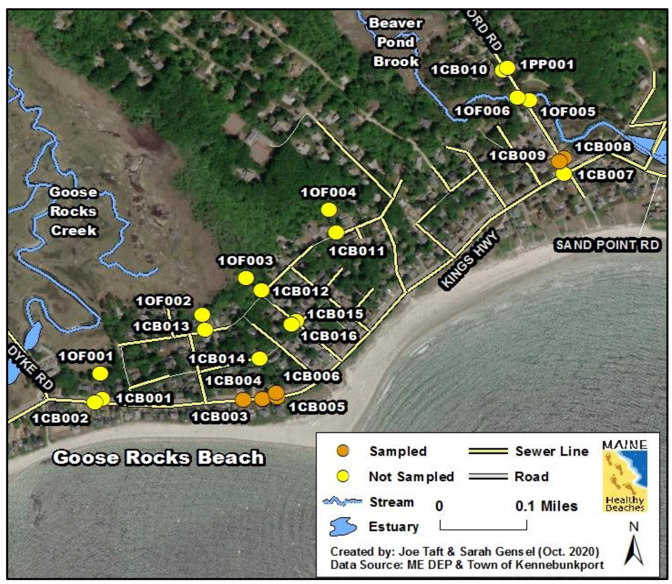


Figure 23. Goose Rocks Beach (GRB) watershed stormwater basins tested 9/12/2019 for mammal, human, bird, and canine DNA source markers.

[31] Locations for 2018-2019 study sites used to compare data to 2006 study sites were approximate as many 2018-2019 sites did not coincide with exact locations of those from the 2006 study. The 2006 site used for the 2018-2019 site BR-3 comparison was located just downstream of BR-3 (site BR1c in 2006 report). The 2006 sites used for the 2018-2019 site comparisons for CG-1 and LR-1 were located just upstream (sites SB-2 and LR1c in 2006 report). Site SB-2 was also established for the present study in 2019. Although this site coincided with the approximate location of the 2006 SB-2 site, the sample size for DNA analyses at this site was small and data collected was not used for comparisons to 2006 sites.

[32] 1CB009 was not tested for birds and 1CB008 was the only basin (of five tested) that tested negative for birds.

282 to 4,106 MPN/100mL and OB values from 73 to 214 µg/L (Figure 23; Appendix A, Table A7).

The greatest mammal DNA concentrations detected in the sampled basins were values >7.5 x $10^{\wedge 7}$ (75 million copies) and were observed for structures 1CB003 and 1CB006. Single sample values for these two structures exceeded the copy numbers for the majority (94%) of GRB stream monitoring sites. Bird DNA concentrations at the four structures with positive detections were similar to those observed for stream monitoring sites (Appendix A, Table A7). DNA results for the GRB stormwater collection system for bird and mammal copy numbers (no human positive detections for GRB stormwater structures) were compared to a similar study conducted in 2015. In this study, authors assessed DNA concentrations for mammal, human, and bird source markers for stormwater structures and nearby marine beach locations in York, ME (42). Overall mammal copies for GRB stormwater structures were greater than those observed for York's stormwater structures. Bird copies for GRB structures were on the lower end of those observed for York structures. Statistical comparisons to values observed for similar studies were not possible due to the small sample size (six locations on one monitoring date) for the GRB study. A more thorough assessment of possible fecal source inputs to Kennebunkport's stormwater collection system is recommended to better understand how these monitoring locations compare to data collected in similar Maine watersheds.

3.4.4 Identified Problematic Areas

Monitoring sites with elevated/positive results for multiple toolbox parameters were considered suspect locations with the potential for human fecal contamination, warranting follow up investigative efforts by Kennebunkport. Most MST efforts focused primarily on these areas and downstream beach sites; however, additional monitoring sites were tested on a limited basis to better understand the distribution of potential pollution sources throughout the watershed. Data for ENT, MST and, to a lesser extent, OBs, were the primary data used for identifying problematic sites/areas. When analyzing these data, less emphasis was placed on OB monitoring results as interference from organic matter was suspected for the majority of samples. Limited ammonia, surfactant, total chlorine, and PPCP testing (1-3 monitoring dates) was conducted. Pharmaceutical and ammonia results indicated little to no human sanitary contamination, and surfactant and chlorine monitoring did not indicate any non-sanitary sources of human pollution (e.g. soaps, oils, disinfectants). These results were consistent with low ENT values detected at those sites. Priority sites identified through ENT monitoring efforts were primarily located in the Smith Brook (SB-5, SB-4, SB-3, SB-2) and Little River – Beaver Pond sub watersheds (BP-3, BP-2 and BP-1). Of these sites, human DNA was identified at SB-5, SB-3, BP-3, and BP-1, which largely aligned with predictions based on ENT results. These prioritization efforts were meant to be used as a guide, not a definitive indicator that illicit source(s) were present. Further investigations are necessary to verify sources exist and identify their causes.

4. DISCUSSION

Given the history of persistently elevated fecal bacteria in the GRB watershed, particularly at the mouths of the Batson and Little Rivers, MHB has worked collaboratively with Kennebunkport and other partners to support water quality monitoring efforts, assist with the identification of possible human-sourced contributions to fecal contamination in the watershed, and support the prioritization of local investigative and remediation efforts. By using source-tracking data collected by FB Environmental (2005-2006) and by MHB and the Town of Kennebunkport (2018-2019), several bacteria hot spots throughout the watershed were identified and prioritized for further investigation using source-specific methods.

Although traditional FIB monitoring is less expensive, allowing for a greater number of samples and more comprehensive monitoring regimes, these FIB can only confirm the presence of fecal bacteria in the water, not indicate where that bacteria might be coming from. Sources of FIB pollution can be difficult to identify and eliminate as they are often diffuse, intermittent, and can change from year to year. Coastal beaches and wetlands are complex systems where the regrowth and persistence of FIB in sand, seaweed and sediments further confounds our understanding of observed bacteria levels and possible fecal pollution sources. Understanding bacteria sources is important as this information can be used to prioritize investigations which often require extensive time and resources. This information can also support public outreach initiatives related to practices that may be contributing to elevated bacteria threatening public health at GRB.

To address this limitation of FIB sampling, recent watershed monitoring activities were focused on integrating more source-specific tools and techniques like MST, PPCPs, and additional toolkit parameters (ammonia, surfactants, total chlorine) for locations identified through ENT and OB monitoring as problematic sites/areas. The purpose of this additional monitoring is to better understand the source(s) contributing to bacterial pollution in the GRB watershed and prioritize remediation efforts when sources are of human origin. MST methods were the primary tool used for follow-up source-specific investigations. These source-specific tools assisted MHB and Kennebunkport with verifying suspected fecal bacteria hot spots, supported the refinement of locations of possible illicit human sources, and facilitated improved understanding of the prevalence of those sources.

FIB monitoring results revealed the widespread presence of fecal bacteria throughout each GRB subwatershed, particularly in the Smith Brook and the Little River (Beaver Pond drainage) subwatersheds. Over the course of this study, nearly all stream monitoring sites exceeded Maine's single sample safety criteria at least once. Additionally, the majority of sites exceeded EPA's recommended ENT geometric mean threshold in 2018, and a handful of those same sites also exceeded the threshold in 2019. Many of these sites showed consistently high bacteria values as the majority of sites with the greatest ENT geomeans also represented those with the highest single sample exceedance rates. DNA analyses were prioritized based on previous water quality issues or sites/dates with suspected sources. This resulted in inconsistent sample sizes among sites/years. This lack of consistency makes it difficult to directly compare data between sites and among monitoring seasons.

MST results suggest that fecal contamination in the GRB watershed is likely a product of a diverse set of host sources, as five of the six host source markers tested were detected at stream monitoring sites representing each of the three subwatersheds. Ruminant DNA was not detected at any stream monitoring sites. Overall, DNA detections varied widely among stream monitoring sites, with some sites testing positive for one source (mammals) and others testing positive for four or five host-specific markers.[33] The most frequently detected DNA source targets for submitted samples were those specific

[33] Variability in sample submissions for specific host markers (See Appendix A, Table A9). Just four total samples for two sites (GR-1 and GR-5) tested for gulls.

to mammals, birds, and gulls (percent samples detected: mammals-100%; birds-93%; gulls-100%). Given the proportion of the watershed dominated by forested areas and wetlands, the ubiquitous detection of mammal and bird DNA in samples analyzed was not surprising and aligns with observations for similar watershed source tracking studies in Maine. Although human and canine source targets were also detected in each of the three subwatersheds, these detections were intermittent, with positive detections for less than half of submitted samples (percent samples detected: humans-20%; canines-46%). These results suggest that non-human sources (wildlife, pets) may be the principal contributors to bacterial water quality impairments at GRB sites monitored as part of this study. Although human sources were detected only intermittently, they do exist, and efforts to identify and these source(s) should continue.

Stormwater runoff may play a key role in the mobilization of fecal pollution sources (including those of human origin) and resulting water quality impairments observed in the GRB watershed. Overall, bacteria exceedances and site specific geomeans were greater for the 2018 season, when more monitoring events were conducted within 48 hours of wet weather compared to 2019. Although samples were analyzed for DNA source targets for just two monitoring dates in 2018, compared to seven dates in 2019, a greater percentage of samples tested positive for human DNA for 2018 monitoring events. As with ENT exceedances, the majority of samples with human-specific DNA detections were associated with wet weather events, particularly for one wet weather monitoring date in 2018 (10/3/2018 – 0.99 inches of rainfall 48 hrs. prior to monitoring) when eight of eleven total samples tested positive for human DNA. Overall canine DNA percent detections were greater in 2019 samples and canine source markers were detected under a mix of dry and wet weather conditions.

Though bacterial exceedances and human-specific DNA detections were greater overall for wet weather monitoring events, dry weather exceedances and human-sourced detections were also observed at several stream sites, demonstrating that stormwater runoff may not represent the entire mechanism contributing to water quality impairments. Wet weather bacteria exceedances are difficult to track to the source(s), as fecal waste from an unknown number of non-human (e.g. dogs, wildlife, and humans) and human (e.g. pollution from saturated septic drain fields with high water tables) sources can be transported from upland areas during storm events and exacerbate downstream water quality issues. Elevated fecal bacteria during dry weather conditions are often associated with subsurface point sources of pollution, such as malfunctioning septic systems or compromised sewer infrastructure. Based on suggestions from Boehm and Weisberg, it is also possible that groundwater discharges containing elevated concentrations of bacteria are being transported (during all weather conditions) to nearby monitoring locations and contributing to persistent pollution issues in the watershed (11). Assessing possible groundwater contributions was outside the scope of this project. Though the data suggests non-human fecal sources as the principal contributor to impaired water quality, consistently elevated FIB and the intermittent detection of human fecal sources for portions of the watershed during both dry and wet weather conditions indicates possible issues with municipal or private wastewater disposal systems warranting further investigative efforts in those areas.

Suspect locations, as demonstrated by persistently elevated bacteria concentrations and intermittent human DNA detections, were primarily located in the downstream portions of each of the three subwatersheds including the mouth of the Batson River (GR-5), where Goose Rocks

Creek discharges into Smith Brook (SB-3), the outlet where Beaver Pond Brook discharges into the Little River (BP-1), and upstream of the mouth of the Little River (LR-1). These sites tested positive for canine-sourced DNA and human DNA (GR-5, BP-1, LR-1) under dry weather monitoring conditions. Most of these monitoring sites (excluding LR-1) are located in some of the most residentially developed areas of the watershed, where the combined presence of municipal sewer, private septic systems, and stormwater discharges pose potential threats to GRB water quality. However, these downstream residential areas were not the only areas that tested positive for human source(s) on at least one occasion. Positive human detections at several upstream sites (BR-3, TB-1, CG-1, SB-5, and BP-3) may also indicate upstream sources of bacteria are contributing to exceedances at downstream sites and would require additional source-specific monitoring to verify potential illicit discharges.

Downstream portions of the watershed are particularly sensitive to the impacts of stormwater surface runoff, not only as a result of greater development and associated impervious surfaces, but also due to the presence of nearby stormwater collection system discharges. Stormwater management is limited in Kennebunkport, with the majority of flow discharging from the collection system to the marsh surrounding Goose Rocks Creek just upstream of monitoring site SB-3 and near monitoring site BP-1 which is just upstream of where Beaver Pond Brook discharges into the Little River. Limited monitoring of the stormwater collection system in 2019 revealed elevated bacteria levels. Overall, tested basins were stagnant and shallow, providing ideal conditions for bacteria to persist and proliferate. During intense storms, stormwater (including any bacterial contamination) is flushed out of the collection system and discharged into the Goose Rocks Creek marsh and lower reaches of Beaver Pond Brook, eventually reaching downstream beaches at the mouth of the Batson and Little Rivers (and monitoring sites GR-5 and GR-1).

For monitoring locations with persistently elevated bacteria, consistent mammal DNA detections, and no human detections (as was observed for several sites in the Smith Brook (SB-2, SB-4) and Beaver Pond (BP-2) subwatersheds), elevated bacteria may be due to contributions from other mammalian source(s) not tested in this study, human or canine sources not identified due to small sample sizes, or a combination of these factors. Although sample sizes were limited, DNA source tracking efforts were helpful in identifying possible areas where canine waste may be more problematic than those of human origin (BR-1, CG-2, GR-1). This information can be used to better inform targeted outreach efforts (See *Recommendations – Expand Education and Outreach Initiatives*). Increased source-specific monitoring, including the integration of additional mammalian source targets (if available), is recommended to better discern sources of fecal pollution for these areas.

The integration of source-specific methods like MST can be an effective tool to support water quality assessments; however, the applications of these methods are limited, as is true for all source tracking tools used in this study. MST is advantageous for this type of work because it can be helpful with prioritizing funds to further assess problematic sites suspected to be impacted by human sources. However, it is important to note that MST assays are not directly linked to ENT bacteria concentrations. The detection of ENT is meant to be used as an indicator of potential harmful fecal pathogens. The MST assays used in this study detect actual fecal bacteria from specific sources, but do not detect fecal pathogens specifically, and are not correlated with the presence of fecal pathogens the same way fecal indicator bacteria are. While ENT results were used to prioritize source-specific testing, detection of fecal sources via MST is possible without corresponding elevated ENT concentrations, as was true for a portion of samples collected in this study.

It is also important to consider that source-specific detections are largely dependent on the conditions at the time of sampling and the location of the contributing source(s). When available, copy numbers were used to isolate potential fecal sources, but not indicate if a pollution problem existed below a specific threshold. It is possible that sources weren't detected in certain samples, but were present in the watershed, because dry weather conditions prevented the mobilization of those sources to water quality monitoring sites. Additionally, because these DNA markers do not persist for extended periods of time outside of a host, as is common for FIB, it means they are typically only detected if there was a recent contamination event. Therefore, it is possible that specific sources may not have been detected due to the lag time between a contamination event and the time of sampling. Furthermore, the identification of possible sources, particularly those contributing to mammal detections, is limited to the source-specific assays currently developed.

This work is meant to help inform local efforts to identify and eliminate possible source(s) of human fecal pollution degrading water quality and threatening public health at GRB. Over the course of this study, suspected human fecal sources have been identified and removed, supporting the town's goals of improving water quality in the watershed and increasing public health protection. However, fecal bacteria issues remain throughout the watershed, including the intermittent presence of human DNA in some regions. While the majority of OBDs in the watershed have been removed and upgrades/expansions to Kennebunkport's municipal sewer infrastructure performed, the prevalence of aging subsurface disposal systems in the watershed continues to pose a significant threat to GRB water quality. Failure to perform routine septic system maintenance, particularly for older systems, can result in premature malfunctions or complete system failures. The increase in homes used for seasonal or recreational use in Kennebunkport may also place increased pressure on subsurface wastewater infrastructure and contribute to poor septic maintenance if renters are unaware of proper septic system practices.

It is important to maintain the current momentum, utilizing the water quality data collected and expertise of project partners to further address contamination issues in the GRB watershed. To tackle human-sourced contributions, continued assessment of the watershed's wastewater disposal infrastructure, including property and infrastructure investigations, are necessary. Ongoing water quality monitoring efforts are recommended, as they are integral for documenting any intra-annual variability for fecal contamination in the watershed, verifying when suspected sources are removed, and ensuring any emerging fecal contamination sources (See *Recommendations* for more information) are addressed. Watershed monitoring efforts for the 2020 season will be shared once analyses are complete, and the MHB program will continue to discuss monitoring results and provide recommendations for future water quality improvement efforts when possible.

5. LOCAL ACTIONS TO IMPROVE WATER QUALITY

Kennebunkport has demonstrated a clear commitment to improving water quality in the Goose Rocks Beach watershed and ensuring a safe beach experience for residents and visitors. To accomplish this, the Town has taken actions above and beyond routine beach monitoring to tackle persistent pollution issues at GRB. Most recently, in 2018, the Town increased the frequency of routine beach monitoring at all beaches (Goose Rocks Beach and Colony Beach) to 2x per week and has continued this monitoring frequency through the 2020 season.[34] Additionally, Kennebunkport has continued partnering with MHB and others to incorporate enhanced pollution monitoring and outreach efforts in the GRB watershed into ongoing beach management. The goal of these efforts has been to identify and remediate source(s) of bacterial pollution in the watershed and communicate those issues to the public, including promoting best practices at the beach and throughout the watershed.

5.1 Education and Outreach

To broadly distribute water quality information and best protect public health, Kennebunkport Public Health staff provide timely notifications of bacteria monitoring results on signs at Goose Rocks and Colony Beaches, their community website, and at locations where beach stickers are sold. The Public Health Office also responds to local water quality inquiries when necessary.

In 2019, the town worked with MHB to provide the public with information regarding septic system maintenance and best practices for pet waste management. Staff from Kennebunkport and MHB conducted an outreach event (10/21/2019) throughout the densely populated, lower reaches of the GRB watershed. At this event, approximately 100 septic education packets containing a pet waste education flyer (Figure 24) created by Kennebunkport and MHB staff specifically for Kennebunkport's beaches, septic educational materials published by EPA, and a septic best practices magnet created by Kennebunkport and MHB staff (Figure 25) were distributed. The Town has continued making these materials available to residents and visitors in 2020 and provides information regarding septic maintenance best practices via their Town's website.

In 2020, the Town updated their beach signage to provide more specific information regarding impaired water quality and possible public health risks from swimming at Goose Rocks Beach river mouth sites (GR-1: mouth of Little River, GR-5: mouth of Batson River), particularly following moderate to heavy rainfall. This update included recommendations to the public to swim at the main portion of GRB instead of river mouth sites.

Figure 24. Kennebunkport's pet waste brochure.

Figure 25. Kennebunkport's septic best practices magnet.

When possible, Kennebunkport will work with partners to expand outreach initiatives in 2021.

5.2 Infrastructure Investigations and Improvements

Kennebunkport has worked strategically to utilize staff time and resources to address bacterial water quality impairments in the GRB watershed. As part of these efforts, the Town initiated an intensified review and assessment of the integrity of Kennebunkport's wastewater and stormwater

[34] 3x per week for Goose Rocks Beach river mouth sites (GR-1 and GR-5) in 2018.

collection systems in the watershed. This effort involved the collaboration between multiple municipal departments and included the creation of an inventory of properties serviced by private subsurface wastewater disposal systems (septic), property inspections of parcels with suspect subsurface systems, the creation of an inventory of stormwater structures and direction of flow determinations, and an assessment of the age and integrity of the Town's municipal sewer system servicing properties along Kings Hwy., Sand Point Rd., and the lower reaches of Dyke Rd. and New Biddeford Rd. (up to Binnacle Ln.) (Figures 26-27). To support this work, interns were hired in 2018 and 2019 to assist municipal staff with surveying properties serviced by private septic systems, support with stormwater structure identification and mapping efforts, provide education regarding septic system best practices, and contribute to watershed monitoring activities.

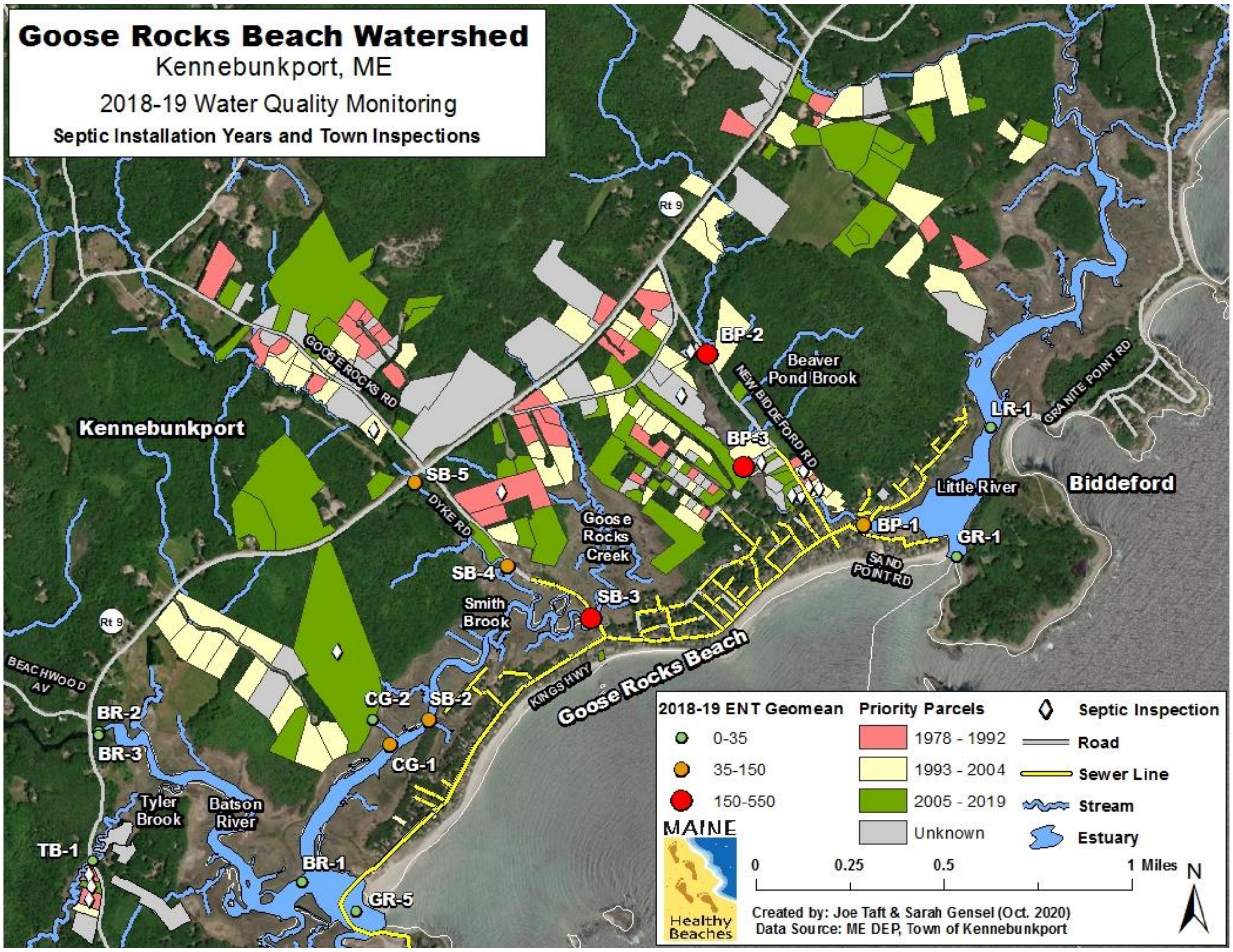


Figure 26. Kennebunkport's wastewater collection systems (municipal sewer system and private subsurface septic systems), septic inspections, and 2018-2019 enterococci (ENT) geometric mean (MPN/100mL) stream monitoring results for the Goose Rocks Beach (GRB) watershed. Parcels symbolized based on septic installation year (data provided by the Town of Kennebunkport). Inspections performed by the Town indicated by a diamond symbol. See Appendix E, Figures E3-E7 for additional detail.

Watershed monitoring results were used to prioritize follow-up investigations of wastewater disposal systems (municipal sewer and septic systems), targeting areas with persistent bacterial pollution and positive human DNA detections. As a result, the majority of investigations were focused on the lower reaches of the watershed (infrastructure below Rt. 9) (Figure 26).

From 2018-2019, Kennebunkport's Planning and Code Enforcement Department performed visual inspections of 14 properties in priority regions and follow up dye tests at two properties where malfunctioning systems were suspected (Figure 26). No obvious malfunctions were identified during these inspections. The Department continues to work with interested property owners to investigate and dye test systems and, when feasible, to verify systems are working properly. In 2019, the Department worked with MHB staff to identify and map existing stormwater structures, documenting structure condition, direction of flow, and performing water quality monitoring when possible (Figure 27). This information was used to compile an inventory to support any necessary future infrastructure upgrades and better understand the possible contributions of stormwater effluent to impaired water quality in the watershed.

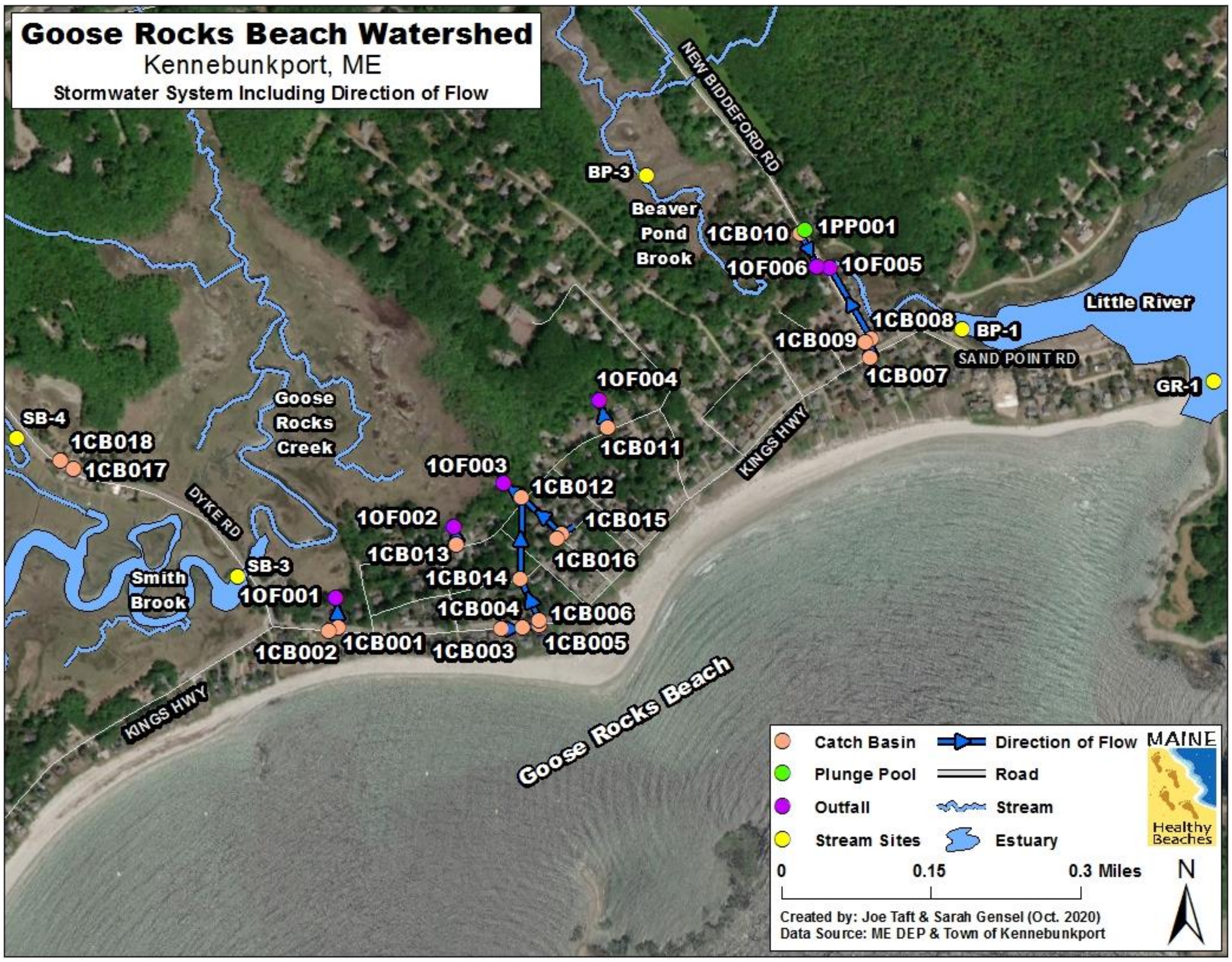


Figure 27. Kennebunkport's stormwater collection system structures (catch basins, plunge pools, and outfalls) including direction of flow and nearby 2018-19 Goose Rocks Beach (GRB) watershed stream monitoring sites.

In October of 2018, Kennebunkport's Wastewater Department identified several potential areas near priority monitoring sites where possible exfiltration or infiltration into and out of the Town's sanitary system or compromised infrastructure might be contributing to impaired water quality in the GRB watershed. The Town contracted with EcoClean to conduct closed circuit television (CCTV) inspections of nearly 4,850 ft. of the Town's municipal sewer system (gravity mains) servicing properties in the watershed. Additionally, Wastewater Department staff, with assistance from the Kennebunkport Fire Department, performed follow up dye testing on two force mains including one running from Pump Station 13 under Beaver Pond Brook to Sand Point Rd. and ultimately Kings Hwy. and another running from Pump Station 12 to Mills Rd. in Cape Porpoise. For all inspections (CCTV and dye tests), there were no indications of compromised infrastructure or exfiltration. Minor infiltration into the system was noted for a few sagging manholes. Investigations for the municipal sewer system in 2018 were performed in addition to routine and ongoing maintenance and inspections performed by Kennebunkport's Wastewater Department.

Although not identified as part of the investigations described, faulty sewer infrastructure and malfunctioning subsurface wastewater disposal systems have been identified and eliminated in portions of the watershed over the past several years. Additionally, the installation of a sewer line extension (2019) along New Biddeford Rd. provided hookup opportunities previously unavailable to homes serviced by septic systems in that region. Kennebunkport plans to continue their work to upgrade sewer and stormwater infrastructure when feasible, perform routine maintenance (catch basin and sewer line cleaning, street sweeping, etc.), and conduct dye tests and CCTV surveys to ensure the integrity of municipal wastewater infrastructure as needed. The Town plans to continue integrating data into prioritization of future wastewater infrastructure inspections and upgrades for GRB watershed priority regions.

5.3 Continued Watershed Monitoring, Education, and Assessment

In 2020, Kennebunkport, in partnership with MHB, continued intensified monitoring efforts including ENT, OB, and limited MST monitoring to further pinpoint potential source(s) of fecal pollution impacting the GRB watershed.[35] Additionally, the Town plans to continue expanding education and outreach efforts to better inform the public of potential health risk(s) at Goose Rocks Beach and promote best practices throughout the watershed. When feasible, MHB will continue to work with Kennebunkport to build local capacity to identify and address pollution issues, support water quality monitoring, expand outreach initiatives, and establish collaborative partnerships.

6. RECOMMENDATIONS

6.1 Maintain Watershed Water Quality Monitoring Program

Continue annual baseline water quality monitoring, increasing monitoring frequency and further bracketing suspect sources when possible. Consider using source-specific tools (when available) to target possible sources of human fecal contamination. This work will help verify that implementation of projects is successful, including the Town's remediation and education/outreach efforts. This data can also be used to support prioritizations of future investigative and source removal efforts and help identify new bacteria issues. As time and resources allow, MHB suggests expanding the scope of current water quality monitoring efforts to better understand bacteria impairments in the watershed and more effectively target public outreach. Examples of additional monitoring efforts include:

- Expanding rainfall monitoring to track bacteria concentrations during dry and wet weather events. This information can be used to better understand when contamination is most likely to occur for river mouths and main beach sites and further refine the Town's preemptive rainfall advisory notification threshold (currently 1 inch of rain in 24 hours) for Kennebunkport's beaches.

[35] Additional monitoring work in 2020 was conducted and those results will be shared once compiled.

- Increasing monitoring efforts of GRB's stormwater infrastructure to identify the extent of stormwater contributions to water quality issues near Beaver Pond site BP-1, Smith Brook site SB-3, and at downstream beaches.
- Incorporating monitoring efforts over various tidal cycles, specifically targeting spring and neap high tides to better understand the effect of tidal inundation and associated flushing of upstream marshes and tidal waterbodies on downstream water quality.
- Integrating wind speed, direction, and wave height into beach monitoring efforts to determine any effects of sea state on FIB levels (*See Slovinski and Dickinson, 2005*). This information can be used to better inform beach management decisions including the issuance of public health advisories.

6.2 Prioritize Identification and Remediation of Human Fecal Sources

Continued integration of source specific analyses for suspect areas is recommended to support the prioritization of resources towards addressing sources of human fecal contamination. Of particular concern are the priority regions with potential wastewater issues indicated by consistently elevated FIB concentrations and the presence of human fecal DNA.

A number of source-specific test methods exist to accomplish this work. MHB recommends that Kennebunkport continues implementing PCR and qPCR methods in partnership with UNH or a similar entity using comparable methods to provide consistency in data sets, allowing for year to year comparisons. When possible, this approach should include further bracketing of monitoring sites in suspect areas and the use of qPCR methods track the relative strength of the DNA source markers and better isolate contamination sources. To reduce overall project costs and prioritize limited resources, MST methods should only be used once traditional and less expensive methods to identify potential suspect areas have been conducted (FIB monitoring, stormwater toolkit, etc.). A number of samples collected during the 2018-2020 monitoring seasons, but not prioritized for immediate lab submission, remain available for analysis. Although analyzing these samples may help project partners better understand DNA source distributions and concentrations over the course of those three monitoring seasons, MHB recommends prioritizing resources for new sample collections as bacteria sources often change over time and under varying environmental conditions.

6.3 Wastewater Infrastructure Investigations and Upgrades

MHB recommends the Town continue routine maintenance and investigations of the integrity of wastewater disposal systems servicing GRB properties, particularly those in close proximity to documented priority areas where human DNA sources have been detected. Where feasible, consider expanding areas within the watershed serviced by municipal sewer to decrease the number of aging, and possibly malfunctioning, subsurface systems potentially contributing to water quality impairments. Continued maintenance of inspection and infrastructure inventory files generated over the course of this project is recommended to support future planning and assessment efforts. These actions will support current watershed water quality improvement goals and assist with preventing future pollution issues. As part of these efforts, consider:

- Municipal Sewer
  - Encouraging property owners to connect to the municipal sewer system when available by providing education regarding the impacts of failing septic systems

on GRB water quality and public health. Consider financial incentives when possible to support participation by offsetting costs to connect.

  - Continuing monitoring of municipal sewer system for any compromised infrastructure or infiltration/exfiltration into or out of the system.

- Private Subsurface (Septic) Systems
  - Expanding current review of parcels serviced by septic systems near priority regions and continuing property surveys for suspect properties.

  - Investigating septic replacement grants where applicable (See *4. Pursue Funding Opportunities – Small Community Grant Program* below).

  - Encouraging regular septic system pump-outs, including the consideration of offering a septic pump-out reimbursement and/or inspection tax credit as an incentive. Examples include:
    - ***Old Orchard Beach, ME****:* Reimbursement of septic waste hauler charges towards real or personal property taxes. For full ordinance language see: https://library.municode.com/me/old_orchard_beach/codes/code_of_ordinances?nodeId=PTIICOOR_CH58UT_ARTIISETA_DIV2DICO_S58-58RECORE
    - ***State of Massachusetts****:* Credit for repair or replacement of a failed cesspool or septic system to comply with state sewer system requirements https://www.mass.gov/technical-information-release/tir-97-12-personal-income-tax-credit-for-failed-cesspool-or-septic

6.4 Stormwater Infrastructure Inspections and Upgrades

As time and resources allow, it is recommended that Kennebunkport continues routine maintenance of stormwater infrastructure servicing areas of the GRB watershed, including the consideration of possible expansions to areas currently not serviced and upgrades of aging structures to ensure management strategies are effective at minimizing impacts to both watershed and downstream beach water quality. Efforts to map all stormwater system structures (outfalls, basins, pipes, etc.) and maintenance of inventory and property inspection files generated over the course of this project should continue to aid with future planning and assessment efforts. When feasible, consider water quality testing of identified basins and outfalls to help identify possible illicit connections or illegal dumping activities.

6.5 Establish and Maintain Collaborative Partnerships

The development and implementation of a successful management plan for the GRB watershed moving forward will be largely dependent on effective collaboration between project partners and stakeholders. By soliciting expertise from members of the community, state and federal partners, and local organizations (conservation commissions, planning and select boards, land trusts, universities etc.), Kennebunkport can increase their understanding of the GRB watershed and leverage limited resources to develop effective strategies to protect and restore water quality in the GRB watershed. Consider collaborative efforts with the City of Biddeford to identify potential pollution sources in Biddeford's portion of the GRB watershed.

6.6 Pursue Funding Opportunities

Investigate and pursue funding opportunities to support interns, continue baseline water quality monitoring and additional source tracking work, and incorporate innovative resource management and water quality monitoring strategies. Consider working with local experts and stakeholders to research opportunities and develop applications. When possible, MHB recommends enlisting the support of a local conservation district or environmental consultant to assist with these efforts as funding applications are extensive and very competitive. Depending on the grant program, municipalities may need to work with a sponsoring agency to be eligible to receive funds. Examples of existing funding opportunities include:

- ***Nonpoint Source Water Pollution Control Grants*** – *Maine Department of Environmental Protection (Maine DEP)*[36]
  - Grants awarded to support communities with restoring or protecting waterbodies identified as NPS Priority Watersheds. Funding opportunities include:
    - **604(b):** Grants to develop a watershed-based management plan.
    - **319(h):** Grants to implement a watershed-based management plan.

- ***Coastal Community Grant Program (Municipal Planning Assistance Program)*** – *Maine Department of Agriculture Conservation and Forestry (DACF)*[37]
  - Grant program geared towards providing technical and financial assistance to municipalities to improve Maine's economy. Examples of funded projects include but are not limited to those focused on sustainable development, water quality and land use improvements, restoring and preserving coastal habitats, and coastal resiliency.

- ***Maine Outdoor Heritage Fund Grant Program*** – *Maine Department of Inland Fisheries and Wildlife*[38]
  - Grant program awarding funds for projects that fall into four distinct categories including promoting conservation of fish and wildlife habitat, acquisition and management of public lands, conservation of endangered species, and conservation law enforcement. This program requires sponsorship from a Qualified Sponsoring Agency to submit an application.

- ***Small Community Grant Program*** – *Maine DEP*[39]
  - Grants awarded to municipalities to support replacement of malfunctioning septic systems. Proof of an existing pollution problem is required to qualify. Grants to property owners are based on annual income.

6.7 Expand Education and Outreach Initiatives

Expand current education and outreach efforts to communicate water quality findings and best practices to the general public, residents, and other interested stakeholders. This transparency will facilitate informed decision making for resource managers and beach users and will be

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[36] https://www.maine.gov/dep/water/grants/319.html
[37] https://www.maine.gov/dacf/municipalplanning/financial_assistance.shtml
[38] https://www.maine.gov/ifw/programs-resources/grants/outdoor-heritage-fund.html
[39] https://www1.maine.gov/dep/water/grants/scgp.html

instrumental in supporting Kennebunkport's efforts to bring awareness to water quality issues, address suspected pollution sources, and protect public health at GRB. To accomplish these objectives, MHB suggests Kennebunkport continues to work with partners (e.g. MHB, GRB Advisory Committee, Maine DEP, local K-12 schools and universities, Kennebunkport Conservation Commission) on outreach and education campaigns promoting best practices such as septic system maintenance, responsible pet stewardship, and stormwater management. Examples of outreach initiatives include:

- Promoting septic system maintenance and best practices
  - Continue distribution of EPA factsheet, septic magnets, and other relevant materials to property owners throughout the watershed (See *Local Actions to Improve Water Quality – Education and Outreach*).
  - Given the increase in the number of homes being utilized as rental properties in recent years, documenting these usage differences can support more effective targeting of outreach material distributions. It is possible that seasonal visitors to the area may not understand how to properly maintain a septic system if they've never owned one themselves.
- Expand pet waste management education campaign
  - Continue pet waste education efforts throughout the watershed, specifically targeting regions where DNA results indicate the presence of canine DNA. These positive detections were observed for portions of each of the three GRB subwatersheds and included downstream sites (BR-1, GR-5, SB-3, CG-1, BP-1, GR-1), Sandy Pines Campground site CG-2, and several upstream locations (BR-3, LR-1). As part of these efforts, consider:
    - Implementing pet waste specific signage or modify existing signage to educate the public regarding the impacts of undisposed of pet waste on water quality.
    - Installing pet waste bag stations and trash cans, particularly at beach entrances, to encourage pet waste disposal.
    - Collaborating with Sandy Pines Campground to provide pet waste best practices information to seasonal visitors.
- Initiate stormwater public outreach program to raise awareness and educate the public regarding the benefits of stormwater management and water quality issues related to stormwater runoff. Implementing this type of program in conjunction with a pet waste education campaign is advantageous as many of the pet waste threats to water quality impairments are exacerbated by stormwater runoff. In addition to improved signage, storm drain stenciling is a simple, low-cost method to create public awareness regarding the Town's goal to reduce stormwater pollution.

6.8 Continue Implementing Precautionary Advisories

Given the history of impaired water quality at Goose Rocks Beach, it is recommended that Kennebunkport continues to post precautionary rainfall advisories when local precipitation levels exceed 1 inch within 24 hrs. MHB recommends the advisory remains in place for at least 24 hrs. after the rainfall ends or if water quality monitoring conducted after the advisory is issued demonstrates bacteria levels below the EPA safety threshold. MHB recommends the Town continues to post permanent signage until bacteria results are consistently below the safety threshold at the high-risk portions of GRB (GR-1: mouth of the Little River and GR-5: mouth of the Batson River) where the effluent of the rivers has the greatest potential to negatively impact water quality. In 2020, Kennebunkport updated their swim advisory signs to include specific language pertaining to the swimming beaches located at the mouths of the Batson and Little Rivers (Figure 28) (See *Local Actions to Improve Water Quality – Education and Outreach*).

Figure 28. Kennebunkport's Swimming Advisory Sign for Goose Rocks Beach (GRB).

6.9 Promote Best Practices

Kennebunkport is encouraged to implement low impact development (LID) practices throughout the watershed such as reducing impervious surfaces to allow rainwater to naturally percolate into the ground, preserving and recreating natural landscapes to treat polluted runoff, protecting natural water flow, restoring vegetative buffers (sections of vegetation adjacent to bodies of water used to minimize runoff effects), etc. Where suitable, Kennebunkport should consider implementing stormwater best management practices (BMPs) to minimize the negative impacts of storm water runoff on downstream water quality. Examples of these BMPs include, but are not limited to, biofilters, wet ponds, drywells/infiltration basins, and vegetated swales/ditches.

DISCLAIMER

This report has been compiled to the best of the Maine Healthy Beaches program's knowledge. Please submit any comments or additions to MHB staff.

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