SUMMARY REPORT OF ENHANCED MONITORING AND POLLUTION SOURCE TRACKING EFFORTS IN THE NEW SALT RD. TRIBUTARY, GOOSEFARE BROOK OLD ORCHARD BEACH, MAINE

2012-2016

Photo: Meagan Sims

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Executive Summary

The Goosefare Brook (GFB) forms the border between the City of Saco to the south and Town of Old Orchard Beach (OOB) to the north. In response to concerns over water quality in the mouth and adjacent beach water, the Maine Healthy Beaches (MHB) program has supported multi-year enhanced monitoring and pollution source tracking efforts, held Stakeholder Workshops, and more to address impaired water quality throughout the watershed. Over the past five years, the MHB program has focused primarily on paired enterococci and optical brightener samples in OOB's New Salt Rd. Tributary (NSRT). This work identified widespread bacterial contamination throughout the tributary as well as two priority regions likely impacted by human-sourced fecal contamination.

In 2016, 36 samples were collected during eight events at nine sites within the two priorty areas identified through previous source-tracking efforts. Parameters tested include enterococci (ENT), optical brighteners (OBs), and microbial source tracking (MST) DNA analyses. ENT values ranged from 31 to 10,462 MPN/100mls with a combined geometric mean of 1,021 MPN for all sites. OB values ranged from 50 to 144 µg/l with a combined mean of 95 µg/l for all sites. All samples were tested for mammal and human DNA (presence/absence) and a subset of samples were also tested for the presence of bird, ruminant, and canine DNA. All samples tested positive for mammal DNA whereas percent detection of human sources varied between the two priority regions (mouth vs. marsh). Human sources were detected consitently in the mouth region with seasonal spikes in signal stregth during July and September, the portion of the year when OOB experiences its peak population comprised primarily of seasonal residents and visitors. Human sources were detected intermittely at marsh locations, potentially pointing to occasional use of a residence and/or groundwater transport of pollution sources. Bird DNA was detected in all samples tested and the signal strength remained consistent throughout the season for both regions. No ruminant or canine was detected in samples tested.

The pollution source tracking tools used as part of this study were combined into a risk factor analysis highlighting sites potentially impacted by human sources of fecal contamination. It is recommended that OOB prioritize investigations in these priority regions to identify and remove sources of human sewage. As part of ongoing efforts to address water quality in the GFB, both municipalities have investigated and removed sources of human wastewater, have expanded and upgraded sewer and stormwater infrastructure, and have worked together to acquire supplemental funding to complete a watershed management plan and begin implementation of best management practices (BMPs). However, persistent human-sourced contamination issues underscore the need to continue investigations to ensure the integrity of wastewater disposal methods throughout the GFB watershed.

Acknowledgements

Special thanks to all of the dedicated staff/volunteers who have helped collect data since this study began, especially the late John Bird who was instrumental in transforming the data to information to action. Also thank you to Maine DEP, US EPA, OOB, and Saco for their support. Funding for the Maine Healthy Beaches program is provided by US EPA and Maine DEP.

Background

The Goosefare Brook (GFB) Watershed is approximately 9.83mi^2 and is shared by the City of Saco (approximately 4,000 acres) and Town of Old Orchard Beach (OOB) (approximately 1,000 acres). The mouth of the GFB demarcates the beach and boundary between Saco and OOB. Just inland from the mouth, the brook splits into two branches, one draining primarily from Saco (Main Stem) and the other from an OOB tributary named the New Salt Road Tributary (NSRT) for purposes of this study (Figure 1). Progressing upland in the watershed (the land area draining to the brook), the two major sections of the brook continue to branch into a network of smaller tributaries. Municipal and private sewer services the majority of the GFB watershed, yet some properties have subsurface wastewater disposal (septic, cesspool) systems. Additionally, both municipalities are designated as "MS4" communities requiring them to implement a multifaceted approach to improving the quality of stormwater. A 5.54-mile segment of the GFB and several upstream tributaries are listed on ME-DEP's 303(d) list of urban impaired waters for bacteria and other stressors.

Since 2003, Saco and OOB have participated in routine beach monitoring as part of the MHB program. Monitoring at Ocean Park beach sites near the mouth of the GFB revealed frequently elevated bacteria levels and prompted the need to expand monitoring further upland. Enhanced efforts began with routine monitoring of two sites (GFB-01 and Saco-00) (Figure 2) located just above the mouth where the brook splits into the Main Stem and NSRT. Subsequent monitoring was initiated further upland to address impaired water quality throughout the entire watershed in 2010. Results of this larger assessment revealed extensive bacterial pollution throughout the watershed with a high likelihood of human fecal contributions particularly in Saco's Bear Brook and OOB's NSRT (Figure 1).

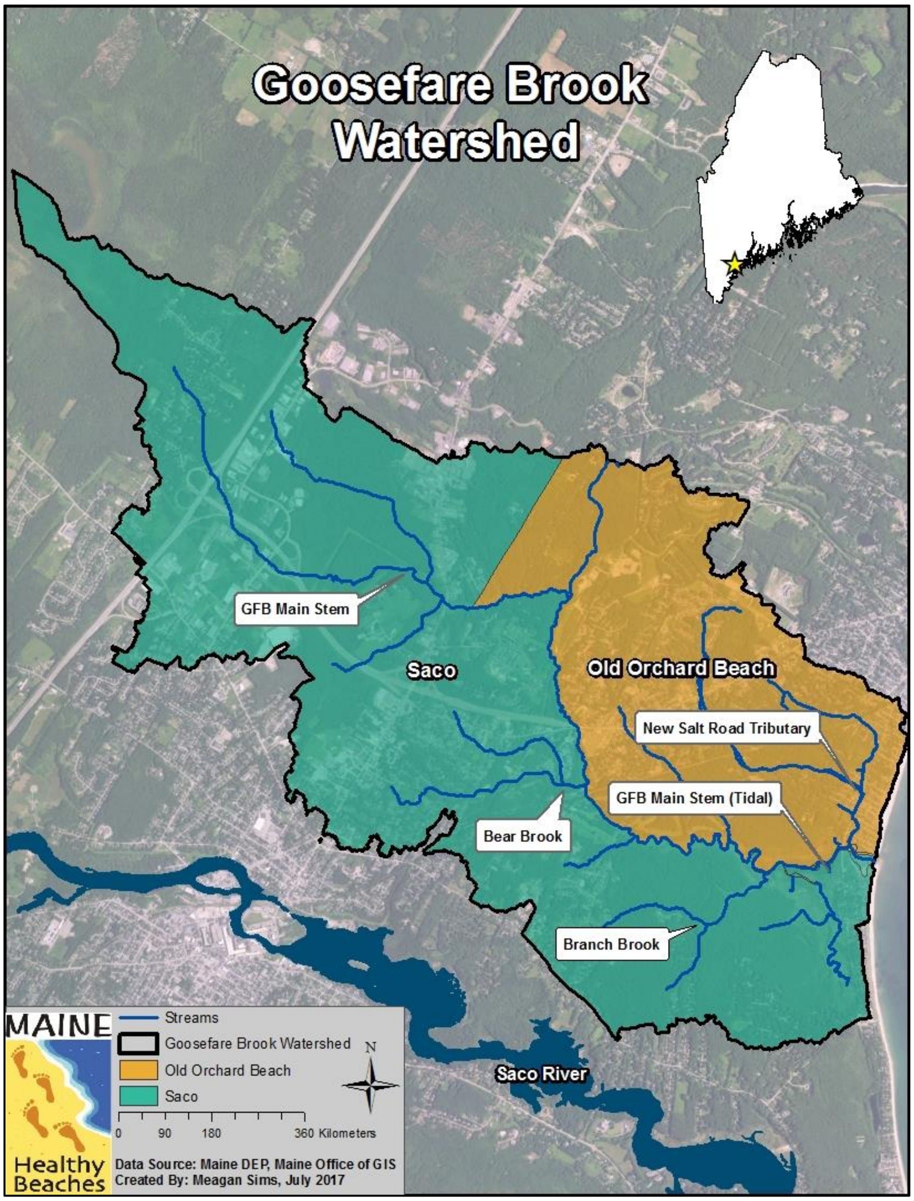


Figure 1. Goosefare Brook Watershed boundary, GFB main stem, and several major tributaries including the NSRT.

In response, MHB planned/facilitated meetings with representatives from Saco, OOB, ME DEP, and US EPA to share data and develop remediation strategies in 2011. From 2012-2016, MHB program efforts have concentrated primarily on the OOB branch, the NSRT and ME DEP efforts have focused on several upland regions of the GFB impaired for a number of criteria including Bear Brook (Figure 1). MHB staff continue to use local knowledge of potential suspect areas and collected data hone in on problematic areas

In an effort to pinpoint human sources, the pollution source tracking toolbox approach has been utilized incorporating multiple parameters (Table 1). 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. Toolbox parameters utilized are largely dependent on staff availability and funding, and have therefore varied for each season. For 2016, parameters used included enterococci (ENT), optical brighteners (OB), and microbial source tracking (MST). The incorporation of MST was made possible through an applied research partnership with University of New Hampshire researchers Steve Jones and Derek Rothenheber. MHB staff combined all parameter results to create a risk factor analysis highlighting suspect areas warranting further investigation by the Town of Old Orchard Beach (Table 3). Although wildlife, pet, and waterfowl waste can contribute to impaired water quality, it is recommended to target human sources first.

Table 1. Source tracking toolbox parameters used in the GFB by MHB and associated partners.

Parameter	Method	Source Target	Cost/Expertise
Enterococci (ENT)	Grab sample, Enterolert	Warm blooded animals	Low/Low
Optical brighteners (OB)	Grab sample, Fluorometry	Human	Low/Low
Pharmaceuticals and personal care products (PPCP)	Grab sample, metabolite analysis	Human	High/High
Canine detection	Grab sample in tandem with canines	Human	Low/Med
Microbial source tracking (MST)	Grab sample, DNA extraction	Variety of human and non-human sources	High/High

ENT indicate the presence of fecal contamination from warm-blooded animals and the possible presence of disease-causing microorganisms. However, fecal indicator bacteria (FIBs) like ENT do not differentiate the source(s) of bacterial pollution and have been found to persist and regrow in sand and sediments.[1] OBs are commonly used in commercial/retail products such as clothing detergents, dishwashing agents, and personal care products to brighten the whiteness of materials. These products are typically flushed down the drain and when concentrations are coupled with elevated fecal bacteria levels, can be indicative of human-sourced fecal contamination.

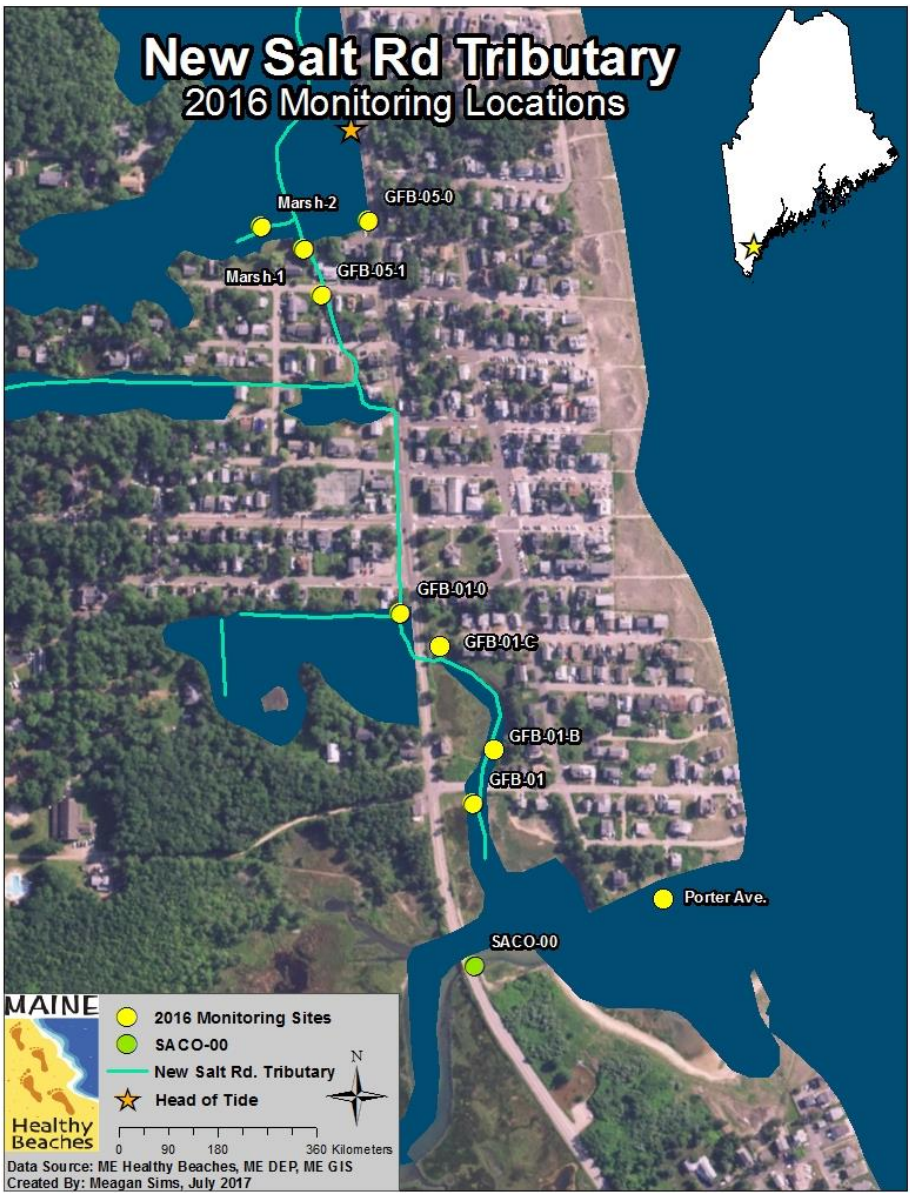
MST methods are used to complement traditional FIB monitoring, specifically targeting DNA of individual source markers using PCR[2], allowing for the differentiation between human and non-human fecal sources potentially contributing to observed elevated FIB levels. In contrast to FIBs, DNA source markers quickly degrade outside of their host (approximately 1 week) and therefore, a positive PCR assay suggests a recent contamination event. This is advantageous in the NSRT because of the potential persistence of FIBS in

[1] Badgley B.D., Thomas F.I., & Harwood V.J. 2011. Quantifying environmental reservoirs of fecal indicator bacteria associated with sediment and submerged aquatic vegetation. Environmental microbiology 13.4: 932-942.
[2] PCR= Polymerase chain reaction. It is a method used to amplify segments DNA resulting in a copy number for specific DNA targets.

several low-lying marsh regions. These markers demonstrate host specificity, allowing for the quantification of numerous specific host sources from one sample. MST methods can also provide the relative strength of the fecal marker by using a quantitative PCR (qPCR) test resulting in a DNA copy number that can be used to better track fecal contamination to the source(s) and give a sense of the contribution from human waste.There are currently no established safety limits for MST markers as there are for FIBs. Therefore, it is useful to compare data to similar regional watersheds to gain a greater context of the results. Data can also be compared to known human-associated contamination events to better understand the potential human-sourced contribution given observed concentrations.

Project Methods

Since 2012, the MHB program has supported over 550 paired ENT and OB samples at 22 routine sites stratified througout the NSRT portion of the GFB watershed. Monitoring locations targeted suspect areas identified through previous monitoring efforts, suspected human-sourced fecal contamination "hot-spots", and local information keeping in mind ease of accessibility and avoidance of private property. Due to this approach, site locations and monitoring frequency have varied each year.



Multi-year pollution tracking efforts highlighted two priority regions within the NSRT with the highest likelihood of human fecal contributions. These are GFB-01 located at the mouth of the brook near the tide gate where the NSRT combines with the GFB main stem before it reaches popular downstream swimming beaches and the marsh region located upstream at the outlet of the NSRT drainage from the Jordan Marsh. Monitoring sites were reduced in 2016 to further hone in and bracket suspected hot spots and prioritize resources for follow up DNA analyses to confirm suspected human-sourced fecal contributions to observed elevated bacteria levels. In order to assess NSRT water quality before mixing with seawater, MHB staff monitored during outgoing tides at three routine sites and six FYI sites in 2016 (Figure 2).

Figure 2. 2016 NSRT monitoring sites, 3 routine and 6 FYI locations.

Efforts for 2016 included 36 samples collected over eight events at nine monitoring stations from late May to early October to document potential baseline ENT, OB, and DNA readings before and after the majority of seasonal residents arrived in the region of Ocean Park. Collections included a combination of dry and wet weather events although the MHB program is most concerned with potential point sources of human fecal pollution (malfunctioning septics, faulty sewer infrastructure) indicated by FIB exceedances during dry weather conditions. During wet weather events, multiple sources (human and non-human) act together and often result in extremely elevated fecal bacteria levels that often do not provide insight as to what the problem(s) are and where they are located.

Five DNA markers were targeted for this study and include general mammal, human, canine, ruminant,[3] and bird. For all samples, initial tests were conducted to determine the presence (PCR) of mammal and human DNA markers to confirm suspected contamination hot spots. Subsequent qPCR analyses were conducted for sites testing positive for the presence of the human DNA marker to determine the strength of the signal and its fluctuation over time relative to the general mammal marker. This is meant to give an indication of human contibution relative to other mamamals. To assess potential mammalian fecal inputs in the absence of consistent human DNA detection, follow-up ruminant DNA tests were conducted for sites with suspected wildlife contributions. Canine and bird DNA analyses were also performed. qPCR general mammal DNA values are greater than human specific qPCR results because the general marker represents all mammal sources contributing, just not humans. Birds represent a separate animal class and while they cannot be directly compared to the mammal source marker as a component, they can provide information regarding other potential fecal sources contributing to elevated FIBs.

Results & Discussion

Enterococci and Optical Brighteners

In general, all identified suspect sites demonstrated elevated ENT levels over the past five years, and for many sites particularly in the GFB-01 (mouth) and GFB-05 (marsh) series, those levels have increased over time, particularly from 2015 to 2016 (Figure A4). Additionally, OB concentrations at these locations have generally been greater compared to less problematic sites within the NSRT drainage area (Figure A5).

For the three routinely monitored sites in 2016, all exceeded the ENT geometric mean[4] safety threshold[5] for marine waters. Single sample ENT values ranged from 31 to 10,462 MPN/100ml. ENT geometric mean levels varied between monitoring stations and ranged from 429 to 3,430 MPN/100ml with a combined geometric mean value for all NSRT sites of 1,021 MPN/100ml. This is over 29 times the EPA geometric mean safety criteria for recreational water contact (Table A2, Figure A6). OB single sample concentrations ranged from 50 to 144 µg/l with a combined NSRT mean of 95 µg/l (Table A2, Figure A7). While the NSRT-wide ENT geometric mean value has fluctuated since 2012, primarily as result of changes in site locations, monitoring frequency, and changes in the number of wet weather monitoring events, results have remained well over the EPA safety threshold for all monitoring seasons.

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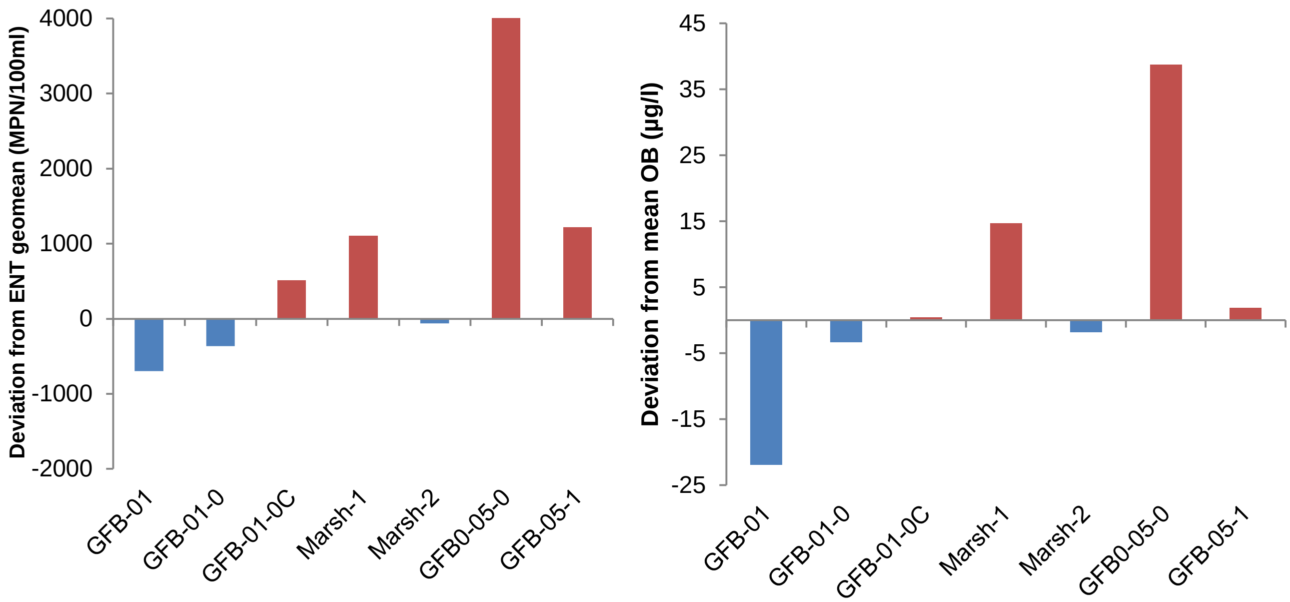
3 Ruminants include cattle, sheep, goats, deer, giraffes, antelopes, and camels. Canine and ruminant source markers were tested based on local feedback of potential sources contributing in this watershed.

4 A geometric mean represents the typical value of a set of numbers. It is calculated using the product of a set of values rather than using their sum as when calculating an arithmetic mean (average). Any ENT single sample results of <10 MPN/100ml were considered 5 MPN/100ml for report calculations.

5 US Environmental Protection Agency (EPA) recommend single sample maximum value for enterococci in marine waters is 104 (MPN/100 ml) and 61 (MPN/100 ml) for fresh water sites. EPA recommended geometric mean values are 35 (MPN/100 ml) and 33 (MPN/100 ml) respectively.

For the NSRT watershed, the OB 100µg/l threshold may not be a good metric for indicating human-sourced pollution due to interference from humic substances (tannins and other dissolved organic compounds) that can elevate OB readings and cause a "background level" contribution to measured OBs in systems like the NSRT that have tea colored water, an indicator of humic content. To help identify "hot-spots" of contamination, calculating individual site deviations from the overall mean can help pull a meaningful signal when most sites exhibit elevated ENT levels and are impacted by organic matter/interference (i.e. the most problematic sites within the system). Sites with positive deviations for both ENT and OB levels represent suspect locations potentially impacted by human sources. Sites with historical positive deviations for both parameters were targeted for further source identification using MST in 2016.



Figures 3-4. Deviations from 2016 ENT geometric mean and mean OB value for all NSRT sites. Bars above the x-axis indicate sites where ENT/OB values were greater than the geomean/mean and bars below represent those lower than the geomean/mean. See table X for sample sizes. Sites GFB-01-1B and Porter Ave were single sample events and not included in geomean/mean comparisons.

Microbial Source Tracking

Confirm suspected contamination hot-spots

All samples were tested for the presence of mammal and human DNA markers. PCR (presence/absence) analyses confirmed the presence of human DNA in both priority regions of the NSRT. The human DNA marker was consistently detected at the mouth of the NSRT (GFB-01 region) whereas human sources were sporadic in the marsh region. For example, human sources were detected 92.9% of the time in mouth sites vs 31.8% of the time in marsh associated sites. All sites tested positive for mammal sourced DNA, a trend not uncommon in regions like the GFB with numerous potential mammalian fecal sources present throughout the watershed. Of the sites tested, bird DNA was detected 100% of the time (Figure 5). Percent detection information was used to prioritize sites for additional human DNA analysis, prioritizing the mouth region as this location demonstrated consistent human sources and is wideley used by the public Because human DNA was not consistently detected at marsh locations, follow up PCR analyses for canine and ruminant DNA were conducted.

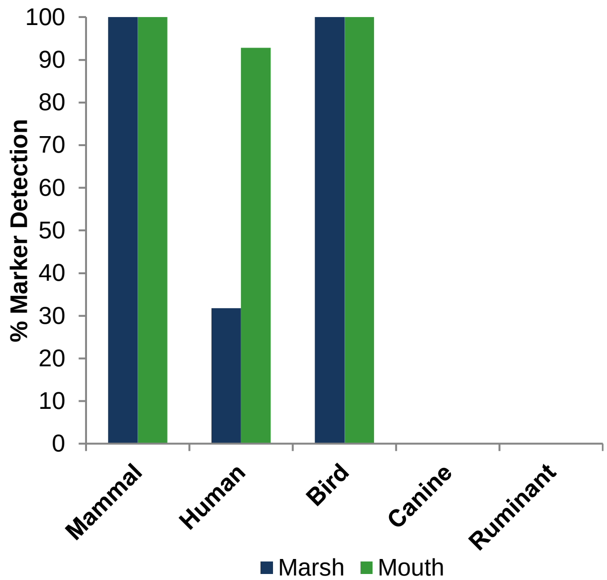


Figure 5. Total % detection of each source marker for marsh and mouth regions.

Table 2. PCR summary for GFB monitoring sites including total sample number and number of samples tested for each marker. M=mammal, H=human, B=bird, C=canine, R=ruminant.

Site	Sample #	Sources Tested (# of samples)
Marsh-1	8	**M**(8),**H**(8),**B**(5),**C**(5),**R**(5)
Marsh-2	8	**M**(8),**H**(8), **B**(5),**C**(5),**R**(5)
GFB-05-1	3	**M**(3),**H**(3),**B**(2)
GFB-05-0	3	**M**(3),**H**(3),**B**(3),**C**(3),**R**(3)
Marsh Region	**22**	**M(22) ,H(22), B(15), C(13), R(13)**
GFB-01	8	**M**(8),**H**(8),**B**(8),**C**(8)
GFB-01-C	2	**M**(2),**H**(2),**B**(2),**C**(2)
GFB-01-0	2	**M**(2),**H**(2), **B**(2),**C**(2)
GFB-01-B	1	**M**(1),**H**(1), **B**(1),**C**(1)
Porter Ave	1	**M**(1),**H**(1)
Mouth Region	**14**	**M(14), H(14), B(13), C(13)**

Canine sources were also tested at the mouth region, as local input suggested this residental area just upstream from popular beaches may be impacted by canine fecal waste. All samples tested negative for canine and ruminant markers, suggesting either another mammalian source contributing to elevated FIBs, possibly regrowth and persistence of FIBs in favorable conditions, or a combination of the these two.

Subsequent qPCR analyses were used to better assess the strength of the source marker, resulting in a DNA copy number. Data were combined for both regions to obtain an overall signal strength for each marker (mammal, human, bird). Results indicate a stronger human signal at GFB-01 and associated sites at the mouth compared to marsh locations. The bird singal detected was similar between the two regions but slightly higher in the marsh assoicated sites and the strength of the mammal signal was nearly identical between the two. Because there are no established thresholds for these MST markers, data were compared to similar watersheds and results indicate greater human DNA levels overall in the OOB mouth region compared to others tested in Maine. Bird qPCR results were among the highest detected for both GFB regions compared to similar locations.

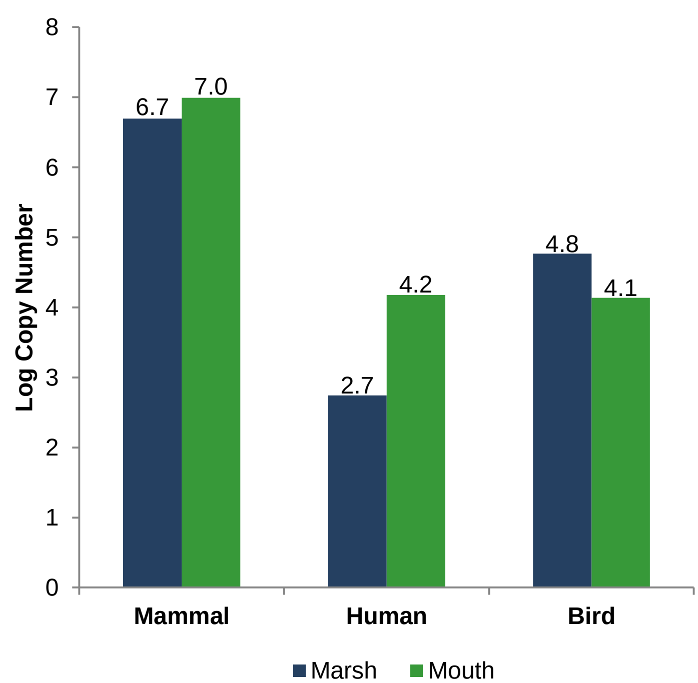
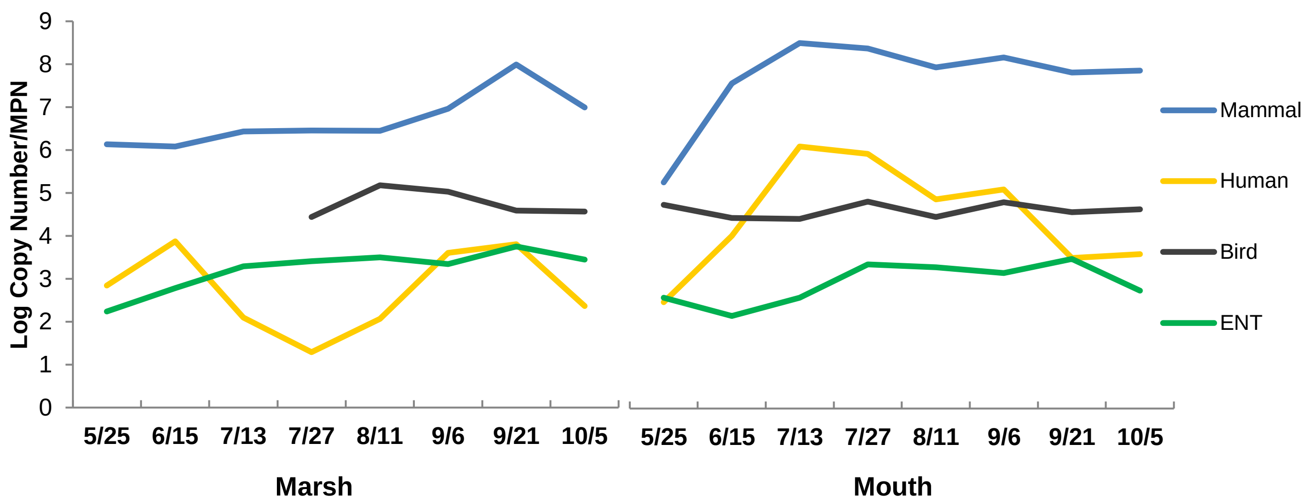


Figure 6. qPCR log copy numbers for marsh and mouth regions of the GFB.

Seasonal fluctuations

Samples were collected on eight dates (May-October), allowing for the use of qPCR results to assess persistence of fecal sources and any seasonal fluctuations in source signal strength over time. Bird signal strength remained fairly constant over the course of the season for both regions whereas more notable fluctuations were observed for human and mammal DNA markers. Fluctuations in signal strenth were distinctly different between the two priority regions.

For the marsh region, the human signal was detected 31.8% of the time, and there was no clear relationship between the human and mammal signal strength, indicating the possibility of another mammalian fecal source driving the strength increase in the mammal DNA signal (Figure 7). Given the fairly steady mammalian signal (peak in late September) and inconsistent human DNA detection, regrowth and persistance of FIBs may be contributing to elevated ENT levels recorded in this low lying marsh with little consistent stream flow.



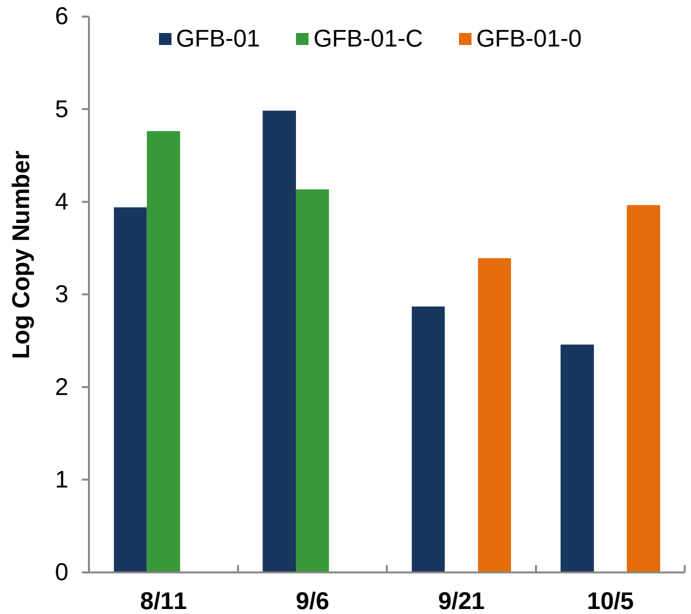
Figures 7-8. qPCR copy numbers/ENT MPN for all sources tested in GFB priority regions (marsh and mouth).

For the mouth region where the human signal was detected throughout the monitoring season, the human signal strength closely mirrored that of the mammal sginal, suggesting that the human source(s) in this region may be the primary source driving the strength of the mammal DNA detected. Seasonal peaks in signal strength were observed throughout the season, one larger peak in mid-July and one smaller peak in early September (Figure 8). These peaks coincide with historical ENT seasonal patterns with peaks during these months, suggesting these portions of the season are those when the greatest pressure is being placed on subsurface waste systems (Figure A7).

Refine hot spots

qPCR results were also used to initiate more intensive fecal tracking in the mouth region of the NSRT where greater concentrations of human sources were detected. Because samples were collected at multiple sites within each priority region, the strength of the source marker was tracked along sites progressing upland in the watershed. Pollution source refinement was considered preliminary as funding constraints limited the number of samples collected/processed for a given date.

Starting at the mouth of the NSRT (GFB-01) and progressively moving upstream, the human signal strength increased slightly (exception: 9/6/16), indicating samples upstream were likely collected closer to potential contributing source(s). While more work is needed to further hone in on suspect properties/infrastructure, this information can be used to prioritize ongoing investigative efforts that are often costly and time consuming.



Figures 9-10. qPCR copy numbers (Fig. 9) and sites monitored (Fig. 10) over the course of 4 monitoring events to refine priority areas needing further investigation in the mouth region of the NSRT.

Risk Factor Analysis

Given the pervasiveness of fecal contamination in the GFB watershed, it is important to use multiple source tracking tools to identify human-sourced contributions. This work is meant to help inform local pollution remediation efforts. The pollution source-tracking tools applied in the NSRT for 2012 -2016 were combined into a risk factor analysi where ENT results were analyzed in conjunction with other co-indicators of human sewage. Risk factors included whether or not ENT geomean results exceeded established thresholds, if sites exhibited a positive deviation from the geomean ENT and mean OB values, if there was 4 or more detectable PPCP compounds, if the canine detection results were positive, and if sites were positive for human DNA markers (Table 3).

Monitoring stations with ≥ 4 elevated/positive parameters are highlighted as priority sites with the potential for point sources of human associated fecal pollution. The risk factor analysis is meant as a guide and is not a definitive or conclusive indicator that illicit source(s) are present, and further investigations are needed to ensure the integrity of nearby wastewater disposal.

Table 3. 2012-2016 Pollution source tracking toolbox risk factor analysis. Y= Yes, N=No, (-) = not monitored. Sites with 5 samples or greater included. See Appendix B for canine and PPCP data.

MONITORING STATION	ENT ≥ 35 MPN/100ml	OB ≥100 µg/l	+ Dev. from ENT Mean	+ Dev. from OB Mean	≥4 PPCPs ng/l	+ Canine Det.	+ Human PCR
GFB-01	**Y**	N	**Y**	**N**	N	**Y**	**Y**
GFB-01-0	**Y**	**N**	**Y**	**Y**	N	N	**Y**
GFB-01-1	**Y**	N	**Y**	**Y**	N	N	-
GFB-04	**Y**	N	N	N	-	N	-
GFB-04-0	**Y**	N	N	N	N	N	-
GFB-04-0-1	**Y**	N	**N**	N	**Y**	**Y**	-
GFB-04-1	**Y**	N	**Y**	**Y**	-	N	-
GFB-04-2	**Y**	N	N	**Y**	N	N	-
GFB-04-3	**Y**	N	N	N	N	N	-
GFB-05	**Y**	**Y**	**Y**	**Y**	-	N	-
GFB-05-0	**Y**	**Y**	**Y**	**Y**	**Y**	N	
GFB-05-1	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	
GFB-05-2	**Y**	N	N	**Y**	N	N	-
Marsh-1	**Y**	**Y**	**Y**	**Y**	-	-	**Y**
Marsh-2	**Y**	**N**	**Y**	**N**	-	-	**Y**

Impaired bacterial water quality in the NSRT is likely a combination of human, wild, and domestic animal waste. Human sources may include but are not limited to faulty sewer lines, cross-connections between sewer and stormwater infrastructure, and malfunctioning septic systems/cesspools. Segments of the sewer infrastructure in the NSRT are aging and comprised of sub-optimal materials (clay, asbestos) (Figure C1). Additionally, stormwater drains directly to the NSRT sub-watershed at no fewer than 20 locations and polluted runoff transports waste from various diffuse sources throughout the watershed.

Local Actions to Improve Water Quality

Saco and OOB continue to work creatively to use limited resources to address water quality impairments in the GFB. In 2016, Saco and OOB continued their collaborative work to protect and restore water quality in the GFB by securing additional ME DEP 319 grant funding to begin work on a Phase I Implementation grant focused on action items detailed in their Watershed Based Management Plan finalized in May 2016. As part of this initiative, both communities have worked with diverse partners to collect data, identify sites for installation of best management practices (BMPs), and conduct education/outreach initiatives to engage and inform the public regarding restoration efforts for the GFB. Additionally, Saco and OOB have continued routine maintenance (catch basin and sewer line cleaning, street sweeping, etc.), completed illicicit discharge detection and elimination studies, performed line and catch basin replacements, and conducted other efforts including smoke, dye, and CCTV surveys to ensure the integrity of storm and sanitary infrastructure. As a result, faulty sewer lines, cross connections between sewer/stormwater infrastructure, and malfunctioning subsurface wastewater disposal (septic/cesspool) systems have been identified and eliminated throughout the watershed.

In addition to 319 funds, Saco received a grant from ME DEP to perform culvert upgrades and the City amended their Zoning Ordinance for stormwater management, increasing requirements for water quality treatment for new and redevelopment projects. The MHB program continued working with OOB Public

Works to digitally document previous investigations and identify priority areas within the sanitary system for CCTV surveys. The town purchased a GIS program to better track and access future inspection information including catch basin cleanings, sewer investigations, street sweeping, etc. Both communities continued to post supplemental signage at the mouth of the GFB in 2016, alerting the public of the potential risk of water contact.

In 2017, both communities will continue efforts to implement objectives for the 319 Implementation grant, continue enhanced monitoring and pollution source tracking work, and investigate the integrity of and make improvements to sewer/stormwater infrastructure. OOB Public Works will continue to prioritize CCTV and other maintenance efforts by collaborating with MHB staff to document investigations/cleanings, incorporating their new GIS program to streamline future work and will follow up on suspect properties identified through smoke testing efforts in 2015. MHB staff will also partner with the OOB Conservation Commission and UNH researchers to conduct follow-up MST work in priority areas where human sources were identified in 2016. The City of Saco will partner with the MHB program, ME DEP, and UNH to initiate MST efforts in an impaired tributary upstream (Bear Brook). As part of 319 grant initiatives, the communities will partner to create a Restoration Committee composed of members of each municipality, Conservation Commissions, state agencies, local schools, and non-profits to guide the implementation of current and future restoration efforts. Additionally, an Outreach Committee will be formed to ensure outreach initiatives are effective and targeting appropriate audiences.

Recommendations and Next Steps

Target Human Sources

It is recommended that the towns continue investigations of suspect areas to rule out sources of human sewage, as research indicates human sources present the greatest health risk due to the host-specificity of associated pathogens.[6] Of particular concern are potential wastewater sources in the vicinity of documented contamination hotspots with elevated bacteria and co-indicators of human sewage including the presence of human DNA sourced from fecal matter.

- Follow-up on identified parcels from smoke tests (2015) indicating home to sewer connection issues (OOB PW & LPI jurisdiction) (Figure C2).
- Continue to maintain and update septic inventory/pump out records (Figure C1).
- Provide education/outreach material to the public on septic best practices and promote the Town’s pump out tax credit.
- Continue partnering with community and state organizations to implement outreach initiatives and BMPs in priority regions.
- Continue supporting bacteria/DNA monitoring of priority sites to hone in on potential sources and to ensure existing sources have been removed/new ones haven’t emerged.

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[6] Ferguson C.M., Coote B.G., Ashbolt N.J., & Stevenson I.M. 1996. Relationships between indicators, pathogens and water quality in an estuarine system. Water Res. 30:2045–2054.
Wade T.J., Calderon R.L., Brenner K.P., Sams E., Beach M., Haugland R., Dufour A.P. 2008. High sensitivity of children to swimming-associated gastrointestinal illness: results using a rapid assay of recreational water quality. Epidemiology. 19:375–383.

- Use DNA results (2016-17) to prioritize future investigations in the following areas:
  - **Mouth/Outlet of NSRT Region (GFB-01 series)**
    - Human sources were detected in this region throughout the 2016 monitoring season with seasonal peaks in source strength.
    - The historical trend at the mouth of the GFB has been higher ENT results on an incoming tide (Figure A17, Table A8) suggesting potential source(s) in the vicinity of the mouth and/or conditions favoring persistence and possibly regrowth of ENT.
    - Although the town has tested the tide gate and areas directly upland, it is recommended to continue investigations in this region to ensure a tight system at the tide gate.
    - Human DNA strength appears to increase moving upland from the tide gate. Target investigations along West Grand from New Salt Rd. to Colby Ave.
    - Survey septic systems in the region (particularly 6 & 8 Marshview Rd).
    - Investigate infrastructure integrity near GFB-01-2 where the NSRT goes underground (in a closed box culvert parallel to Rt. 9) between sites GFB-01-0 (Randall Ave.) and GFB-01-1 (Ancona Ave) (Figure A1).
  - **Marsh Region (GFB-05 & Jordan Marsh series)**
    - Investigate where the brook runs beneath a residential area between sites GFB-05-1 (Oceana Ave.) and branches to the right at GFB-05-0 (Rt.9 near Casco Ave.) and to the left at Marsh-2.
    - Rule out human sources in this region. MST data indicates a recent fecal source. Human pulses may indicate an issue with a residence used intermittently during the summer season.
    - The area may be impacted by water table/groundwater overland flow. Sources may be further away if ideal transport conditions are present. Priority homes and associated infrastructure to test: 24 Oceana, 22 Oceana, 170 West Grand.
    - The culvert in this region is decaying. Replacement is recommended to ensure no pollution sources can infiltrate the NSRT.
    - Additional camera and dye testing is recommended to determine potential infiltration/exfiltration issues.
    - Investigate septic systems in the area (particularly along W. Tioga).

As time and resources allow, it is also recommended to continue expanding and improving sewer and stormwater infrastructure. More qPCR data is recommended to further hone in on the source(s) of human fecal DNA detected by stratifying monitoring sites in priority areas and tracking the strength of the DNA signal to isolate contamination sources. On a broad scale, it is recommended the towns incorporate water quality assessment and investigation of these sites into their MS4 Permit/Plan that requires the towns to develop and implement a stormwater management program. The MHB program will continue to meet with the town to discuss results and will provide recommendations on future remediation efforts based on continued source tracking work.

Implement Precautionary Advisories

Due to the history of impaired water quality in the brook and its impact on adjacent coastal beaches, it is recommended that Saco and OOB beach managers post precautionary rainfall advisories at Bay View, Kinney Shores, and Ocean Park beaches when local precipitation levels are greater than one inch within 24hrs. The advisory should be kept in place for at least 24hrs after the rainfall ceases to allow flushing of the system. Additionally, recreational water contact occurs in the mouth of GFB including swimming and people jumping off of the Rt. 9 Bridge. It is recommended that Saco and OOB continue to post permanent signage at the bridge and on both banks of the river mouth alerting the public to the potential hazards of swimming at this location until ENT levels are consistently within acceptable limits.

Promote Best Practices

The towns are encouraged to follow low impact development 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, restoring vegetative buffers (sections of vegetation adjacent to bodies of water used to minimize runoff effects), etc. It is suggested that the towns continue to work with partners (e.g. MHB, OOB Conservation Commission) on outreach and education campaigns such as septic system maintenance, responsible pet waste management, and storm drain stenciling (e.g. no dumping, drains to ocean).

Disclaimer

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

Appendix A: Monitoring Data

2012-2016 Monitoring Data

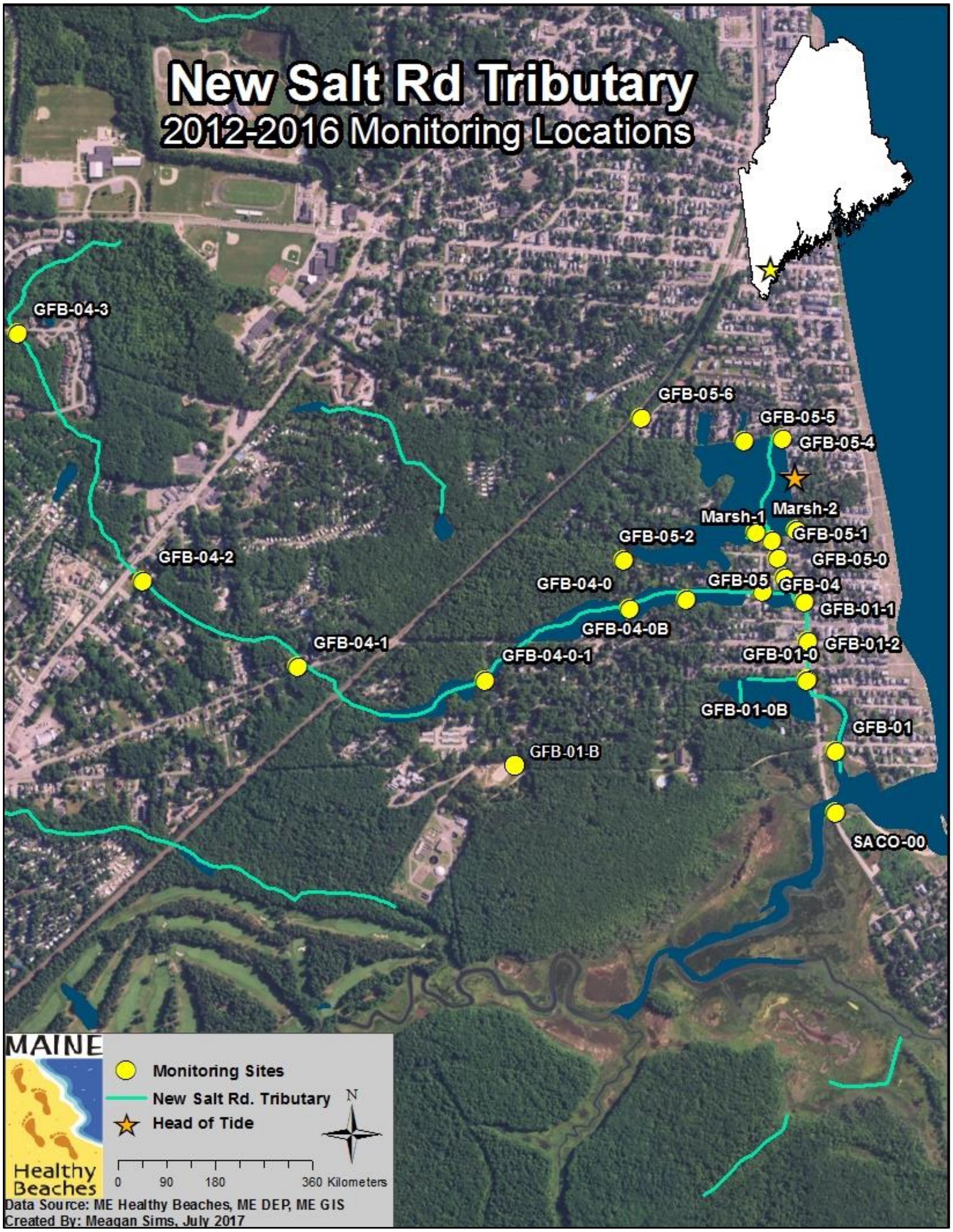

Figure A1. 2012-2016 NSRT Routine monitoring locations.

Table A1. 2012-2016 data summary for Goosefare Brook watershed monitoring including the year sampled, mean ENT concentration, geometric mean ENT concentration, mean optical brightener concentration, and the sample size at each site.

Site	Year	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-04-1	2012	339.6	88.4	4	5
GFB-04-2	2012	199.7	89.5	4	5
GFB-04-3	2012	131.9	46.3	4	5
GFB-01-0B	2012-13	274.6	79.7	4	5
GFB-01-2	2012-14	504.7	87.0	13	13
GFB-01	2012-16	323.7	78.2	56	47
GFB-01-0	2012-16	410.4	94.8	38	39
GFB-01-1	2012-15	288.8	95.3	36	37
GFB-04	2012-15	169.6	86.5	35	36
GFB-04-0	2012-15	118.4	78.6	34	35
GFB-04-0-1	2012-15	116.1	76.2	33	34
GFB-05	2012-15	564.7	101.4	36	37
GFB-05-0	2012-16	873.5	118.8	38	39
GFB-05-1	2012-16	739.2	100.9	39	40
GFB-05-2	2012-15	59.3	95.7	34	34
SACO-00	2012-15	33.2	46.4	28	19
GFB-05-6	2013	44.6	81.7	9	9
GFB-04-0B	2013-15	129.8	78.6	29	29
GFB-05-4	2013-15	46.1	64.6	30	30
GFB-05-5	2013-15	13.5	85.9	30	29
Marsh-1	2015-16	1832.6	101.5	17	17
Marsh-2	2015-16	1051.5	85.8	17	17
GFB-01-C*	2016	1806.0	95.1	2	2
Total		**204**	**88**	**570**	**563**

*GFB-01-C mean value given.

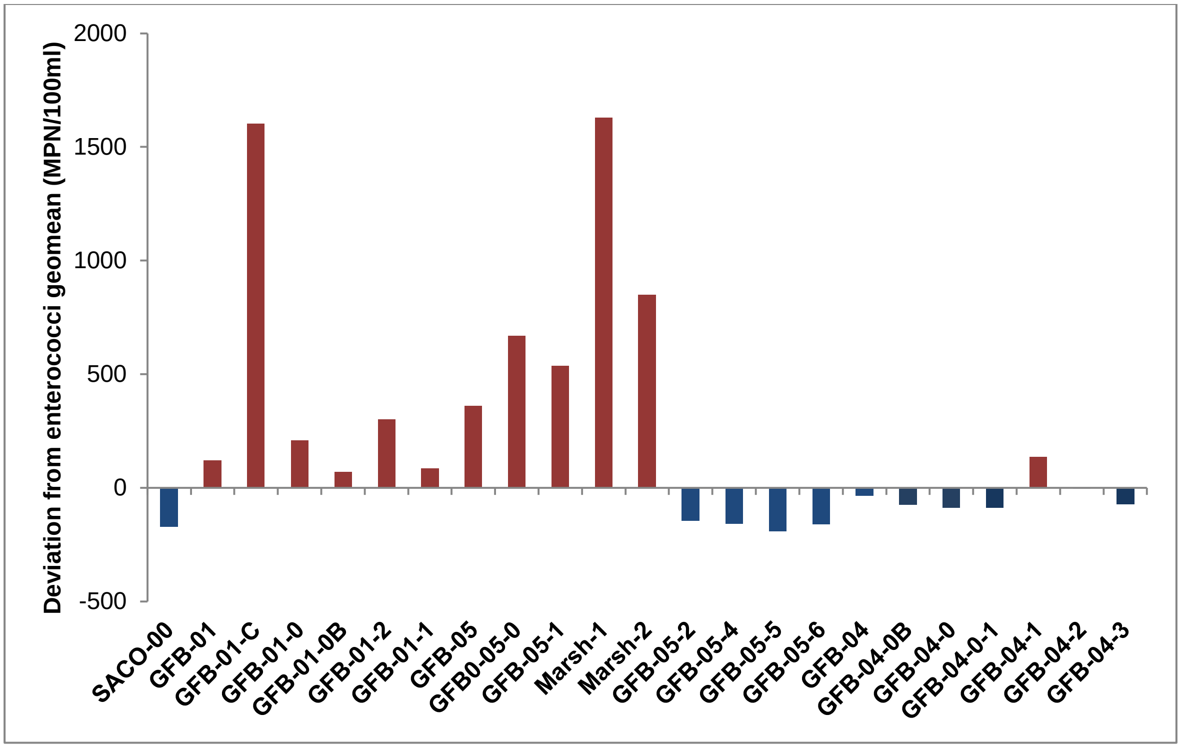

Figure A2. Deviations from the 2012-2016 combined ENT geometric mean for all NSRT sites. Bars above the X-axis indicate sites where ENT values were greater than the overall geomean and bars below represent those lower than the overall geomean (See table A1 for sample sizes).

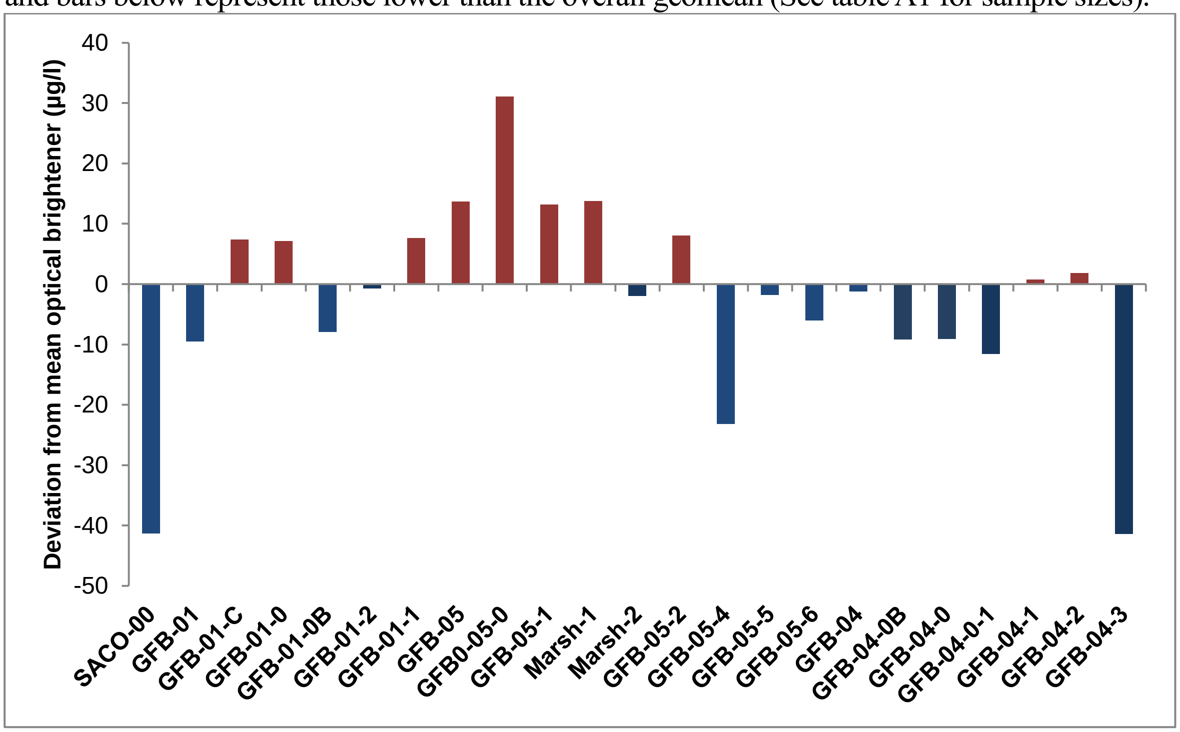

Figure A3. Deviations from the 2012-2016 combined mean OB value for all NSRT sites. Bars above the X-axis indicate sites where OB values were greater than the average value and bars below represent those that were lower than the average value (See table A1for sample sizes).

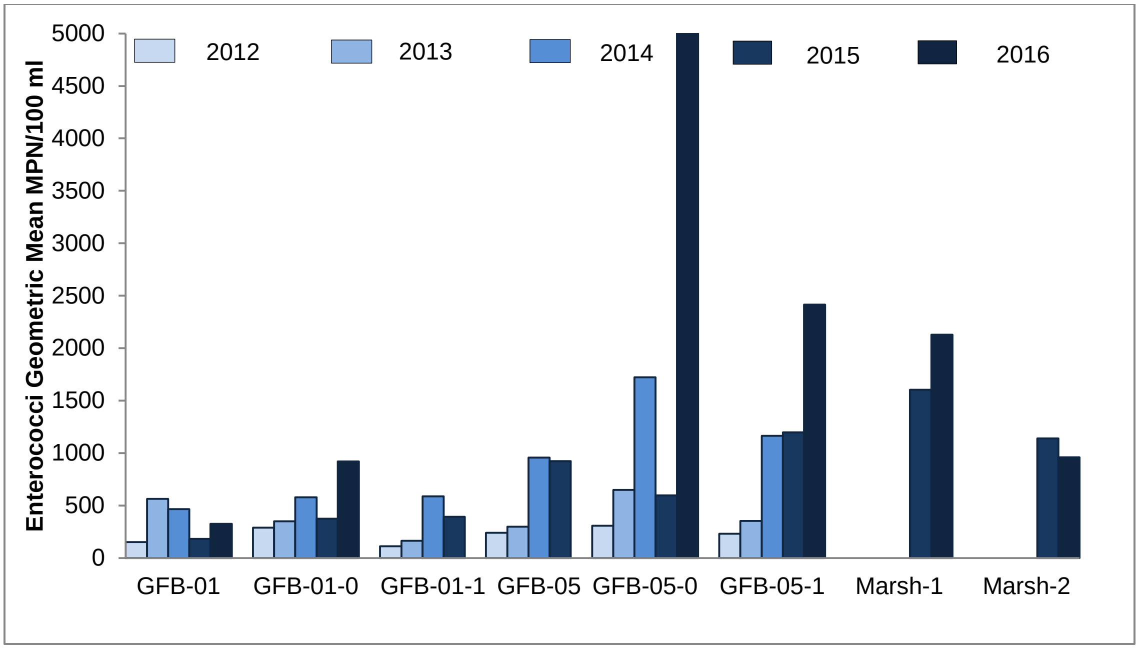

Figure A4. ENT geometric mean for priority sites within the GFB-01 and GFB-05/Marsh series from 2012-2016 (Note differences in sample size (Table A1)).

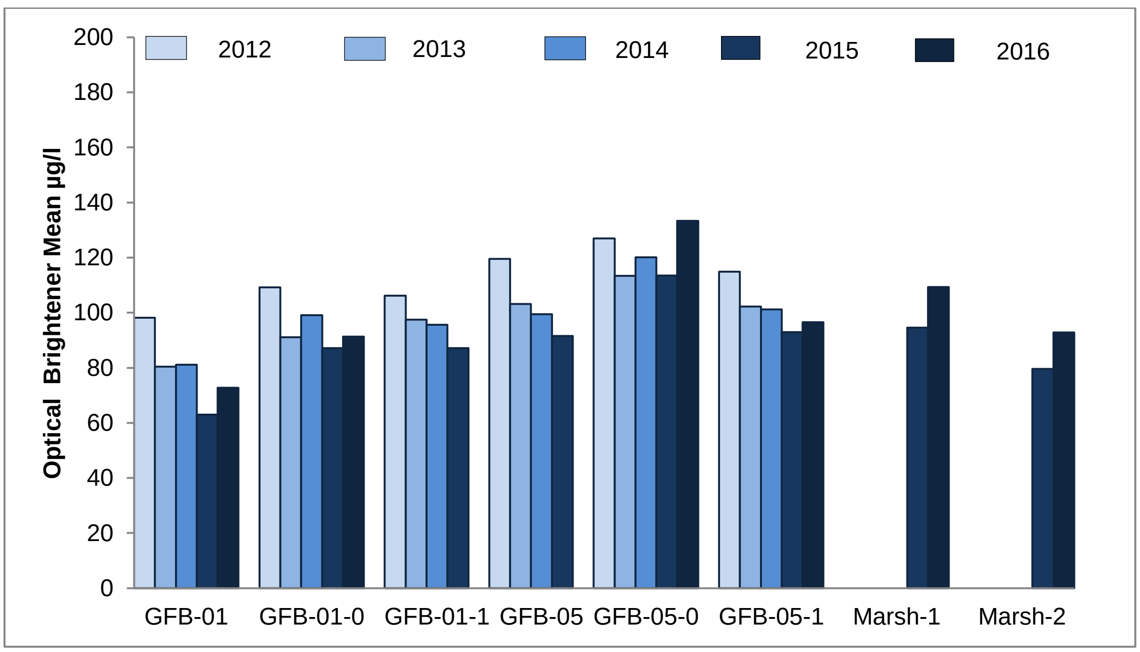

Figure A5. OB mean values for priority sites within the GFB-01 and GFB-05 series from 2012-2016 (Note differences in sample size (Table A1)).

2016 Monitoring Data

Table A2. 2016 data summary for Goosefare Brook watershed monitoring including the mean enterococci concentration, geometric mean enterococci concentration, mean optical brightener concentration and the sample size at each site for enterococci and optical brightener samples.

Site	Mean ENT	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-01	428.88	323.91	72.76	8	8
GFB-01-0	920.00	656.03	91.35	2	2
GFB-01-B*	1236	1236	94.4	1	1
GFB-01-C	1806.00	1536.57	95.10	2	2
Porter Ave*	31	31	50.6	1	1
Marsh-1	3430.38	2129.67	109.31	8	8
Marsh-2	1640.75	959.63	92.88	8	8
GFB-05-0	5150.33	5068.33	133.33	3	3
GFB-05-1	2413.67	2238.24	96.52	3	3
Total	**2039**	**1021**	**95**	**36**	**36**

*Single sample values given.

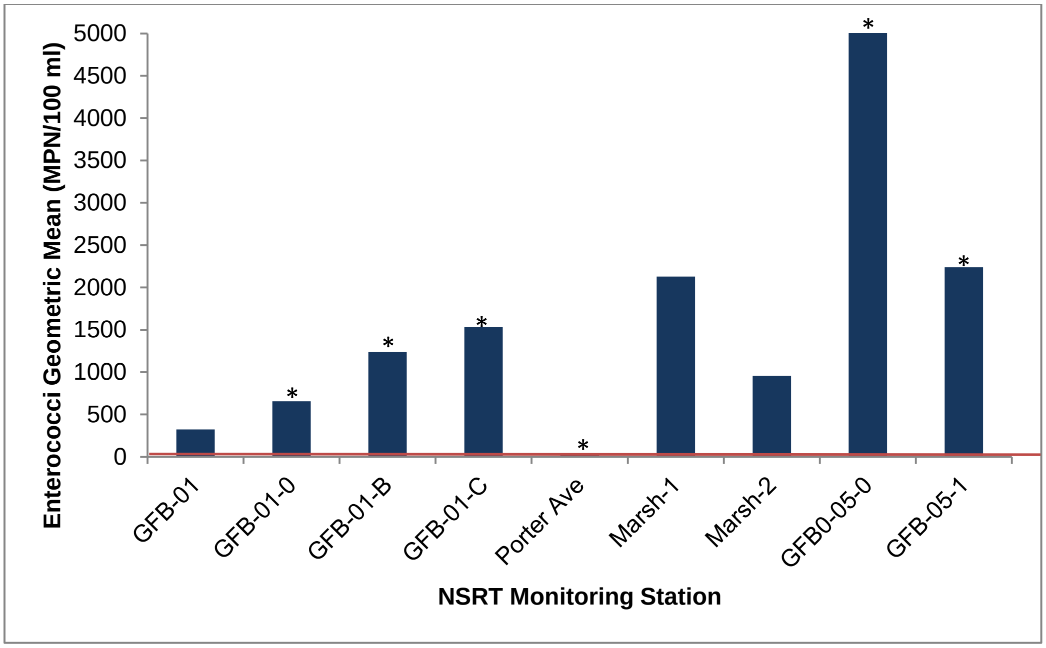

Figure A6. The 2016 enterococci geometric mean (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples.

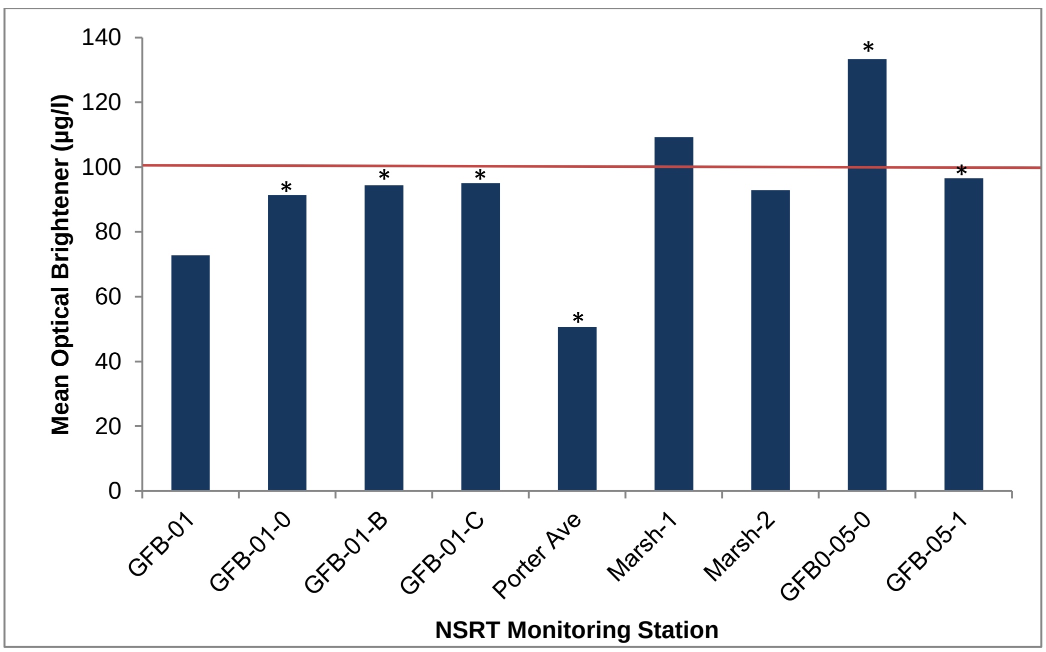

Figure A7. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2016. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

2015 Monitoring Data

Table A3. 2015 data summary for Goosefare Brook watershed monitoring including the mean enterococci concentration, geometric mean enterococci concentration, mean optical brightener concentration and the sample size at each site for enterococci and optical brightener samples.

Site	Mean ENT	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-01	264.3	182.0	63.0	11	11
GFB-01-0	460.4	373.6	87.2	11	11
GFB-01-1	434.6	391.6	87.2	11	11
GFB-04	182.0	132.1	80.6	11	11
GFB-04-0	95.6	83.3	70.5	10	10
GFB-04-0-1	55.1	43.9	68.1	10	10
GFB-04-0B	97.8	77.4	70.1	10	10
GFB-05	1071.9	923.8	91.6	11	11
GFB-05-0	865.3	597.1	113.5	11	11
GFB-05-1	1330.2	1196.5	92.9	11	11
GFB-05-2	51.4	30.9	91.0	10	10
GFB-05-4	97.6	25.9	54.6	10	10
GFB-05-5	14.8	9.0	74.6	10	10
Marsh-1	2266.4	1603.5	94.6	9	9
Marsh-2	1581.8	1140.6	79.5	9	9
SACO-00	66.5	14.5	40.5	11	11
Total	**538**	**160**	**80**	**166**	**166**

*Note sample size does not reflect duplicates (field and lab) or FYI sampling events. Sample size including FYI sites = 171 for both parameters.

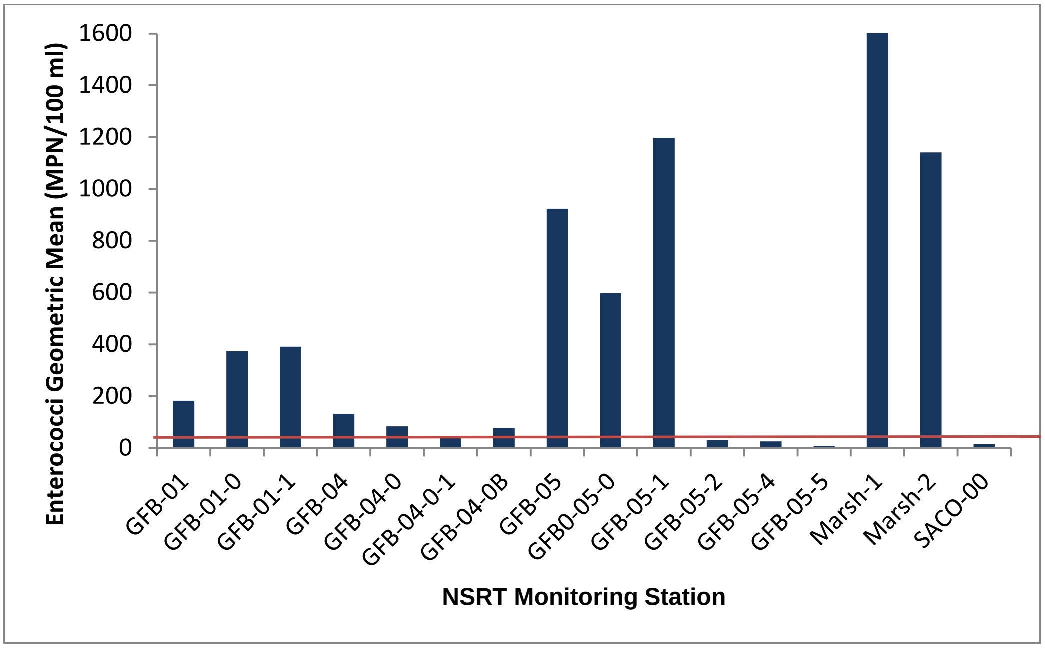

Figure A8. The 2015 enterococci geometric mean (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml.

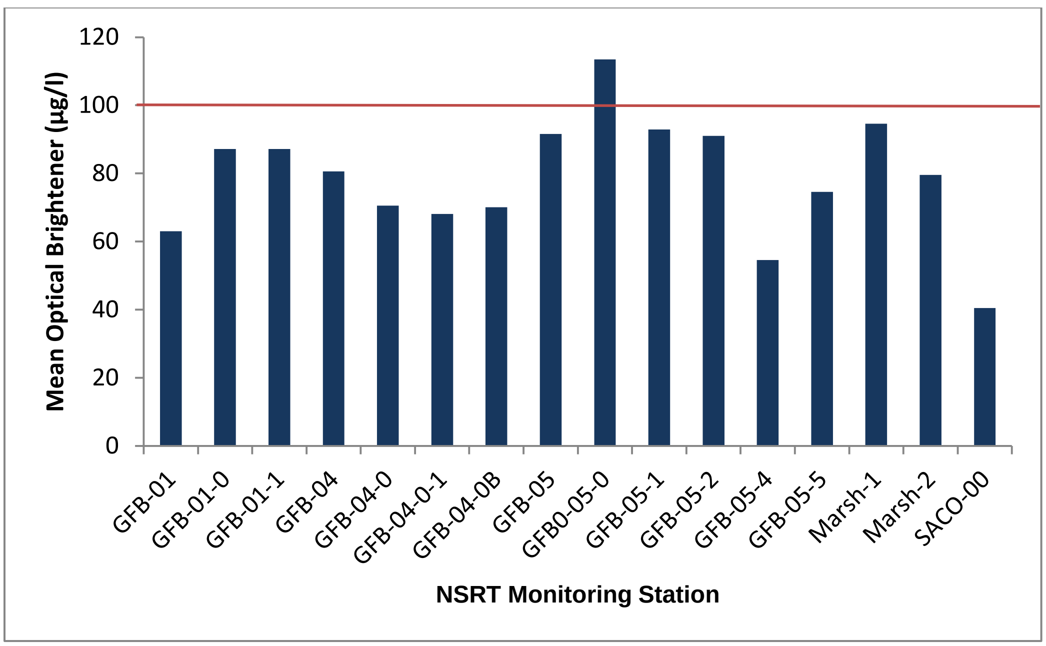

Figure A9. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2015. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.

2014 Monitoring Data

Table A4. 2014 data summary for Goosefare Brook watershed monitoring including the mean enterococci concentration, geometric mean enterococci concentration, mean optical brightener concentration and the sample size at each site for enterococci and optical brightener samples.

Site	Mean ENT	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-01	627.9	467.1	81.2	16	11
GFB-01-0	650.4	578.4	99.1	11	11
GFB-01-1	647.4	586.4	95.6	10	10
GFB-01-2	579.3	476.5	89.8	10	10
GFB-04	233.6	191.8	88.4	10	10
GFB-04-0	266.4	193.4	81.4	11	11
GFB-04-0-1	276.3	186.4	78.7	11	11
GFB-04-0B	226.3	188.6	82.5	10	10
GFB-05	1143.4	958.2	99.5	11	11
GFB-05-0	2276.4	1721.9	120.2	10	10
GFB-05-1	1500.1	1165.7	101.2	11	11
GFB-05-2	121.1	82.5	115.5	11	10
GFB-05-4	209.6	139.6	63.4	10	10
GFB-05-5	28.1	14.1	91.1	10	10
SACO-00	509.4	37.8	NA	4	NA
Total	**624**	**276**	**92**	**156**	**146**

*Note sample size does not reflect duplicates (field and lab) and includes 8/14/15 sampling event. Those results are not included in analyses.

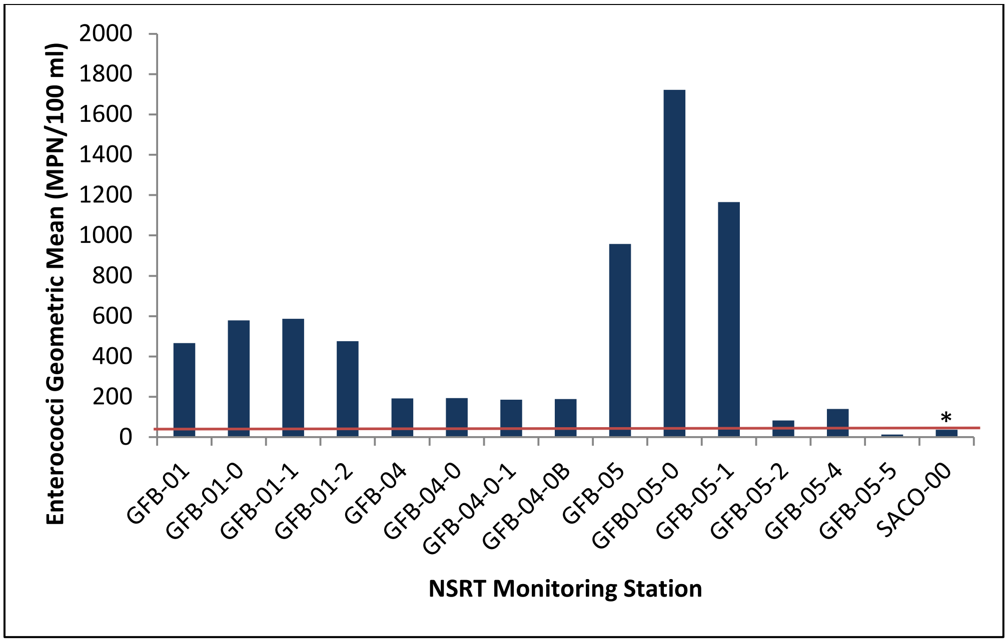

Figure A10. The 2014 enterococci geometric mean (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml.

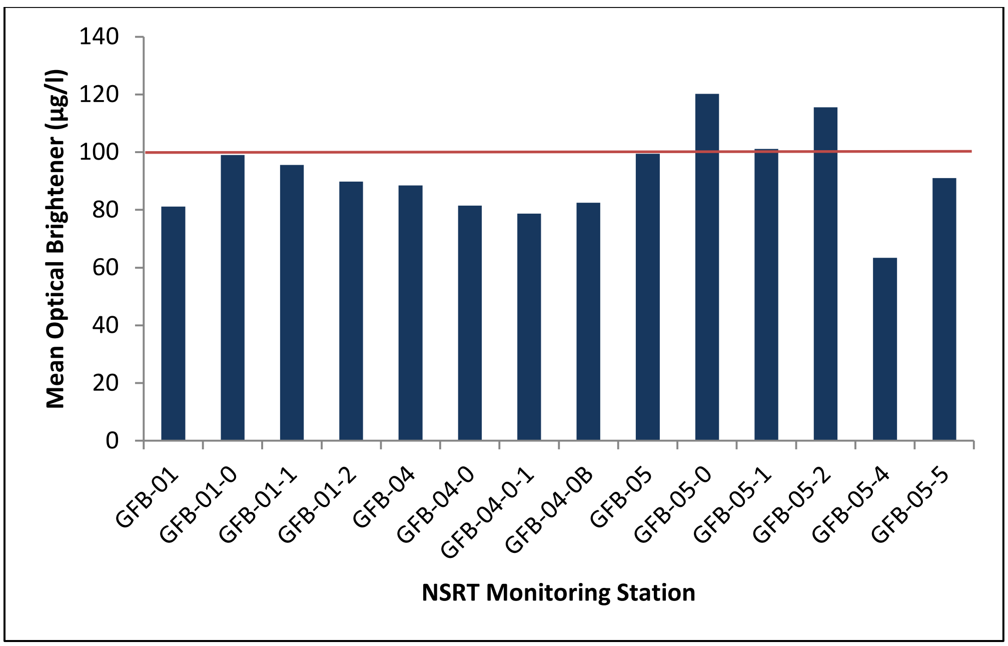

Figure A11. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2014. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.

2013 Monitoring Data

Table A5. 2013 data summary for Goosefare Brook watershed monitoring including the mean enterococci concentration, geometric mean enterococci concentration, mean optical brightener concentration and the sample size at each site for enterococci and optical brightener samples.

Site	Mean ENT	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-01	1347.3	564.2	80.4	14	10
GFB-01-0	449.0	350.7	91.1	10	10
GFB-01-0B	181.0	179.5	37.6	2	3
GFB-01-1	213.2	163.9	97.5	10	10
GFB-04	207.9	183.3	88.1	9	9
GFB-04-0	132.9	108.9	81.9	9	9
GFB-04-0-1	188.1	131.3	79.8	9	9
GFB-05	315.6	297.2	103.2	10	10
GFB-05-0	729.9	650.1	113.4	9	9
GFB-05-1	381.9	354.2	102.2	10	10
GFB-05-2	89.8	52.8	102.8	9	9
SACO-00	2039.2	91.0	-	5	-
GFB-01-2	658.3	611.4	77.6	3	3
GFB-04-0B	181.1	152.5	83.7	9	9
GFB-05-4	37.7	27.1	75.9	10	10
GFB-05-5	25.7	19.4	92.8	10	5
GFB-05-6	74.7	44.6	81.7	9	6
Total	**409**	**148**	**89**	**147**	**131**

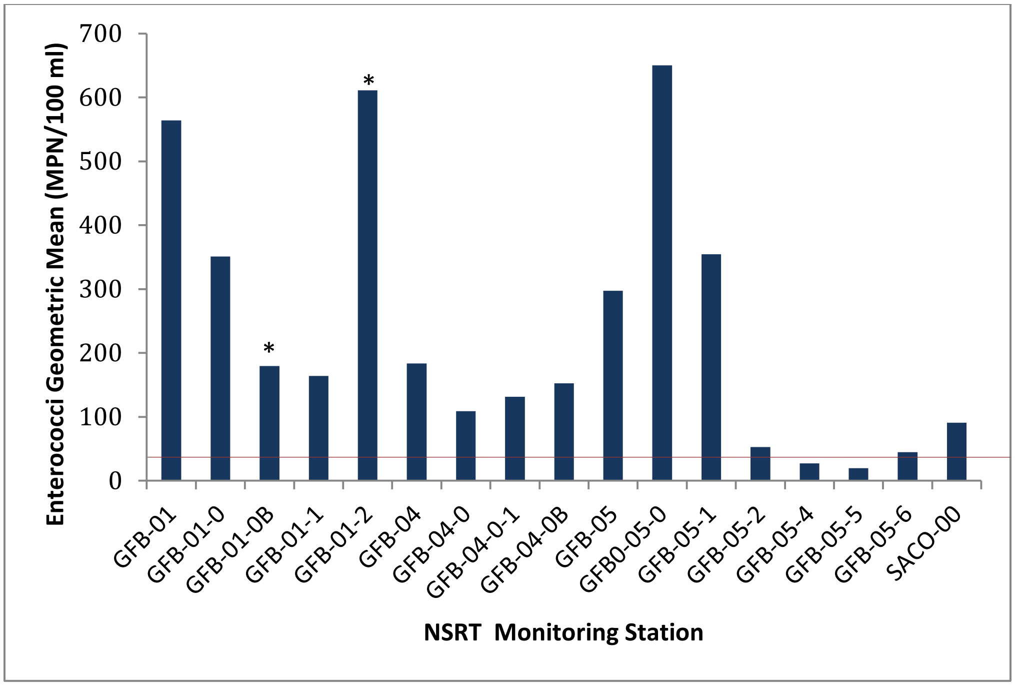

Figure A12. The 2013 geometric mean enterococci (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5samples.

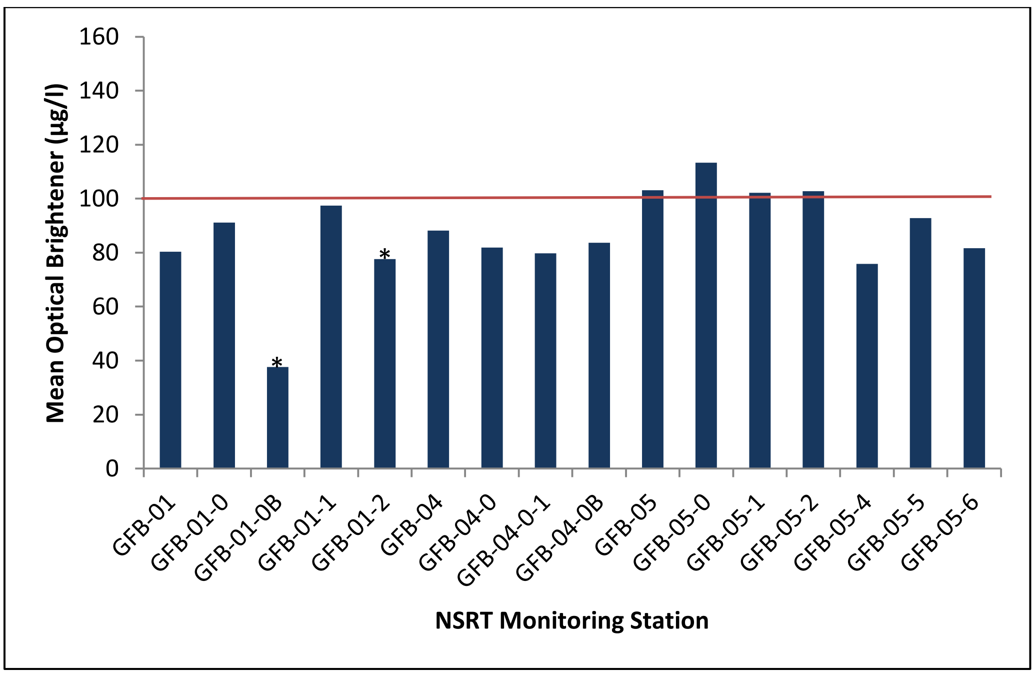

Figure A13. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2013. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

2012 Monitoring Data

Table A6. 2012 data summary for Goosefare Brook watershed monitoring including the mean enterococci concentration, geometric mean enterococci concentration, mean optical brightener concentration and the sample size at each site for enterococci and optical brightener samples.

Site	Mean ENT	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
GFB-01	268.1	151.4	98.1	8	8
GFB-01-0	334.0	288.6	109.2	5	6
GFB-01-0B	509.5	419.9	143.0	2	2
GFB-01-1	239.6	111.1	106.2	5	6
GFB-04	292.8	200.2	91.7	5	6
GFB-04-0	226.0	103.8	82.6	5	6
GFB-04-0-1	535.0	305.6	80.7	4	5
GFB-04-1	494.5	339.6	88.4	4	5
GFB-04-2	282.0	199.7	89.5	4	5
GFB-04-3	158.5	131.9	46.3	4	5
GFB-05	271.0	239.9	119.5	5	6
GFB-05-0	337.2	307.6	127.0	5	6
GFB-05-1	253.2	230.8	114.9	5	6
GFB-05-2	182.6	140.1	63.5	5	6
SACO-00	117.9	54.2	54.5	7	8
Total	**282**	**174**	**92**	**73**	**86**

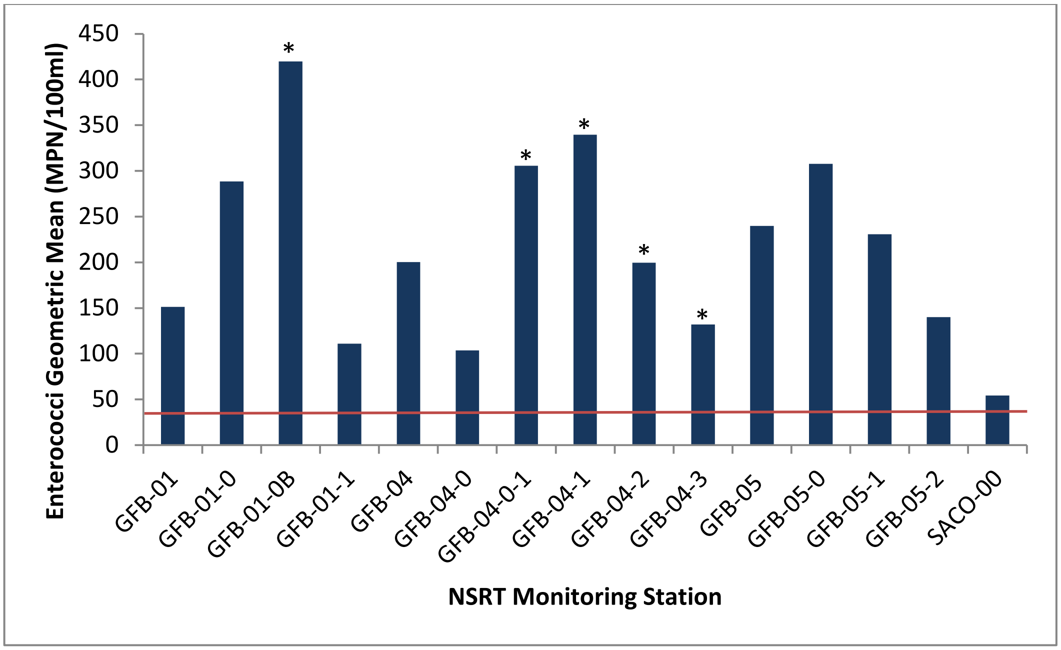

Figure A14. The 2012 geometric mean enterococci (MPN/100ml) values by monitoring station in the NSRT as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples.

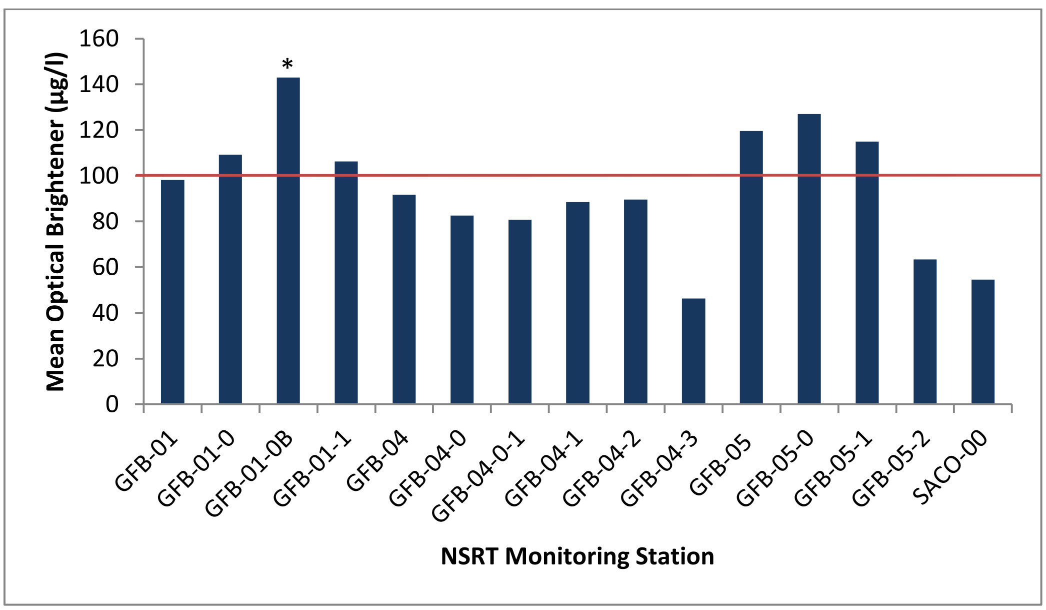

Figure A15. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2012. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

ADDITIONAL MONITORING DATA

Seasonal Shifts

Table A7. Total 2012-2016 ENT geometric mean concentration, OB mean concentration, ENT sample size, and OB sample size for each month monitored.

Month	GeoMean ENT	Mean OB	Sample Size ENT	Sample Size OB
May	45.9	74.6	28	28
June	117.7	93.6	94	85
July	300.3	99.4	112	107
August	213.9	86.9	121	133
September	241.5	83.2	119	116
October	118.7	70.8	62	62

Flood vs Ebb Tidal Conditions

Comparison of ENT geometric mean results (2012-2014) for weekly samples collected during all tidal conditions at two sites (GFB-01 and Saco-00) at the mouth of the brook revealed distinct differences between ebb and flood tidal stages (Figure A16). In all years, ENT geometric mean results were greater during flood (incoming) conditions vs. ebb (outgoing) and in many cases, the flood bacteria values were more than double those observed during ebb conditions. Also, for GFB-01 in particular, the bacteria results during both incoming and outgoing tidal conditions appear to be increasing over time (Figures A17, Table A8). Given the documented bacteria issues throughout the GFB watershed, it was expected that ebbing tide conditions would result in greater ENT results compared to flood conditions. Presumably, outgoing tides pull water from tributaries (including contaminates from upland areas) compared to incoming tides when ocean waters mix with the brook. Higher flood tide ENT levels suggest potential pollution source(s) in or near the mouth and/or conditions in this area favor persistence and possibly regrowth of ENT.

Figure A16. Monitoring stations GFB-01 and Saco-00 located at the mouth of the Goosefare Brook.

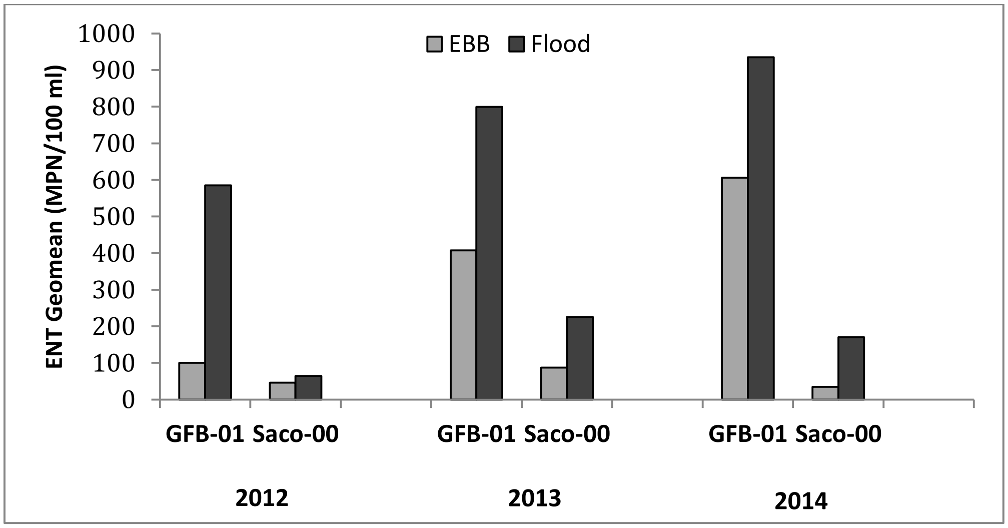

Figure A17. Season-wide ENT geomean results for GFB-01 and Saco-00 samples collected at ebb and flood tidal conditions.

Table A8. 2014 data summary for Goosefare Brook watershed ebb vs. flood monitoring including the geometric mean ENT concentration and sample size for both tidal conditions.

Site	Year	GeoMean ENT Ebb	GeoMean ENT Flood	Sample Size Ebb	Sample Size Flood
GFB-01	2012	100.4	584.8	6	8
	2013	407.2	799.7	7	8
	2014	606.0	935.3	7	8
Saco-00	2012	46.4	64.0	6	9
	2013	87.4	225.0	7	8
	2014	34.3	169.9	7	8

Wet vs. Dry

Overall geomean ENT values for two consecutive wet vs. dry weather monitoring events were compared to better understand the effects of preceding rainfall on ENT concentrations within the NSRT (Figure 8). Consecutive monitoring events were used to minimize effects of seasonal differences in ENT concentrations observed for the NSRT. For each monitoring date, ENT concentrations were combined to obtain one geomean value. In all cases, ENT geomean concentrations exceeded the EPA threshold of 35 MPN/100ml. ENT concentrations during wet weather events were more than twice those observed during dry weather events. The over two-fold increase in ENT geomean concentrations under wet weather conditions highlight the importance of continued posting of supplemental signage at the mouth of the brook as well as posting precautionary rainfall advisories at the beach when local precipitation levels are greater than one inch within 24hrs

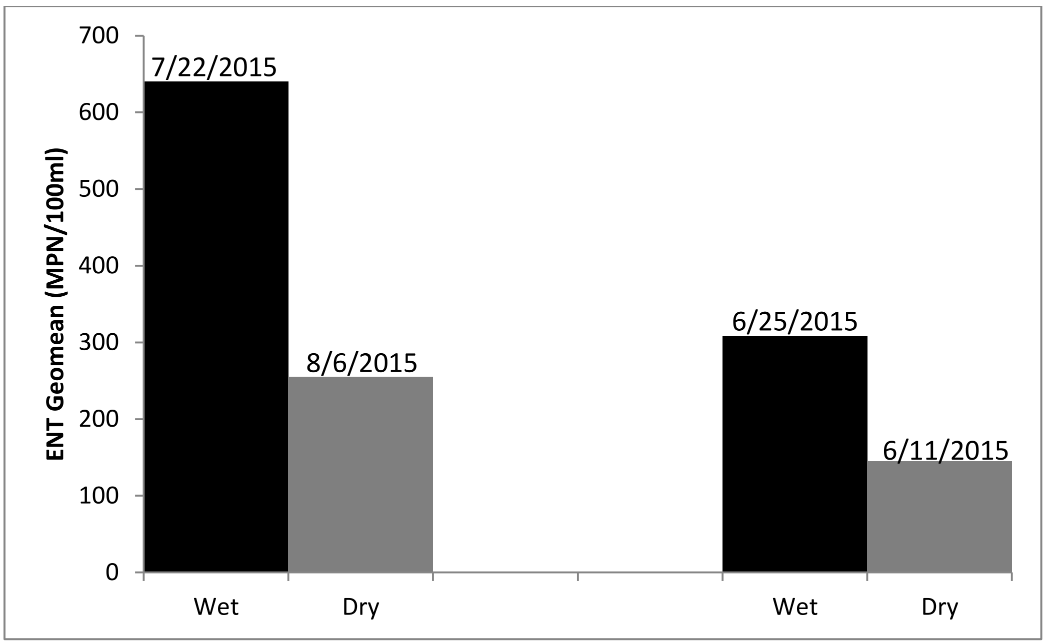

Figure 18. Wet vs. dry weather comparisons for two consecutive monitoring 2015 scenarios. Prior rain for 7/22/2015=1.10 inches in 5 days; prior rain for 6/25/2015=2.36 inches in 5 days.

Appendix B: Additional Source Tracking Efforts

Pharmaceutical and Personal Care Products (PPCP)
With the help of US EPA, the source tracking toolbox was expanded to include the analysis of 7 PPCPs in 2012. The presence of these compounds can be indicative of human sourced fecal contamination. In 2012, US-EPA analyzed PPCPs at 11 of the 15 monitoring locations within the NSRT sub-watershed for 4 of the 6 enhanced monitoring dates (Table B2). US EPA did not provide PPCP support in 2013-2016.

Table B1. PPCPs monitored at selected stations within the NSRT in 2012.

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

PPCP results indicated that all 11 sites monitored had detectable limits of 1,7-dimethylxanthine, caffeine and cotinine (Table 2). These results are likely due to human sources in the NSRT watershed as 1,7-dimethylxanthine (caffeine metabolite) and cotinine (nicotine metabolite) pass through the human body.

Table B2. Mean concentration (n=4) of pharmaceutical compounds (ng/l) for 11 monitoring stations within the New Salt Road Tributary sub-watershed. Rows highlighted in red indicate ≥ 4/7 pharmaceutical compounds present at or above the assay detection limit.

MONITORING STATION	1,7-DIMETHYLXANTHINE	ACETAMINOPHEN	ATENOLOL	CAFFEINE	CARBAMAZEPINE	COTININE	METOPROLOL
GFB-01	2.60	-	-	21.97	-	1.90	-
GFB-01-0	2.30	-	-	7.50	-	3.10	-
GFB-01-1	3.80	-	-	16.75	-	1.55	-
GFB-01-B	1.80	-	-	9.70	-	3.60	-
GFB-04-0	3.80	-	-	15.00	-	4.25	-
GFB-04-0-1	4.30	19.00	-	16.00	-	1.50	-
GFB-04-2	10.60	-	-	18.48	-	2.13	-
GFB-04-3	4.70	-	-	36.00	-	0.76	-
GFB-05-0	3.47	7.35	-	23.43	-	6.70	1.00
GFB-05-1	2.90	2.60	-	23.00	-	5.70	-
GFB-05-2	9.20	-	-	21.40	-	1.33	-

As all sites monitored for PPCPs had detectable limits for the same 3 compounds, monitoring sites (GFB-04-0-1, GFB-05-0, and GFB-05-1) with 4 or more detectable limits out of the 7 PPCP compounds tested were considered to "stand out" in this context. The presence of multiple compounds is likely a "red flag" prompting the need for further investigation into potential illicit discharges in the areas surrounding those monitoring locations. In general, as the number of PPCP compounds with detectable limits increases, so does the likelihood of human sources of pollution are impacting water quality at or near the monitoring site. Further monitoring is recommended to increase the sample size.

Canine Detection Services

A separate study funded by the Ocean Park Conservation Society and conducted by FB Environmental Associates in partnership with Environmental Canine Detection Services was conducted to “sniff” our human sources contributing to elevated bacteria concentrations. This study involved the collection of Enterococci samples while employing 2 sewage-sniffing dogs at 14 of the 15 locations throughout the NSRT watershed in 2012. The canines are trained to alert their trainers to the presence of human sources at distinct locations or in water samples collected from suspect areas. All the sites monitored during this event, excluding Saco-00, exceeded the US EPA-recommended single sample threshold of 61 MPN/100mls for freshwater sites and 104 MPN/100mls for tidally influenced sites. Human sewage was detected by one dog at GFB-04-0-1, by the other dog at GFB-05-1, and both dogs alerted for human sewage at GFB-01. The canines were not part of the GFB source tracking work in 2013-2016.

Appendix C: Local Assessments

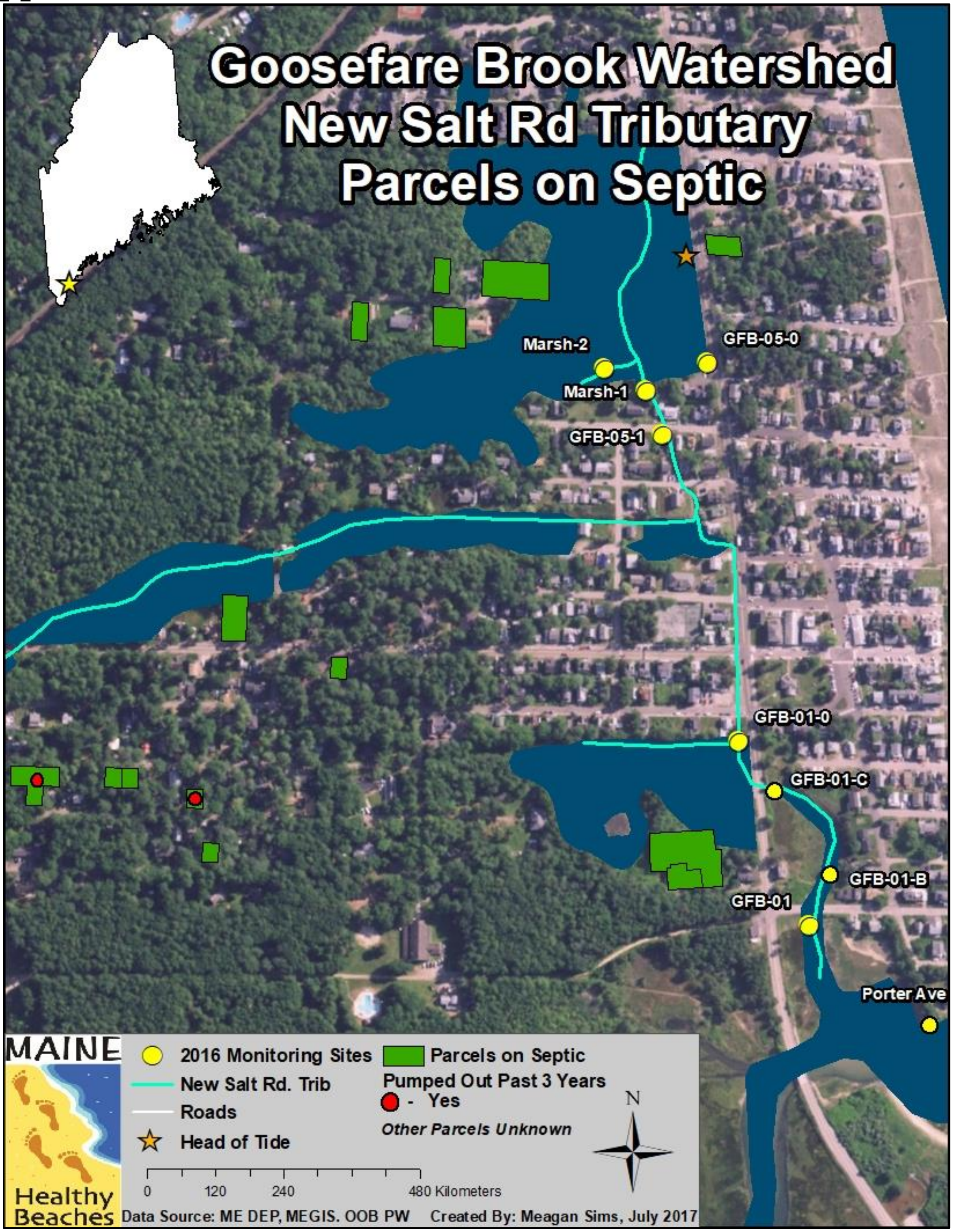

Figure C1. Known parcels on septic in close proximity to the NSRT and 2016 MHB monitoring locations. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB.

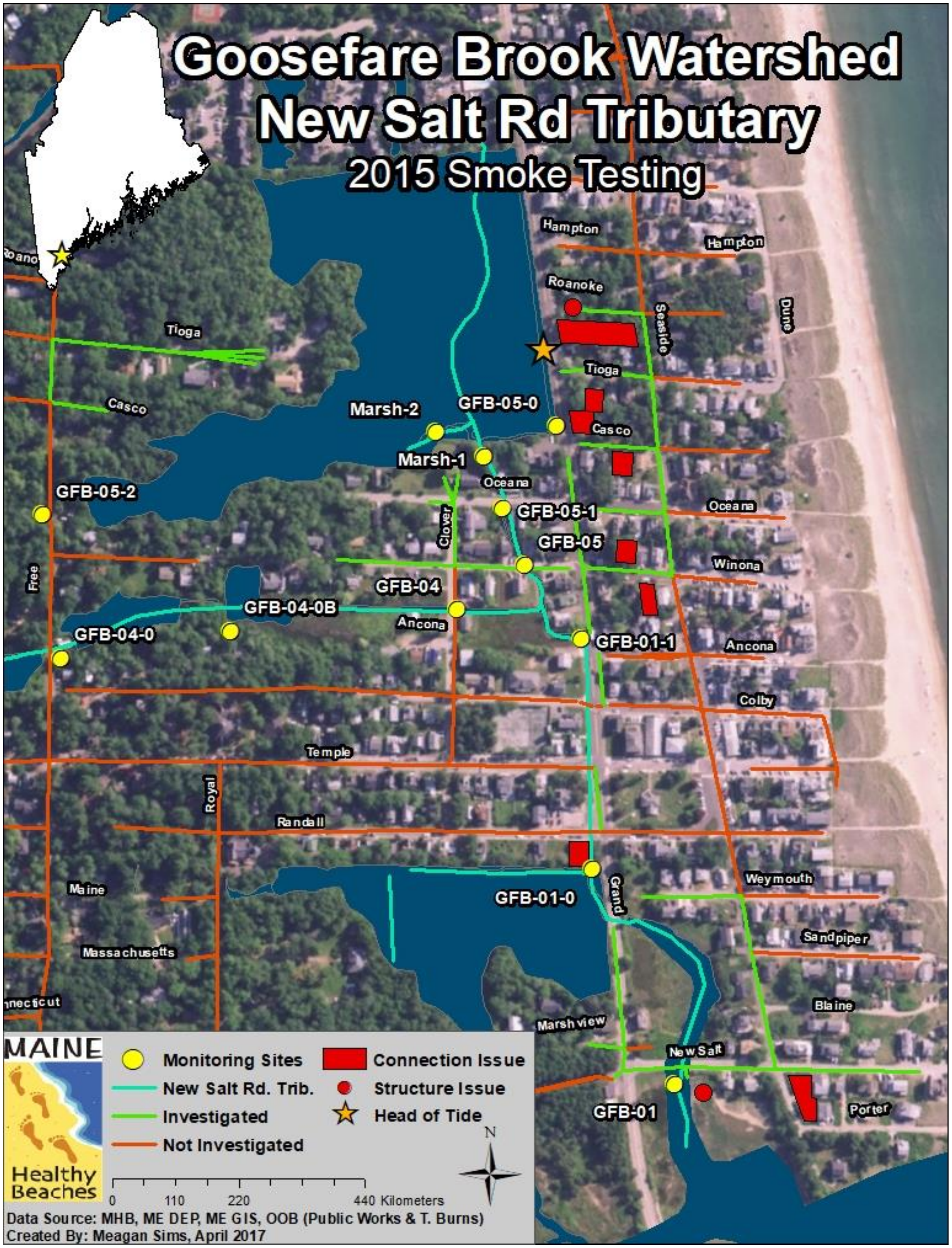

Figure C2. Results from 2015 sanitary system smoke testing and MHB monitoring locations along the New Salt Rd. Tributary. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB.

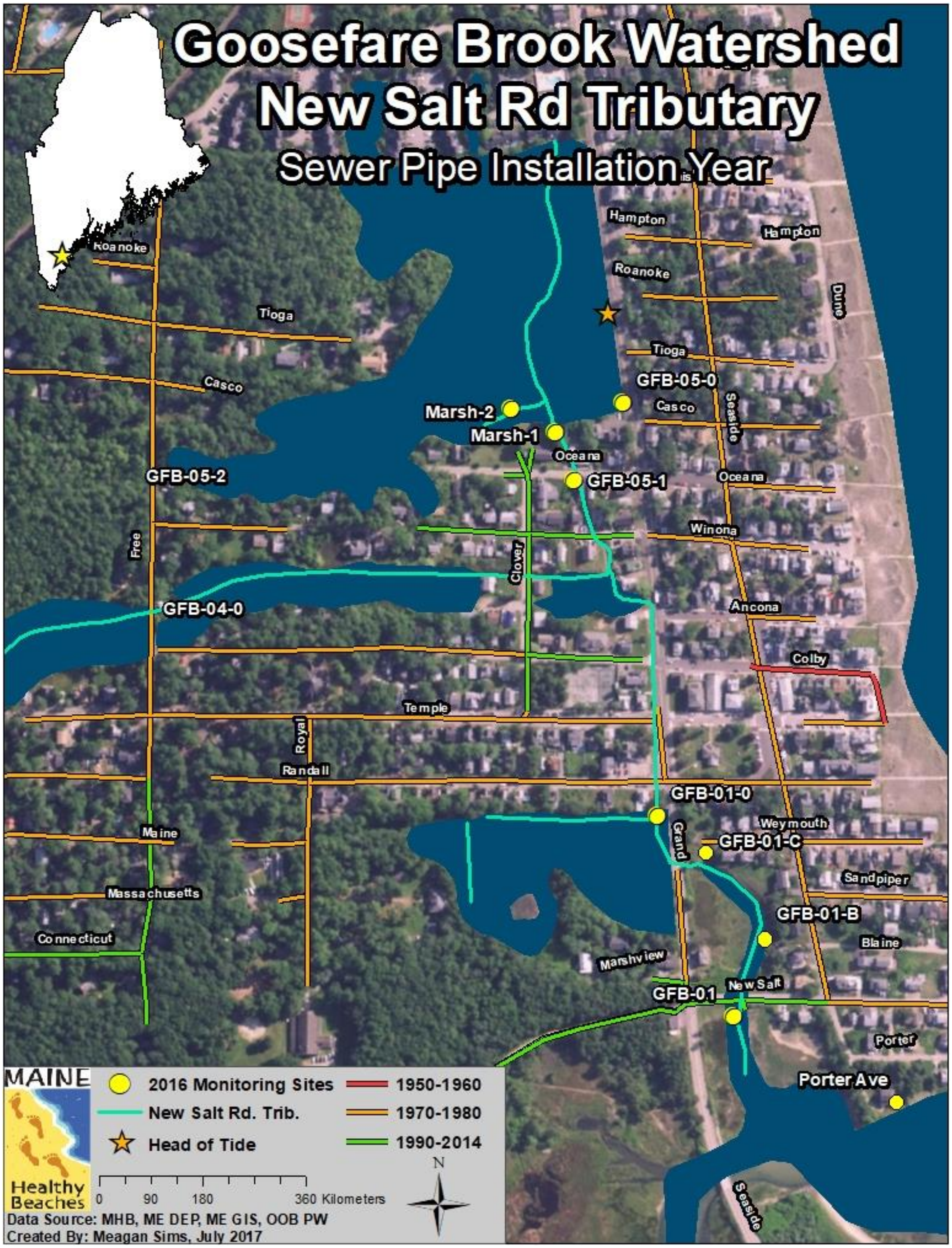

Figure C3. Old Orchard Beach wastewater infrastructure pipe installation year and 2016 MHB monitoring locations along the New Salt Rd. Tributary. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB.

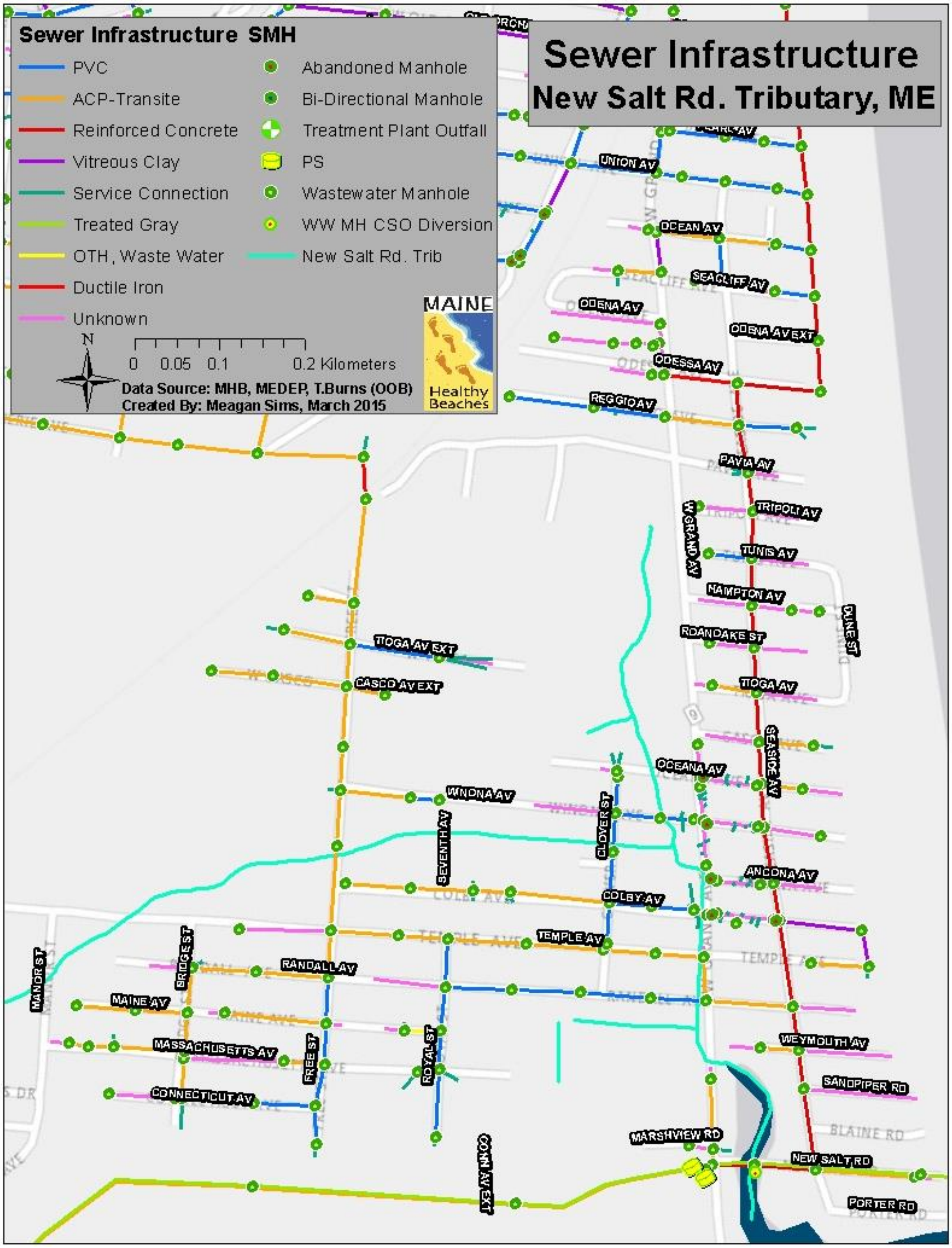

Figure C4. Old Orchard Beach wastewater infrastructure materials (pipe type) and MHB monitoring locations along the New Salt Rd. Tributary. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB (No updates received for the 2016 season).

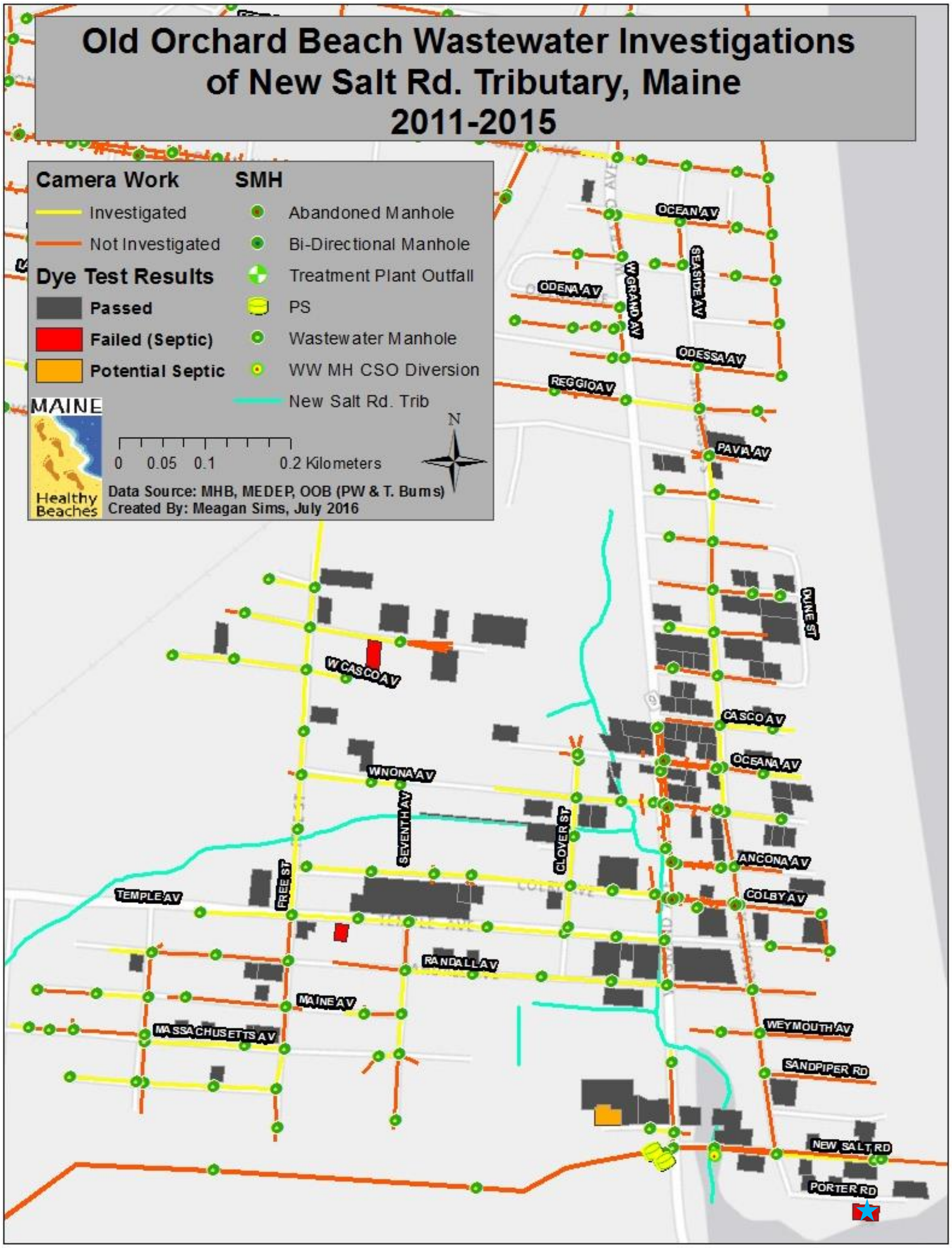

Figure C5. OOB wastewater camera and dye test investigations conducted by Public Works from 2011 to 2015 along the NSRT. This figure may not contain all work completed and it will be periodically updated as new information is received by MHB. Parcel on Porter road (★) identified as being served by a cesspool. Cesspool removed (2014) and property tied into sanitary system (No updates received for the 2016 season).