MAINE HEALTHY BEACHES PROGRAM:
SUMMARY REPORT OF ENHANCED MONITORING AND POLLUTION SOURCE TRACKING EFFORTS IN THE NEW SALT RD. TRIBUTARY, GOOSEFARE BROOK OLD ORCHARD BEACH, MAINE
2012-2015

Photo: Maine Healthy Beaches

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Executive Summary

The Goosefare Brook (GFB) forms the border between the towns of Saco to the south and Old Orchard Beach (OOB) to the north. Maine Healthy Beaches (MHB) 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 four years, MHB has focused primarily on OOB's New Salt Rd. Tributary (NSRT). In 2015, 171 paired enterococci (ENT) optical brightener (OB) samples at 19 sites were analyzed. ENT values ranged from <10 to 7,701 MPN/100mls with a combined geometric mean of 160 MPN for all sites. OB values ranged from 18 to 156 µg/l with a combined mean of 80 µg/l for all sites. Deviations from the NSRT-wide ENT geometric mean and mean OB values were also considered for each site. Eight sites located within the GFB-01 and GFB-05/Marsh series exhibited positive deviations from the NSRT-wide overall ENT geometric mean and 8 sites (primarily within the same region) demonstrated positive deviations from the OB mean. Results indicate widespread bacterial contamination throughout the tributary as well as two priority regions likely impacted by human-sourced fecal contamination. The highest ENT levels were observed for July-September, the portion of the year when OOB experiences its peak population comprised primarily of seasonal residents and vacationers. As part of ongoing efforts to address water quality in the brook, both towns have investigated and removed sources of human wastewater and have expanded and upgraded sewer and stormwater infrastructure. Additionally, the towns worked together to acquire supplemental funding and have completed a watershed management plan. However, persistent contamination issues underscore the need to continue investigations to ensure the integrity of wastewater disposal methods throughout the GFB watershed.

Acknowledgements

Written and compiled by Meagan Sims and Keri Kaczor, Maine Healthy Beaches Program; UMaine Cooperative Extension. Special thanks to all of the dedicated staff/volunteers who have helped collect data since this study began, especially the late John Bird who dedicated much of his life to environmental causes. His tireless efforts to protect and restore the GFB ecosystem have been an inspiration to many. John was instrumental in transforming the data to information to action. He will be missed greatly. Also thank you to Maine DEP, US EPA, OOB, and Saco for their support.

Background

The Goosefare Brook (GFB) demarcates the beach and town boundary between Saco and Old Orchard Beach (OOB). Just inland from the mouth, the brook splits into two branches, one draining primarily from Saco and the other from OOB (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 towns are designated as "MS4" communities that are required to implement a multifaceted approach to improving the quality of stormwater and 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. The watershed is approximately 9.83mi^2 and is shared by the City of Saco (approximately 4,000 acres) and town of OOB (approximately 1,000 acres).

Routine monitoring of 2 sites (GFB-01 and Saco-00) (Figure 2) located just above the mouth where the brook splits into two major sections, revealed consistently elevated bacteria levels and prompted the need to expand the monitoring efforts further upland in the GFB and associated tributaries. As part of an adaptive monitoring regime, site locations and monitoring frequency have varied since efforts began in 2010. Initially, MHB conducted enhanced monitoring and pollution source tracking efforts to address impaired water quality throughout the entire watershed. Results of this larger pollution assessment indicated widespread bacterial contamination throughout the region with a high likelihood of human-sourced fecal contamination, especially in Saco's Bear Brook. In response, MHB planned and facilitated meetings with representatives from Saco and OOB, ME-DEP, and US EPA to share data and develop remediation strategies in 2011. From 2012-2015, MHB efforts have concentrated primarily on the OOB branch, termed the New Salt Rd. Tributary (NSRT) for the purpose of this study. MHB has used local knowledge of potential suspect areas and collected data to target and further hone in on problem areas (Figure 2).

In an effort to pinpoint human sources, the pollution source tracking toolbox approach was utilized incorporating multiple parameters including enterococci bacteria, optical brighteners, pharmaceutical and personal care products (PPCPs), and canine detection. 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. MHB combined the results to create a risk factor matrix highlighting suspect areas warranting further investigations (Table A7). Although wildlife, pet, and waterfowl waste can contribute to impaired water quality, it is recommended to target human sources first. Due to limited resources and staff at all levels, the toolbox parameters focused on enterococci and optical brighteners only in 2013-2015.

Enterococci bacteria (ENT) indicate the presence of fecal contamination from warm-blooded animals and the possible presence of disease-causing microorganisms. However, fecal indicator bacteria like enterococci do not differentiate the source(s) of bacterial pollution. Optical brighteners (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; therefore, when optical brightener concentrations are coupled with elevated fecal bacteria levels, this can be indicative of human-sourced fecal contamination.

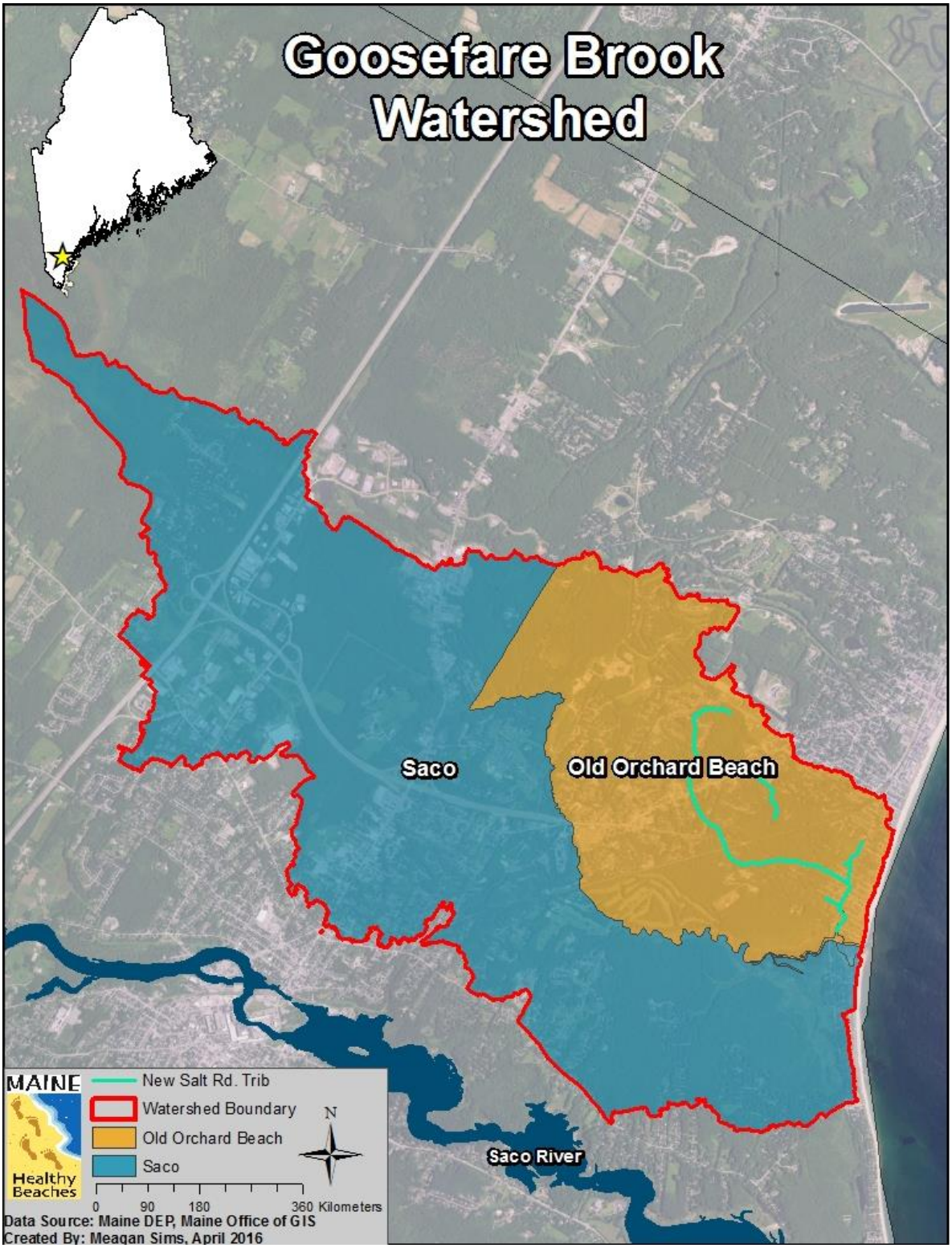

Figure 1. Goosefare Brook Watershed boundary including Saco and OOB town delineations.

Project Methods (2015)

In order to assess NSRT water quality before mixing with seawater, MHB conducted 11 monitoring events during ebb (outgoing) tides in 2015. As a part of this effort, 171 paired ENTand OB samples at 19 sites stratified throughout the NSRT watershed were analyzed. Monitoring locations targeted suspect areas identified through previous monitoring efforts and local information keeping in mind ease of accessibility and avoidance of private property. Monitoring locations included 16 routinely sampled sites and 3 exploratory locations.

For 2015, the monitoring season was expanded to include May and October to document potential baseline ENT and OB readings before and after the majority of seasonal residents arrive in the region of Ocean Park. Additionally, two new monitoring locations were established in 2015 to further investigate suspect areas in the GFB-05 series, a tributary that runs through the marsh with consistently elevated ENT concentrations. One site (Marsh-1) was located just upstream of GFB-05-1 and the other (Marsh-2) further upstream from the first marsh site (Figure 2).

Results/Discussion

Enterococci and Optical Brighteners

For the 16 routinely sampled sites in 2015, 12 out of 16 monitoring locations exceeded the ENT geometric mean[1] safety threshold[2] for marine waters. Variability in the data set was large and single sample values ranged from <10 to 7,701 MPN/100ml. Variability was also observed between monitoring stations for ENT geometric mean levels ranging from 9-1603 MPN/100ml with a combined geometric mean value for all NSRT sites of 160 MPN/100ml (Table A4, Figure A8). OB single sample concentrations ranged from 18 to 156 µg/l with a combined NSRT mean of 80 µg/l (Table A3). Unlike the ENT results, mean OB concentrations showed very little variability between monitoring stations with just 1 routine site exceeding 100 µg/l[3] and 11 others exceeding 70µg/l (Table A4, Figure A9).

Combining ENT data from 2012-2015[4], the overall NSRT geometric mean value of 183 MPN was over five times greater than the EPA threshold of 35 MPN/100ml (Table A1, Figure A1). While the NSRT-wide geometric mean value has fluctuated since 2012, primarily as result of the change in monitoring sites and frequency over time as well as more wet weather monitoring events[5] for some years compared to others, results have remained well over the EPA safety threshold for all monitoring seasons. Shifts over time for ENT concentrations were most

[1] 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.

[2] 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.

[3] The value Maine Healthy Beaches typically considers as a lower threshold for OB results with the potential for human wastewater contamination.

[4] Data for FYI monitoring sites excluded in summaries. Length of monitoring season varied among years.

[5] Precipitation levels preceding monitoring events were greatest in 2014 compared to remaining years (4 consecutive days prior precipitation: 2015 (3.73 in), 2014 (7.07 in), 2013 (5.07 in), 2012 (2.83 in)). Note the difference in number of monitoring events for 2012 (5) compared to 2015 (11), 2014, (10), and 2013 (10).

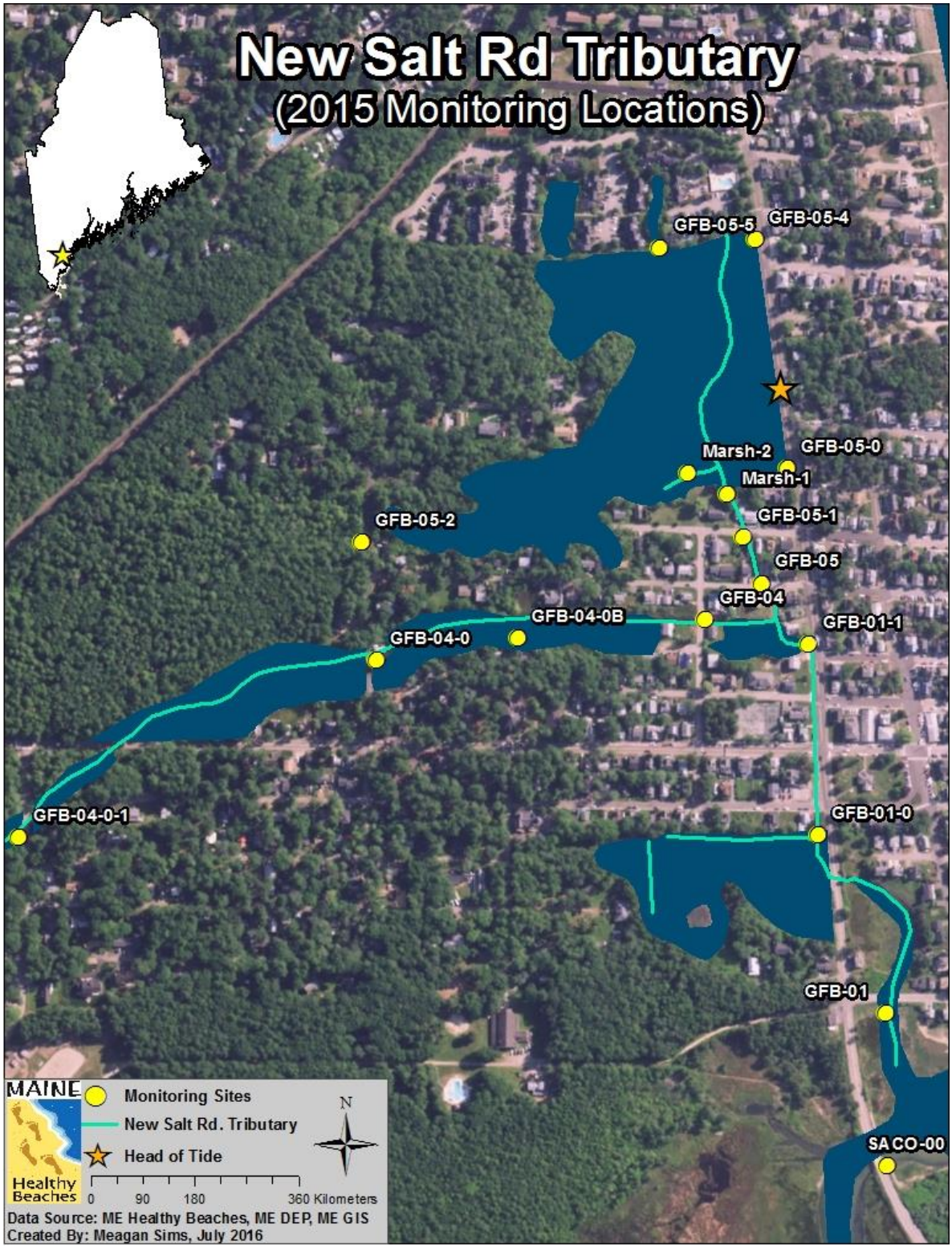

Figure 2. Map of the 15 NSRT monitoring stations for 2015. Three additional sites were monitored as FYI sites and are not included.

notable among the sites in the GFB-01 and GFB-05/Marsh series, where concentrations have generally increased over time (Figure A3). The combined NSRT mean OB was 87µg/l, and this parameter has demonstrated very little change over time (Table A1, Figures A2, A4).

For the NSRT watershed, the OB 100µg/l threshold may not be a good metric for indicating human-sourced pollution due to interference from organic matter. Humic substances (tannins and other dissolved organic compounds) can elevate OB readings. As a result, there will likely be a "background level" contribution to measured OB concentrations in systems like the NSRT that have tea colored water, an indicator of humic content.

One potentially useful approach to identifying "hot-spots" of contamination is by examining how levels for each site deviate from the combined mean of all sites. In areas like the NSRT, examining deviations from the mean may 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). Additionally, sites with positive deviations for both ENT and OB levels represent locations potentially impacted by human sources.

Deviation from Mean Values
In 2015, 8 routinely monitored sites located primarily within the GFB-01 and GFB-05/Marsh series exhibited positive deviations from the NSRT-wide ENT geometric mean value of 160 MPN/100ml. Eight routine sites also located primarily in the GFB-01 and GFB-05/Marsh series demonstrated positive deviations from the NSRT-wide OB mean of 80 µg/l (Table A4). Combining data from 2012-2015, 22 sites have been sampled over the course of the study, and 12 of those exhibited positive deviations from the NSRT-wide ENT geometric mean value of 183 MPN/100ml while 9 demonstrated positive deviations from the NSRT-wide OB value mean of 87 µg/l (Figures 3-6, Table A1).

Results from pollution source tracking efforts since 2012 have highlighted two priority regions, the GFB-01 and GFB 05/Marsh series, with the highest likelihood of human-sourced bacteria contributions. Combining 2012-2015 data, 8 sites exhibited positive deviations for both parameters, suggesting the potential for human-sourced fecal contamination for these areas. These priority sites include GFB-01-0, GFB-01-1, GFB-05, GFB-05-0, GFB-05-1, Marsh-1, Marsh-2, GFB-04-1 and GFB-04-2 (Figures 7, A3-A4).Sites GFB-04-1 and GFB-04-2 were monitored as part of 2012 efforts only as MHB has focused primarily in the GFB-01 and GFB-05 series because they are in closer proximity to the beach and have been consistently problematic. Although not included in the priority list (based on ENT and OB deviations), GFB-01 located at the mouth of the NSRT should be considered a priority site due to the history of consistently elevated fecal bacteria concentrations.

In general, all identified suspect sites demonstrated elevated ENT levels over the past 4 years, and for many sites, those levels have increased over time, particularly from 2012-2014 (Figure A3). Additionally, OB concentrations at these locations have generally been greater compared to less problematic sites within the NSRT drainage area (Figure A4). These results suggest illicit source(s) are present, and further investigations are needed to ensure the integrity of nearby subsurface wastewater disposal (septics, cesspools) as well as sewer and stormwater infrastructure (faulty lines, cross-connections).

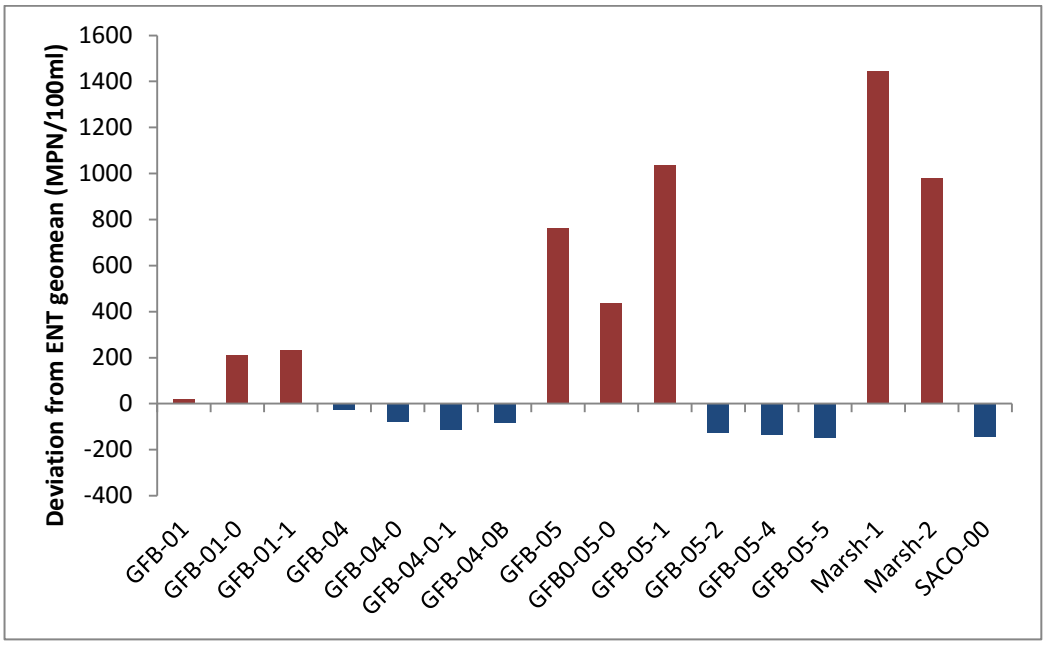

Figure 3. Deviations from the 2012-2015 combined ENT geometric mean for all NSRT sites. Bars above the X-axis indicate sites where ENT values were greater than the average geomean and bars below X-axis represent those lower than the average geomean (See table A1 for sample sizes). Sites not monitored since 2012 or 2013 not included.

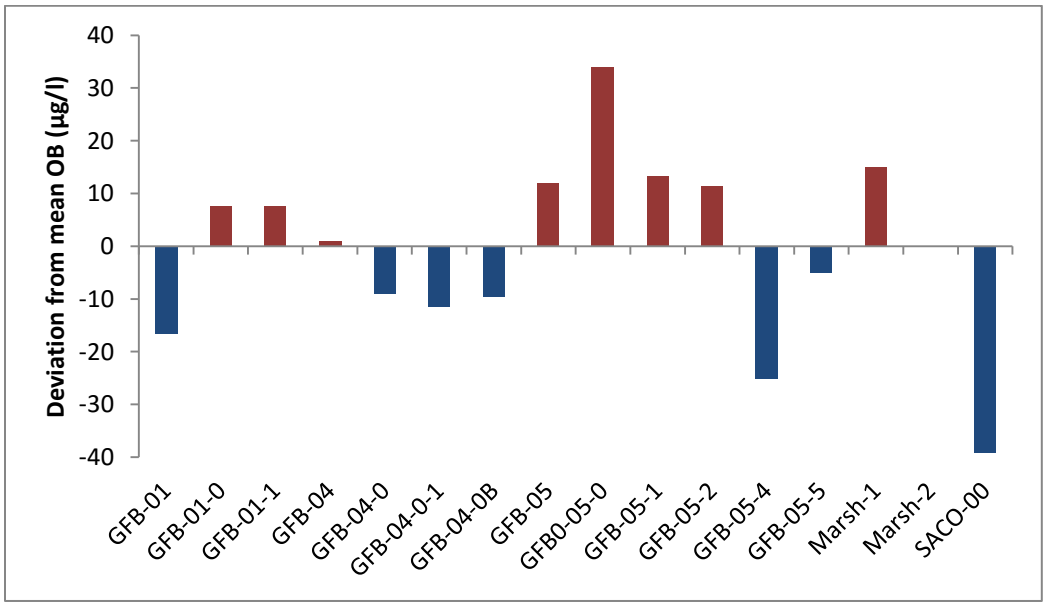

Figure 4. Deviations from the 2012-2015 combined mean OB value for all NSRT sites. Bars above the X-axis indicate sites where OB values were greater than the average value and bars below X-axis represent those that were lower than the average value (See table A1for sample sizes). Sites not monitored since 2012 or 2013 not included.

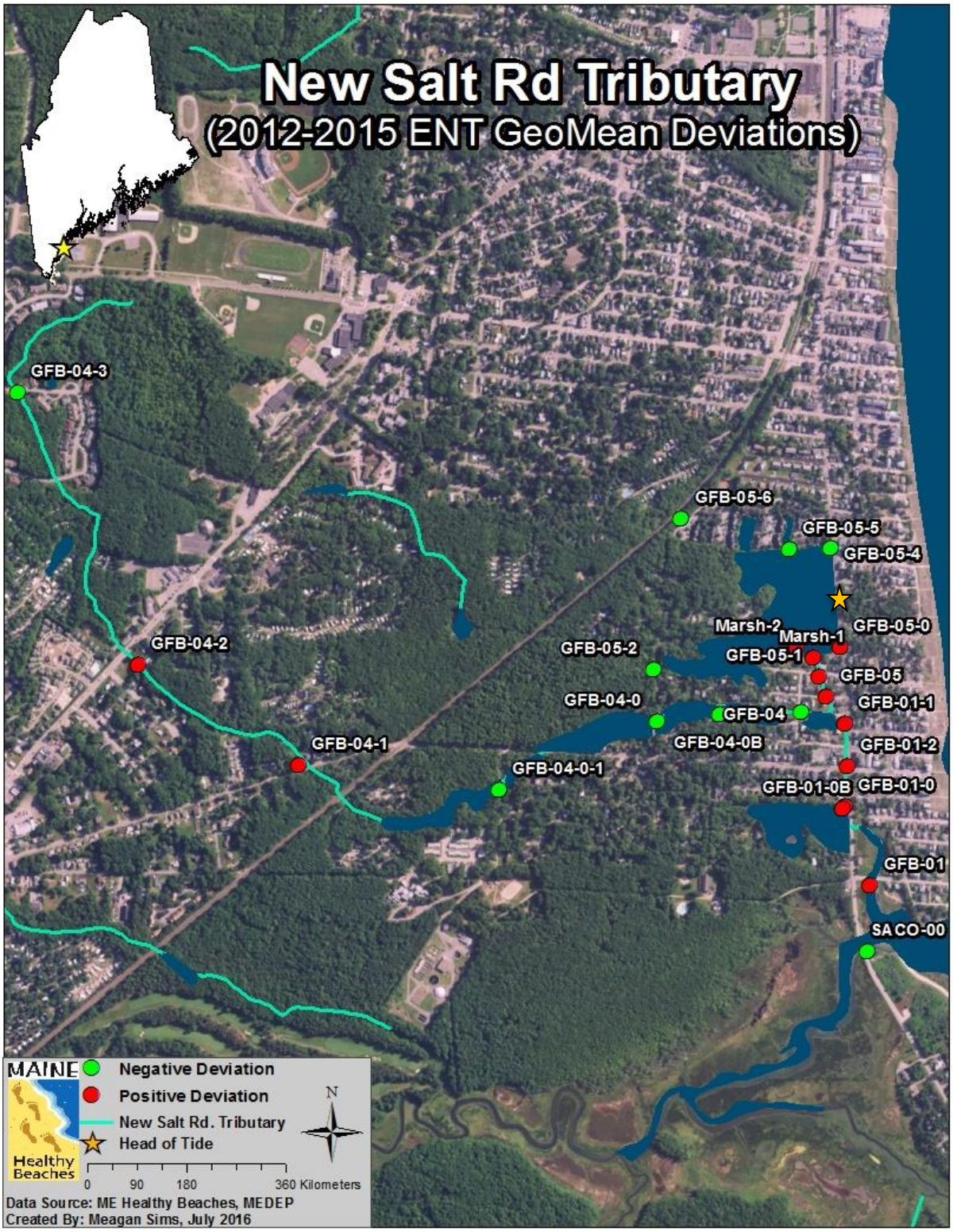

Figure 5. 2012-2015 deviation from watershed-wide ENT geomean concentration. Negative deviations represent sites with geomean ENT results less than the watershed geomean and positive deviations represent sites with geomean ENT values greater than the watershed geomean.

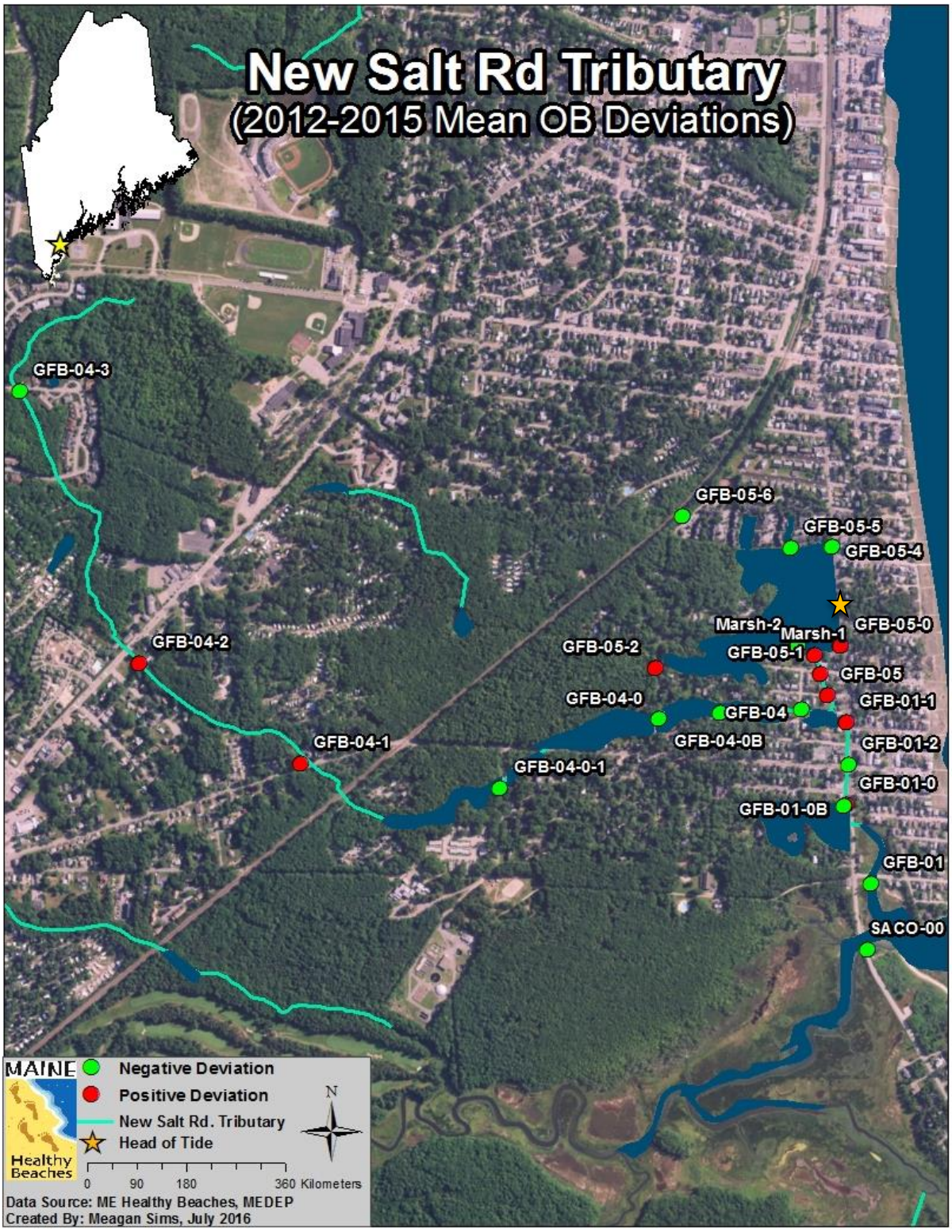

Figure 6. 2012-2015 deviation from watershed-wide mean OB concentration. Negative deviations represent sites with mean OB values less than the watershed average and positive deviations represent sites with OB values greater than the watershed average.

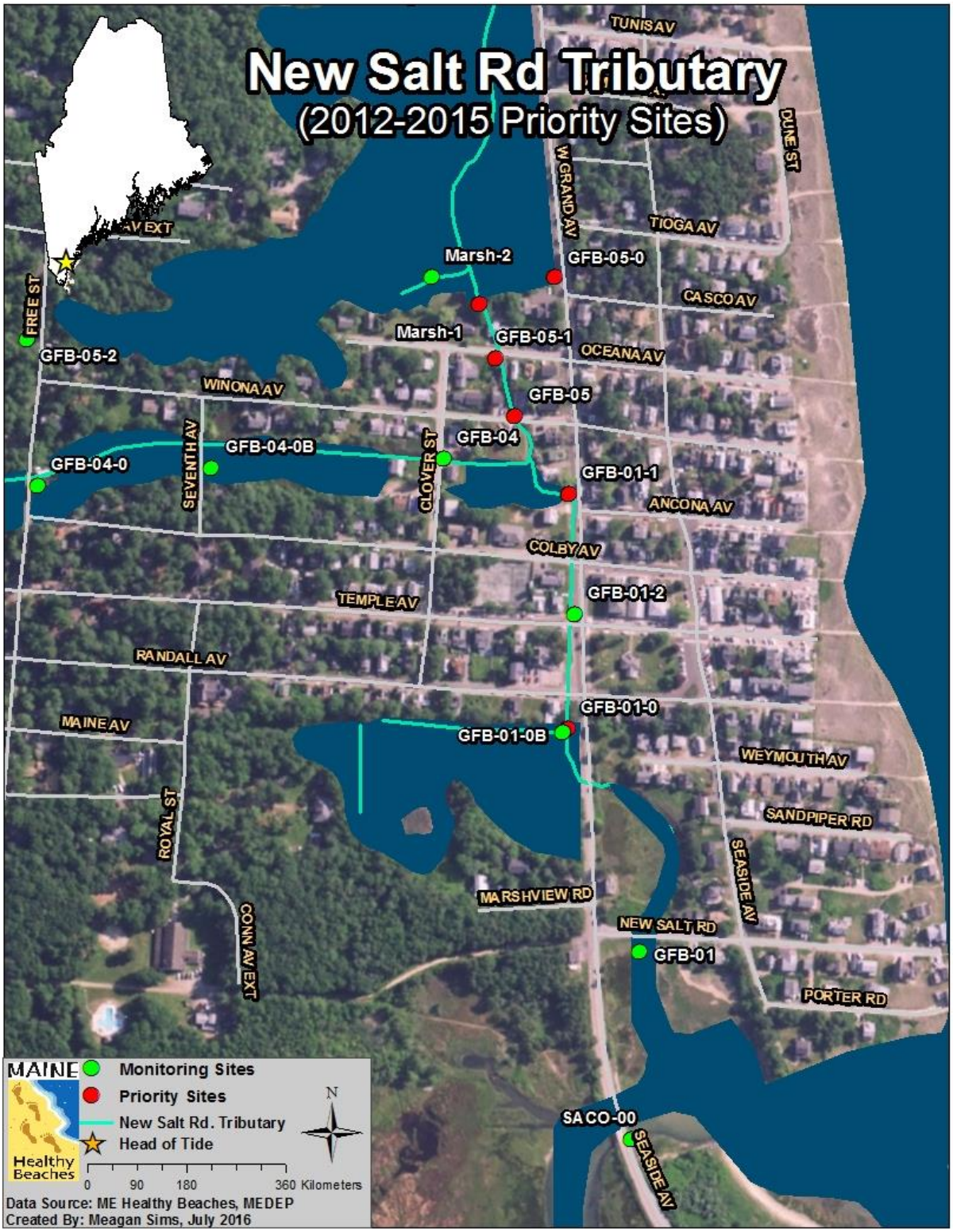

Figure 7. Priority areas within the NSRT represented by sites positively deviating from the combined 2012-2015 ENT geomean and OB mean values. GFB-01 located at the mouth of the NSRT should also be considered a priority site due to the history of consistently elevated fecal bacteria concentrations.

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.

During wet weather events, multiple sources (human and non-human) act together and often result in very elevated fecal bacteria levels. MHB is most concerned with point sources of human fecal pollution as indicated by ENT exceedances during dry weather conditions. 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

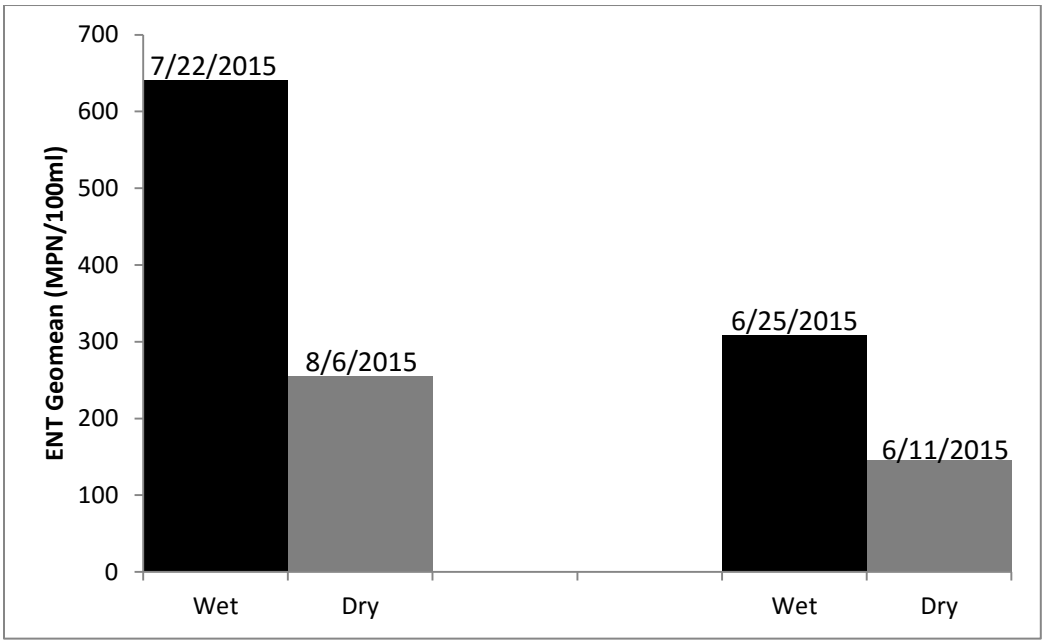

Figure 8. Wet vs. dry weather comparisons for two consecutive monitoring 2015 scenarios. Prior rain for 7/22/2015=1.10 inches in 5 days; prior rain for 6/25/2015=2.36 inches in 5 days.

Seasonal Shifts

As a popular beach community in Maine, OOB experiences a dramatic population increase from approximately 9,000 to over 50,000 seasonal residents and vacationers. During the summer months, this influx can put pressure on waste water systems and this coupled with the seasonal increase in temperatures can contribute to bacteria impairments in the highly developed region of the NSRT and Ocean Park. Seasonal shifts in bacteria concentrations were observed for the NSRT (2012-2015 combined data) (Figure 9, Table A2).

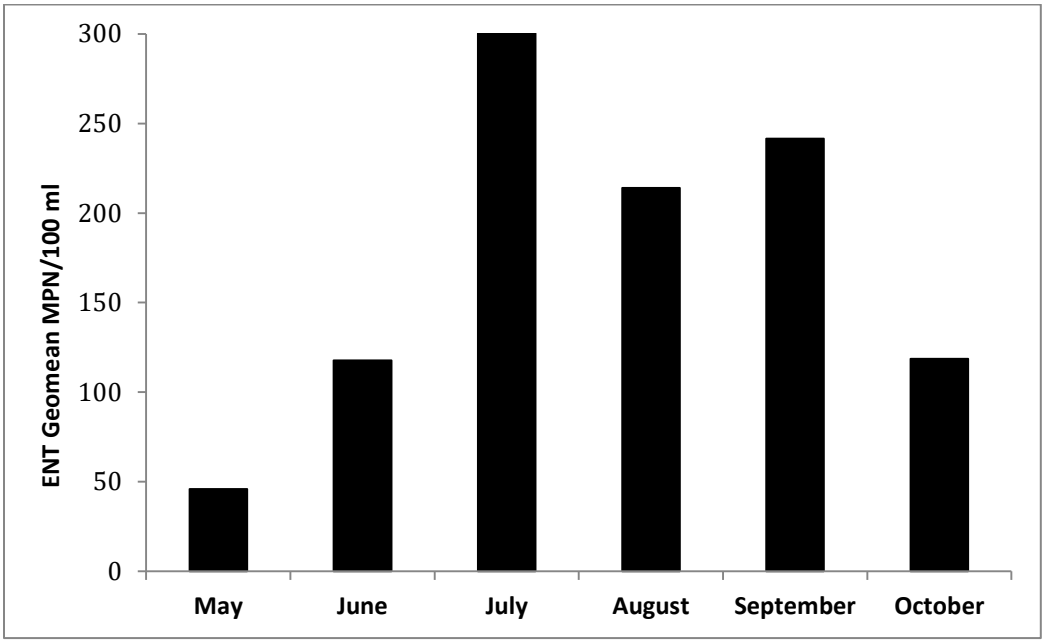

Figure 9. ENT geometric mean values for each month monitored. All data were combined (2012-2015) for each monitoring location to obtain one geometric mean value per month.

Impaired bacterial water quality in the NSRT is likely a combination of human, wild, and domestic animal waste. Potential human sources include but are not limited to leaky sewers, 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). Contributions from non-human sources are likely from pets, waterfowl, and other wildlife. 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. There are also several low-lying and marshy areas within the study area that may facilitate persistence and regrowth of enterococci bacteria in the environment, compounding the already complicated task of pollution source identification.

Local Actions to Improve Water Quality

Monitoring results and other pollution source tracking efforts have informed priority areas needing further investigation. As part of ongoing efforts to address water quality in the brook, Saco and OOB have identified and eliminated faulty sewer lines, cross connections between sewer/stormwater infrastructure, and malfunctioning subsurface wastewater disposal (septic/cesspool) systems throughout the watershed. For example, both communities have investigated storm and sewer infrastructure using video surveys as well as smoke and dye testing to identify illicit cross connections between networks and/or damaged sewer lines.

In 2015, Saco and OOB continued collaborating on their Watershed Management Plan (WMP). As part of the ongoing efforts to improve the health of the entire drainage area, a group of diverse partners worked together to collect a suite of parameters (e.g. FIB, OBs, dissolved oxygen, fauna, conductivity, etc.). This work also included a stream corridor assessment survey, fish presence/abundance study, toxics assessment, stormwater retrofitting, restoration planning, and public education/outreach.

Additionally, Saco's 2014 comprehensive flow analysis was used to prioritize sewer investigations conducted within the Bear Brook watershed. The town televised 2500 ft. of sewer lines and dye tested 5 properties with approximately 15 minor malfunctions detected and repaired. One significant malfunction was the connection of a residential sewer lateral into the storm drain that was reconnected into the sanitary sewer system. Approximately 1,700 ft. of interceptor sewer main along Bear Brook was also replaced. OOB Public Works worked with MHB to choose priority areas for investigations using the MHB generated database detailing dye testing and sewer camera work. Subsequent efforts included dye, camera, and smoke testing to ensure the integrity of 36,000 feet of sewer lines as well as dye[6] and smoke testing 68 properties with 5 malfunctions detected and removed (separate report for smoke testing provided to the town by Ted Berry Company).The town also made upgrades and improvements made to 7,000 feet of sewer/stormwater lines. Both communities continued to post supplemental signage at the mouth of the Goosefare brook in 2015, alerting the public of the potential risk of water contact at this location.

In 2016, both towns will also continue enhanced monitoring and pollution source tracking efforts as well as improvements to sewer/stormwater infrastructure. OOB Public Works plans to work with MHB to document sewer and stormwater camera work to streamline and prioritize future efforts. Additionally, MHB will partner with the watershed committee and Dr. Steve Jones to conduct microbial source tracking in priority areas in the NSRT to help identify human contributions. The watershed plan will include potential stormwater retrofit projects that will be prioritized for upcoming years, and the towns plan to continue their collaboration to restore the Goosefare Brook by applying for a 319-grant to perform prioritized retrofit projects in 2017. Saco also plans to amend the Zoning Ordinance with regards to stormwater management, which will increase requirements for water quality treatment for new and redevelopment projects.

Recommendations

Target Human Sources

It is recommended that the towns continue investigations of suspect areas to rule out sources of human sewage. Sources may include but are not limited to faulty sewer lines, cross connections between sewer and stormwater systems, and malfunctioning septic systems/cesspools. Of particular concern are potential wastewater sources in the vicinity of priority sites as bacteria issues appear to be the same or worsening in these areas (Figures 7, A3).

- **GFB-01/Mouth of GFB**
    - Although the town has tested the tidegate and areas directly upland, it is recommended to continue investigations at GFB-01-2 where the brook 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 7).
    - The apparent trend in the mouth of the brook is higher ENT results on an incoming tide (Figure A6, Table A3) suggesting potential pollution source(s) in the vicinity of the mouth and/or conditions in this area favor persistence and possibly regrowth of ENT. It may also be worthwhile to recheck the area near the tide gate to ensure a tight system (Figure A5).

[6] Dye testing to ensure properties connected properly to sanitary sewer system, allowing the town to identify properties serviced by septic systems.

- **GFB-05/Marsh Series**
    - Consistently high ENT and OB values 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 necessitate further investigation. Additional sites (Marsh-1 and Marsh-2) established in 2015 indicate the source of pollution at GFB-05-1 is likely originating from source(s) within the Jordan Marsh portion of the NSRT flow just upland of site GFB-05-1 (Figure 7).
    - Additional survey work is needed along the tributary (runs parallel to Oceana Ave.) between sites GFB-05-02 (Free St.) and GFB-05-0 (Oceana Ave) and in the drainage north along Rt. 9 between sites GFB-05-1 and GFB-05-4 (Figure 7).

As time and resources allow, it is also recommended to continue expanding and improving sewer and stormwater infrastructure. More data (including human-specific markers) is also needed to hone in further on human sources. ENT monitoring can also help to verify sites are clean following remediation work. It is also suggested to continue to intensely stratify monitoring sites near known priority areas to increase the chances of isolating 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.

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 continue posting precautionary rainfall advisories at Bay View, Kinney Shores, and Ocean Park beaches online and at the beach 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. Also, it is suggested that the towns continue to work with partners (e.g. MHB, OOB Conservation Society) 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 the MHB program.

Appendix A: Monitoring Data

2012-2015 Monitoring Data

Table A1. 2012-2015 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	2012-2013	274.6	79.7	4	5
GFB-01-2	2012-2014	504.7	87.0	13	13
GFB-01	2012-2015	323.7	79.3	48	39
GFB-01-0	2012-2015	399.9	95.0	36	37
GFB-01-1	2012-2015	288.8	95.3	36	37
GFB-04	2012-2015	169.6	86.5	35	36
GFB-04-0	2012-2015	118.4	78.6	34	35
GFB-04-0-1	2012-2015	116.1	76.2	33	34
GFB-05	2012-2015	564.7	101.4	36	37
GFB-05-0	2012-2015	751.3	117.6	35	36
GFB-05-1	2012-2015	674.0	101.2	36	37
GFB-05-2	2012-2015	59.3	95.7	34	34
SACO-00	2012-2015	33.2	46.4	28	19
GFB-05-6	2013	44.6	81.7	9	9
GFB-04-0B	2013-2015	129.8	78.6	29	29
GFB-05-4	2013-2015	46.1	64.6	30	30
GFB-05-5	2013-2015	13.5	85.9	30	29
Marsh-1	2015	1603.5	94.6	9	9
Marsh-2	2015	1140.6	79.5	9	9
Total		**183**	**87**	**536**	**529**

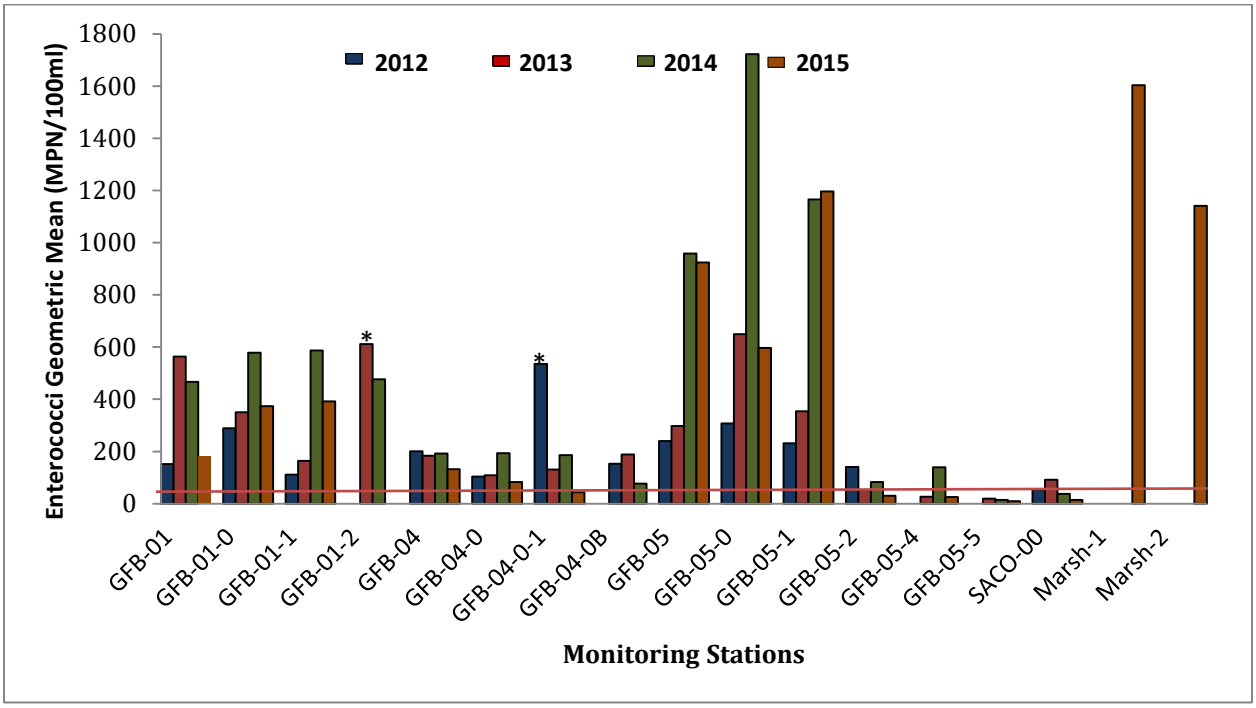

Figure A1. The 2012-2015 ENT geometric mean (MPN/100ml) values by monitoring station in the NSRT as indicated by blue (2012), red (2013), green (2014), and orange (2015) bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples (mean value given). Sites monitored only 2012/2013 removed from summaries.

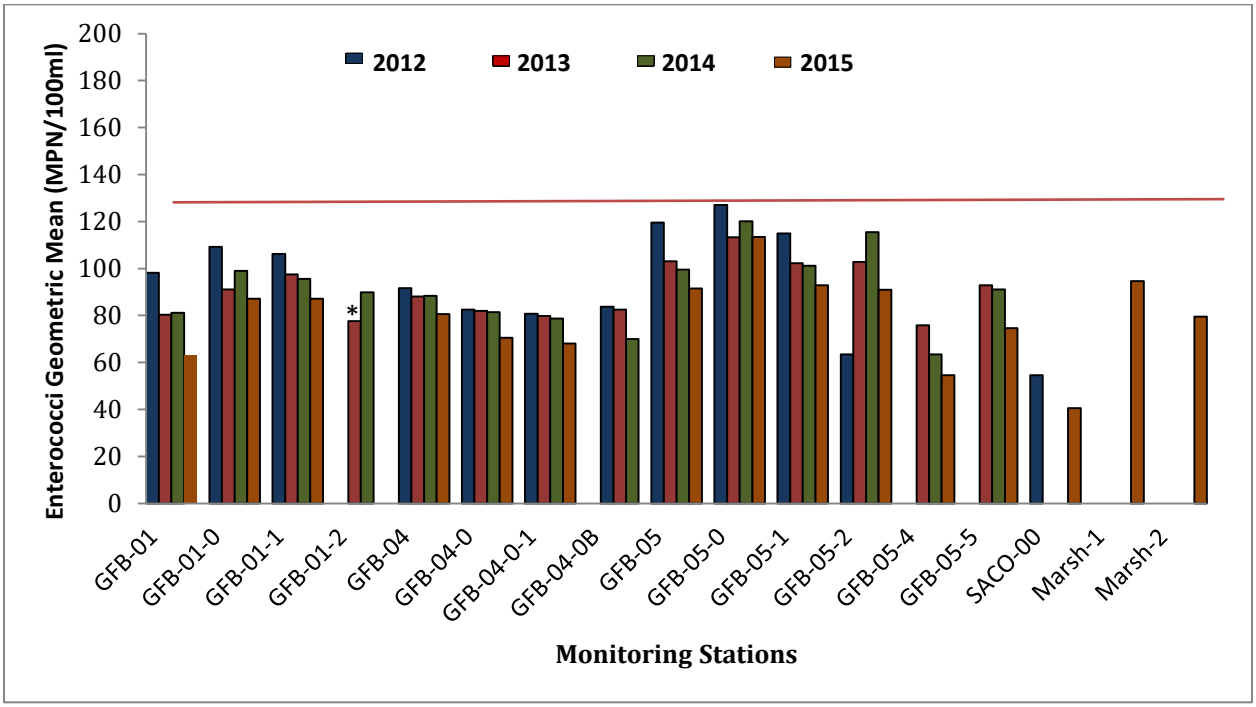

Figure A2. The 2012-2015 mean optical brightener (µg/l) concentration by monitoring station in the NSRT as indicated by blue (2012), red bars (2013), green (2014), and orange (2015) bars. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples. Sites monitored only 2012/2013 removed from summaries.

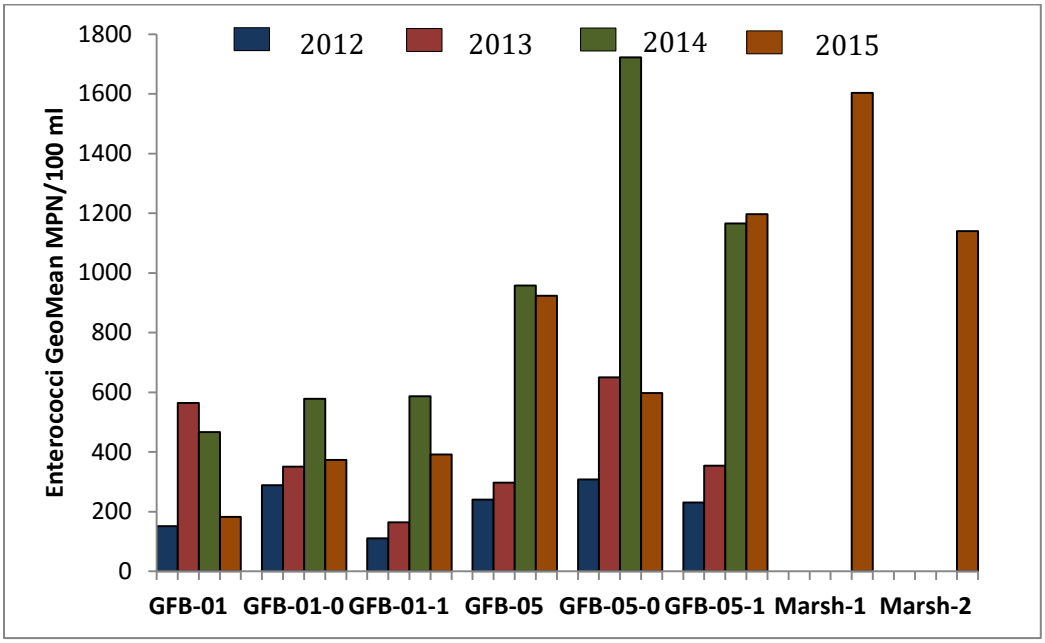

Figure A3. ENT geometric mean for priority sites within the GFB-01 and GFB-05/Marsh series from 2012-2015 (Note differences in sample size (Table A1)).

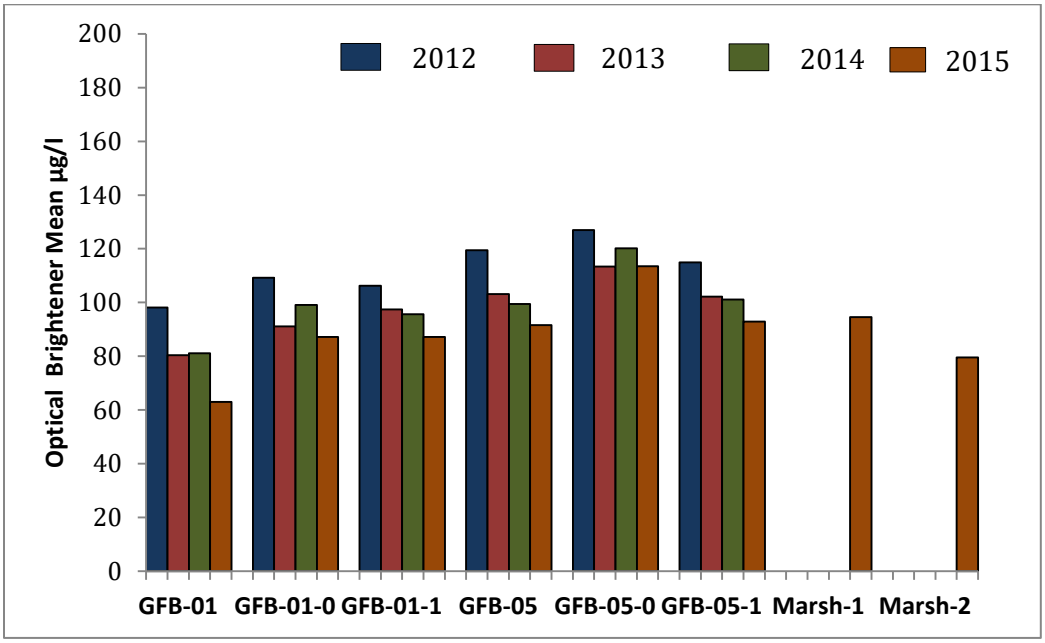

Figure A4. OB mean values for priority sites within the GFB-01 and GFB-05 series from 2012-2015 (Note differences in sample size (Table A1)).

Seasonal Shifts

Table A2. Total 2012-2015 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 A5). 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 (Figure A6, Table A3). 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 A5. Monitoring stations GFB-01 and Saco-00 located at the mouth of the Goosefare Brook.

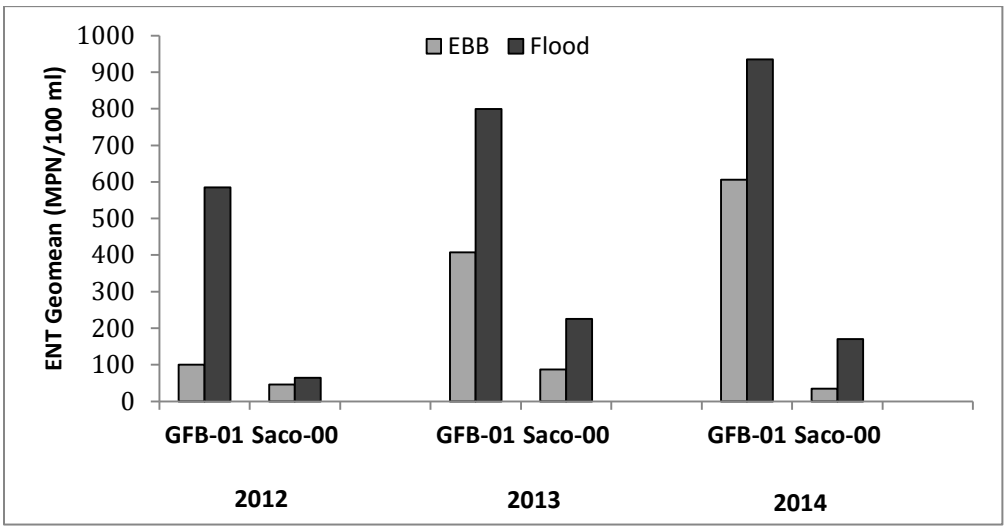

Figure A6. Season-wide ENT geomean results for GFB-01 and Saco-00 samples collected at ebb and flood tidal conditions.

Table A3. 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

Flood (Rainfall) Event

On August 13, 2014 nearly 6.5 inches of rainfall fell within a 24-hour period causing flood conditions in several regions throughout southern Maine. As a result, all 7 NSRT sites monitored on this date were flooded and single sample values (SSV) ranged from 1,119-24,200 MPN/100ml with all sites exceeding the ENT single sample safety threshold of 104 MPN/100ml (Figure A7). Given samples were collected during flood conditions, results are likely indicative of multiple sources compounding together under these extreme conditions. Although this event demonstrates impaired water quality, it has little value in highlighting the most problematic areas in the watershed. As a result, this data was not used in this report's data summaries.

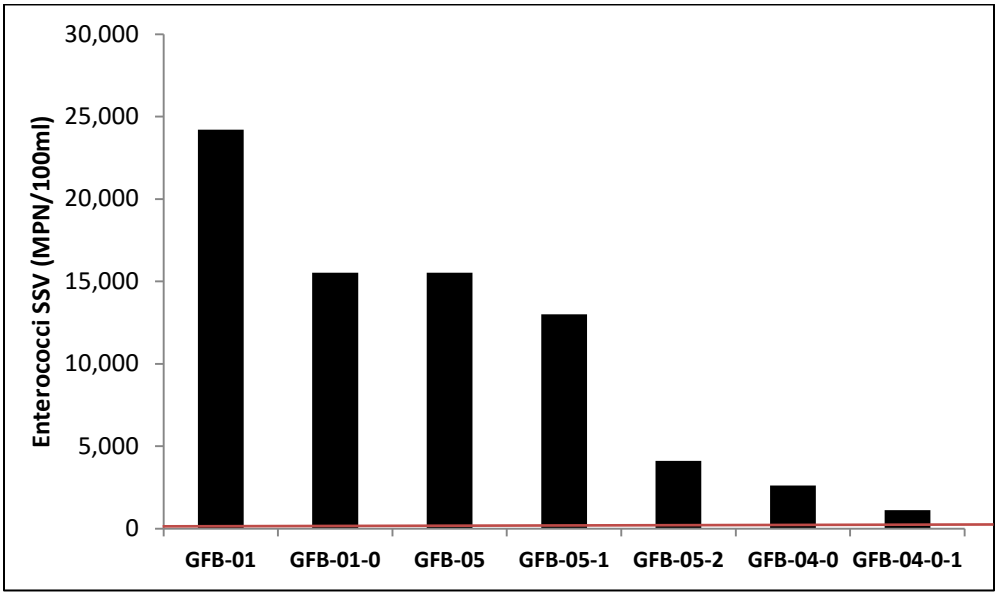

Figure A7. Enterococci single sample value (SSV) for seven sites within the NSRT following the August 13th rainfall event. Results for all sites were above the EPA single sample maximum level of 104 MPN/100ml indicated by the red solid line.

2015 Monitoring Data

Table A4. 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.

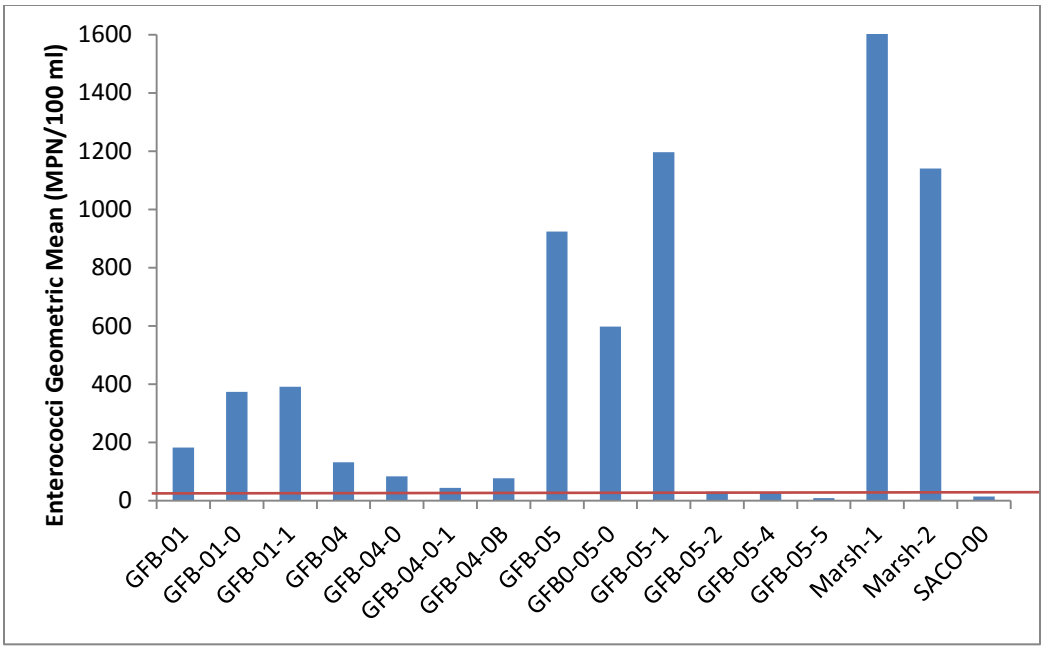

Figure A8. The 2015 enterococci geometric mean (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml.

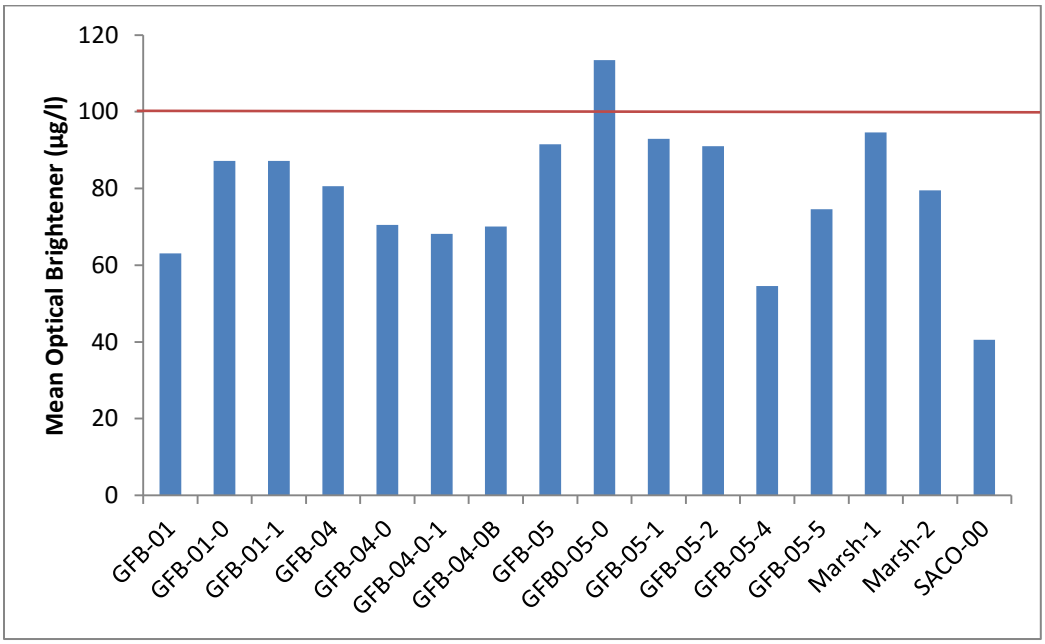

Figure A9. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2015. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.

2014 Monitoring Data

Table A5. 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.

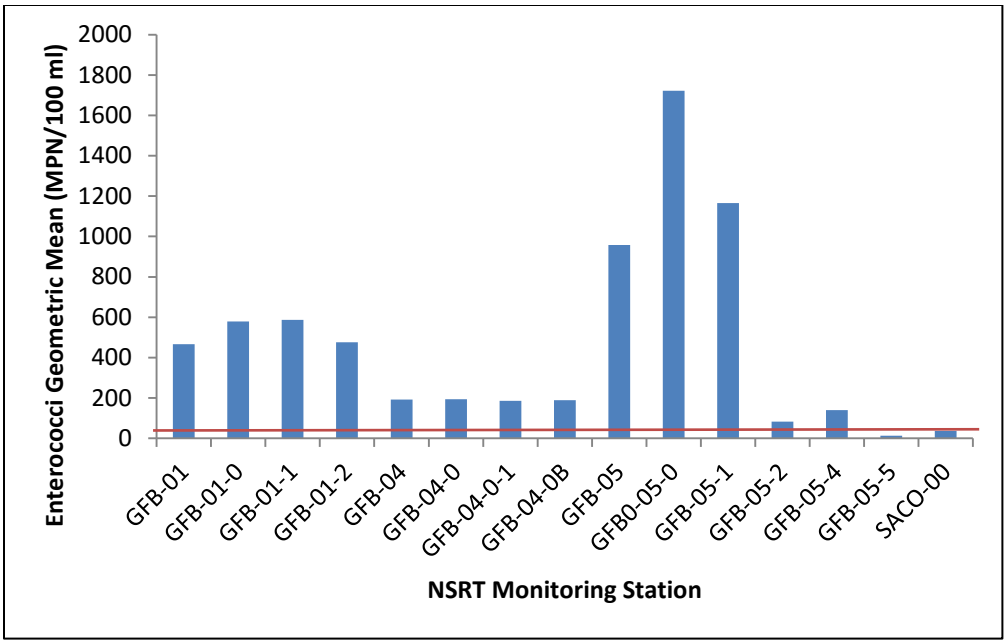

Figure A10. The 2014 enterococci geometric mean (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml.

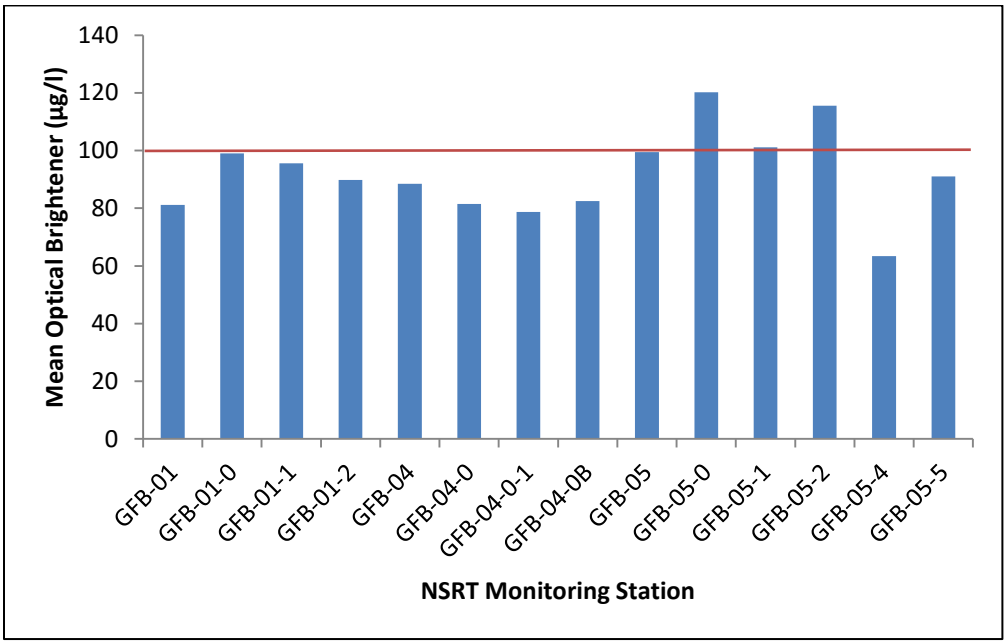

Figure A11. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2014. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.

2013 Monitoring Data

Table A6. 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**

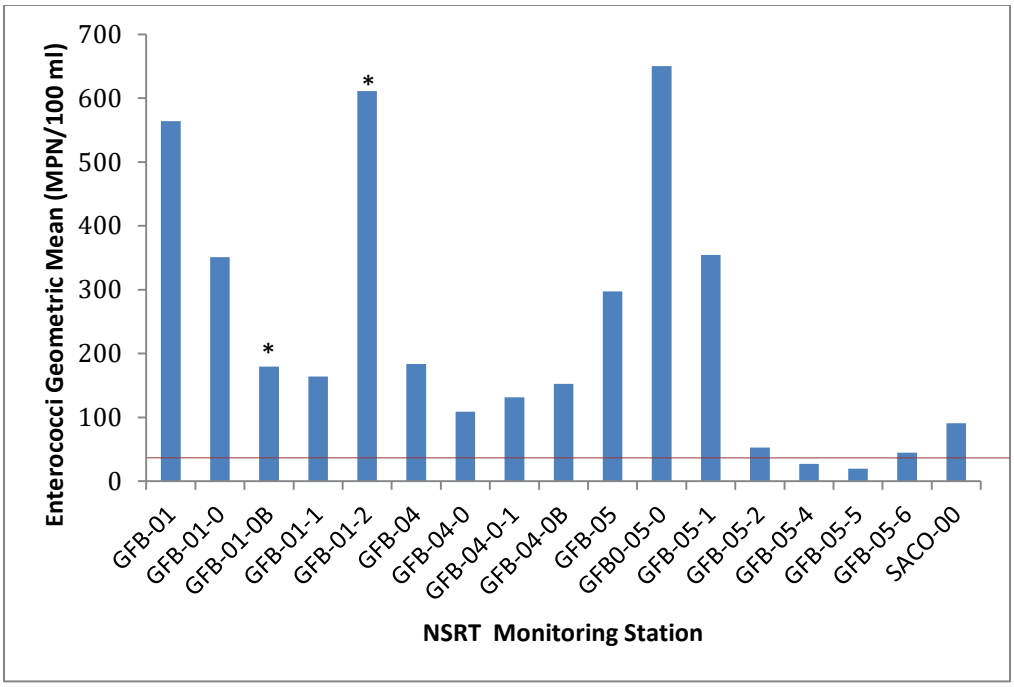

Figure A12. The 2013 geometric mean enterococci (MPN/100ml) values by monitoring station as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5samples.

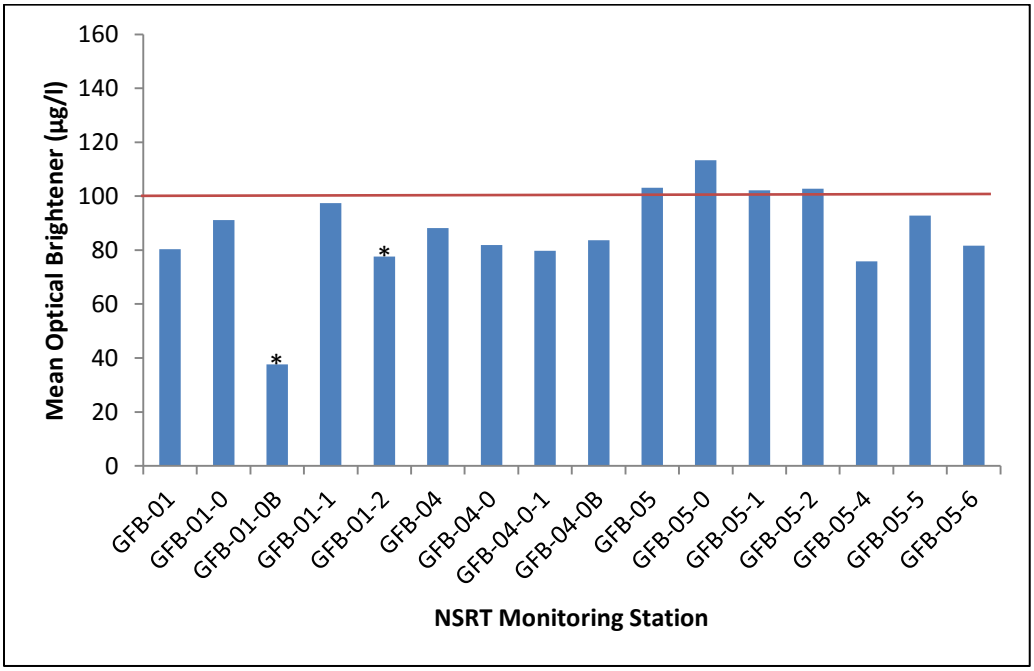

Figure A13. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2013. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

2012 Monitoring Data

Table A7. 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**

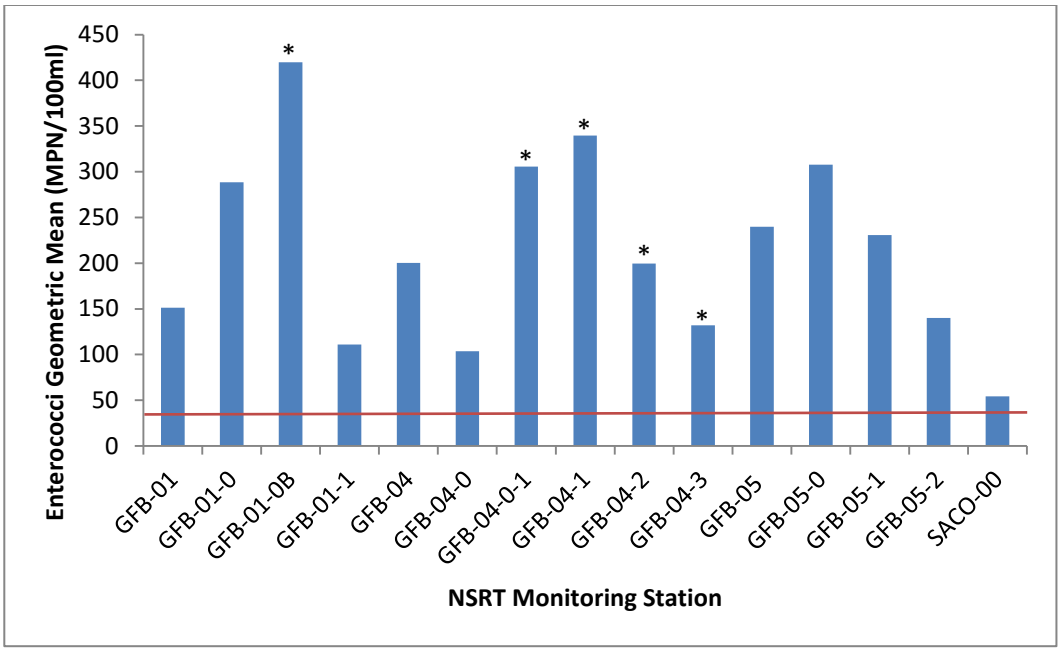

Figure A14. The 2012 geometric mean enterococci (MPN/100ml) values by monitoring station in the NSRT as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples.

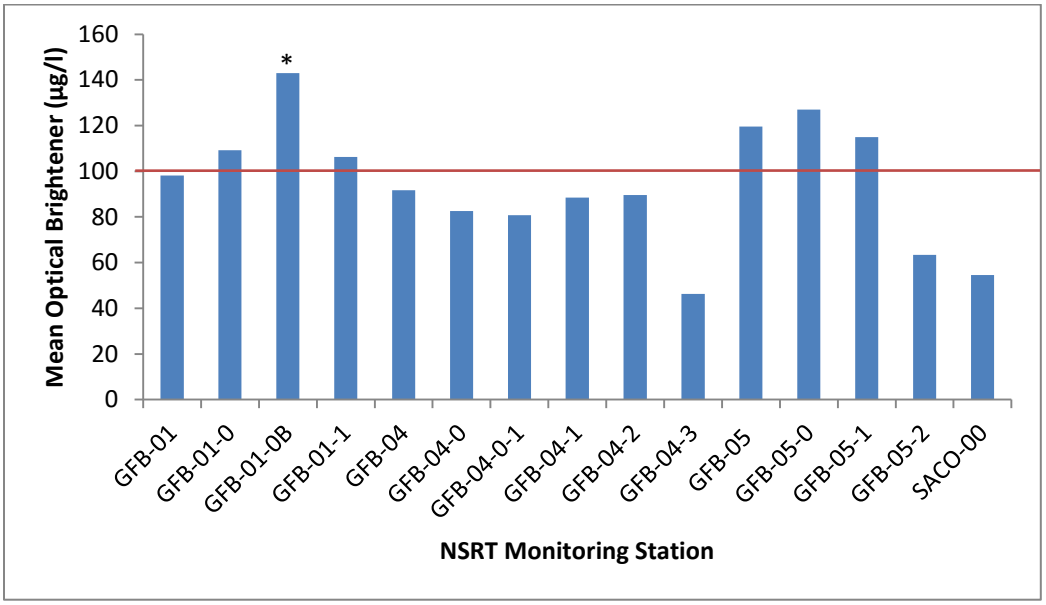

Figure A15. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2012. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

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 locations within the NSRT sub-watershed for 4 of the 6 enhanced monitoring dates (Table B2). US EPA did not provide PPCP support in 2013-2015.

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

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. The canines were not part of the GFB source tracking work in 2013-2015.

Risk Factor Matrix

The pollution source-tracking tools applied in the NSRT for 2012 were combined into a risk factor matrix, highlighting priority areas needing further investigation. Factors include whether or not Enterococci (geometric mean) results exceeded the US EPA-recommended safety threshold of 35 MPN/100ml, if OB (mean) levels surpassed the "red-flag" threshold (100 µg/l) for human influence, if there was a positive deviation from the Enterococci (ENT) mean for all NSRT sites, if there was a positive deviation from the optical brightener (OB) mean, if there was 4 or more detectable limits out of the 7 PPCP compounds tested, and if the canine detection results were positive (Table B2).

Table B2. 2012 Pollution Source Tracking Toolbox, Risk Factor Matrix. Y = Yes, N= No.

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

Monitoring stations with ≥ 4 “Y” values are highlighted as priority sites with the potential for point sources of human associated fecal pollution within the New Salt road Tributary sub-watershed for 2012. The highlighted sites necessitate further investigation into potential sources of human fecal contamination, however, it should be noted that the matrix is merely an indicator of the likelihood of human-sourced fecal contamination and is not a definitive or conclusive indicator that illicit source(s) are present.

Appendix C: Local Assessments

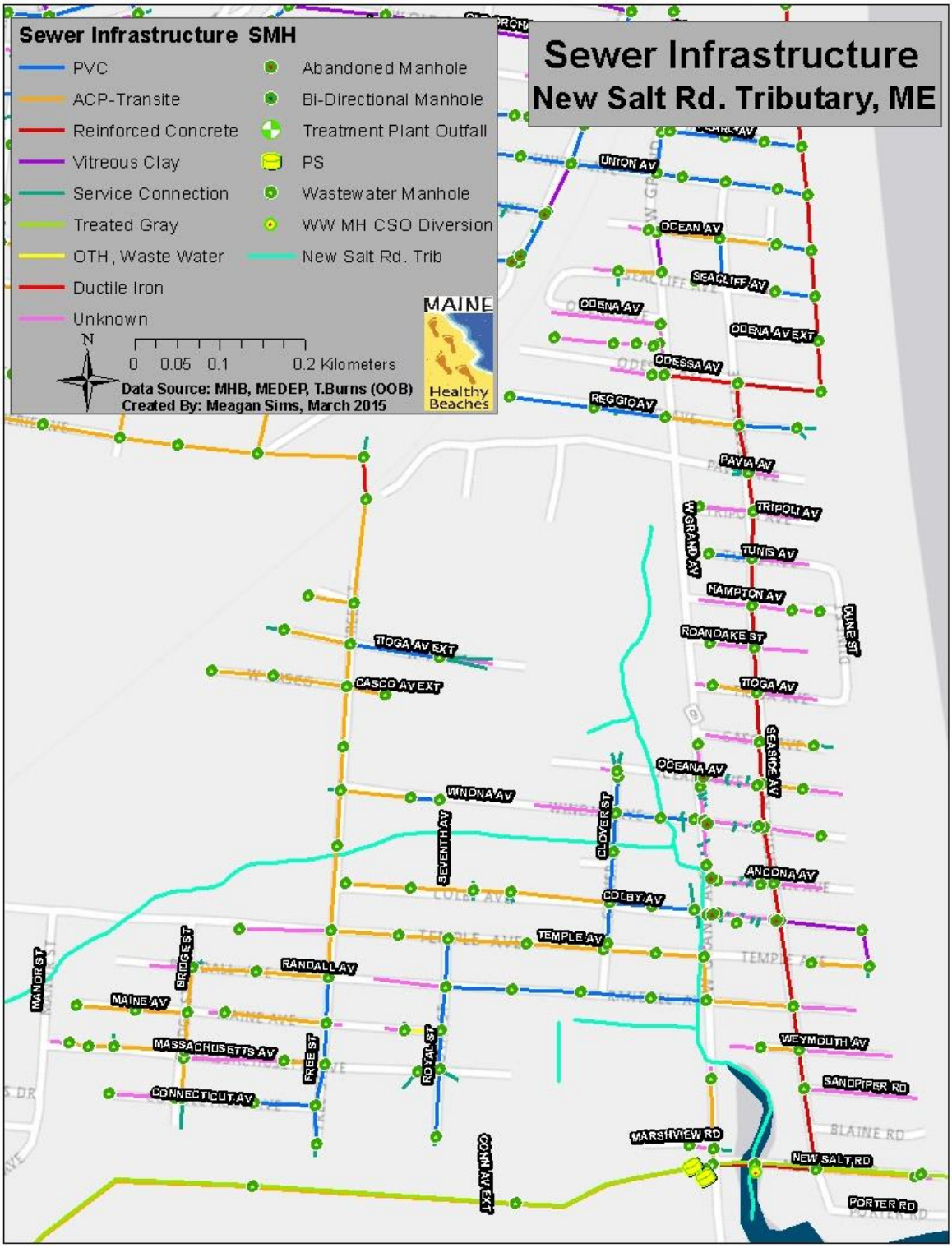

Figure C1. Old Orchard Beach wastewater infrastructure materials (pipe type) and MHB monitoring locations along the New Salt Rd. Tributary. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB (No updates received for the 2015 season).

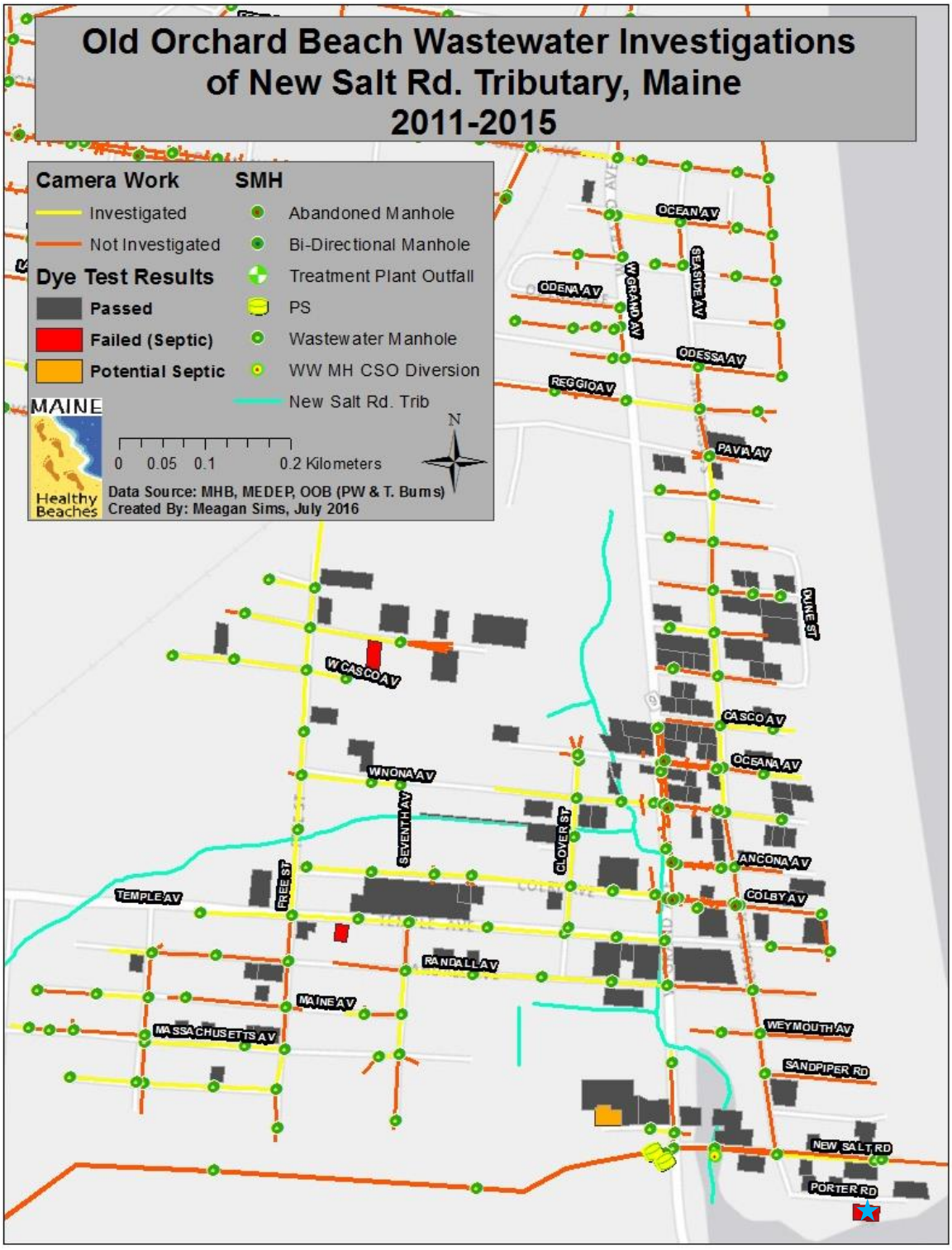

Figure C2. Old Orchard Beach wastewater camera and dye test investigations conducted by Public Works from 2011 to 2015 along the New Salt Rd. Tributary. This figure may not contain all work completed and it will be periodically updated as new information is received by MHB. Parcel on Porter road (★) identified as being served by a cesspool. Cesspool removed (2014) and property tied into sanitary system.