2015

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 2012-2014

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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
2012-2014

Photo: Maine Healthy Beaches

TABLE OF CONTENTS

Executive Summary

The Goosefare Brook 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 three years, MHB has focused primarily on OOB's New Salt Rd. Tributary (NSRT). In 2014, 180 enterococci (ENT) samples at 17 sites and 149 optical brightener (OB) samples at 16 sites were analyzed. ENT values ranged from <10 to 6,490 MPN/100mls with a combined geometric mean of 275 MPN for all sites. OB values ranged from 34 to 163 µg/l with a combined mean of 92 µg/l for all sites. Deviations from the NSRT-wide ENT geometric mean and mean OB values were also considered for each site. Seven sites located within the GFB-01 and GFB-05 series exhibited positive deviations from the NSRT-wide overall ENT geometric mean and 6 sites (largely within the GFB-05 series) demonstrated positive deviations from the OB mean. Results indicate widespread bacterial contamination throughout the tributary as well as priority areas likely impacted by human-sourced fecal contamination. Additionally, ENT levels appear to be increasing in the NSRT since 2012. 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 initiated a watershed management plan. However, persistent contamination issues underscore the need to continue investigations to ensure the integrity of wastewater disposal methods throughout the watershed.

Acknowledgements

Written and compiled by Meagan Sims and Keri Kaczor, Maine Healthy Beaches Program; UMaine Cooperative Extension. Reviewed by John Bird and Larry Mead. Special thanks to all of the dedicated staff/volunteers who have helped collect data since this study began. Those who assisted during the 2014 season include Bill Bell, Wil Trottier, Beckie Gombos, John Bird, Larry Mead, and Taylor Mason. Also thank you to Maine DEP, US EPA, OOB, and Saco for their support.

Background

The Goosefare Brook demarcates the beach and town boundary between Saco and 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 Goosefare Brook 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.

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 Goosefare Brook 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 brook and associated tributaries. Results of this larger pollution assessment indicated widespread bacterial contamination throughout the watershed and 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 2012-2014, MHB efforts have concentrated primarily on the OOB branch termed the New Salt Rd. Tributary (Figure 2).

In an effort to pinpoint human sources, MHB has utilized the pollution source tracking toolbox approach that incorporates the use of 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. Although wildlife, pet, and waterfowl waste can contribute to impaired water quality, it is recommended to target human sources first. MHB combined the results to create a risk factor matrix highlighting suspect areas warranting further investigations (Table A7). Due to limited resources and staff at all levels, the toolbox parameters focused on enterococci and optical brighteners only in 2013-2014.

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.

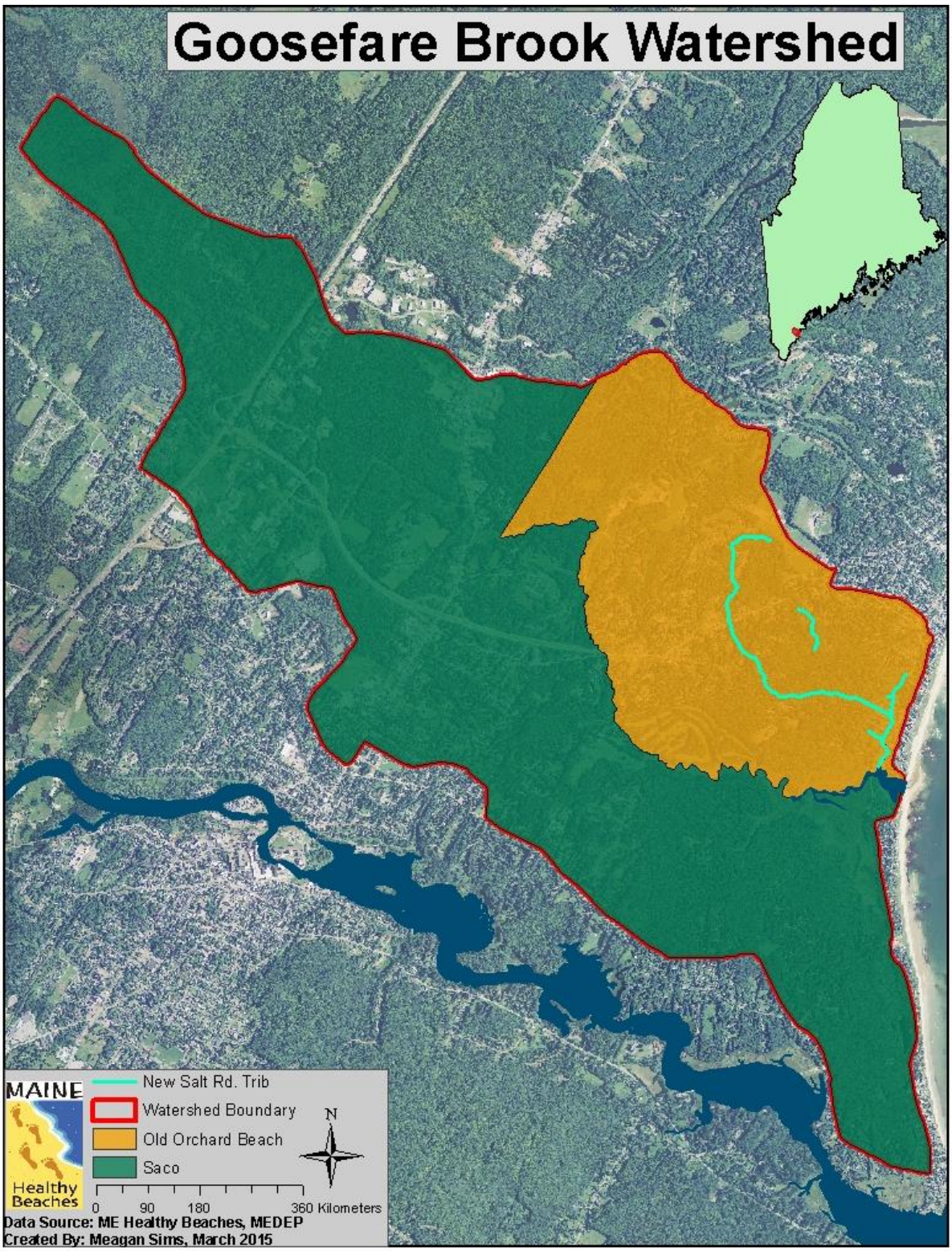

Figure 1. Goosefare Brook Watershed boundary including Saco and OOB town delineations. The watershed is approximately 9.83mi^2 and is shared by the towns of Saco (approximately 4,000 acres) and OOB (approximately 1,000 acres).

Project Methods (2014)

MHB monitored two sites located at the two branches near the outlet of Goosefare Brook (Saco-00 and GFB-01) for ENT levels on a weekly basis throughout the 2014 beach season (Figure 2). These samples were collected during all tidal and weather conditions. In order to assess NSRT water quality before mixing with seawater, MHB conducted 10 monitoring events during ebb (outgoing) tides in 2014. As a part of this effort, 180 enterococci samples at 17 sites and 149 optical brightener samples at 16 sites stratified throughout the NSRT watershed were analyzed. Sites targeted suspect areas identified through previous monitoring efforts keeping in mind ease of accessibility and avoidance of private property.

Results/Discussion

Enterococci and Optical Brighteners

All but one site (GFB-05-5) exceeded the ENT geometric mean[1] safety threshold[2] (Figure A3). Variability in the data set was large and single sample values ranged from <10 to 6,490 MPN/100ml. ENT geometric mean levels also showed variability between monitoring stations and the combined geometric mean value for all NSRT sites was 275 MPN/100ml (Table A3). The variability of OB concentrations was considerably lower than the ENT data with levels ranging from 34 to163 µg/l and a combined NSRT mean of 92 µg/l (Table A3). Unlike the ENT results, mean OB concentrations showed very little variability between monitoring stations with 3 sites exceeding 100 µg/l,[3] and the remaining 11 sites exceeding 60 µg/l (Figure A4).

Combining ENT data from 2012-2014, the overall NSRT geometric mean value of 197 MPN is over five times greater than the EPA threshold of 35 MPN/100ml (Table A1). Additionally, the NSRT-wide geometric mean value increased since monitoring of this area began in 2012, particularly from 2013 (148 MPN/100ml) to 2014 (276 MPN/100ml) (Figure A1, Table A1). These differences are most notable among the sites in the GFB-01 and GFB-05 series. The combined (2012-2014) mean OB value for the NSRT was 91 µg/l, and this parameter has demonstrated very little change over time (Figure A2, Table A1).

For the NSRT watershed, the 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 always be a "background level" contribution to measured OB concentrations in systems like the NSRT that have tea colored waters, 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, where

[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.

most sites exhibit elevated ENT and OB concentrations and are likely impacted by humic interference, examining deviations from the mean may help pull a meaningful signal from the variability as well as help identify 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 2014, 7 sites located within the GFB-01 and GFB-05 series exhibited positive deviations from the NSRT-wide ENT geometric mean value of 275 MPN/100ml. Six sites located primarily in the GFB-05 series demonstrated positive deviations from the NSRT-wide OB mean of 92 µg/l (Table A3). Combining data from 2012-2014, 9 out of 20 sites exhibited positive deviations from the NSRT-wide ENT geometric mean value of 197 MPN/100ml and 7 sites demonstrated positive deviations from the NSRT-wide OB value mean of 91 µg/l (Figures 3-6, Table A1). For both parameters, positive deviations were predominantly concentrated in the GFB-01 and GFB-05 series.

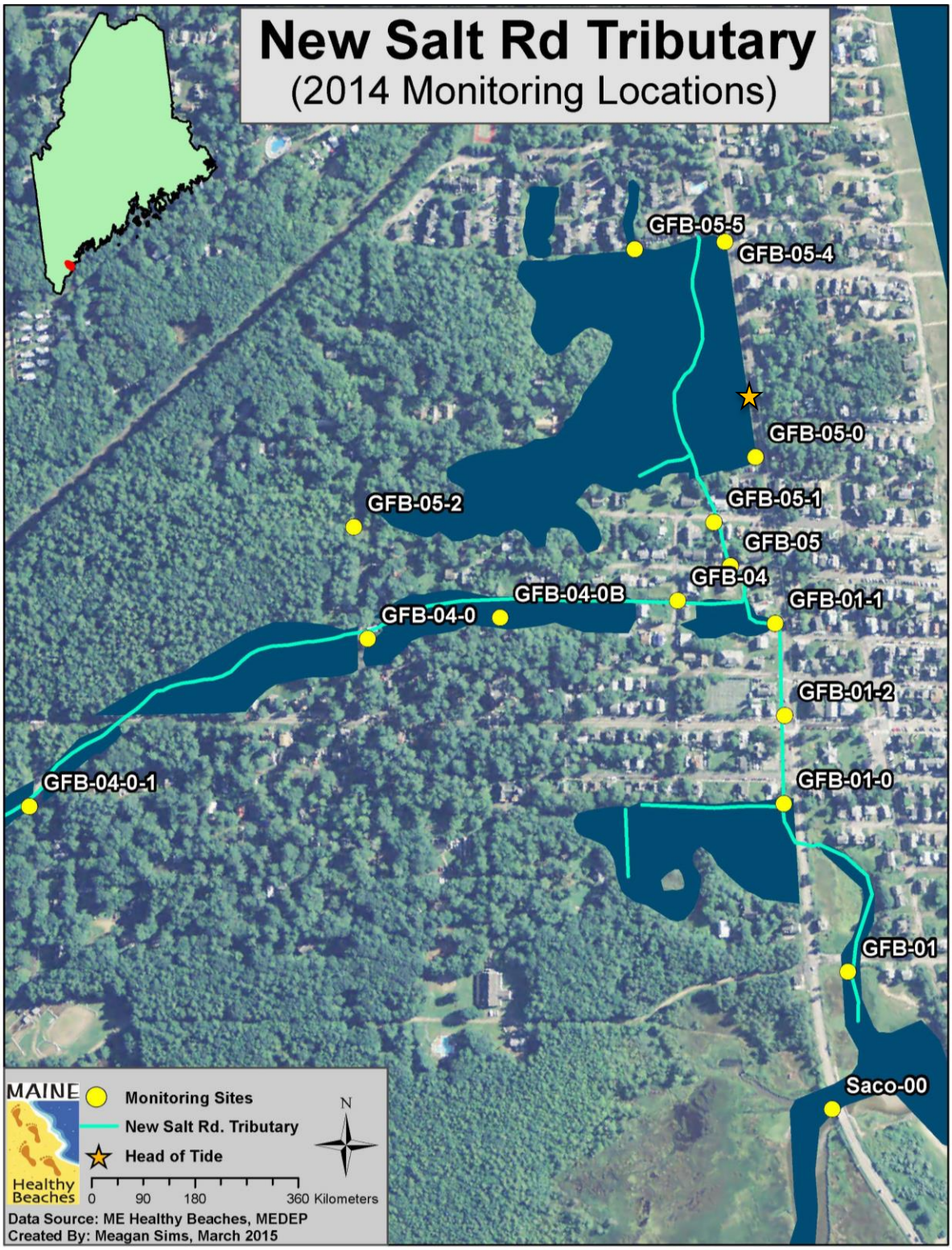

Figure 2. Map of the 15 NSRT monitoring stations for 2014. Two additional sites were monitored as FYI sites and are not included.

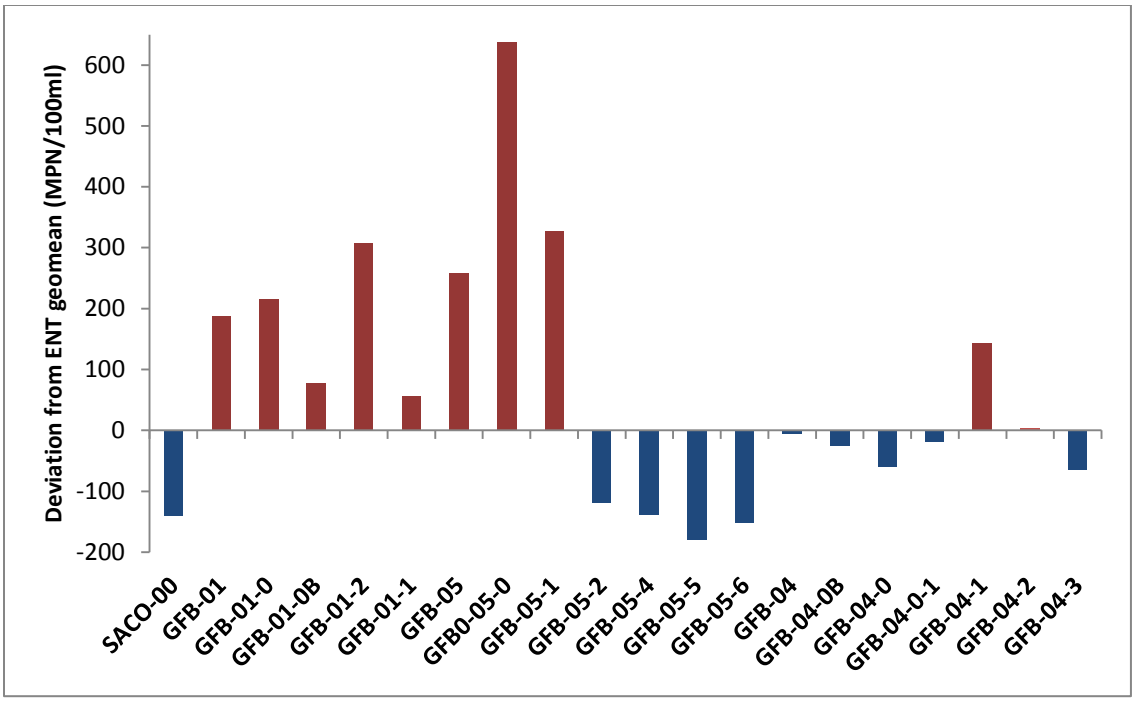

Figure 3. Deviations from the 2012-2014 combined ENT geometric mean for all NSRT sites. Bars above the X-axis indicate monitoring sites where ENT values were greater than the average geomean and bars below X-axis represent those that were lower than the average geomean (Note differences in sample size (Tables A3-A5).

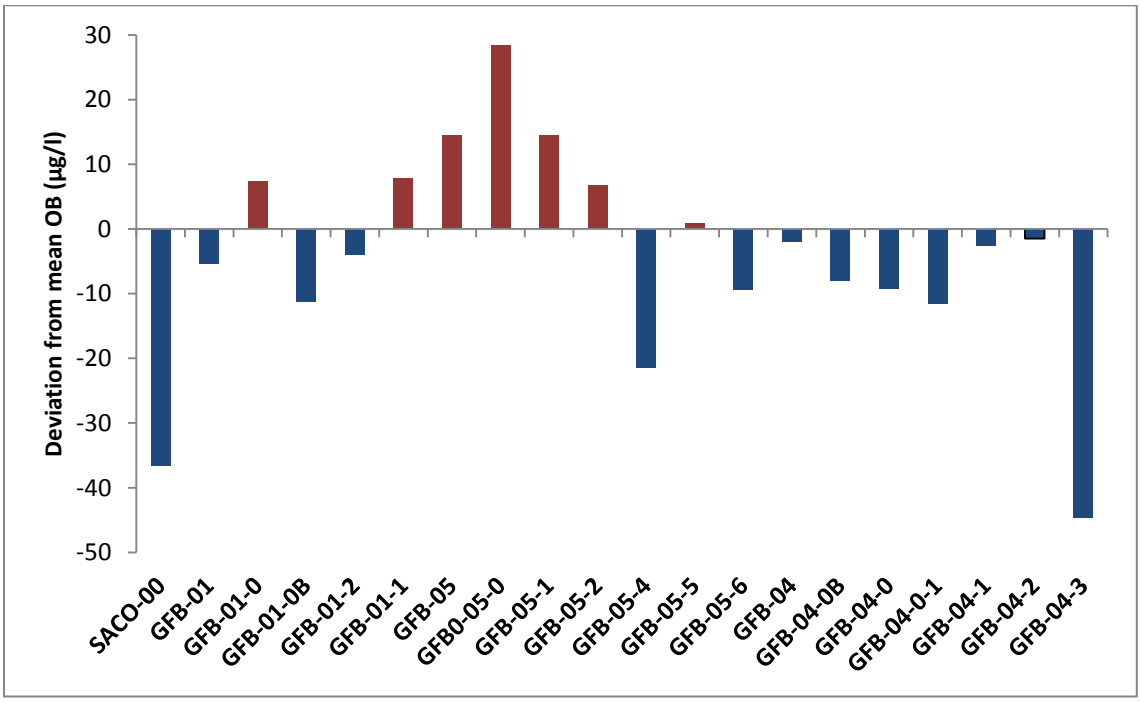

Figure 4. Deviations from the 2012-2014 season-wide mean optical brightener value for all NSRT sites. Bars above the X-axis indicate monitoring sites where OB values were greater than the average value and bars below X-axis represent those that were lower than the average value (Note differences in sample size (Tables A3-A5).

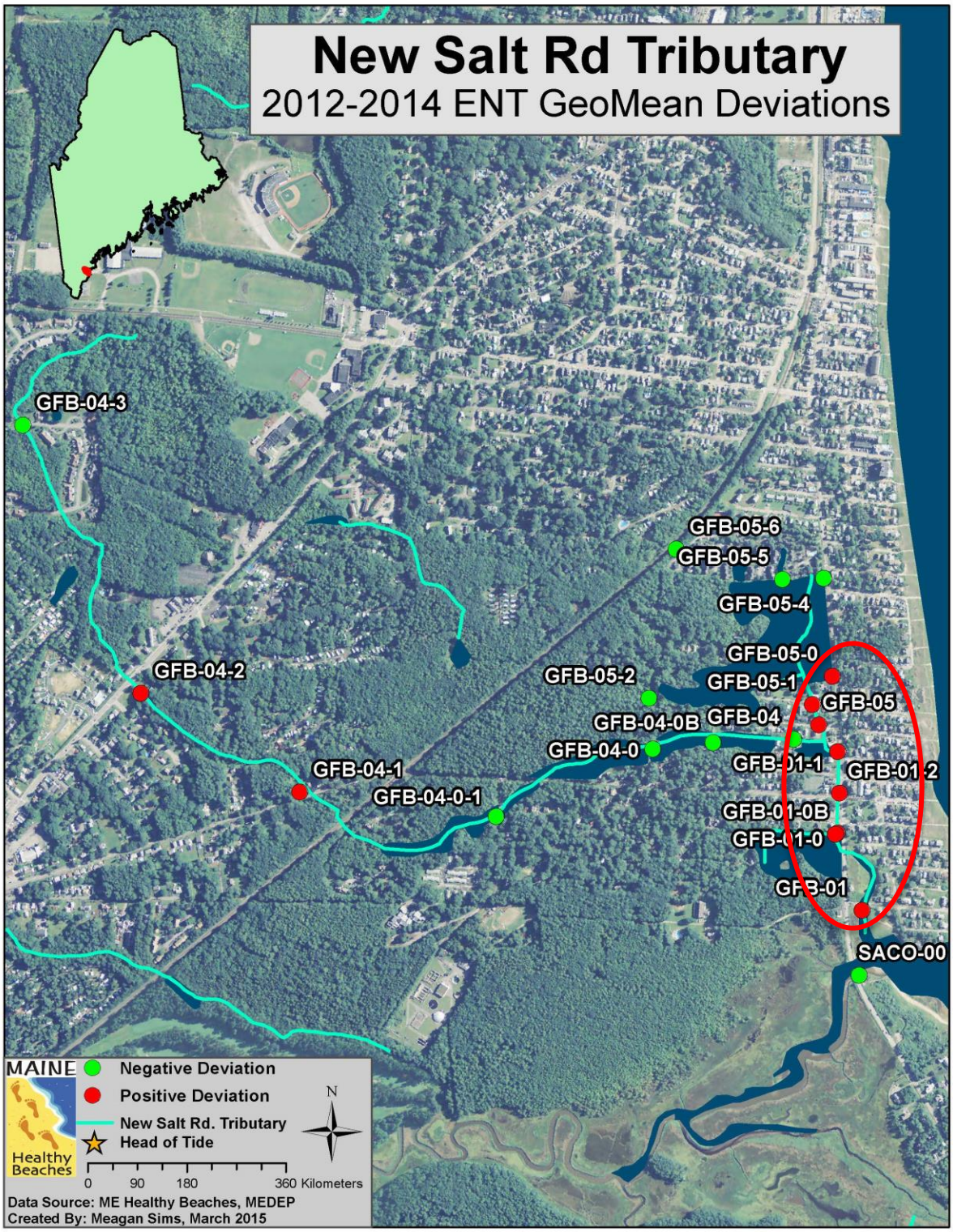

Figure 5. 2012-2014 deviation from watershed-wide ENT geomean concentration. Negative deviations represent sites with geomean ENT results less than the watershed geomean and positive deviations represent sites with geomean ENT values greater than the watershed geomean. Red circle indicates priority sites necessitating further investigation.

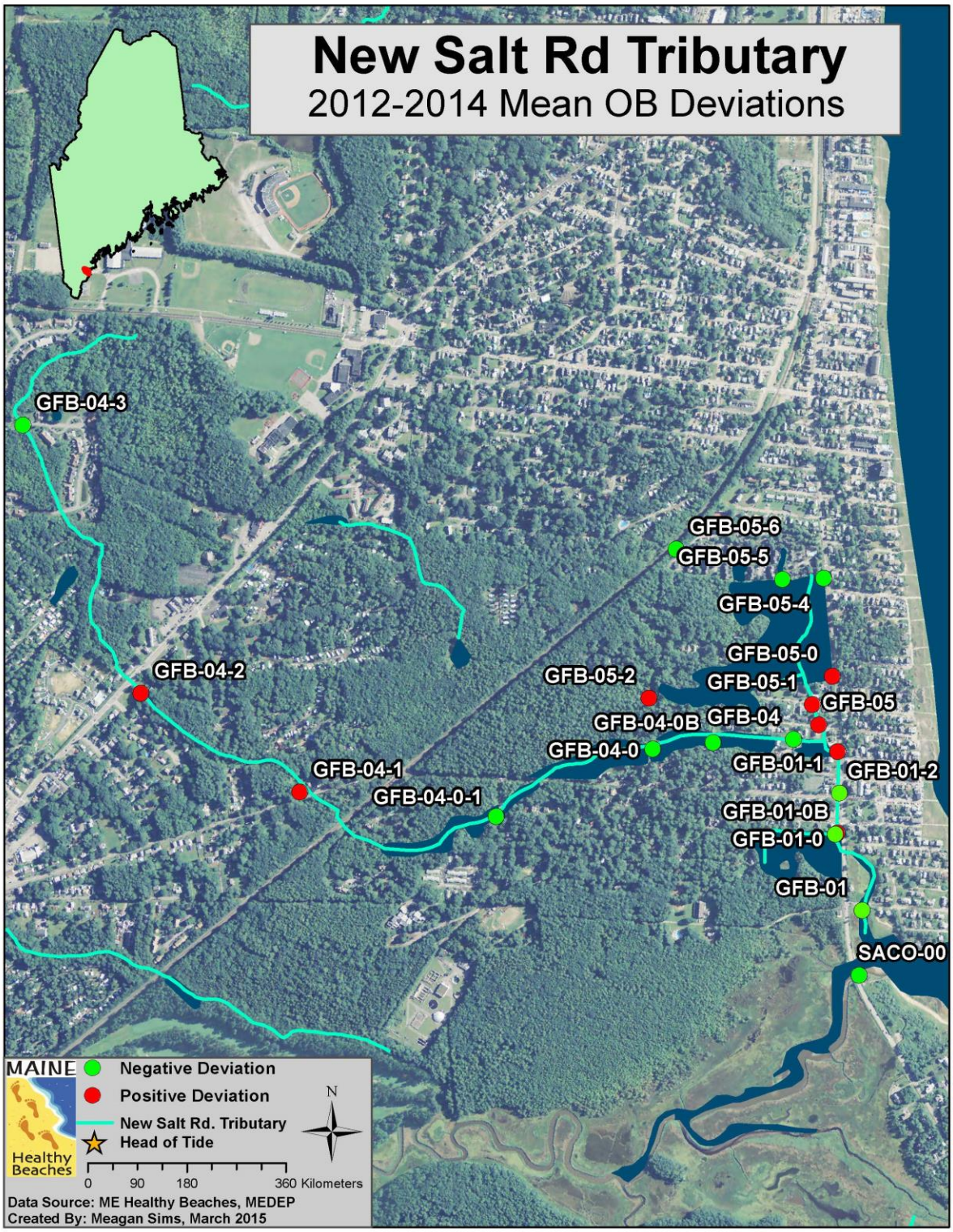

Figure 6. 2012-2014 deviation from watershed-wide mean OB concentration. Negative deviations represent sites with mean OB values less than the watershed average and positive deviations represent sites with OB values greater than the watershed average.

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 7). 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 8). 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 7. Monitoring stations GFB-01 and Saco-00 located at the mouth of the Goosefare Brook.

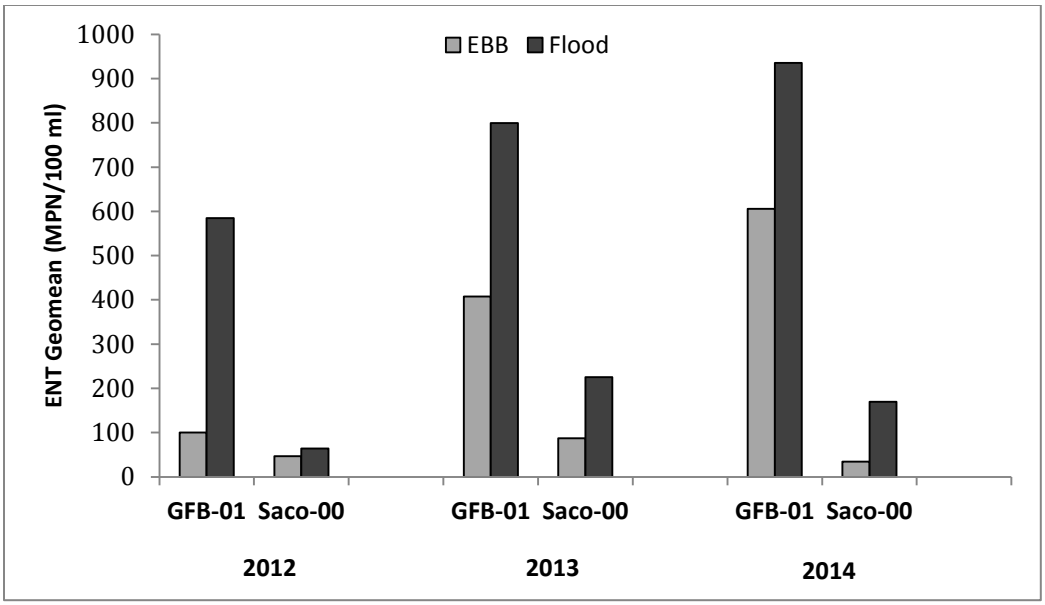

Figure 8. Season-wide ENT geomean results for GFB-01 and Saco-00 weekly samples collected at ebb and flood tidal conditions.

Suspect Areas

In addition to the mouth of the brook, results from 2014 and previous pollution source tracking efforts highlighted sites located within the GFB-01 and GFB-05 series as having the highest likelihood of human-sourced contributions (Figures 3-6, Figure 8, Table A7). These sites include GFB-01, GFB-01-0, GFB-01-1, GFB-05, GFB-05-1, and GFB-05-0 (Figure 2). Compared to other NSRT sites, these areas have consistently demonstrated elevated levels for both ENT and OBs. In general, all identified suspect sites demonstrated increasing ENT levels over the past 3 years, particularly from 2013-2014 (Figures 8-9). Similarly, recorded OB concentrations at these locations have been greater compared to less problematic sites within the NSRT drainage area (Figure 10). Results are suggestive but do not verify that illicit source(s) are present. These suspect sites necessitate further investigation to ensure the integrity of nearby subsurface wastewater disposal (septics, cesspools) as well as sewer and stormwater infrastructure (faulty lines, cross-connections).

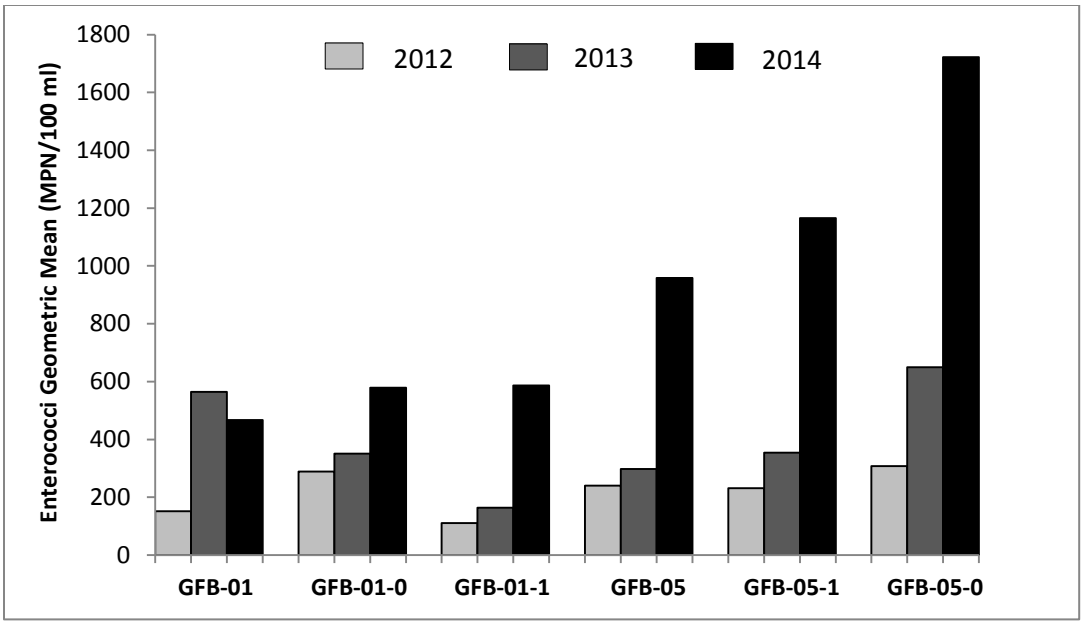

Figure 9. ENT geometric mean for suspect areas within the GFB-01 and GFB-05 series along the NSRT from 2012-2014 (Note differences in sample size (Tables A3-A5)).

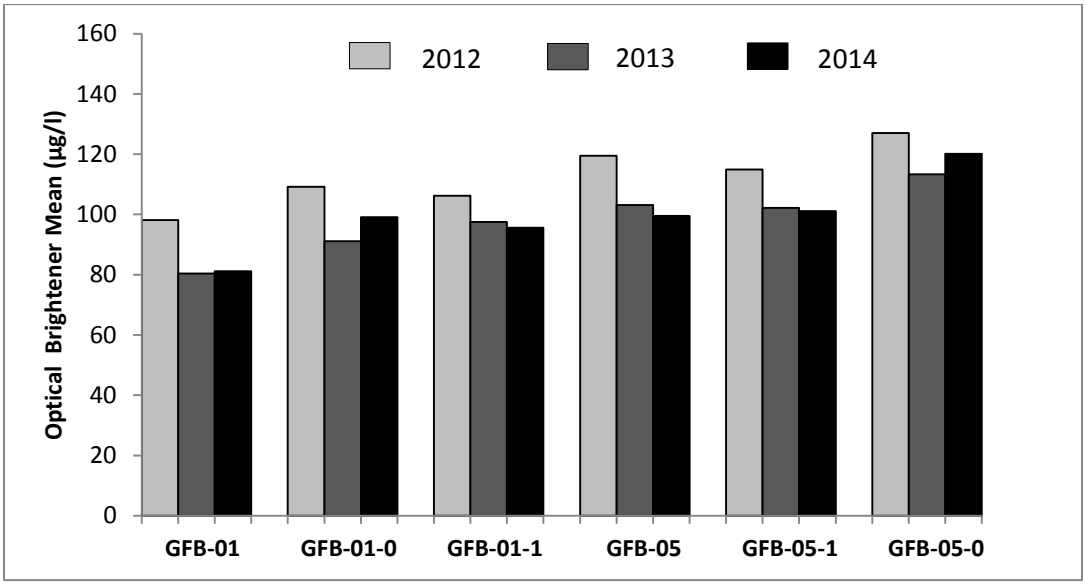

Figure 10. OB mean values for suspect areas within the GFB-01 and GFB-05 series along the NSRT from 2012-2014 (Note differences in sample size (Tables A3-A5)).

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 (Figure 11). 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 12). 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 11. Extent of flooding along West Grand Avenue, Ocean Park following the August 13, 2014 rain event.

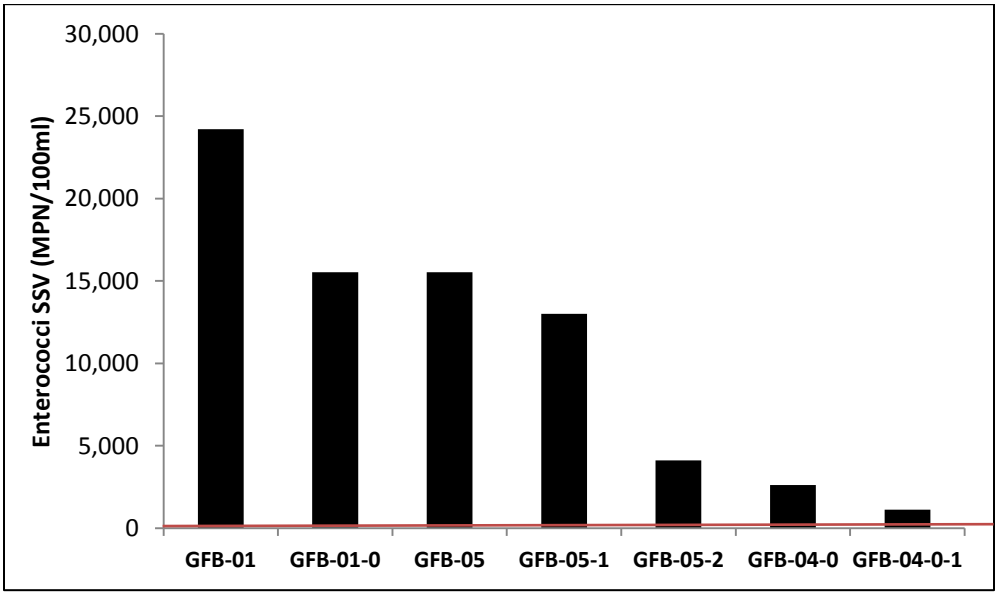

Figure 12. Enterococci single sample value (SSV) for seven sites within the NSRT following the August 13th rainfall event. Results for all sites were above the EPA single sample maximum level of 104 MPN/100ml indicated by the red solid line.

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 13). 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

Both towns have been committed to improving water quality in the Goosefare Brook watershed. 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, both the towns 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, Saco and OOB 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 (some are clay, some asbestos). Collectively, the towns have assessed the integrity of 35,500 ft. of sewer and storm drain lines and at least 134 properties have been dye tested within the GFB watershed (OOB work-Figures 13-14). Both towns have created and updated GIS layers of sewer and storm water networks to assist with source-tracking efforts. Additionally, both towns have made infrastructure improvements by replacing sewer lines, stormwater catch basins, etc. Upgrades are costly and must be spread out over time. Since 2010, over 14,000 ft. of sewer lines have been upgraded to PVC material and over 12,000 ft. of stormwater infrastructure has been replaced. Additionally, lines and catch basins are maintained and cleaned each year.

As a part of these efforts, OOB continued work to ensure the integrity of septic systems, sewer, and stormwater infrastructure including dye and camera testing of over 13,500 ft. of sewer lines in 2014. Additionally, 68 homes were dye tested with no malfunctions detected and at least 75 catch basins were cleaned. The town also hired a contractor to replace 8 ft. of frozen sewer lines and the town completed multiple drainage projects (replacing over 2,500 ft. of sewer lines) within the watershed including the installation of new manholes, sewer, drain lines, tie-ins, and the repair of 2 sets of leeching pipes at dead end roads along the beach. Old Orchard Beach also continued to offer a bi-annual tax credit for property owners that pump-out their septic systems.

As part of Saco's clean water initiatives, in 2014 the town televised over 21,000 linear ft. of sewer and storm drain lines in the GFB watershed as well as cleaned 178 catch basins and over 10,000 linear ft. of sewer lines (town-wide). Saco also completed a comprehensive flow analysis within the Bear Brook watershed sanitary sewer system, replaced manholes and sewer laterals, and separated a drain line from the sanitary system. Additionally, Saco delivered education events for school-aged children and adults through public tours of the Water Resource Recovery facility and educating residents about water-conservation and pathways through sewer and stormwater infrastructure. Saco will use the results of the comprehensive flow analysis for the

Bear Brook Watershed sewer system to formulate a priority list of areas needing further investigation for 2015.

In an effort to inform the public, both towns have supported signage regarding the potential risk of water contact in the mouth of the brook. Additionally, the towns collaborated and obtained a 319 grant to develop a Goosefare Brook Watershed Management Plan. In 2014, a suite of watershed health characteristics were monitored and data was collected by a diverse group of partners including the Maine DEP, York County Soil and Water Conservation District (YCSWCD), MHB, and environmental consultants. Parameters collected included enterococci, optical brighteners, aquatic fauna, dissolved oxygen, temperature, and conductivity. Maine DEP also conducted a sonde study, watershed and stormwater mapping, and biological monitoring (rock bags). As part of their MS4 requirements, both towns will continue investigations of septic systems, sewer, and stormwater infrastructure in 2015. Work will also continue on the GFB Watershed Management Plan including stormwater-retrofitting projects, watershed restoration planning, collecting watershed health data, and delivering public outreach events.

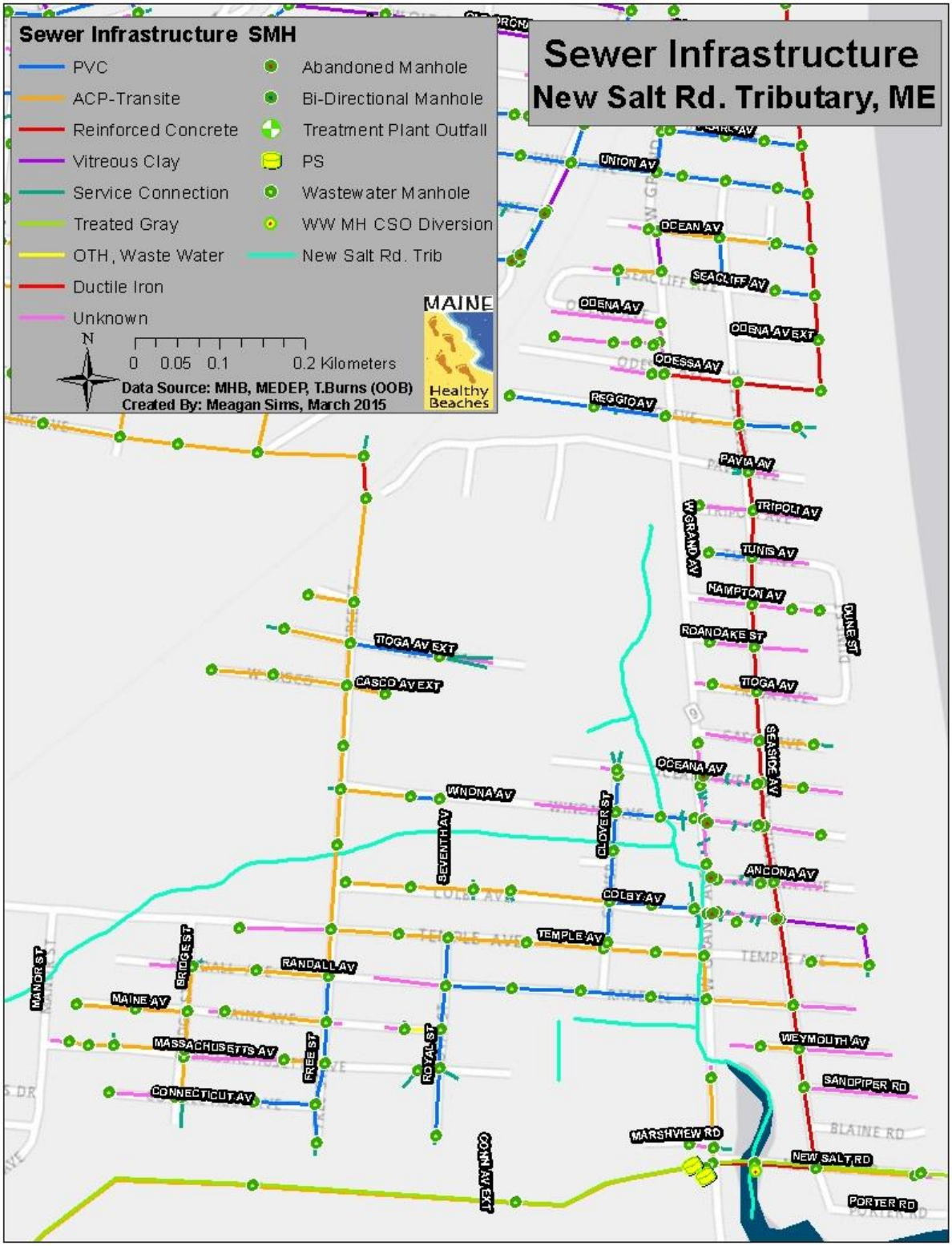

Figure 13. Old Orchard Beach wastewater infrastructure materials (pipe type) and MHB monitoring locations along the New Salt Rd. Tributary. This figure may not contain all relevant information and it will be periodically updated as new information is received by MHB.

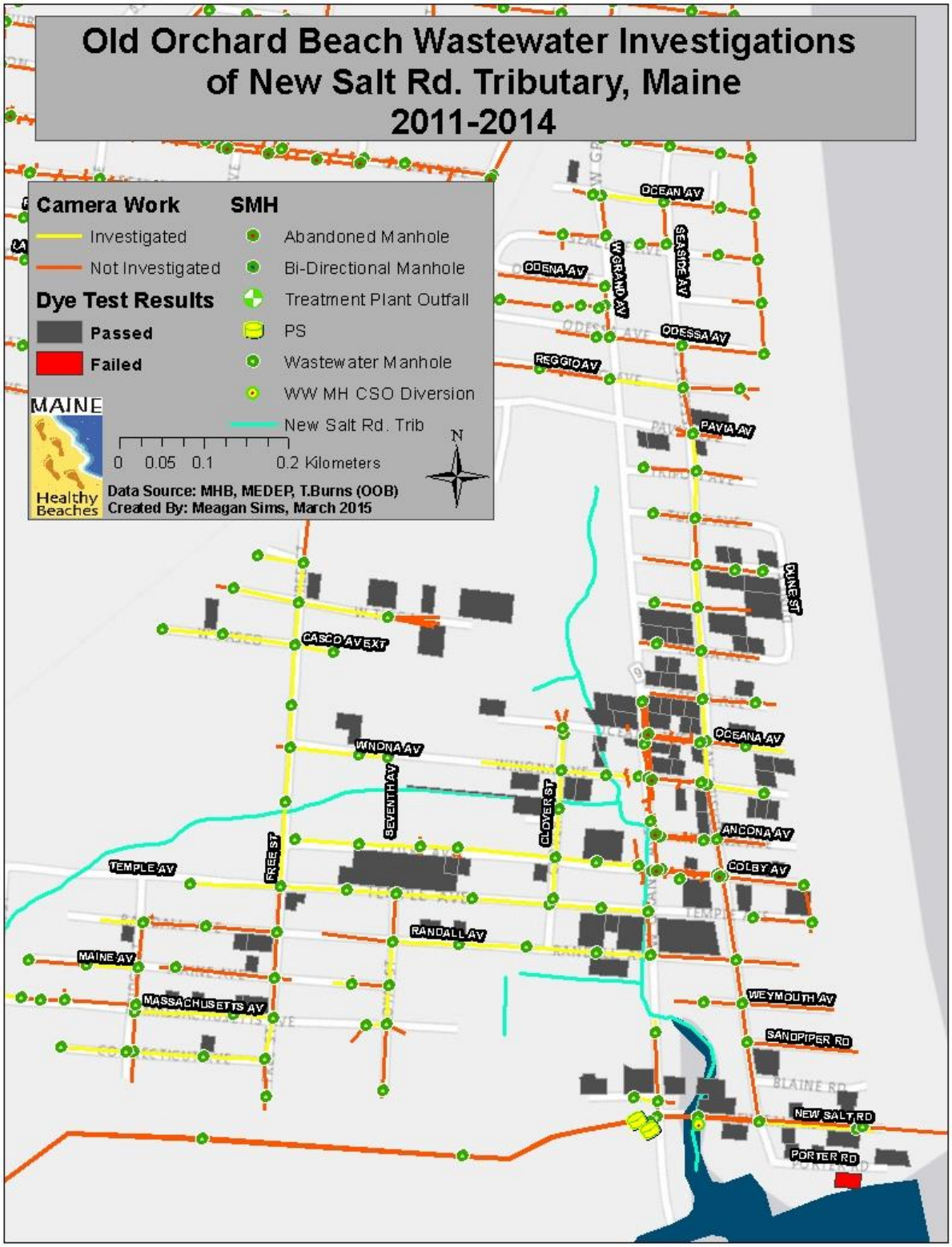

Figure 14. Old Orchard Beach wastewater camera and dye test investigations conducted by Public Works from 2011 to 2014 along the New Salt Rd. Tributary. This figure may not contain all work completed and it will be periodically updated as new information is received by MHB.

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 9-10, Table A7).

- **Mouth of GFB**
    - The apparent trend in the mouth of the brook is higher ENT results on an incoming tide (Figure 8, Table A2) 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 7).
- **GFB-05 Series**
    - Consistently high ENT and OB values where the brook runs beneath a residential area between sites GFB-05-1 (Oceana Ave.) and GFB-05-0 (Rt.9 near Casco Ave.) necessitate further investigation (Figure 2).
    - 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 2).
- **GFB-01 Series**
    - Although the town has tested this area, 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 2).

As time and resources allow, it is 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 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 post a precautionary rainfall advisory 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.

Supplementary Data

2012-2014 Monitoring Data

Table A1. 2012-2014 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-05-6	2013	44.6	81.7	9	9
GFB-01	2012-2014	384.1	85.7	37	29
GFB-01-0	2012-2014	412.0	98.3	25	26
GFB-01-1	2012-2014	252.5	98.8	25	26
GFB-04	2012-2014	190.2	89.1	24	25
GFB-04-0	2012-2014	137.0	81.9	24	25
GFB-04-0-1	2012-2014	177.1	79.5	23	24
GFB-05	2012-2014	454.8	105.5	25	26
GFB-05-0	2012-2014	834.7	119.4	24	25
GFB-05-1	2012-2014	523.6	105.4	25	26
GFB-05-2	2012-2014	77.9	97.7	24	24
SACO-00	2012-2014	56.8	54.5	17	8
GFB-01-2	2012-2014	504.7	87.0	13	13
GFB-04-0B	2013-2014	170.5	83.1	19	19
GFB-05-4	2013-2014	58.2	69.6	20	20
GFB-05-5	2013-2014	16.5	91.9	20	19
Total		**197**	**91**	**370**	**364**

Table A2. 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

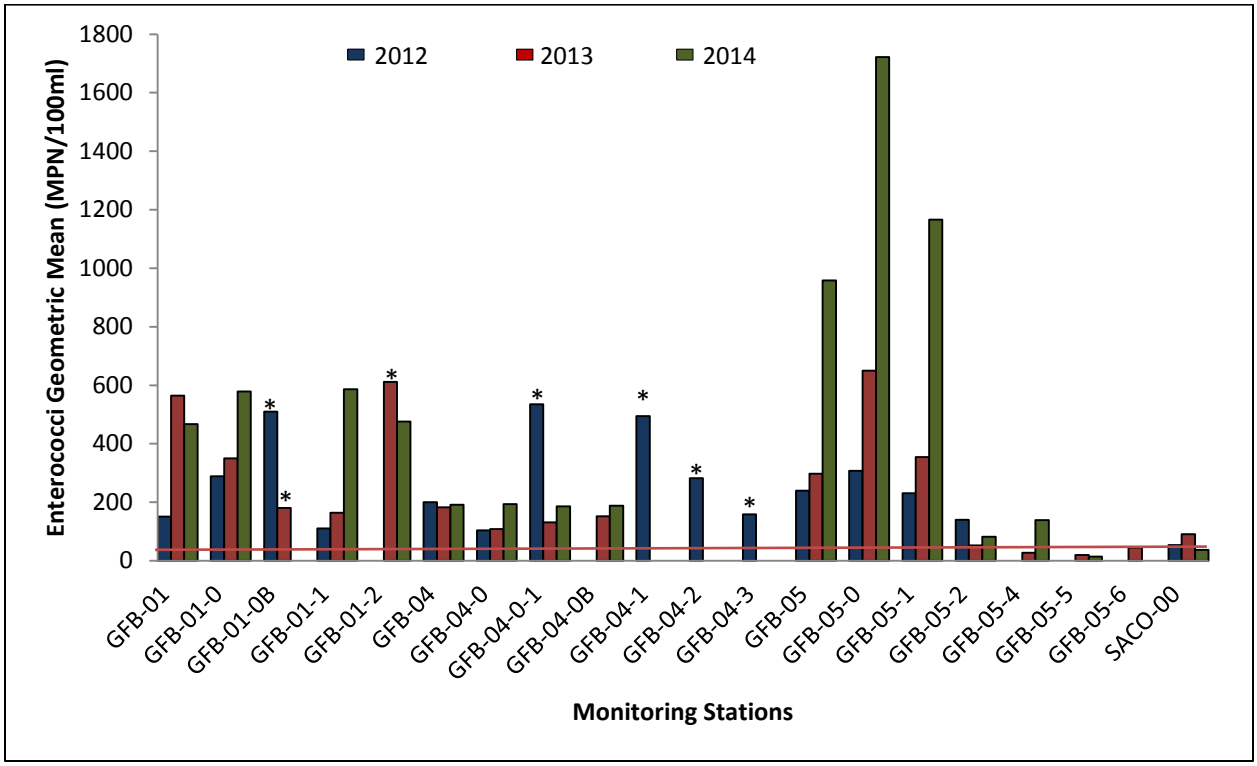

Figure A1. The 2012-2014 ENT geometric mean (MPN/100ml) values by monitoring station in the NSRT as indicated by blue (2012), red (2013), and green (2014) bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples (mean given rather than geomean).

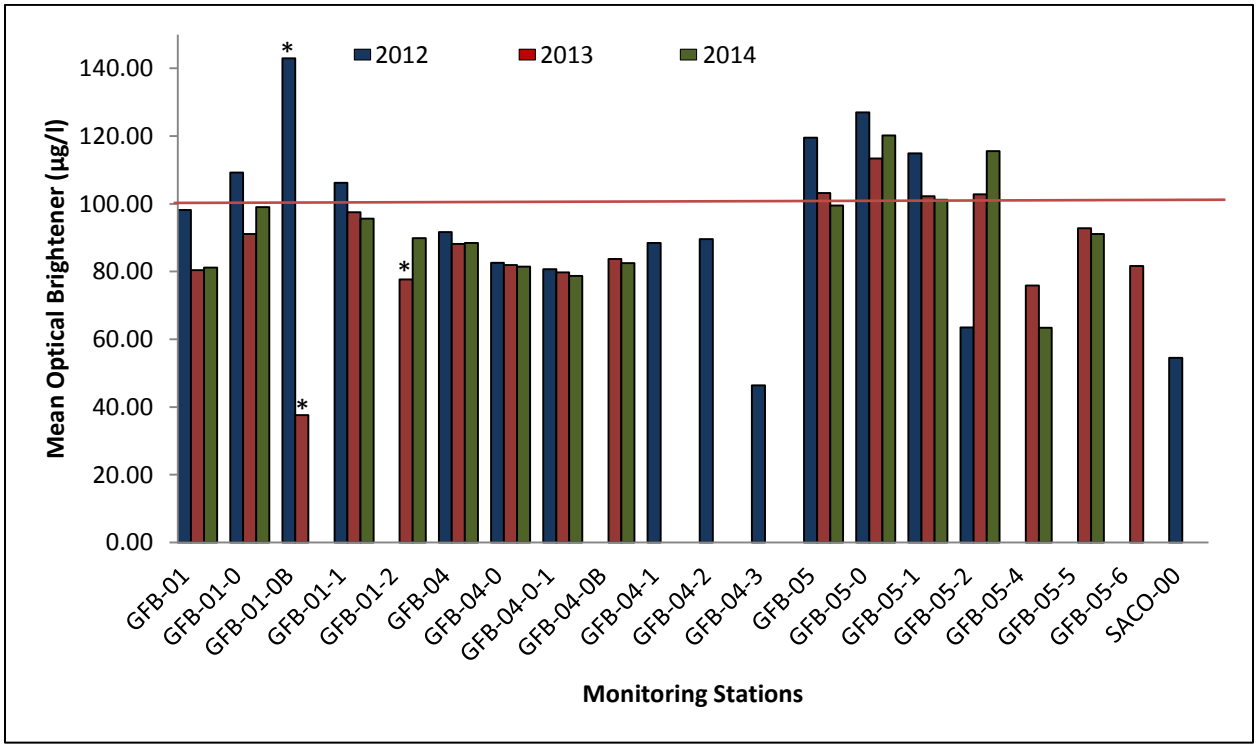

Figure A2. The 2012-2014 mean optical brightener (µg/l) concentration by monitoring station in the NSRT as indicated by blue (2012), red bars (2013) and green (2014) bars. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.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

2014 Monitoring Data

Table A3. 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	**616**	**275**	**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.

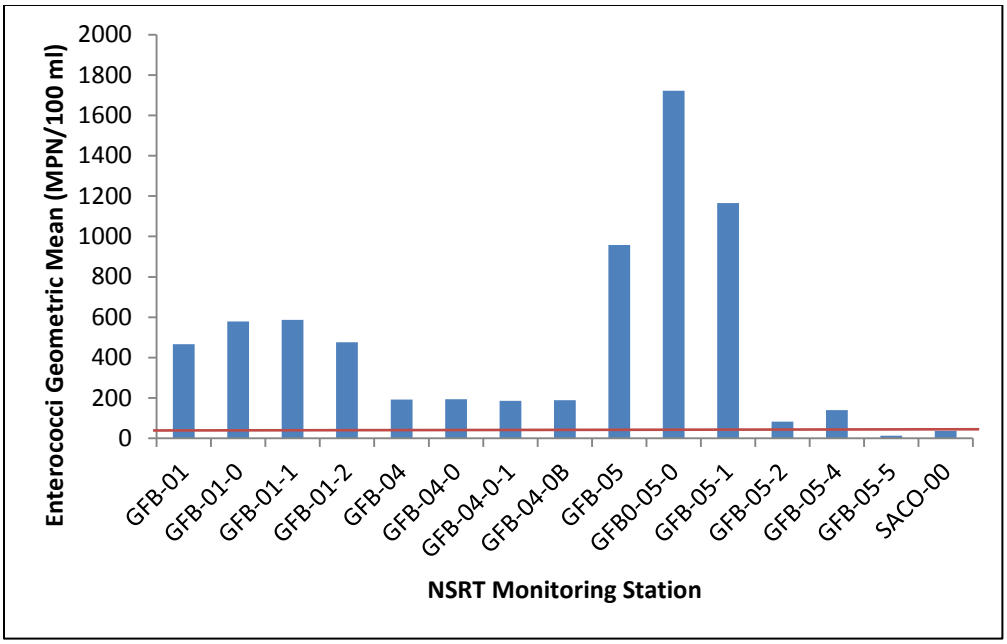

Figure A3. The 2014 enterococci geometric mean (MPN/100ml) values by monitoring station in the NSRT as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml.

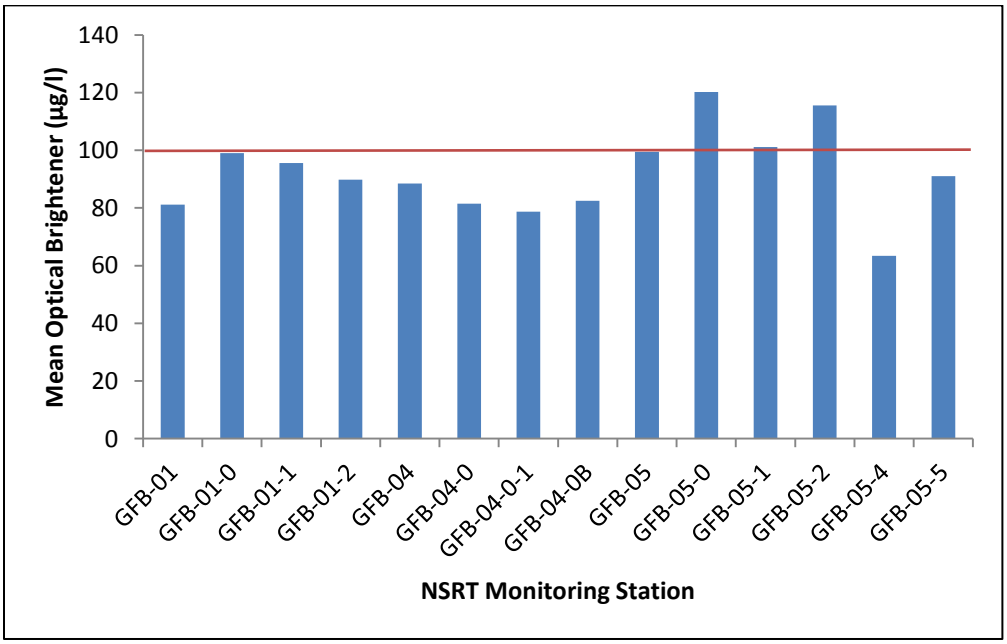

Figure A4. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2014. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination.

2013 Monitoring Data

Table A4. 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**

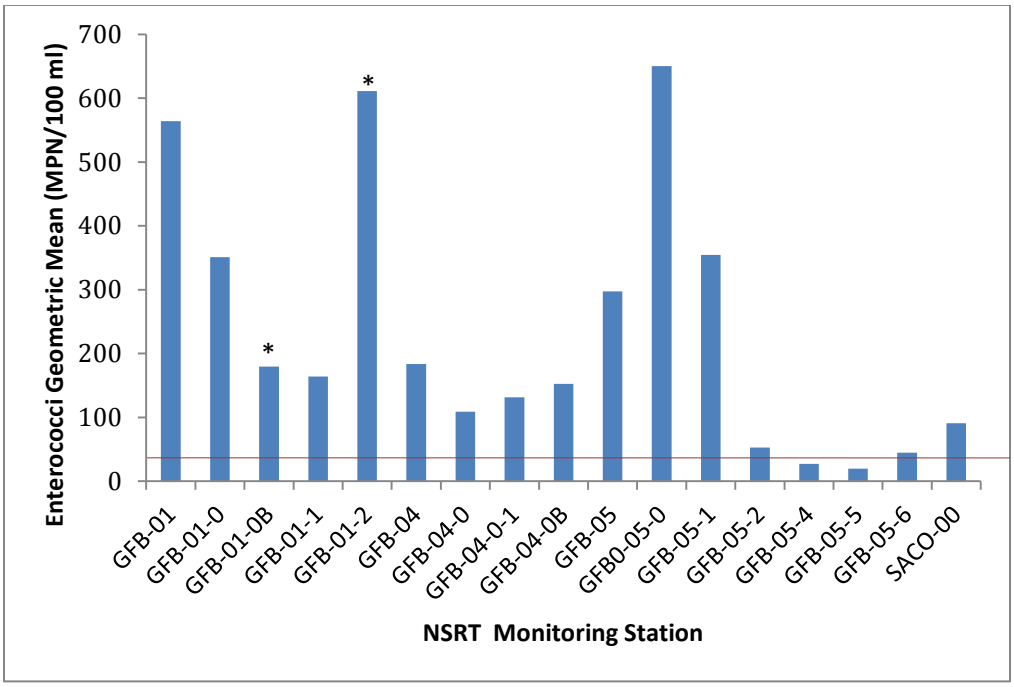

Figure A5. The 2013 geometric mean enterococci (MPN/100ml) values by monitoring station in the NSRT as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5samples.

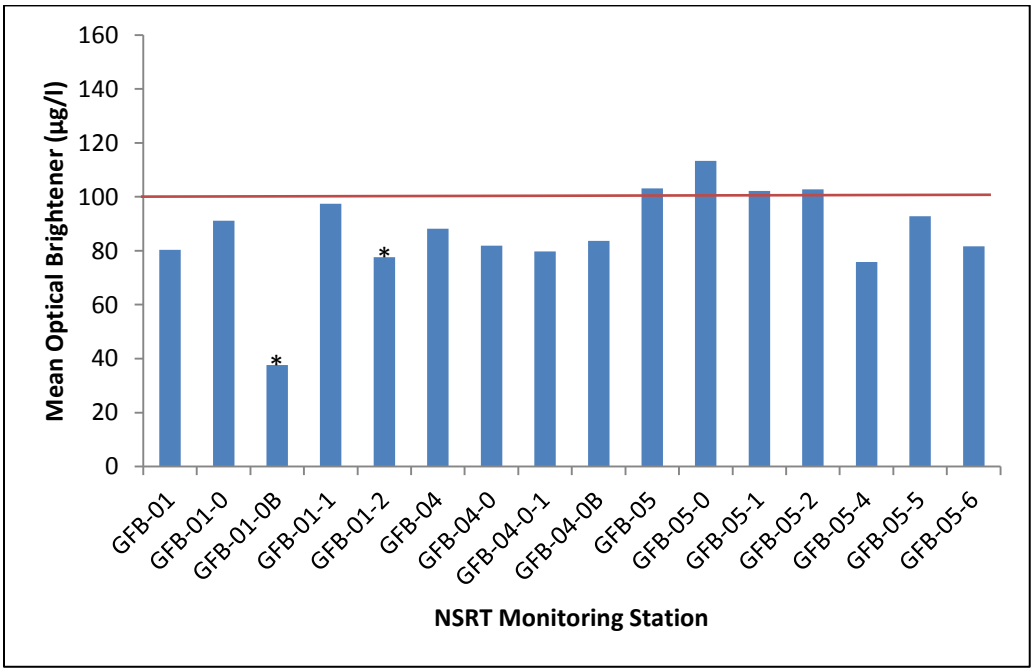

Figure A6. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2013. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

2012 Monitoring Data and Source Tracking Toolbox

Table A5. 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**

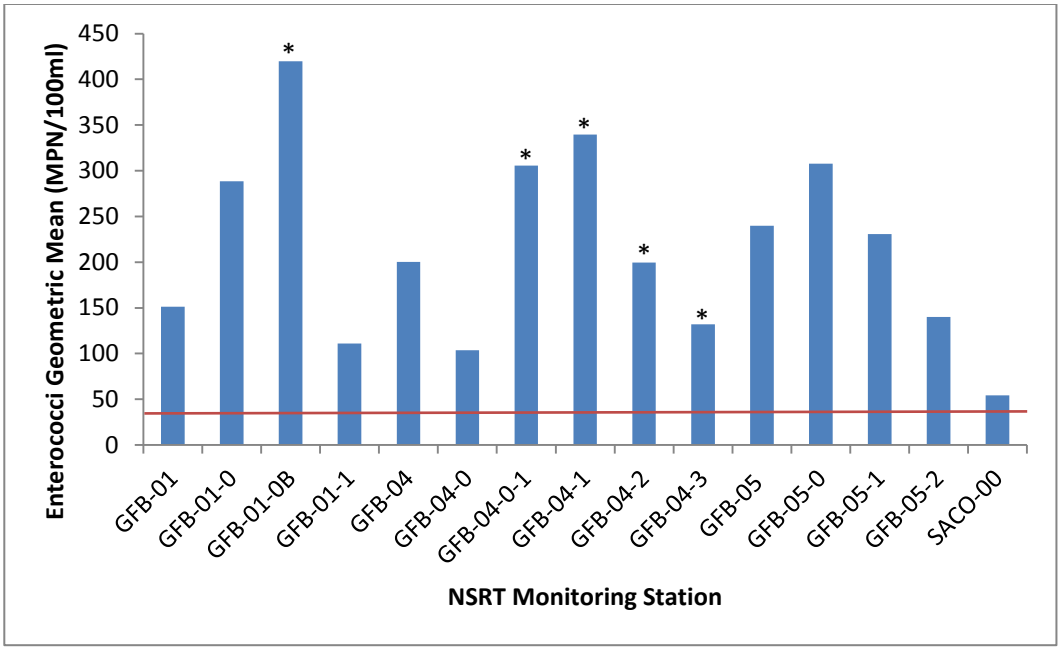

Figure A7. The 2012 geometric mean enterococci (MPN/100ml) values by monitoring station in the NSRT as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on fewer than 5 samples.

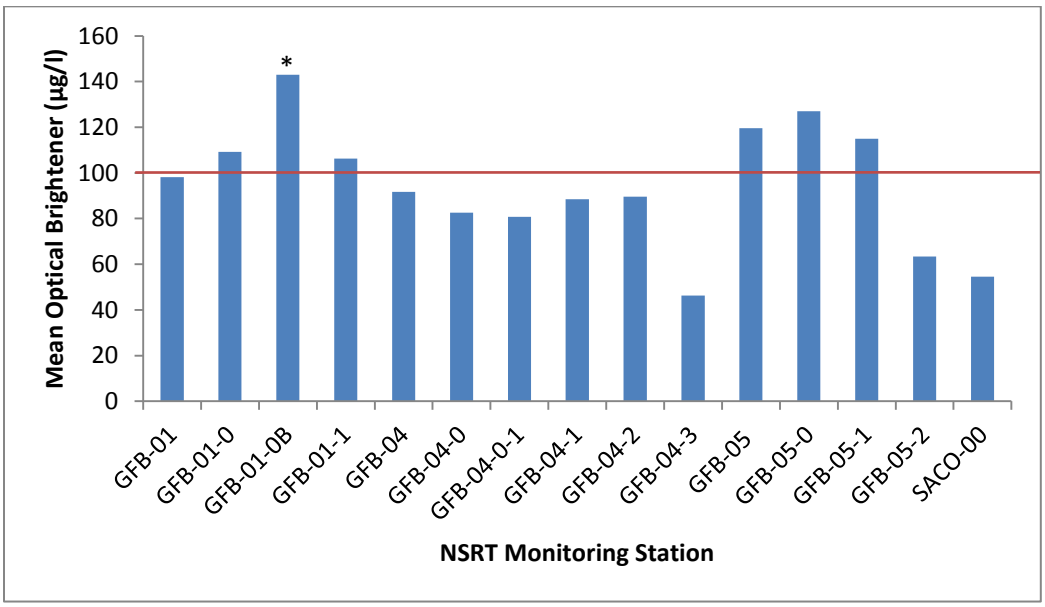

Figure A8. NSRT mean optical brightener (µg/l) concentrations by monitoring station for 2012. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on fewer than 5 samples.

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 A7). US EPA did not provide PPCP support in 2013-2014.

Table A6. Description of 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 2013-2014.

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 A7. 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.