

**Summary Report of Enhanced Monitoring and Pollution Source Tracking Efforts in the  
Spurwink River, Maine, 2010-2013**

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## **Executive Summary**

The Spurwink River empties on to the western edge of Higgins Beach and the watershed is shared by the towns of South Portland, Cape Elizabeth, and Scarborough. Routine water quality exceedances on Higgins Beach prompted the need to add additional sites upland in the Spurwink River to pinpoint pollution sources. Impaired water quality degrades ecosystems and threatens human health and Maine's tourist economy. Maine Healthy Beaches (MHB) initiated enhanced monitoring in 2010 and continued for the 2012 and 2013 beach seasons. Monitoring sites were evaluated based on whether or not Enterococci (geometric mean) values exceeded the US EPA-recommended safety threshold and if optical brightener (mean) levels surpassed the "red-flag" concentration suggestive of human-sourced fecal contamination. MHB brought together local and state agency partners in 2012 to share data and develop next steps. Monitoring was concentrated in the lower reaches of the river in 2013. Sites HC-1, SPRAGUE-2, and SPUR-02-1 exhibited high mean concentrations of both Enterococci and optical brighteners and positive deviations from the overall means for both parameters suggesting the likelihood of human-sourced fecal contamination impacting water quality at these locations. Alternatively, SPUR-03, SPUR-05, and SPUR-06 exhibited high bacteria levels and moderate to low optical brightener concentrations suggesting wildlife as a likely contributor to impaired bacteria levels at these sites. Additionally, Maine DEP and MHB surveyed 23 priority properties and one malfunction was detected and remediated in 2013. It is recommended that the towns within the watershed expand property surveys upland in the river and conduct Illicit Discharge Detection and Elimination (IDDE) studies to ensure the integrity of sewer and stormwater infrastructure. Best practices such as routine pumping of septic systems, vegetative buffers, pet waste and manure management, and posting precautionary rainfall advisories at Higgins Beach are also recommended.

## **Acknowledgements**

Written and compiled by Keri Kaczor and Meagan Sims, Maine Healthy Beaches Program; UMaine Cooperative Extension. Reviewed by John Greene-The Sprague Corporation. Special thanks to the dedicated volunteers who helped collect samples: James Riechel, Maureen Burns, John Greene, Suzan Nixon and Aileen Crawford, as well as Maine DEP, US EPA, and Scarborough for their support.

## **Introduction**

The Spurwink River watershed is a tidal river estuary with a total area of approximately 55 km<sup>2</sup> and is divided between three municipalities: Scarborough (34.69%), Cape Elizabeth (49.16%), and South Portland (13.63%), Maine. Land use and wastewater infrastructure varies significantly by municipality (Figure 1).

### *South Portland*

While the portion of the watershed in South Portland is small (13.63%), developed area (31%) comprises the highest percent of total land area, followed by open space (23%), much of which is encompassed by a complex of athletic fields. All properties within this portion of the watershed

are serviced by municipal sewer, however all stormwater infrastructure drains directly to Spurwink River tributaries.

### Cape Elizabeth

The majority of the Spurwink River watershed falls within Cape Elizabeth (49.16%). Land cover is split between forests (37%), grasslands (18%), and wetland/wetland forest (14%). While most of the land cover data is not categorized as “developed”, the majority of grassland area adjacent to the river has been developed for residential use and all properties have subsurface wastewater disposal (septic) systems. A large portion of the property along the east bank of the estuarine portion of the Spurwink River is owned by The Sprague Corporation, is largely undeveloped, and is used primarily as an equine facility and agriculture.

### Scarborough

Approximately 35% of the watershed is located within Scarborough. The majority of area bordering the river is classified as “forested or wetland/wetland forest” and most of this area is also residentially developed. While the Higgins Beach community (housing development directly behind the beach) is entirely on municipal sewer, it marks the terminus of public wastewater utilities in the town. All properties beyond Higgins Beach along the west bank of the river are on private septic systems.

### Shellfish Growing Area WH

Higgins Beach and the Spurwink River also fall with the shellfish growing area WH, managed by the Maine Department of Marine Resources (DMR) Shellfish Sanitation Program. Every 12 years, the DMR conducts a full shoreline survey and a “drive through” survey is conducted annually. Recent DMR results suggest the possibility of changing the growing area designation to “year round open” status pending further data and review process. The request to change the designation was made in December 2013 and the area will be reassessed in 2014.

The mouth of the Spurwink River empties onto Higgins Beach in Scarborough, Maine. Maine Healthy Beaches (MHB) routinely monitors four sites during the swim season at Higgins Beach; 3 beach monitoring stations (Hig-1, Hig-2, Hig- 3) and until 2013, one station located on the west bank of the Spurwink River mouth (Hig-0) (Figure 2). Bacterial exceedances on Higgins Beach are often associated with antecedent rainfall. Since the program began monitoring the site in 2008, Hig-0 has had the greatest Enterococci geometric mean value of all 4 sites (Figure 3), suggesting that the river is likely the primary contributor to bacterial pollution to the beach areas at Higgins Beach.

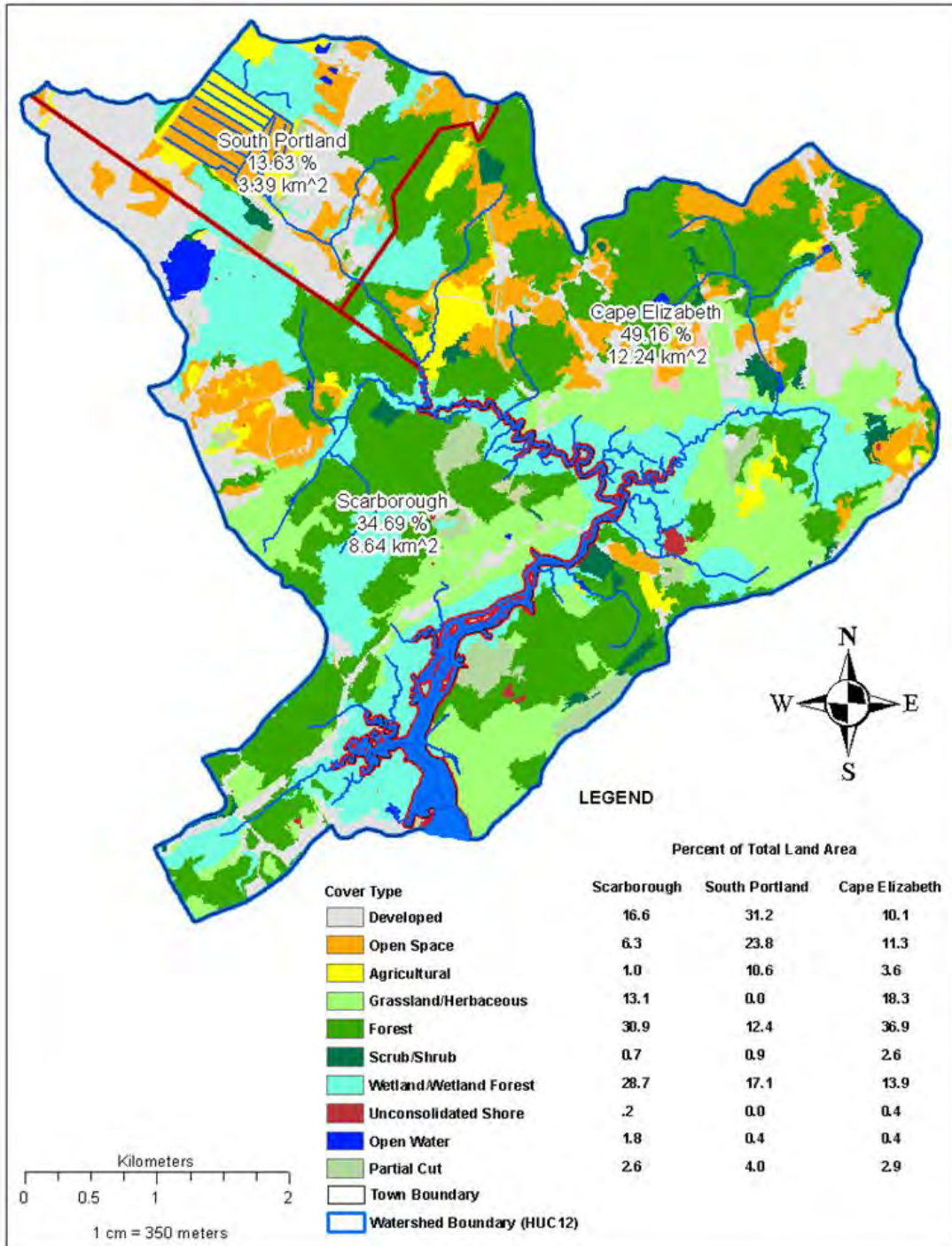


Figure 1. Spurwink River watershed showing land cover percentages, town boarders (red lines), and streams and tributaries (blue).



Figure 2. Routine monitoring sites on Higgins Beach, Scarborough, Maine.

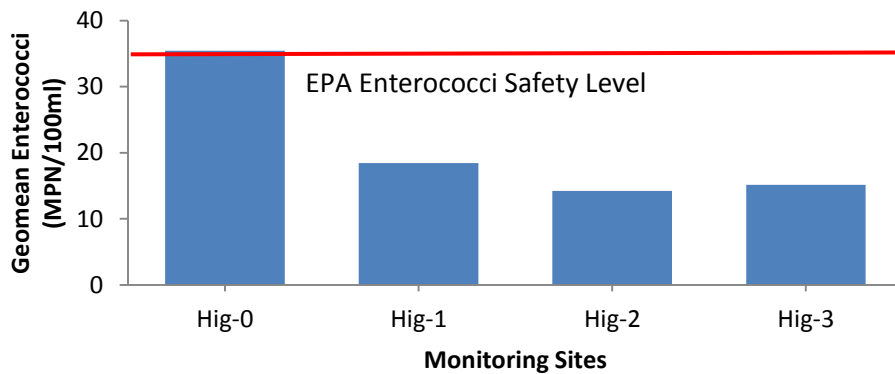


Figure 3. Geometric mean values of routinely monitored beach sites from 2004 to 2013. Red line indicates US EPA geometric mean safety limit of 35 MPN/100mls for recreational marine waters for at least 5 samples collected over a 30-day period (Hig-0 monitoring discontinued after 2012).

## Enhanced Monitoring: Methods and Results

Enterococci bacteria indicate the presence of fecal contamination from warm-blooded animals and the possible presence of disease-causing microorganisms. Optical brighteners are commonly used in commercial/retail products such as clothing detergents, dishwashing agents, and personal care products to brighten the whiteness of materials. Elevated Enterococci levels coupled with high optical brightener concentrations can be indicative of human-sourced fecal contamination.

One potentially useful approach to identifying “hot-spots” of contamination is by examining how levels for each site deviate from the mean of all sites, particularly in areas where humic interference can occur and result in elevated optical brightener readings. This is true for areas of the Spurwink River watershed where these humic substances (tannis and other dissolved organics) can be present. Examining deviations from the mean can help pull a meaningful signal from the variability and help identify the most problematic sites within the system that are likely influenced by human sources.

### 2010

With the help of local volunteers, MHB conducted a preliminary study in 2010 analyzing 56 Enterococci and 52 optical brightener samples at 4 sites within the Spurwink River watershed on a weekly basis (Figure 4, Table 1). Enterococci values ranged from 5-24196 MPN /100mls of sample water and all sites showed elevated Enterococci geometric mean levels except the site located nearest the mouth of the river, SPUR-1 (Figure 15).

Optical brightener concentrations ranged from 13-336  $\mu\text{g/l}$  (Figure 16). Due to the calibration of the instrument used for optical brightener analysis in 2010, 200  $\mu\text{g/l}$  was used as the lower threshold indicating the potential for human wastewater contamination. Although no monitoring sites had optical brightener values exceeding this threshold in 2010, SPUR-03 represented the site with the most elevated Enterococci and optical brightener values (Figures 15 and 16).

The overall geometric mean Enterococci value for all 2010 monitoring sites was 88 MPN/100 ml and one site (SPUR-03) exhibited a positive deviation (Figure 5A, Figure 6A, Table 1). For optical brighteners, the overall mean concentration for all sites was 107  $\mu\text{g/l}$  and two sites (SPUR-03 and SPUR-04) demonstrated positive deviations (Figure 5B, Figure 6B, Table 1). SPUR-03 was the only site monitored that exhibited positive deviations from both the Enterococci geometric mean and the optical brightener mean.

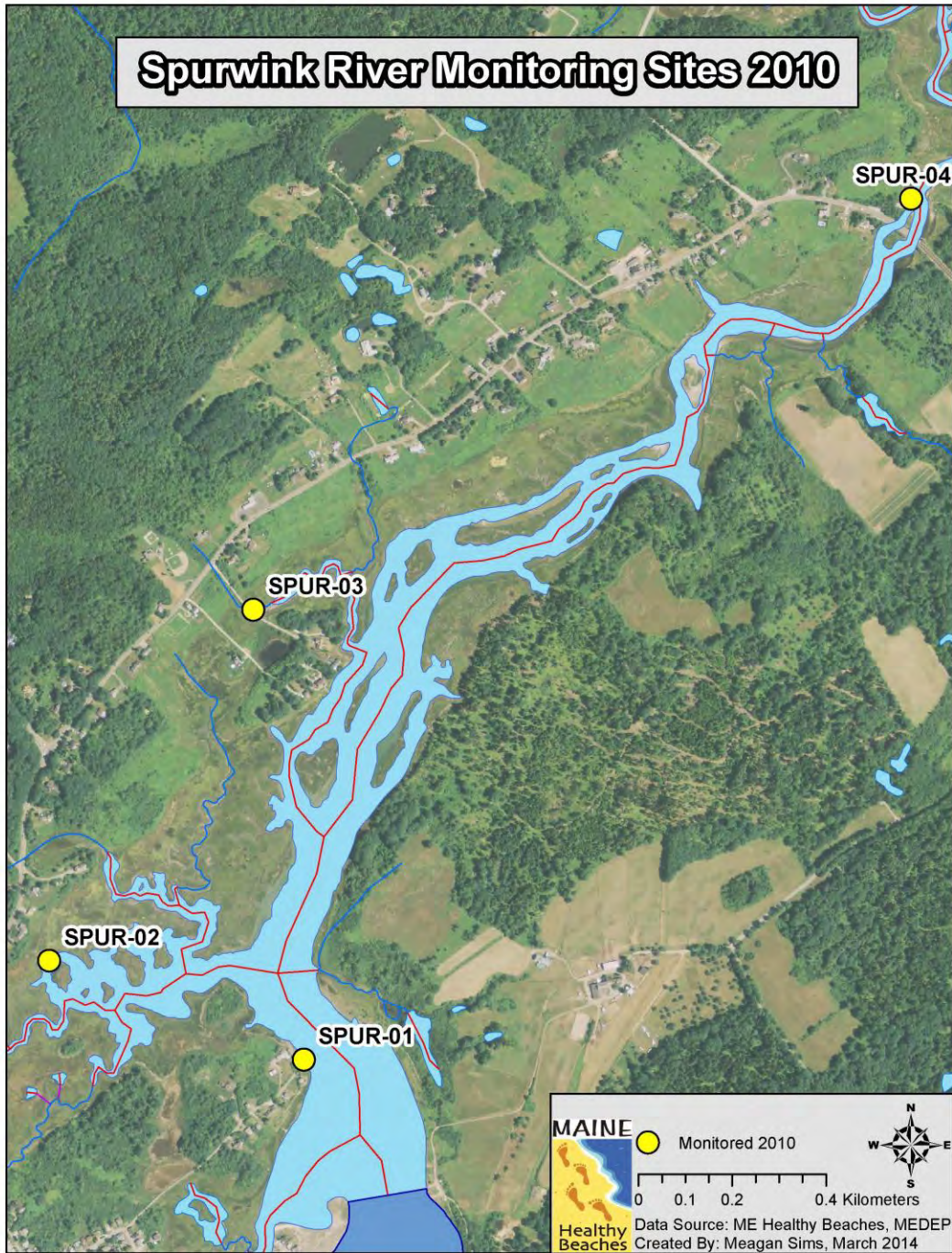


Figure 4. 2010 Spurwink River MHB monitoring stations.

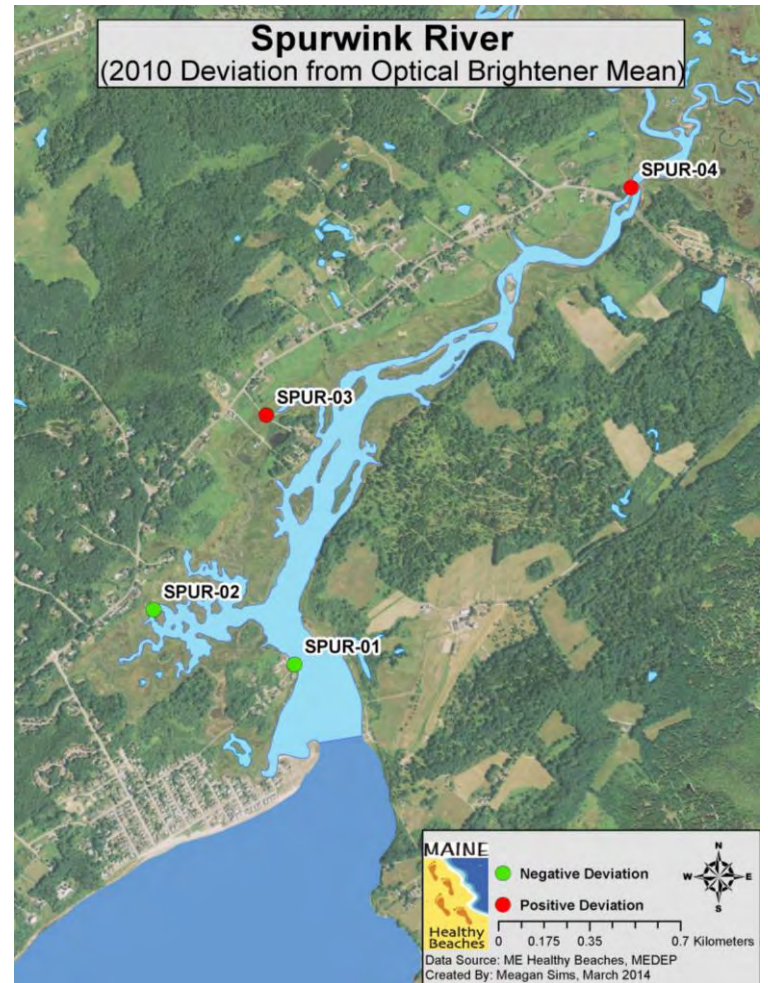
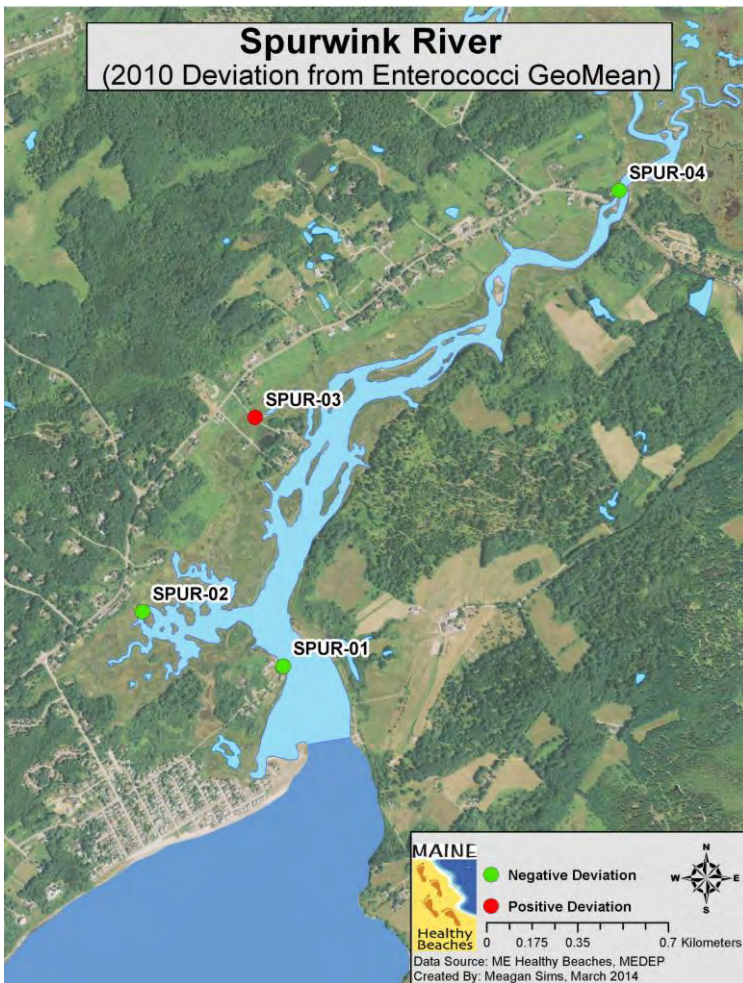


Figure 5, A & B. 2010 monitoring sites and deviations from watershed-wide Enterococci geomean and mean optical brightener concentrations. Negative deviations represent sites with a geomean Enterococci and OB value less than the watershed geomean and average. Positive deviations represent sites with geomean Enterococci and OB value greater than the watershed geomean and average.

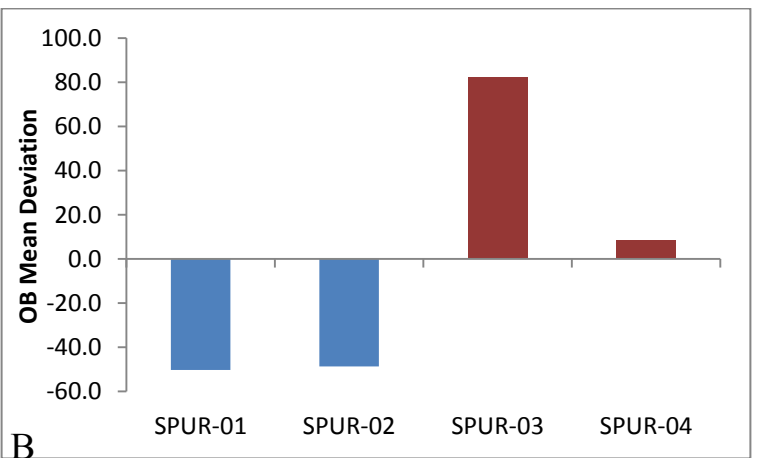
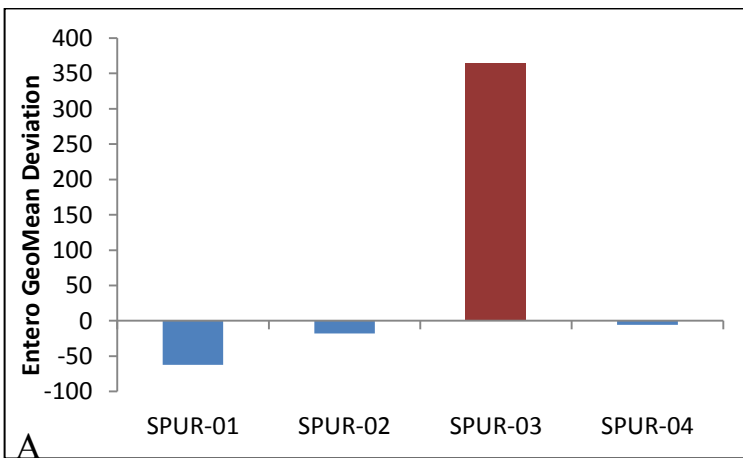


Figure 6, A & B. Deviations from the 2010 season-wide Enterococci geometric mean (A) and optical brightener (B) value for all Spurwink River sites. Bars above the X-axis indicate monitoring locations where Enterococci and optical brightener values were greater than the average value and bars below X-axis represent those that were lower than the average value.



2012

*Enhanced Monitoring*

In 2012, 21 Enterococci and optical brightener samples were analyzed at 7 sites in the Spurwink River watershed keeping in mind ease of accessibility and avoidance of private property (Figure 7). All monitoring events were conducted during ebb tide conditions, approaching low tide to assure downstream flow and decrease dilution with seawater. Enterococci values ranged from 98 MPN to 7270 MPN/100mls of sample water and optical brightener levels ranged from 61 to 234  $\mu\text{g/l}$  (Figures 17 and 18). The instrument used to analyze optical brighteners in 2012 and 2013 was calibrated differently than in 2010 and therefore, a lower threshold of 100  $\mu\text{g/l}$ , indicating the likelihood of human-sourced fecal contamination was used.

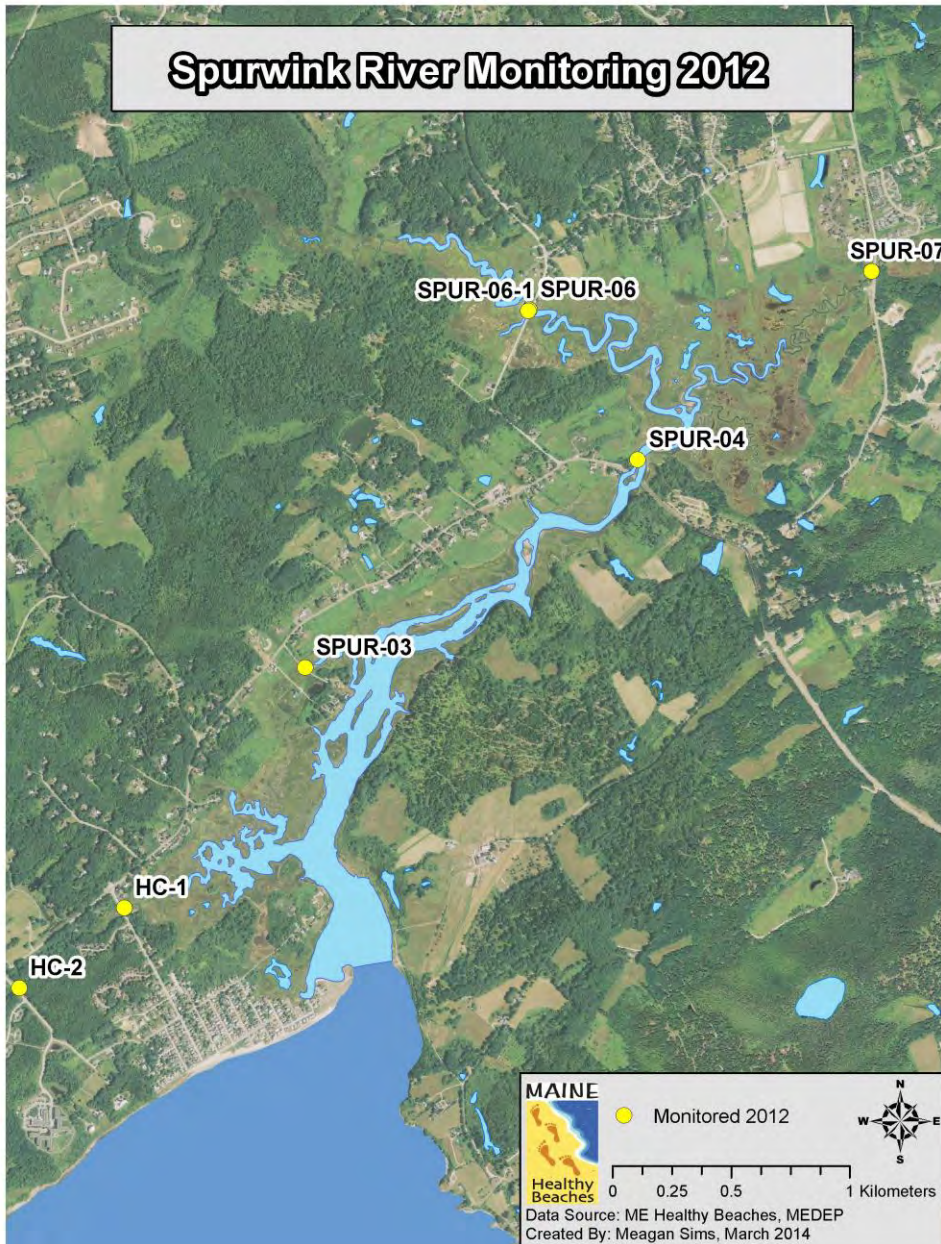


Figure 7. MHB monitoring stations in the Spurwink River in 2012.

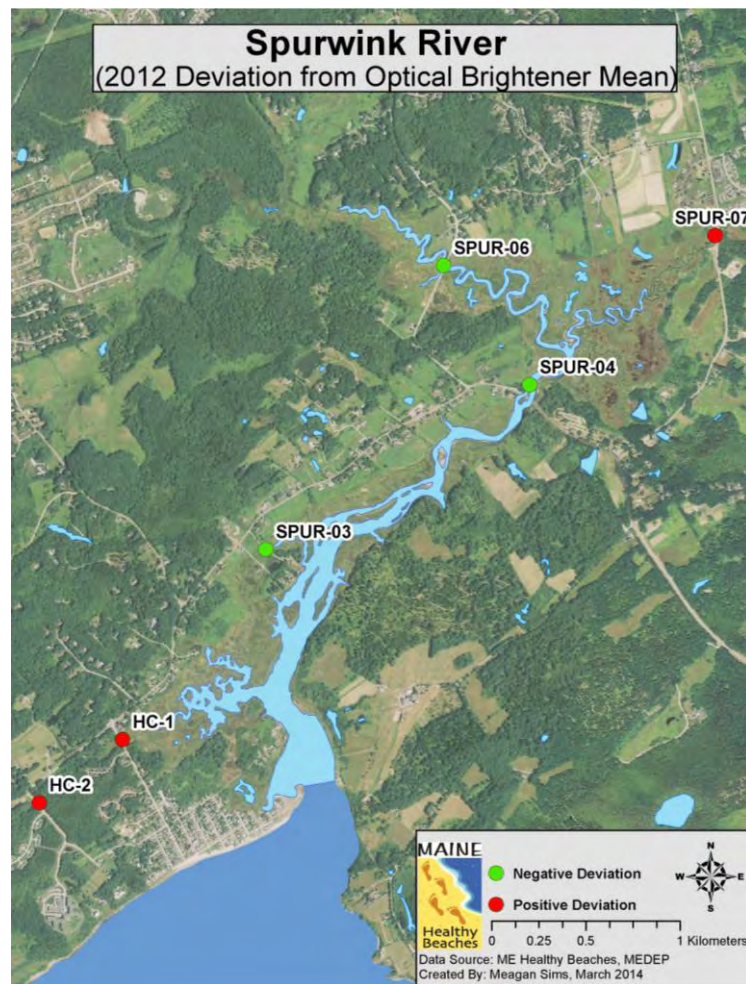
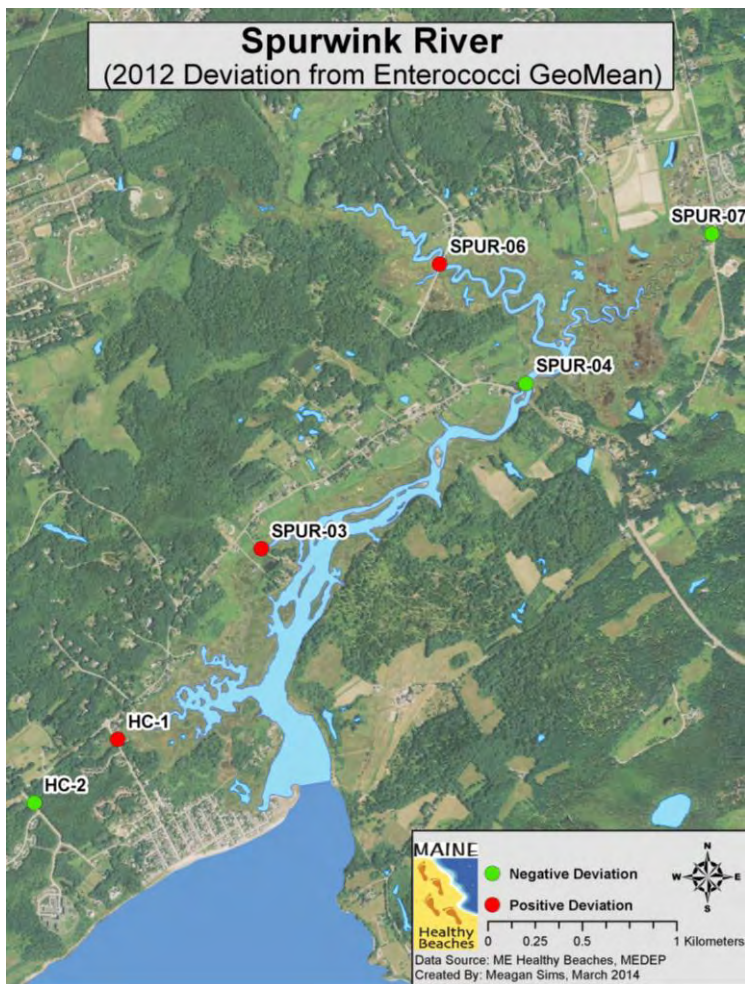


Figure 8, A & B. Deviation from watershed-wide Enterococci geomean and mean optical brightener concentrations. Negative deviations represent sites with a geomean Enterococci and OB value less than the watershed geomean and average. Positive deviations represent sites with geomean Enterococci and OB value greater than the watershed geomean and average.

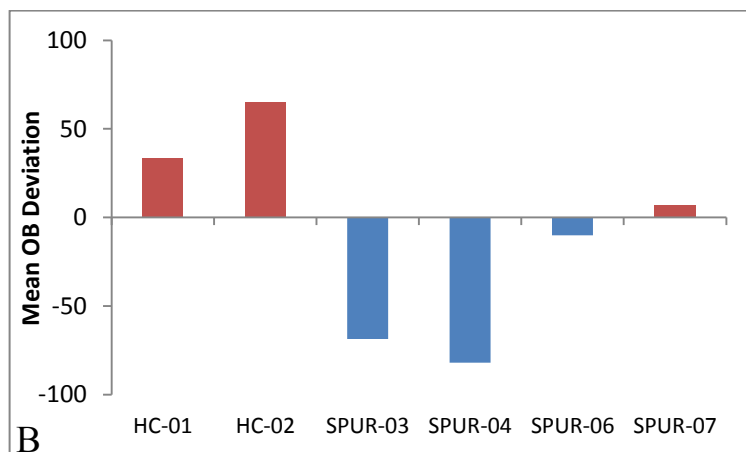
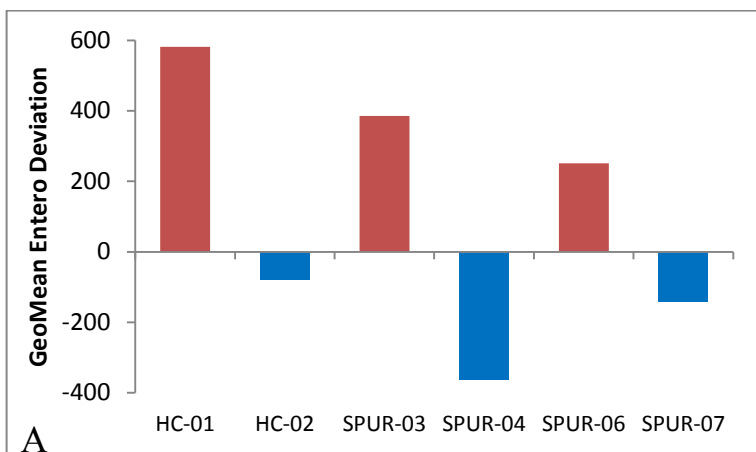


Figure 9, A & B. Deviations from the 2012 season-wide Enterococci geometric mean (A) and optical brightener (B) value for all Spurwink River sites. Bars above the X-axis indicate monitoring locations where Enterococci and optical brightener values were greater than the average value and bars below X-axis represent those that were lower than the average value.

In 2012, all monitored sites exceeded the US EPA-recommended Enterococci geometric mean safety threshold of 35 MPN/100 ml (Figure 17). However, low sample sizes may have inflated Enterococci results and therefore these results should be examined in conjunction with optical brightener data to discern any overall trends for this season. Four out of six sites (HC-01, HC-02, SPUR-06, SPUR-07) exceeded the 100 µg/l optical brightener threshold (Figure 18).

The overall geometric mean Enterococci value for the 2012 monitoring sites was 695 MPN/100 ml and three sites (HC-1, SPUR-03, SPUR-06) exhibited a positive deviation (Figure 8A, Figure 9A, Table 2). The overall mean optical brightener concentration for all sites was 156 µg/l and three sites showed a positive deviation (HC-1, HC-2, SPUR-07) (Figure 8B, Figure 9B, Table 2). HC-1 was the only site monitored that exhibited positive deviations from both the Enterococci geometric mean and the optical brightener mean.

Due to small sample sizes, data was combined for all sites to conduct a Pearson's Product Moment analysis. Results indicated no significant relationship between Enterococci and optical brighteners for stations throughout the Spurwink River watershed ( $R^2=0.0179$ ,  $p=0.5628$ ).

#### *Stakeholder Workshop*

In November 2012, MHB brought together the municipalities, state agency partners, concerned citizens, and a private corporation with significant land holdings along the east bank of the river to share data and next steps. It was recommended to expand monitoring efforts to include the east bank of the Spurwink River, to stratify sites further upstream (Cape Elizabeth and South Portland), conduct enhanced monitoring in areas of known contamination including along Wiley Way and Higgins Creek, and conduct a sanitary survey to determine the status of septic systems in priority areas (Figure 10).

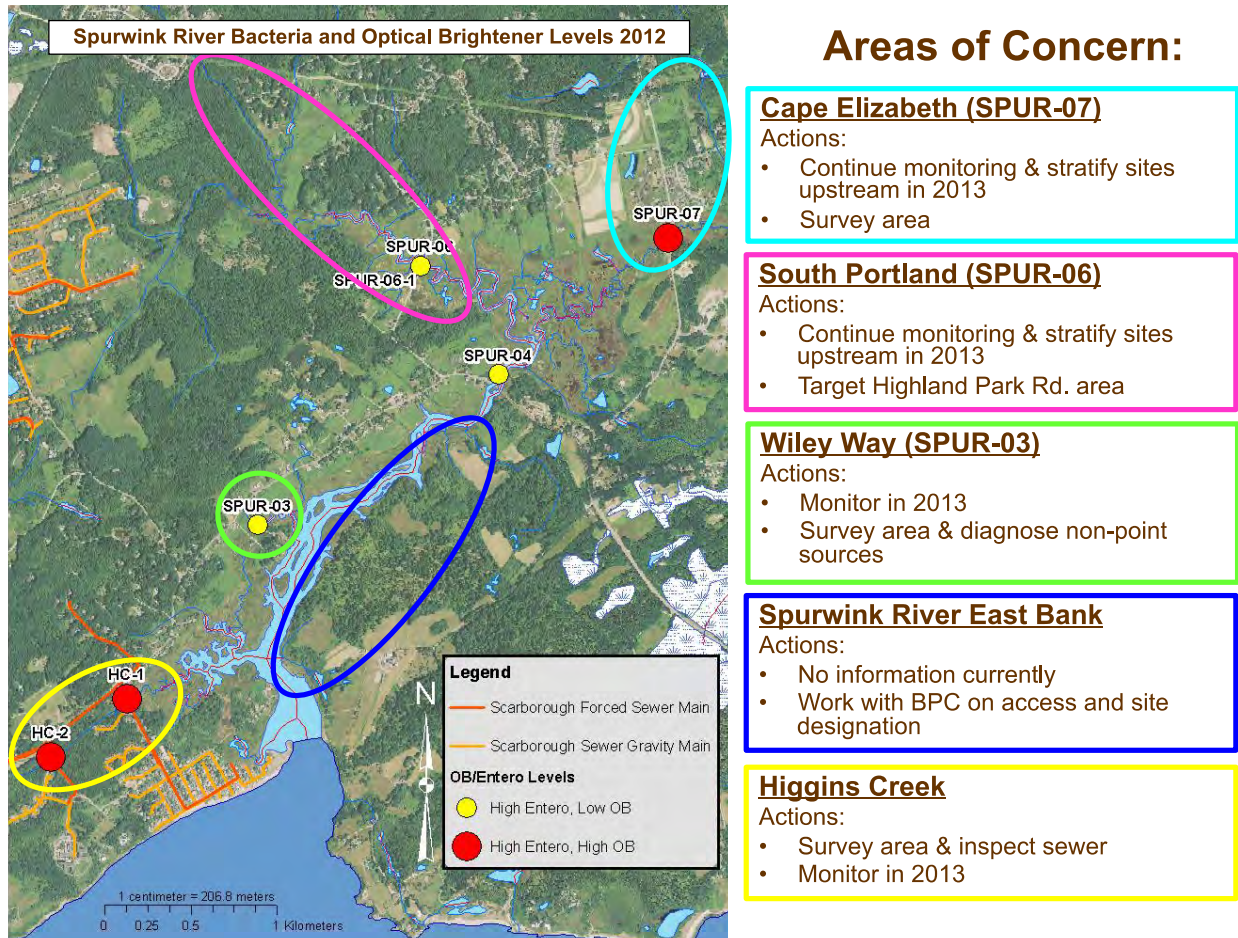


Figure 10. 2012 potential “hot-spots” of fecal contamination and areas warranting further investigation in 2013.

## 2013

### Enhanced Monitoring

Monitoring efforts for 2013 focused on the lower reaches of the Spurwink River, particularly areas associated with Higgins Creek and Wiley Way in an effort to target enhanced bacterial monitoring to those areas closest to the beach. As part of this effort 10 additional monitoring sites were added for the 2013 season. As a part of this effort, 122 Enterococci samples and 123 optical brightener samples were analyzed at 14 total sites throughout the watershed. These 14 sites included the addition of three sites along the east bank of the Spurwink River (SPRAGUE 1-3), an area not previously monitored by MHB (Figure 11). Enterococci values varied widely, ranging from 10 MPN to >24,196 MPN/100mls of sample water (the upper detection limit of the instrument) and optical brightener levels ranged from 6.62 to 220 µg/l. Thirteen out of 14 routine sites exceeded the US EPA-recommended Enterococci geometric mean safety threshold of 35 MPN/100 ml and 6 out of 14 sites exceeded the 100 µg/l optical brightener threshold (Figures 19 and 20).

The geometric mean Enterococci value for all 2013 monitoring sites was 93 MPN/100 ml and six sites (HC-1, SPRAGUE-2, SPRAGUE-3, SPUR-02-1, SPUR-03, SPUR-05) demonstrated a

positive deviation from that mean (Figure 12A, Figure 13A, Table 3). The overall mean optical brightener concentration for all sites was 100  $\mu\text{g/l}$  and six sites exhibited a positive deviation (HC-1, HC-2, HC-2-1, HC-3, SPRAGUE-2, SPUR-02-1) (Figure 12B, Figure 13B, Table 3).

A Pearson Product Moment correlation ( $R^2=0.1750$ ,  $p < 0.0000$ ), revealed a significant but very weak relationship between Enterococci and optical brightener concentrations.

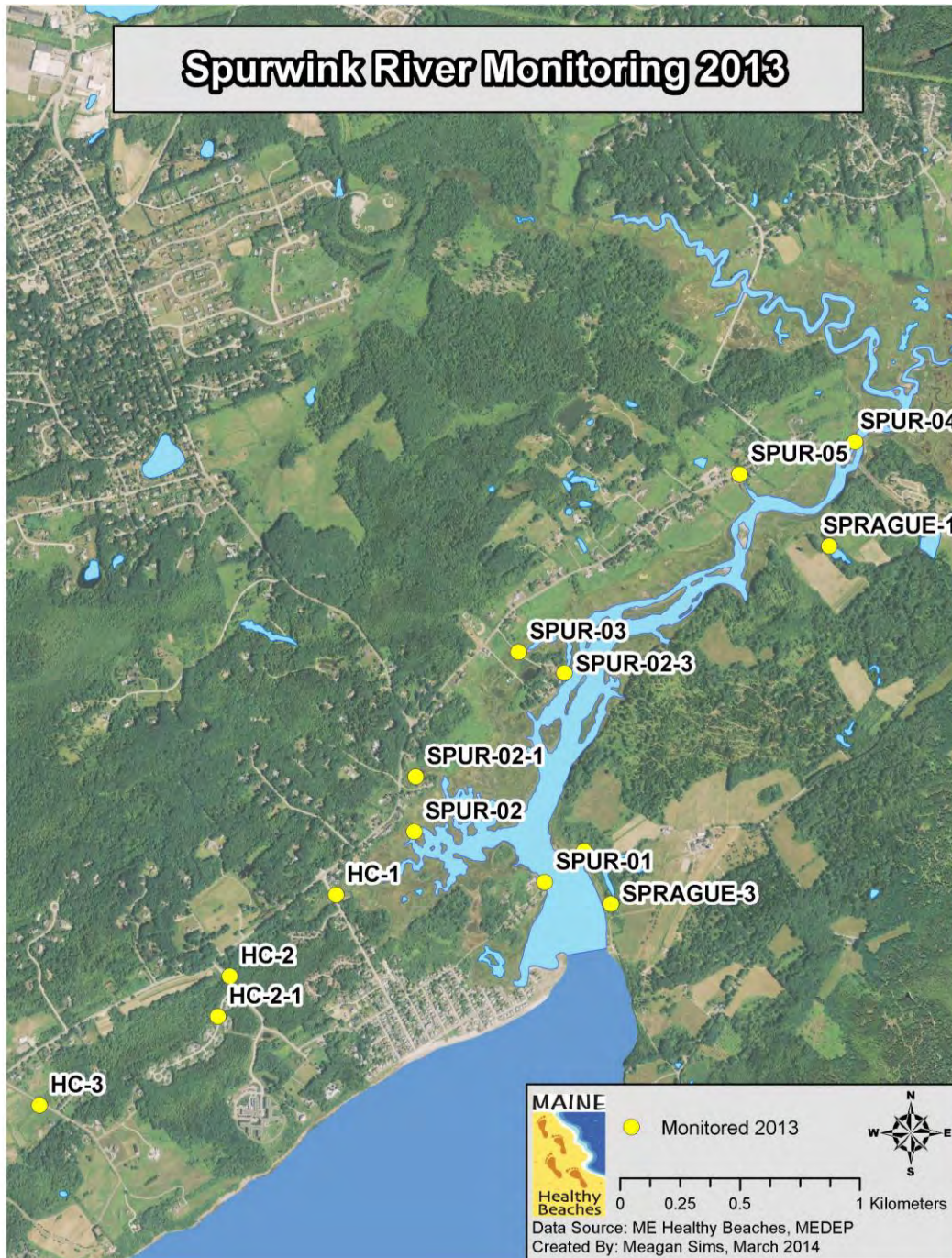


Figure 11. MHB monitoring stations in the Spurwink River in 2013.

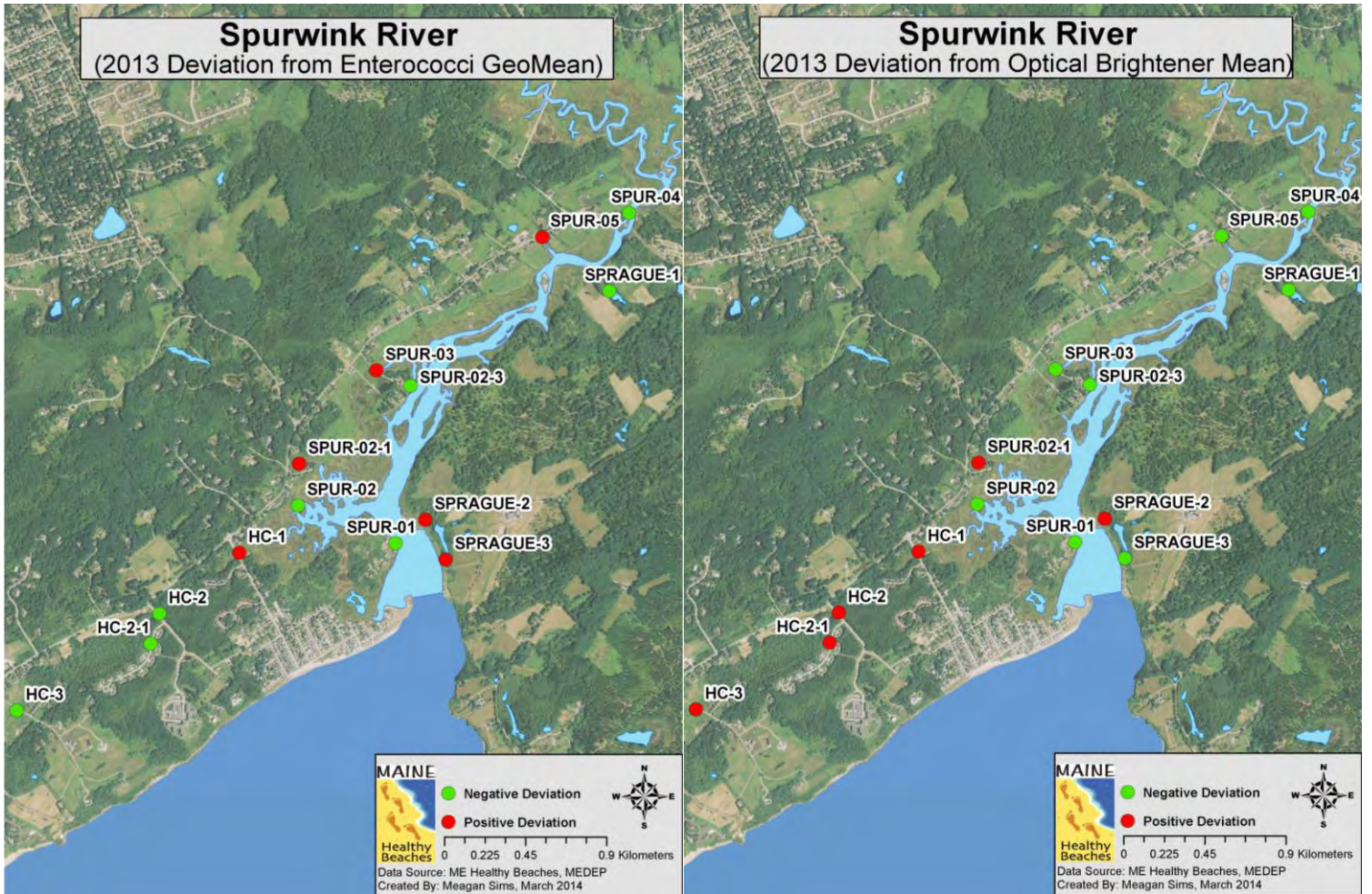


Figure 12, A & B. Deviation from watershed-wide Enterococci geomean and mean optical brightener concentrations. Negative deviations represent sites with a geomean Enterococci and OB value less than the watershed geomean and average. Positive deviations represent sites with geomean Enterococci and OB value greater than the watershed geomean and average.

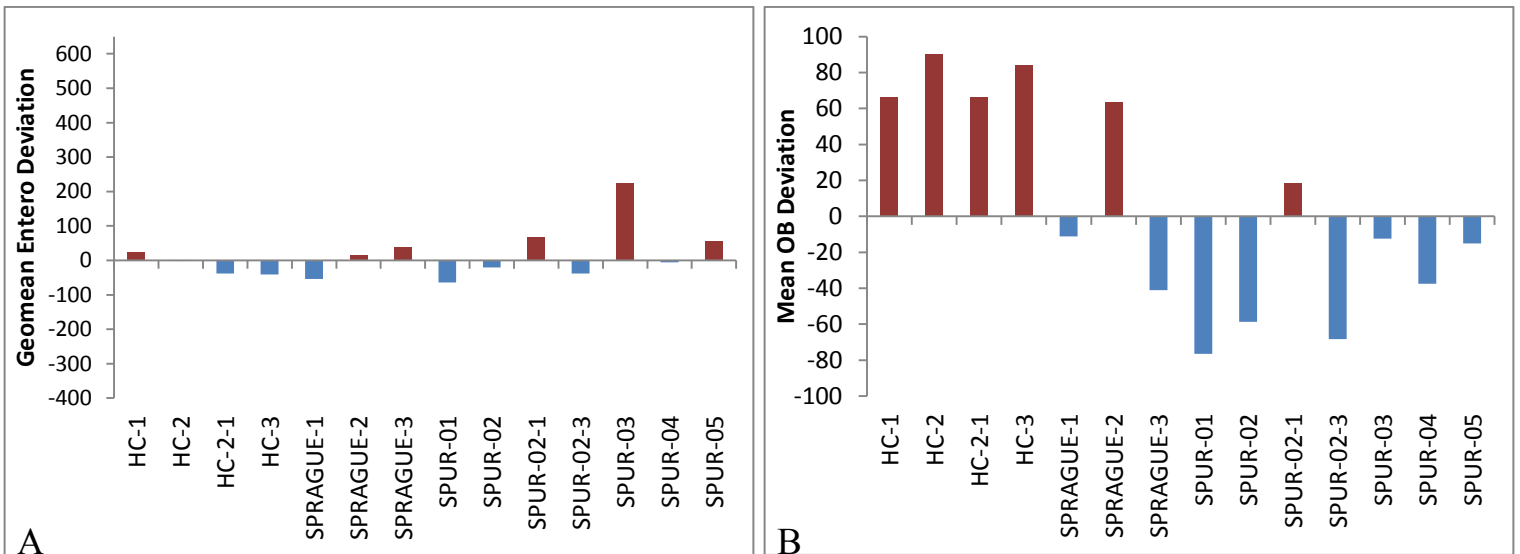


Figure 13, A & B. Deviations from the 2013 season Enterococci geometric mean (A) and optical brightener (B) value for all sites. Bars above the X-axis indicate monitoring locations where Enterococci and optical brightener values were greater than the average value. Bars below X-axis represent those that were lower than the average value.

### Sanitary Survey Work

In order to create the priority list of parcels used for the sanitary survey, MHB staff compiled HHE records from the Scarborough town office, reviewed previous survey work by ME DMR in 2009, created a database containing information for all individuals with septic systems in close proximity to the Spurwink River, and conducted planning meetings with Scarborough and DEP staff.

In July 2013 DEP and MHB surveyed 23 priority properties in close proximity to the river to determine if contamination may have resulted from malfunctioning septic systems (Figure 14). One malfunction was detected and remediated.

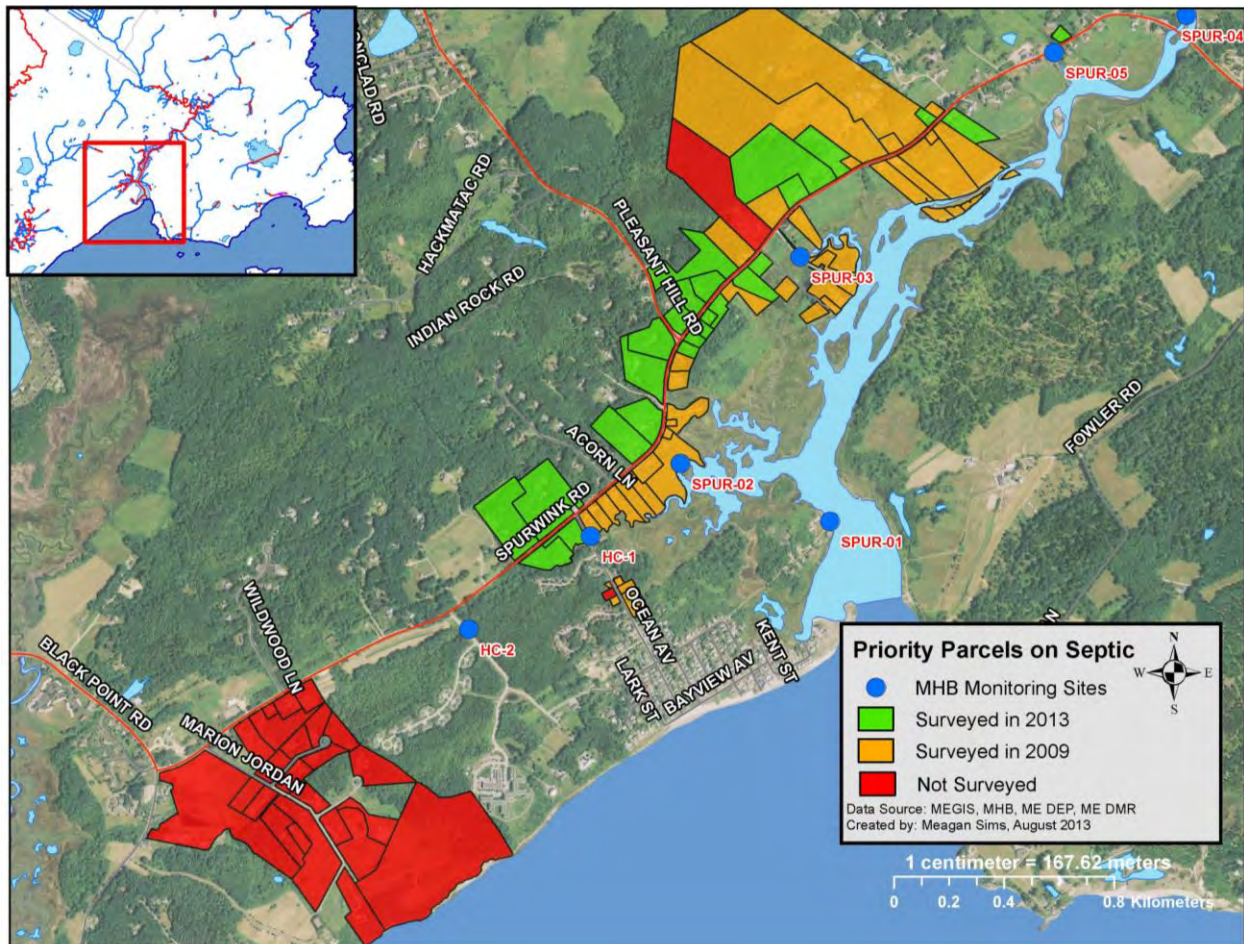


Figure 14. Priority parcels with septic systems within the Spurwink River watershed that were surveyed by DEP in 2009 and 2013, MHB monitoring site locations, and priority parcels that have not been surveyed.

### Discussion

For each year of the Spurwink River analysis, the monitoring effort was increased to include additional locations to help elucidate areas of potential human sourced bacterial contamination. Because the site location and sample sizes vary from year to year, direct comparisons between years were not conducted. Small sample sizes and humic interference may have also confounded

results. However, by examining overall trends in specific regions within the Spurwink River watershed over time, we can determine potential problem areas. Keeping in mind differences in sample sizes and monitoring sites, there appears to be an improvement in water quality from 2012 to 2013 when comparing overall geometric mean Enterococci and mean OB values for all sites (Tables 2 and 3). Additionally, the 2013 geometric mean Enterococci and OB values were lower for individual sites monitored during both 2012 and 2013 (Figures 21 and 22). Although 2013 efforts focused on the lower reaches of the river, upland areas monitored in 2012 (SPUR-06 and SPUR-07) may require additional monitoring to identify potential upstream pollution contributions.

A Pearson Product Moment correlation ( $R^2=0.2084$ ,  $p < 0.0000$ ) combining 2012-2013 data for all sites, revealed a significant but weak correlation between Enterococci and optical brightener levels (Figure 23, Table 4). The weak correlation, elevated mean concentrations of both parameters, and positive deviations from the mean suggests human-sourced fecal contamination in Higgins Creek (site HC-1) on the lower western bank of the river (SPRAGUE-2), and the tributary across from Birch Ln that feeds into the river (SPUR-02-1). Examining the deviation from sample means of both Enterococci data and OB data can derive meaningful information on potential target areas for human contamination. Monitoring sites with elevated Enterococci geometric means with moderate to low optical brightener means indicate wildlife may be the primary contributor to bacteria levels (SPUR-03, SPUR-05, and SPUR-06).

## **Recommendations**

### Monitoring

Additional monitoring is needed to further explore the source(s) of pollution and to verify sites are clean following remediation work. The specific areas of concern include the Higgins Creek Area (HC-1) and a nearby tributary across from Birch Ln (SPUR-02-1), Wiley Way (SPUR-03), upstream of SPUR-05 approaching South Portland (SPUR-06), and along the southern portion east bank of the river adjacent to the property managed by The Sprague Corporation (Figure 11). It is important that monitoring results and remediation work be shared with partners to inform beach management decisions and potentially the reclassification of the shellfish growing area WH.

### Target Human Sources

It is recommended that the towns within the watershed expand property surveys upland in the river to identify any malfunctioning septic systems. Priority areas include the systems upland of site SPUR-7 in Cape Elizabeth located along the edge of wetlands adjacent to the river. Additionally, the towns should consider conducting Illicit Discharge Detection and Elimination (IDDE) studies using video surveys as well as smoke and dye testing to identify illicit cross connections between the sewer and storm drainage networks and damaged sewer lines. Best practices such as routine pumping of septic systems, vegetative buffers, pet waste and manure management, etc. are also recommended, especially along the riverbank and in wet locations throughout the watershed.



*Precautionary Rainfall Advisories*

Considering the impact of the river on Higgins Beach water quality, it is recommended that the local beach manager continue to post precautionary rainfall advisories on the beach in support of public health. Precautionary advisories should be posted when local precipitation levels are greater than 1 inch of rainfall within 24 hrs and should remain in place for 24hrs after the rainfall ceases.

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 program [www.mainehealthybeaches.org](http://www.mainehealthybeaches.org)

# Supporting Figures

## 2010 Monitoring Data

Table 1. 2010 data summary for Spurwink River 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 ENTERO	GeoMean ENTERO	Mean OB	Sample Size ENTERO	Sample Size OB
<b>SPUR-01</b>	98.9	25.9	56.5	16	15
<b>SPUR-02</b>	2802.6	70.1	58.2	10	9
<b>SPUR-03</b>	1080.3	452.4	188.9	14	13
<b>SPUR-04</b>	216.1	82.6	115.1	16	15
<b>Total</b>	<b>861</b>	<b>88</b>	<b>107</b>	<b>56</b>	<b>52</b>

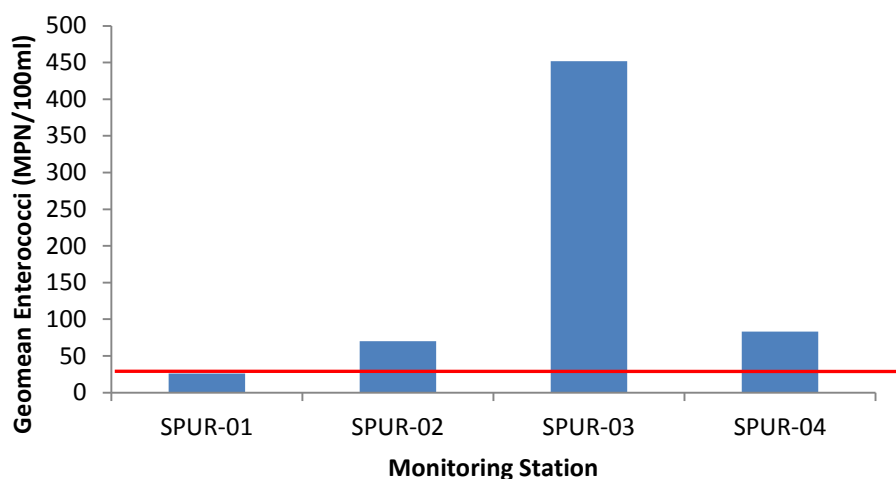


Figure 15. Enterococci geometric mean values for 4 routine monitoring sites monitored in the Spurwink River in 2010. The red line indicates the US EPA-recommended Enterococci geometric mean safety threshold of 35 MPN/100 ml for at least 5 samples collected within a 30-day period.

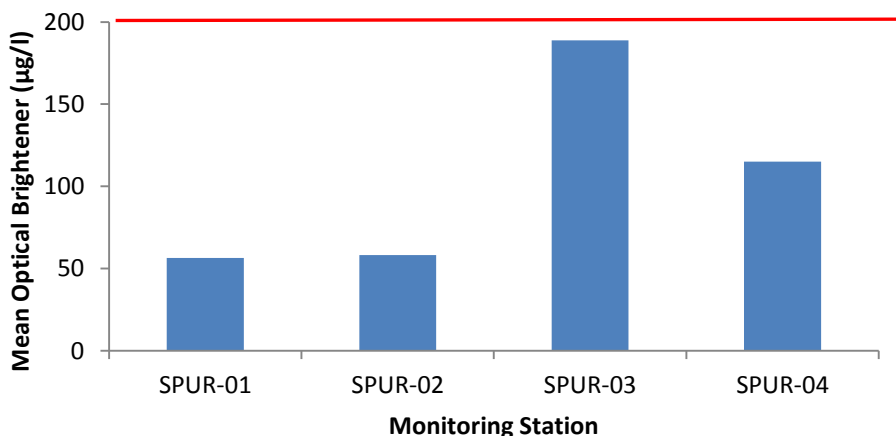


Figure 16. Mean Optical brightener levels for 4 routine sites monitored in the Spurwink River in 2010.

## 2012 Monitoring Data

Table 2. 2012 data summary for Spurwink River 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 ENTERO	GeoMean ENTERO	Mean OB	Sample Size
<b>HC-1</b>	1996.0	1276.7	189	4
<b>HC-2</b>	685.3	617	220.5	4
<b>SPUR-03</b>	2445.0	1080.5	87.0	4
<b>SPUR-04</b>	343.5	332.9	73.7	2
<b>SPUR-06</b>	946.0	946	145.5	2
<b>SPUR-06-1</b>	98*	-	192*	1
<b>SPUR-07</b>	602.3	554	162.5	4
<b>Total</b>	<b>1219</b>	<b>695</b>	<b>156</b>	<b>20</b>

\*Denotes single sample values

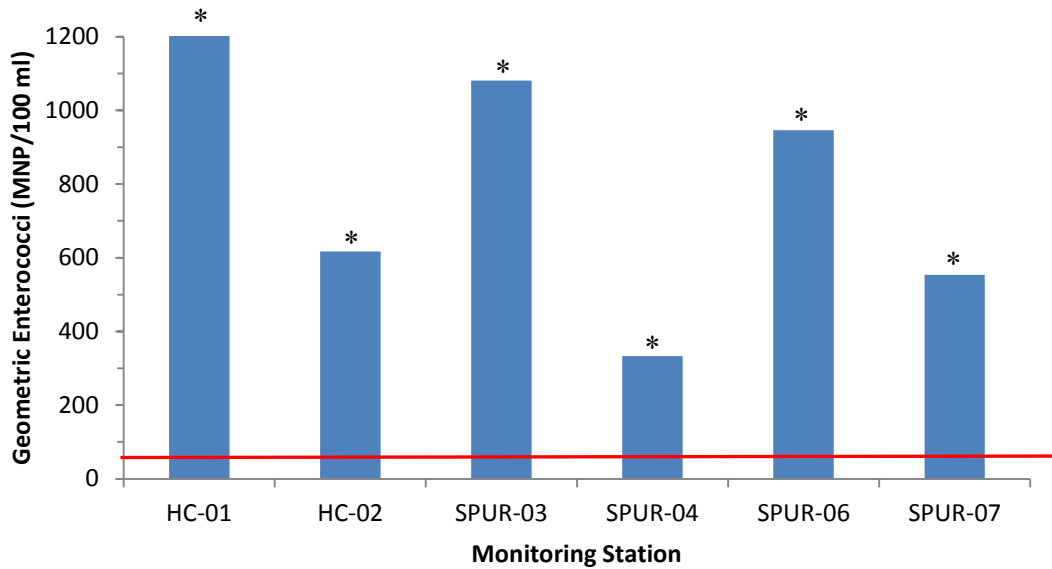


Figure 17. The 2012 geometric mean Enterococci (MPN/100ml) values by monitoring station in the Spurwink River watershed as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on 5 or fewer samples.

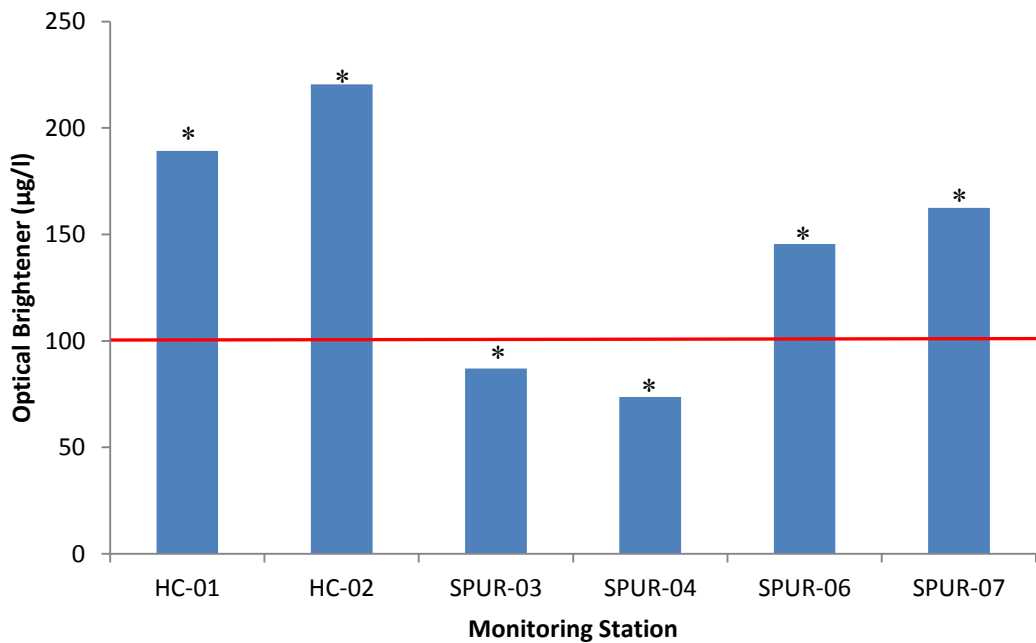


Figure 18. 2012 Spurwink River watershed mean optical brightener (µg/l) concentrations by monitoring station. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on 5 or fewer samples.

## 2013 Monitoring Data

Table 3. 2013 data summary for Spurwink River 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 ENTERO	GeoMean ENTERO	Mean OB	Sample Size
HC-1	225.5	116.5	165.7	11
HC-2	196.7	90.4	189.7	9
HC-2-1	129.5	54.6	165.8	4
HC-3	354.2	51.2	183.8	5
SPUR-01	839.5	28.0	23.3	11
SPUR-02	3487.7	72.3	41.0	7
SPUR-02-1	212.6	160.1	118.2	11
SPUR-02-3	3050.1	54.0	31.4	8
SPUR-03	2470.9	318.6	87.3	11
SPUR-04	1957.6	87.1	62.2	11
SPUR-05	449.0	148.5	84.5	11
SPRAGUE-1	139.2	38.4	88.5	6
SPRAGUE-2	248.1	107.6	163.1	7
SPRAGUE-3	354.6	130.6	58.6	7
<b>Total</b>	<b>1034</b>	<b>93</b>	<b>100</b>	<b>119</b>

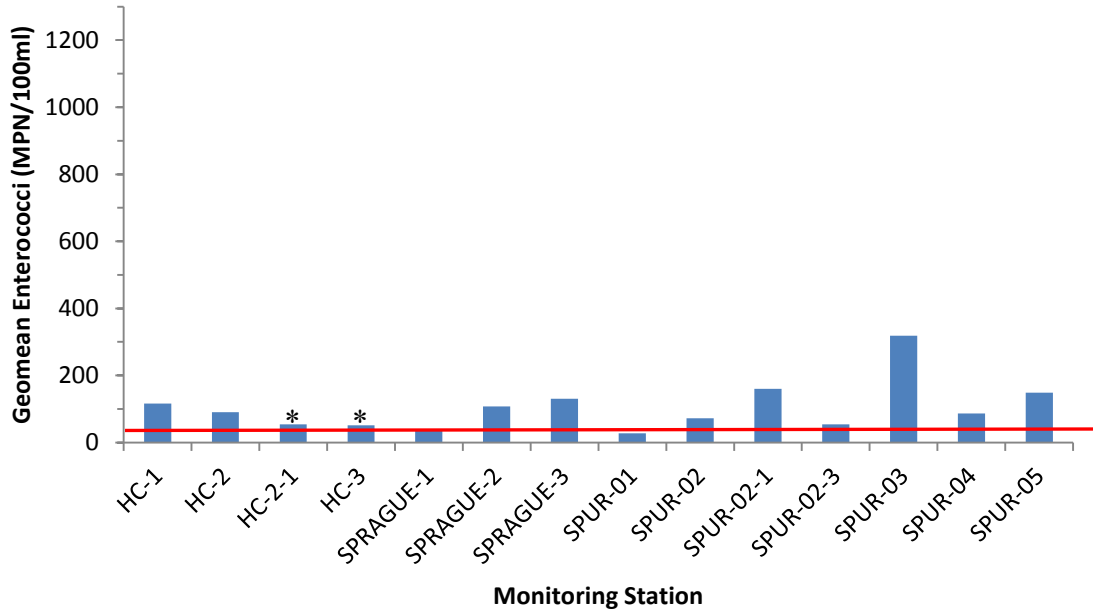


Figure 19. The 2013 geometric mean Enterococci (MPN/100ml) values by monitoring station in the Spurwink River watershed as indicated by blue bars. Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on 5 or fewer samples.

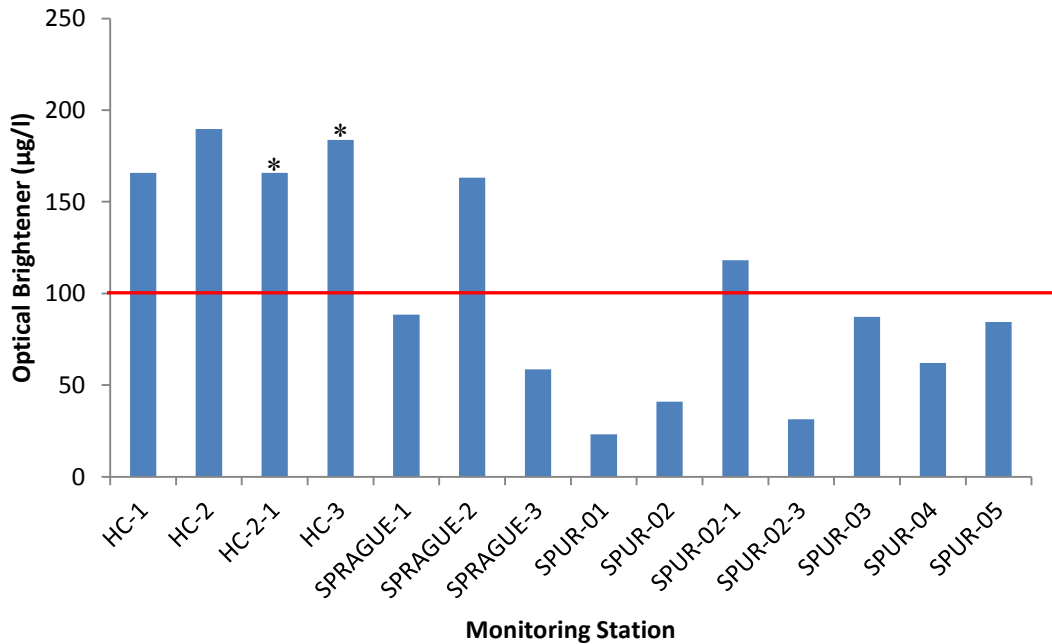


Figure 20. 2013 Spurwink River watershed mean optical brightener (µg/l) concentrations by monitoring station. Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on 5 or fewer samples.

## 2012 & 2013 Monitoring Data

Table 4. 2012-2013 data summary for Spurwink River 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	Year	Mean ENTERO	GeoMean ENTERO	Mean OB	Sample Size
<b>HC-1</b>	2012 & 2013	697.6	220.6	172	15
<b>HC-2</b>	2012 & 2013	361.9	163	197.2	13
<b>HC-2-1</b>	2013	129.5	55	165.8	4
<b>HC-3</b>	2013	354.2	51.2	183.8	5
<b>SPUR-01</b>	2013	839.5	28.0	23.3	11
<b>SPUR-02</b>	2013	3487.7	72.3	41.0	7
<b>SPUR-02-1</b>	2013	212.6	160.1	118.2	11
<b>SPUR-02-3</b>	2013	3050.1	54.0	31.4	8
<b>SPUR-03</b>	2012 & 2013	2464.0	441.3	87.2	15
<b>SPUR-04</b>	2012 & 2013	1675.1	107.0	65.6	13
<b>SPUR-05</b>	2013	449.0	148.5	84.5	11
<b>SPUR-06</b>	2012	946.0	946	145.5	2
<b>SPUR-07</b>	2012	602.3	554	162.5	4
<b>SPRAGUE-1</b>	2013	139.2	38.4	88.5	6
<b>SPRAGUE-2</b>	2013	248.1	107.6	163.1	7
<b>SPRAGUE-3</b>	2013	354.6	130.6	58.6	7
<b>Total</b>		<b>1061</b>	<b>124</b>	<b>108</b>	<b>139</b>

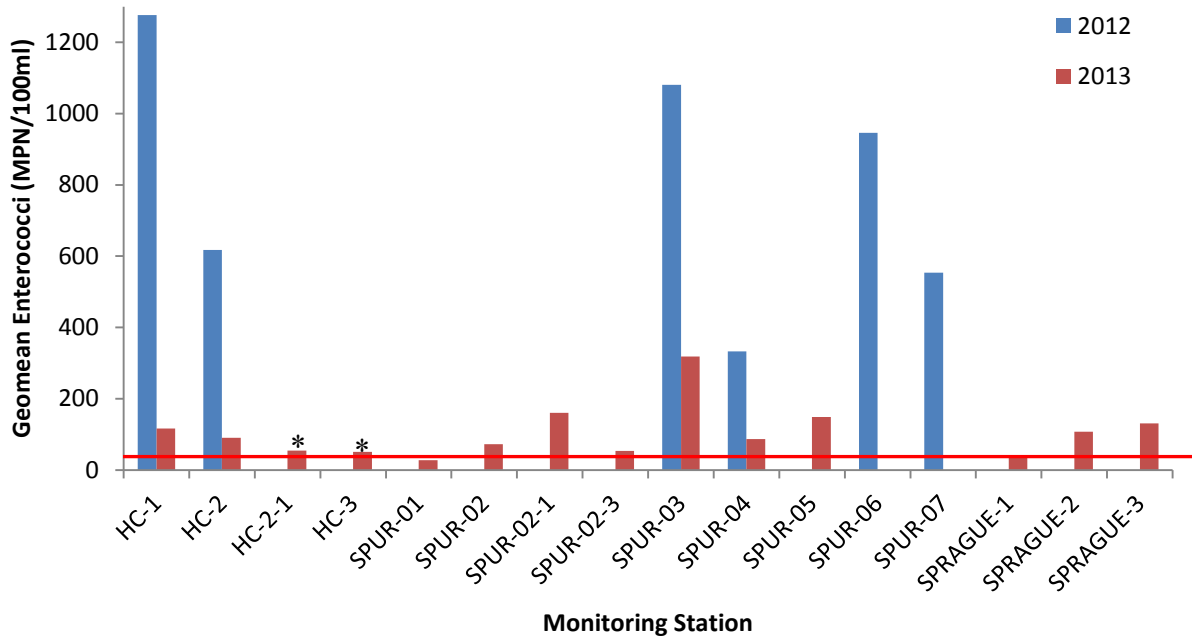


Figure 21. The 2012-2013 geometric mean Enterococci (MPN/100ml) values by monitoring station in the Spurwink River watershed as indicated by blue bars (2012) and red bars (2013). Red solid line indicates safety level of 35 MPN/100ml. Asterisks indicate values based on 5 or fewer samples.

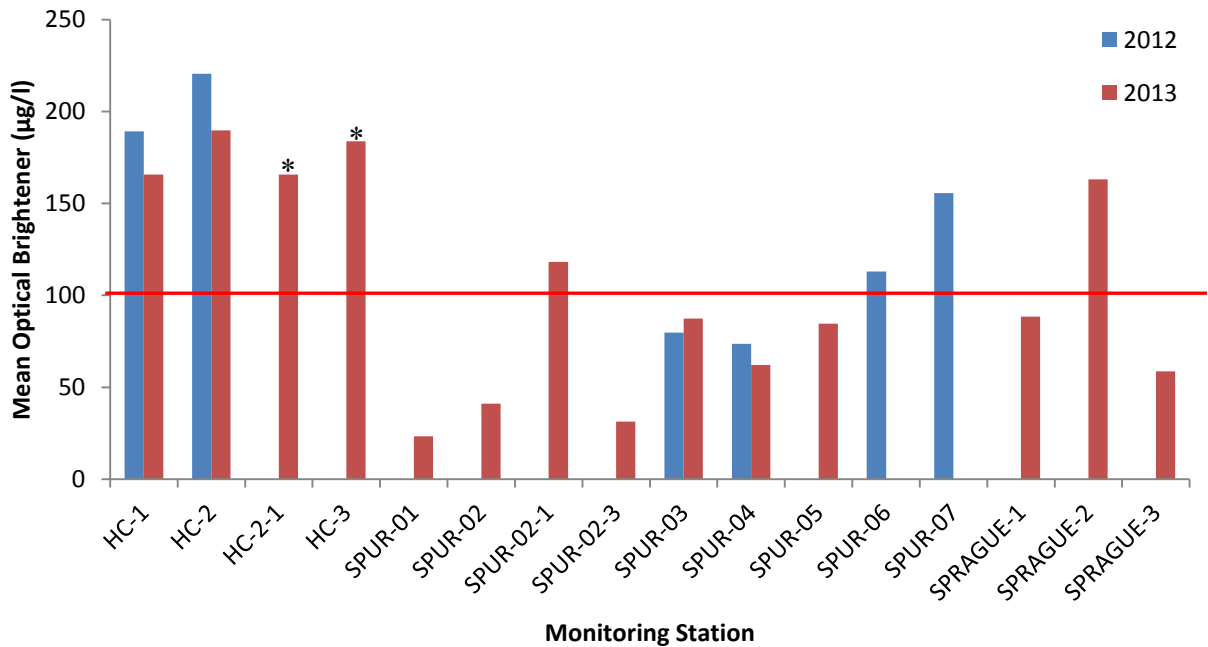


Figure 22. The 2012-2013 mean optical brightener (µg/l) concentration by monitoring station in the Spurwink River watershed as indicated by blue bars (2012) and red bars (2013). Red solid line indicates optical brightener lower threshold (100 µg/l) indicating the potential for human wastewater contamination. Asterisks indicate values based on 5 or fewer samples.



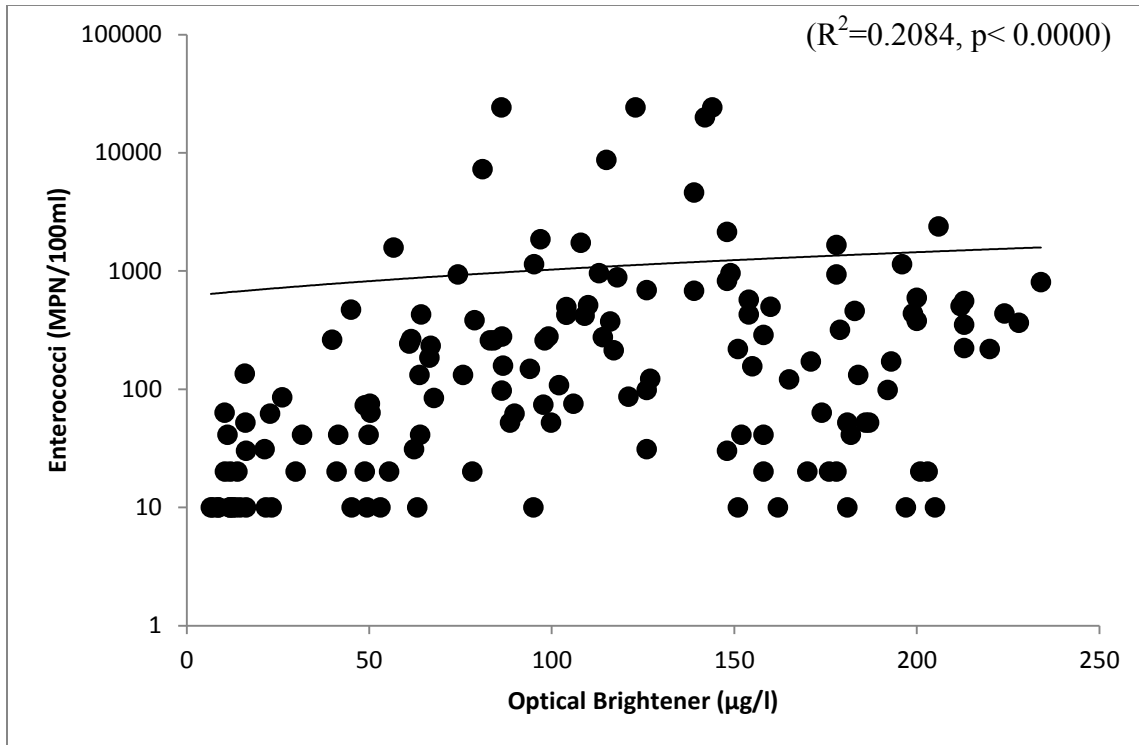


Figure 23. Relationship between Enterococci (MPN/100ml) and optical brightener (µg/l) levels during the 2012 and 2013 seasons for the Spurwink River watershed.