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A Preliminary Examination of the Effects of Local Precipitation on Beach Water Quality at 3 Coastal Beaches in Maine

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Background:

Stormwater runoff can negatively impact recreational water quality. When rain falls on the land, the water washes over the surface picking up bacterial pollutants from malfunctioning septic systems, wildlife, pet waste, etc. and are transported to the coastal surf-zone by runoff directly to the beach or via freshwater inputs such as rivers, streams and storm drains. The lag time (24-30 hrs) in obtaining fecal indicator bacteria results may pose a public health risk; therefore, some states have implemented an automatic precautionary rainfall advisory system where particularly high risk beaches are closed when rainfall exceeds predetermined levels which can vary widely (0.1-1in.) depending on the state, beach, and local conditions (Massachusetts, New Jersey, California, and Ohio[1]).

Analysis:

For each beach management area (BMA) the relationship between antecedent (prior) rainfall within 48hrs of the monitoring event and Enterococci (MPN/100ml) levels was delineated. Each figure represents data collected during routine beach monitoring between Memorial Day and Labor Day from 2008-2013. This analysis was completed for all 60 BMAs spanning Kittery to Mount Desert Island (roughly 200 miles). Included below are three case studies.

Three Case Studies:

Three BMAs (Laite Beach, Goodies Beach, Long Sands Beach-North) were chosen for this report because they are impacted by numerous freshwater inputs. For each figure, the horizontal red line indicates the US EPA single sample safety threshold of 104 MPN/100mls of sample water. Vertical lines indicate three antecedent rainfall scenarios (0.25 in., 0.5 in., 1 in.). Percentages represent the proportion of samples located in each of the four quadrants. Each quadrant represents a unique rainfall and bacteria scenario including high bacteria with low rain (1), high bacteria with high rain (2), low bacteria with high rain (3), and low bacteria with low rain (4). Determining the most appropriate rainfall threshold requires maximizing the number of observations captured corresponding to bacterial exceedances with high antecedent rainfall (quadrant 2) while also minimizing the number of observations captured representing false positives, samples indicating low bacteria concentrations with high antecedent rainfall (quadrant 3).

[1] Reference examples of State's Rainfall Precautionary Advisory procedures

Camden

Laite Beach

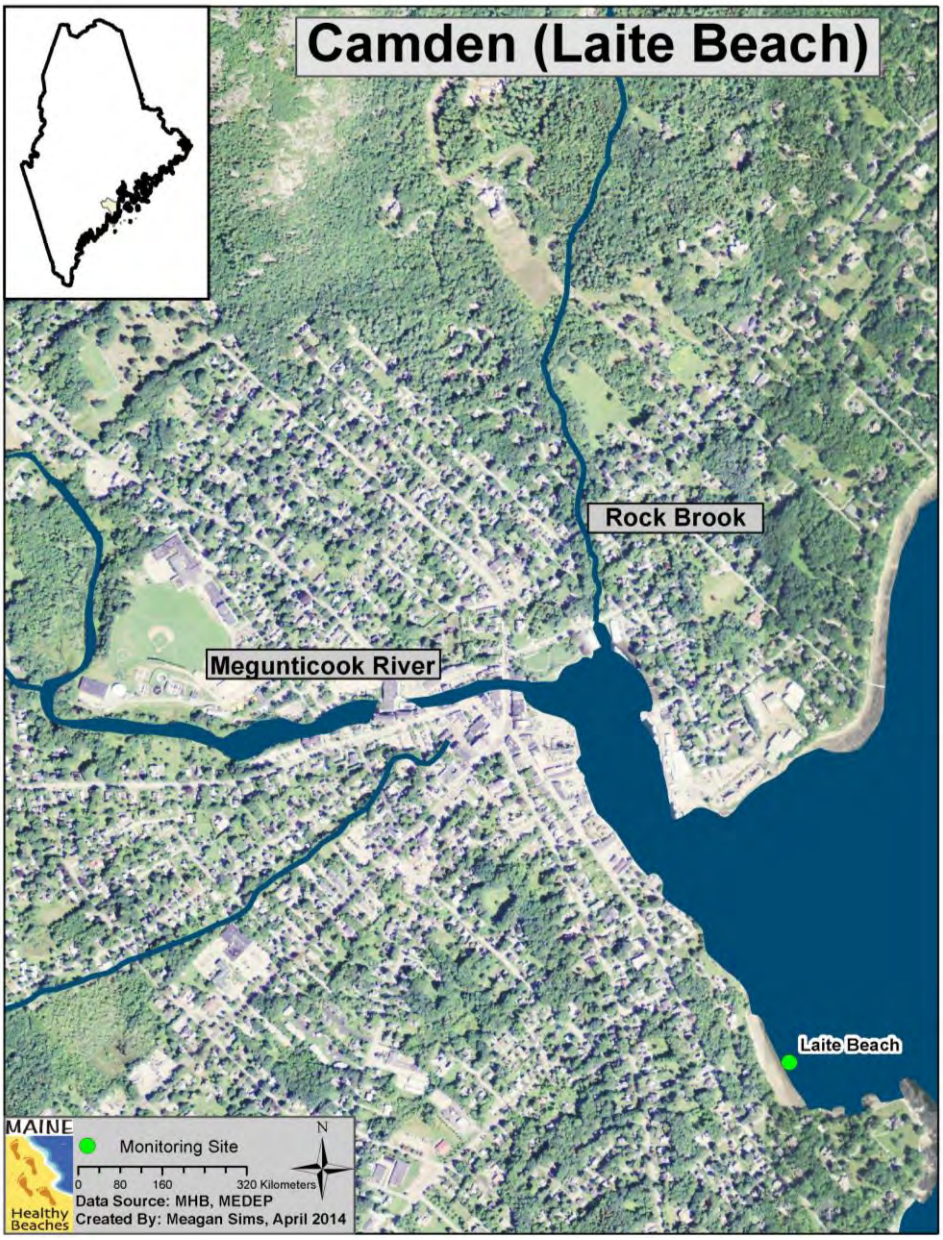

Figure 1. Location of Laite Beach, Camden, ME.

Laite beach is nested within Camden Harbor that receives freshwater inputs from numerous sources including the Megunticook River, Rock Brook, the wastewater treatment plant outfall, the old marina lock system, and several stormwater related flows.

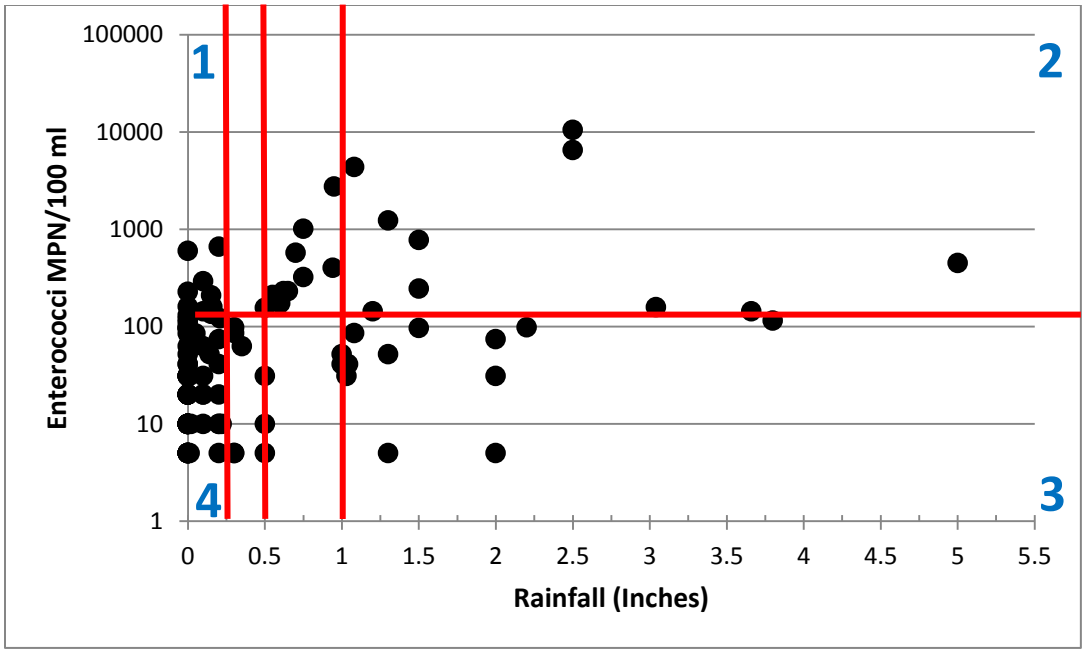

Figure 2. Relationship between bacteria (Enterococci) (MPN/100 ml) and rainfall (in.) for Laite Beach, ME.

48 hr. at .25 inch threshold	**48 hr. at .5 inch threshold**	**48 hr. at 1 inch threshold**
1= High Bac, Low Rain: 12%	1=High Bac, Low Rain: 12%	1=High Bac, Low Rain: 21%
2=High Bac, High Rain: 19%	2=High Bac, High Rain: 19%	2=High Bac, High Rain: 10%
3-Low Bac, High Rain: 18%	3=Low Bac, High Rain: 13%	3=Low Bac, High Rain: 11%
4=Low Bac, Low Rain: 51%	4=Low Bac, Low Rain: 56%	4=Low Bac, Low Rain: 58%

The most appropriate rainfall threshold for Laite Beach would be 0.5 inches. In this scenario, the number of samples exceeding bacteria standards with high antecedent rainfall is maximized (quadrant 2: 19%), while the number of false positives is minimized (quadrant 3: 13%).

Rockport

Goodies (GB-1)

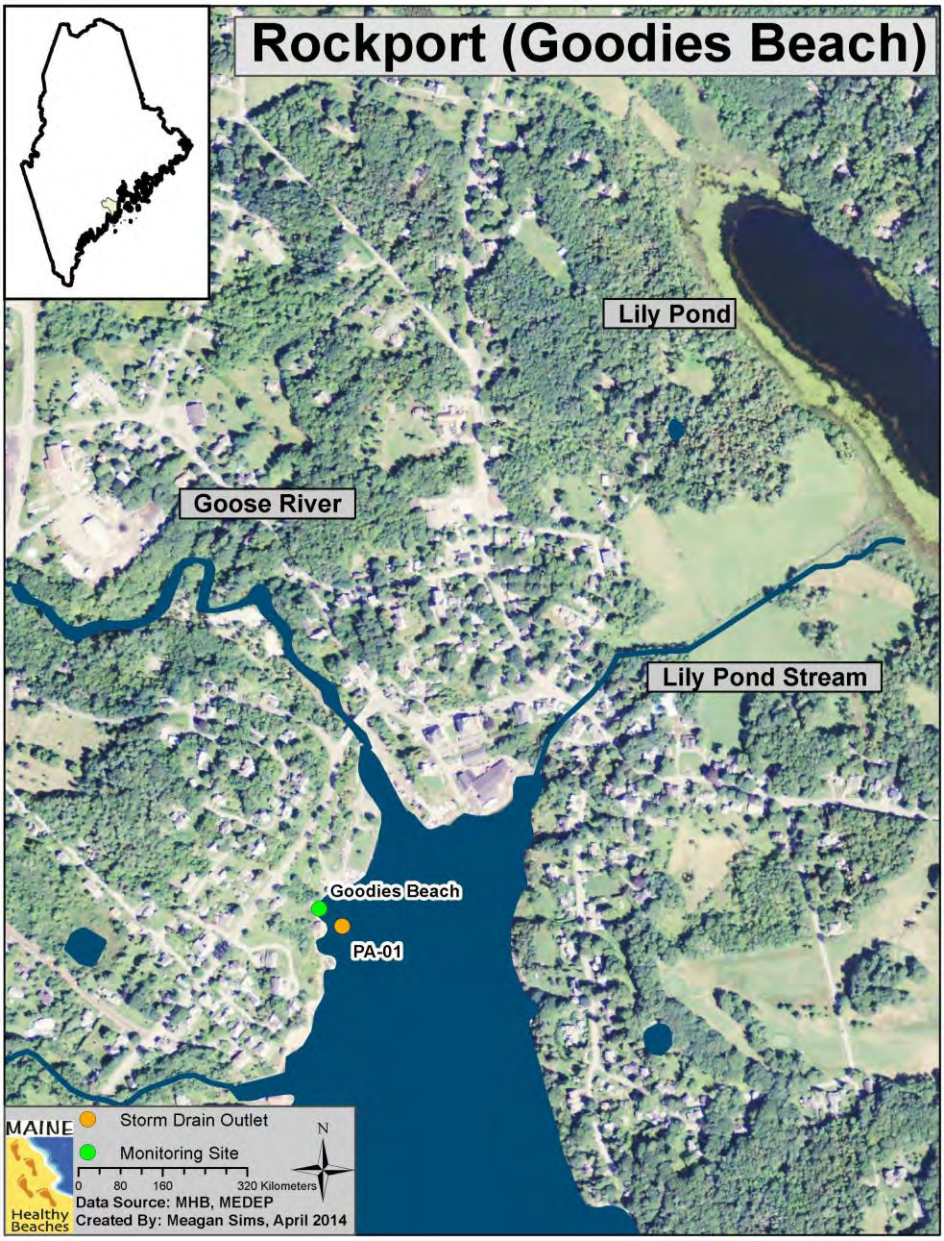

Figure 3. Location of Goodies Beach, Rockport, ME.

Similar to Laite Beach, Goodies Beach in Rockport is nested within a larger harbor system with several freshwater inputs including the Goose River, Lily Pond Stream, the Pascal Avenue storm drain, and other stormwater related flows.

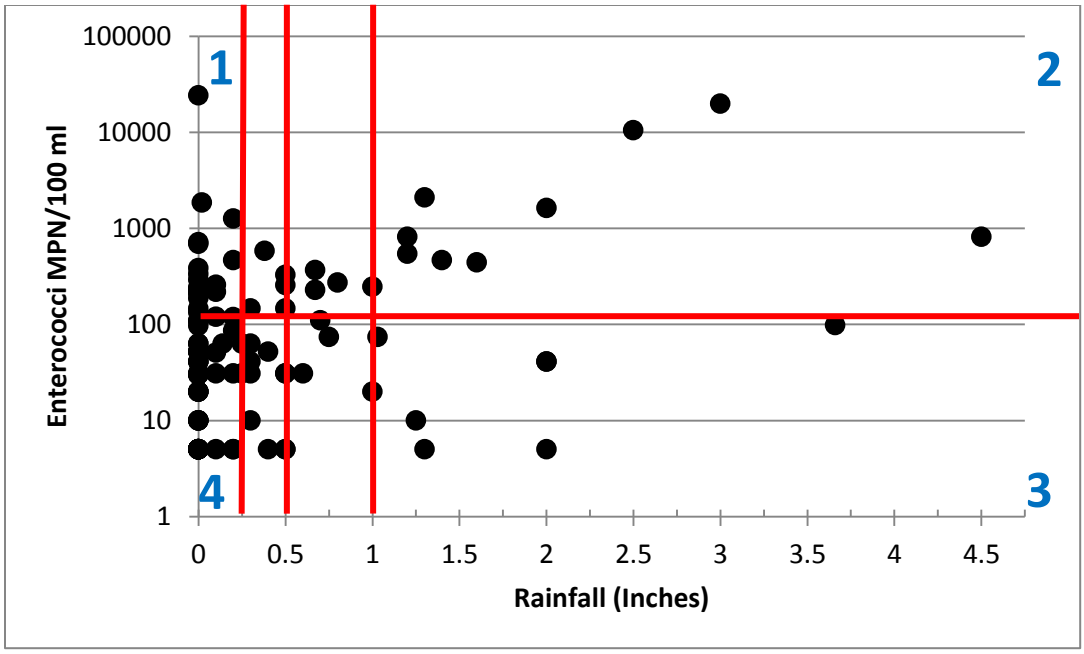

Figure 4. Relationship between bacteria (Enterococci) (MPN/100 ml) and rainfall (in.) for Goodies Beach, ME.

48 hr. at .25 inch threshold	**48 hr. at .5 inch threshold**	**48 hr. at 1 inch threshold**
1= High Bac, Low Rain: 21%	1=High Bac, Low Rain: 23%	1=High Bac, Low Rain: 29%
2=High Bac, High Rain: 18%	2=High Bac, High Rain: 16%	2=High Bac, High Rain: 9%
3-Low Bac, High Rain: 21%	3=Low Bac, High Rain: 13%	3=Low Bac, High Rain: 8%
4=Low Bac, Low Rain: 41%	4=Low Bac, Low Rain: 48%	4=Low Bac, Low Rain: 54%

The most appropriate rainfall threshold for Goodies Beach would be 0.5 inches. In this scenario, the number of samples exceeding bacteria standards with high antecedent rainfall is maximized (quadrant 2: 16%), while the number of false positives is minimized (quadrant 3: 13%).

York

Long Sands North (YK-6, YK-8, YK-10, YK-11, YK-13)

Figure. 5. Location of Long Sands Beach North monitoring sites in York, ME.

Freshwater inputs for Long Sands Beach-North are composed primarily of stormwater outfalls that empty onto the beach.

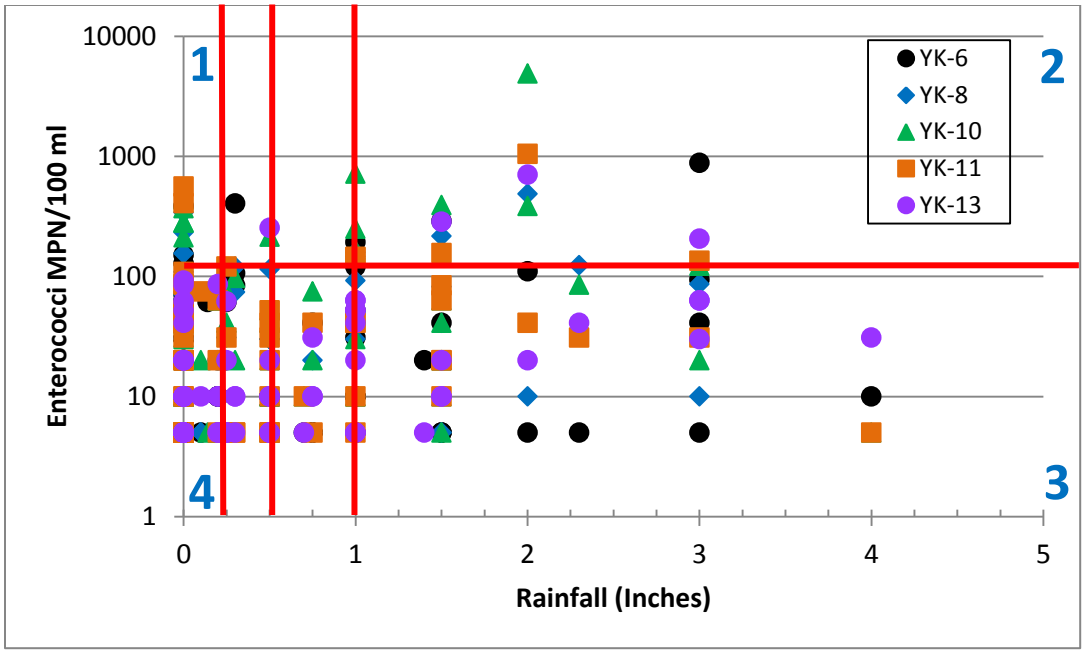

Figure 6. Relationship between bacteria (Enterococci) (MPN/100 ml) and rainfall (in.) for Long Sands Beach North sites in York, ME.

48 hr. at .25 inch threshold	**48 hr. at .5 inch threshold**	**48 hr. at 1 inch threshold**
1= High Bac, Low Rain: 4%	1=High Bac, Low Rain: 5%	1=High Bac, Low Rain: 6%
2=High Bac, High Rain: 8%	2=High Bac, High Rain: 7%	2=High Bac, High Rain: 6%
3-Low Bac, High Rain: 40%	3=Low Bac, High Rain: 32%	3=Low Bac, High Rain: 19%
4=Low Bac, Low Rain: 48%	4=Low Bac, Low Rain: 56%	4=Low Bac, Low Rain: 69%

The most appropriate rainfall threshold for Long Sands Beach North would be 1 inch. In this scenario, the number of samples exceeding bacteria standards with high antecedent rainfall is maximized (quadrant 2: 6%), while the number of false positives is minimized (quadrant 3: 19%). In this case, it is appropriate to choose the 1 inch scenario although it represents the situation with the fewest observations in quadrant 2 (high bacteria with high rain) because of the reduction in false positives gained (quadrant 2: 19%) compared to the 0.5 inch scenario (32%).

Discussion:

No standard antecedent rainfall trigger can be applied across the board for all beaches. The appropriate threshold determined for a particular beach varies depending on the unique characteristics of each beach system including freshwater inputs (e.g. rivers, streams, storm drains), local circulation characteristics, pollution sources, etc.

Additionally, the results of this analysis are limited in what they can reveal regarding the relationship between Enterococci and local precipitation levels primarily because data was obtained through routine beach monitoring rather than through a study specifically designed to capture the typical worst-case scenario for water quality. For example, the Enterococci results used in this analysis were associated with any amount of rainfall within 48hrs. Routine beach

samples are collected on a specific day/time each week and were therefore obtained at any point during a given rainfall event and can range from a sprinkle to flooding conditions. Additionally, a sample collected within the first few hours of rainfall would likely have different results compared to a sample collected on day 3 of the event where it is expected that bacteria levels have dampened due to dilution and flushing by additional rainfall and tides.

A targeted study focusing on rainfall effects would include monitoring to capture first flush conditions as well as conditions when dry weather preceded rainfall. Also this type of study would track the rainfall event through monitoring bacteria, salinity, and temperature levels until it dissipated. The time it takes for the influx of freshwater transporting pollutants to flush out of the system depends on the characteristics and dynamics of the particular beach system and corresponding watershed areas. This includes but is not limited to local circulation patterns, freshwater inputs to the beach, the size and characteristics of the associated watershed areas, proximity of pollution sources, etc. The results of this study can help inform beach management decisions, but in order to further develop our understanding of the relationship between rainfall and bacteria levels on Maine's coastal beaches, a thorough intensified rainfall study is needed.