Citizen Science Monitoring for Pathogen Indicators Along the NJ Raritan Bayshore

A Final Report for the NY-NJ Harbor & Estuary Program

Prepared by:
Meredith Comi, NY/NJ Baykeeper Restoration Program Director
Mitchell Mickley, NY/NJ Baykeeper Restoration Program Assistant

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Introduction:
NY/NJ Baykeeper (Baykeeper), in collaboration with the NY-NJ Harbor and Estuary Program (HEP), the United States Environmental Protection Agency (USEPA), the Bayshore Regional Watershed Council (BRWC), Raritan Riverkeeper, the Lower Raritan Watershed Partnership (LRWP), and the Interstate Environmental Commission (IEC) participated in a Citizen Science Monitoring project that provided data collection and information on water quality for beaches along the Raritan Bayshore that are considered non-bathing beaches, and therefore lacking in sufficient water quality data. In addition, Baykeeper mentored citizen scientists and expanded volunteer programming within Monmouth and Middlesex counties, NJ. An approved QAPP was followed, therefore data generated from this project have the potential be used to inform water quality policy and regulatory decisions at all levels of government (state, federal, local) within the project area and to educate the public.

Project Summary:
Throughout the course of June 13, 2016 - October 3, 2016, Baykeeper, partners, and citizen scientists conducted weekly monitoring events at nine locations along the NJ portion of the Raritan Bayshore (Monmouth/Middlesex Counties). This project engaged over 25 volunteers, who participated in all aspects of monitoring-GPS and YSI operations, data collection, water sample collection, and laboratory testing. At each site measurements were taken (i.e., temperature, salinity, oxygen, pH) along with observations regarding weather patterns, potential pollution inputs (point and non-point sources), and recreational use (e.g., fishing, boating, swimming). Additionally, water samples were collected, and analyzed at the IEC laboratory, to determine the levels of Enterococcus bacteria (an indicator of pathogen contamination). Data were analyzed to determine the highest areas of Enterococcus, especially immediately following precipitation events.

Sampling Protocol:
Nine locations were chosen to be analyzed over summer and fall 2016. Each location was monitored five times per month, for a total of 17 dates over the 4-month period. During each monitoring session, the following parameters were measured with a hand-held YSI probe: water temperature (°C), salinity (ppt), dissolved oxygen (mg/L), and pH; the following observations were made and recorded: cloud cover, precipitation (current, 24 hours, 48 hours), tide stage, water 'condition' (discoloration of water, floating debris and sewage, odors), pollution sources (point and non-point), and observed recreational uses (boating, fishing, swimming, etc.); and the location (latitude, longitude) was determined using a hand-held GPS unit. Observations on weather and pollution were made by looking in a 360-degree arc around the site, as well as photographing the site. Additionally, each sampling event included a water sample for Enterococcus levels. The water sample was placed on ice, and transported to the IEC laboratory (Staten Island, NY) within six hours.

At the laboratory, standard protocols were followed to incubate the sample with Enterolert for 24-hours, after which the specimens were observed by IEC staff under fluorescent lighting to quantify the amount of Enterococcus within the water sample (EPA QAPP methods, 2016). Data were analyzed using simple statistical measures (mean, geometric means) over the entire season (June 13, 2016-October 3, 2016). Conclusions were drawn between precipitation events and the

increase in Enterococcus levels.

Quality Control Measures:
In accordance with the USEPA-approved Citizen Science QAPP (April 2016), the following measures were taken to ensure that data collection was within all quality control means.

1. Precision: For field sampling measures, a duplicate of the YSI readings was taken (temperature, salinity, pH, oxygen). If the duplicate was not similar, a third reading was taken to determine the proper measurements. The measures were only accepted if within 10%. In the laboratory, a duplicate sample was run by EPA staff, with an alternate method (not Enterolert), to check for agreement between the old and new accepted methods. Laboratory and field duplicates were also run. Any sample duplicates not within 30% of the sample should be rejected. There were four data sets that the sample duplicates were not within 30% of the sample, therefore, these sample duplicates and the data should be rejected.

2. Bias: All sampling sites were along the shoreline and within wading depths, which could have led to slight bias, however, the Raritan Bay is very dynamic with a lot of flushing. Seasonal variations in temperature, UV radiation and rainfall are known to influence Enterococcus numbers, and therefore result in bias. Variations in rainfall, wind, tides and currents will also influence project parameters. In the laboratory, field samples were calibrated against blank samples. There was a 'blank' with no bacteria (distilled water), and a 'positive control' with a known concentration of Enterococcus placed in to the distilled water. Then, the 'unknown' samples were run and calibrated against the controls.

3. Representativeness: Along the course of the Raritan Bayshore, nine locations were chosen spanning Port Monmouth, NJ (Monmouth County) to the Raritan Yacht Club in Perth Amboy, NJ (Middlesex County) allowing for a substantial portion of the Raritan Bay to be sampled. All sampling locations are in tidally influenced and saline waters. The sites were only sampled over four months out of the year, which does not give data over any season but summer; however, during the summer months there were samples from five time points each month giving a very representative sample of these four months.

4. Comparability: Only one method was used to collect data (YSI, GPS, or Enterolert methods), therefore, data was unable to be compared to other methods for each sampling point. For the laboratory data, standard USEPA QAPP protocols were followed, so the data will be comparable to other studies using this method (Gotham Whale's pathogen monitoring project and recipients of EPA's Equipment Loan program).

5. Completeness: Of all the samples collected along the Raritan Bay (n=17 sampling events, n=9 sites, for a total of 153 samples), 99.3% were analyzed for Enterococcus levels and 99.3% used in analysis of water conditions and water quality. One out of 153 samples had been accidentally left out of the cooler and therefore was not viable. Since NJDEP does not count the sites monitored as bathing beaches, there are no pre-existing data on the sites that were used for this study.

6. Sensitivity: The YSI hand-held probe has a sensitivity of 0.01mg/L for DO. In the laboratory,

the Enterolert method has a method detection limit of 10 MPN. All readings are considered accepted as the calibration and quality control checks were within 10% of the accepted values.

Interpretation of results:

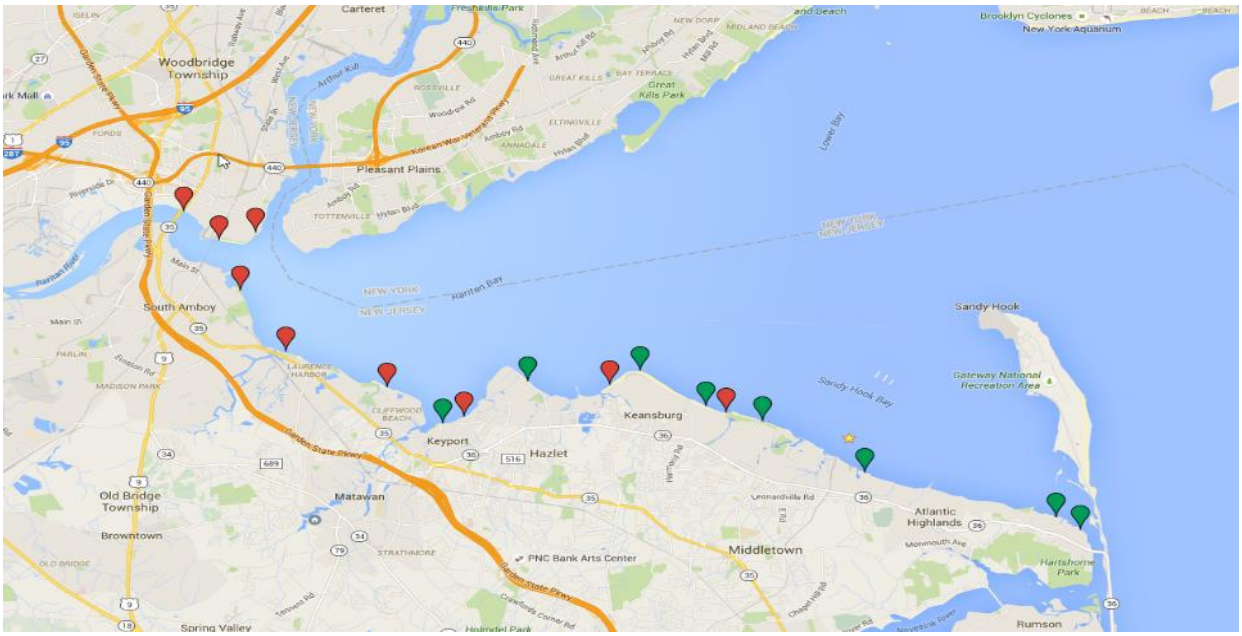


Figure 1: Map of the sampling sites, east to west. RB01: Bayshore Waterfront Park, RB02: Beachway Ave, Keansburg, RB03: Cedar St., Keyport, RB04: Cliffwood Beach Waterfront Park, Aberdeen Township, RB05: Paul's Beach, Laurence Harbor, RB06: Fishermen's Beach, South Amboy, RB07: Route 35 (Victory) Bridge, Perth Amboy, RB08: End of 2nd Street, Perth Amboy, RB09: Raritan Yacht Club, Water Street, Perth Amboy. Green sites are sites currently tested by NJDEP and red sites are those tested during this project.

Over the course of the project, there were 153 discrete sampling sessions performed (n=17 sampling days, n=9 sites sampled each date). On each sampling date, at each site, there were measurements collected for (a) temperature, (b) salinity, (c) pH, (d) dissolved oxygen, (e) Enterococcus levels, (f) weather observations, (g) pollution sources, and (h) recreational uses of the site. For the purposes of this report, the authors focused on parameters most commonly used to classify polluted waters: Dissolved Oxygen, Temperature, and Enterococcus levels.

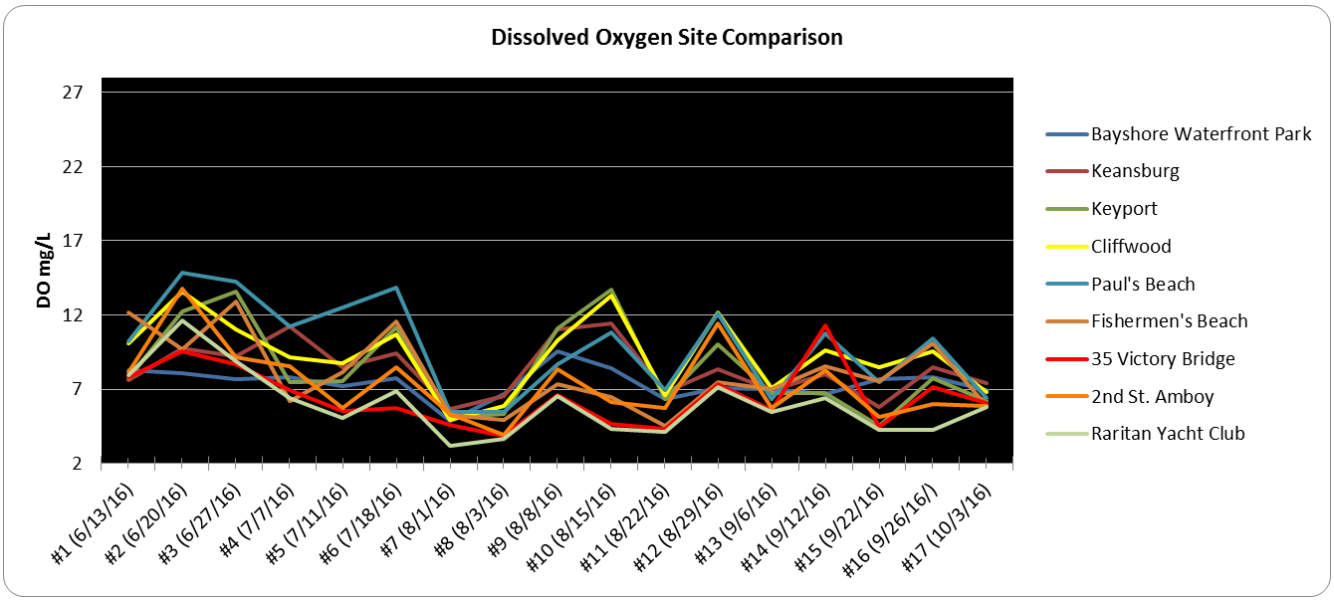


Figure 2: Dissolved oxygen.

Dissolved oxygen was variable over time and site and was mostly within the NJDEP acceptable range (above 4mg/L), meaning that hypoxic events were rare at these sites NJDEP 2014). It should be noted that this represents a discrete measurement; oxygen levels are highly variable over time and throughout the day due to photosynthetic activity of the associated flora (Huggins & Anderson, 2005), and therefore this may not be representative of the daily average. Additionally, there may be periodic hypoxic events that were not recorded over the summer. Dissolved oxygen decreased near combined sewer outfalls in Perth Amboy, dipping below 4mg/L on some sampling days.

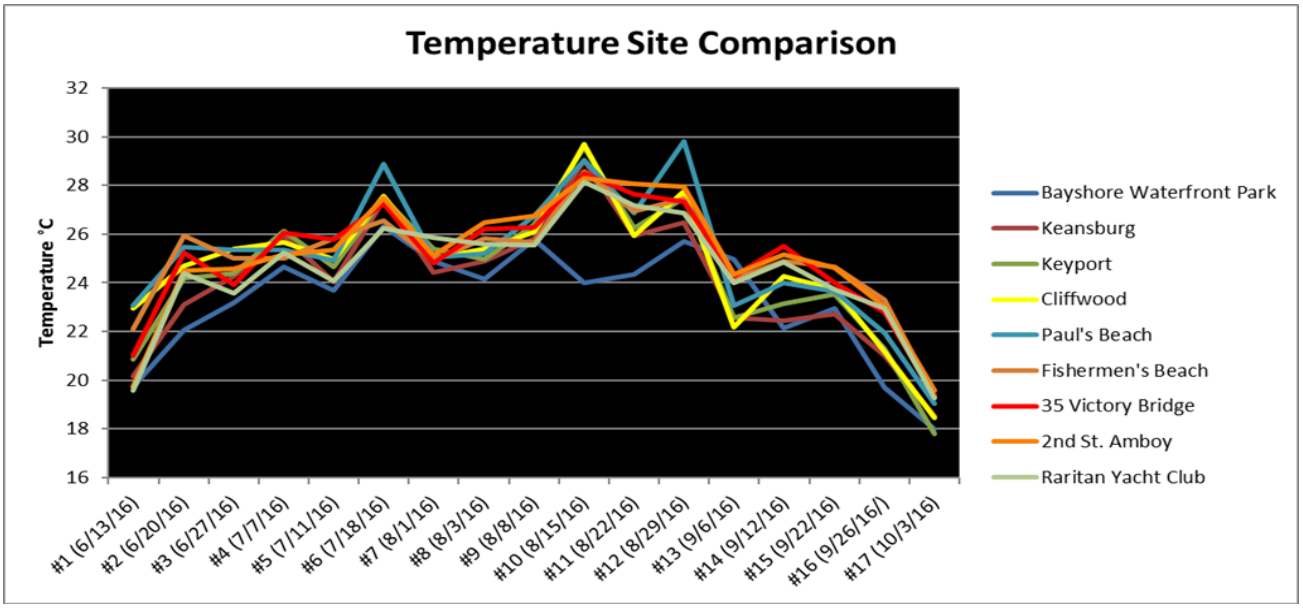


Figure 3: Temperature.

At all sites, temperature followed the general pattern of warming over the summer months. Again, as stated above, a discrete measurement does not give the most accurate picture of the long-term temperature readings at the site.

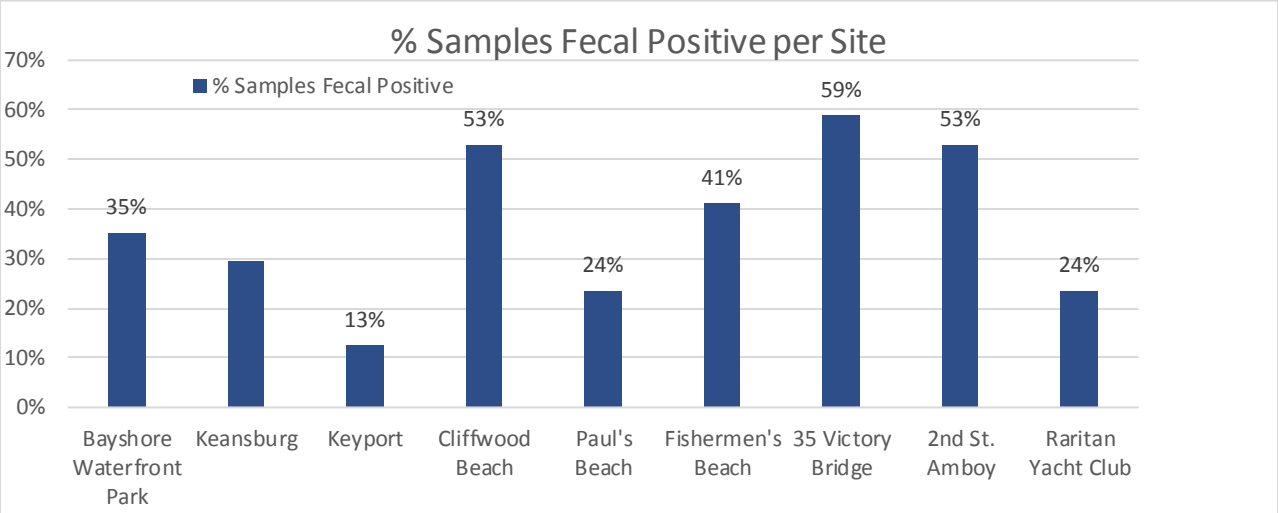
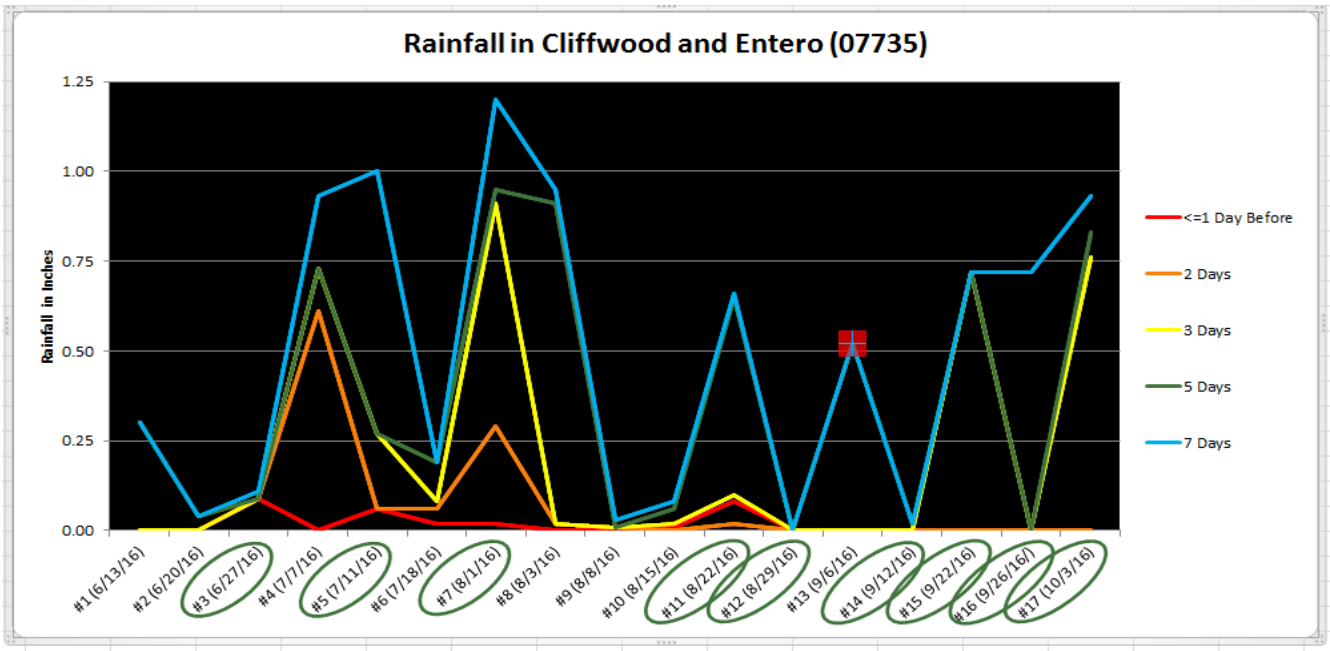
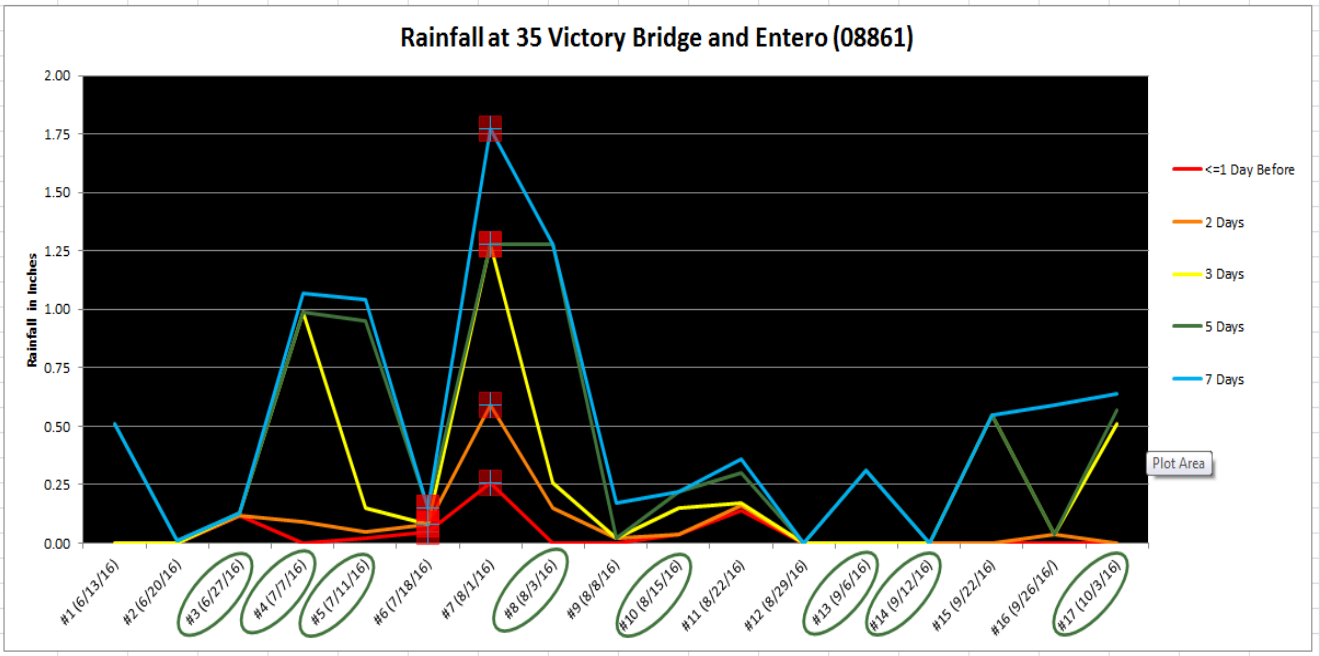


Figure 4: Enterococcus levels.

Geometric means were calculated over the month (n=5 sampling dates; once a week plus an additional date following a rain event). For the most part, the levels of Enterococcus were below the EPA recreational water quality criteria for marine systems, which is a geometric mean below 35 CFU/100mls (USEPA QAPP Methods, 2016).

Three sites stood out from the rest throughout the sampling season as having Enterococci bacteria present in water samples over 50% of the time: RB04, RB07, and RB08 had enterococci positive arithmetic averages of 53%, 59% and 53% of the time. Had the project sites been bathing beaches, all sites, except for RB05, would have had at least one sampling event that resulted in a beach closure. According to EPA standards for beach closures (USEPA QAPP Methods, 2016), RB06 in South Amboy had the poorest water quality with 4 out of 17 samples over the EPA standard. The highest enterococci reading of the season was at RB04 with 4,360 MPN/100ml. More research is needed at this site to determine the cause of this spike since it is not located near a CSO and this sampling date did /not occur after a precipitation event.


Rainfall in Cliffwood and Entero (07735)
Rainfall in Inches
1.25
1.00
0.75
0.50
0.25
0.00
<=1 Day Before
2 Days
3 Days
5 Days
7 Days
#1 (6/13/16)
#2 (6/20/16)
#3 (6/27/16)
#4 (7/7/16)
#5 (7/11/16)
#6 (7/18/16)
#7 (8/1/16)
#8 (8/3/16)
#9 (8/8/16)
#10 (8/15/16)
#11 (8/22/16)
#12 (8/29/16)
#13 (9/6/16)
#14 (9/12/16)
#15 (9/22/16)
#16 (9/26/16)
#17 (10/3/16)


Rainfall at 35 Victory Bridge and Entero (08861)
Rainfall in Inches
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
<=1 Day Before
2 Days
3 Days
5 Days
7 Days
Plot Area
#1 (6/13/16)
#2 (6/20/16)
#3 (6/27/16)
#4 (7/7/16)
#5 (7/11/16)
#6 (7/18/16)
#7 (8/1/16)
#8 (8/3/16)
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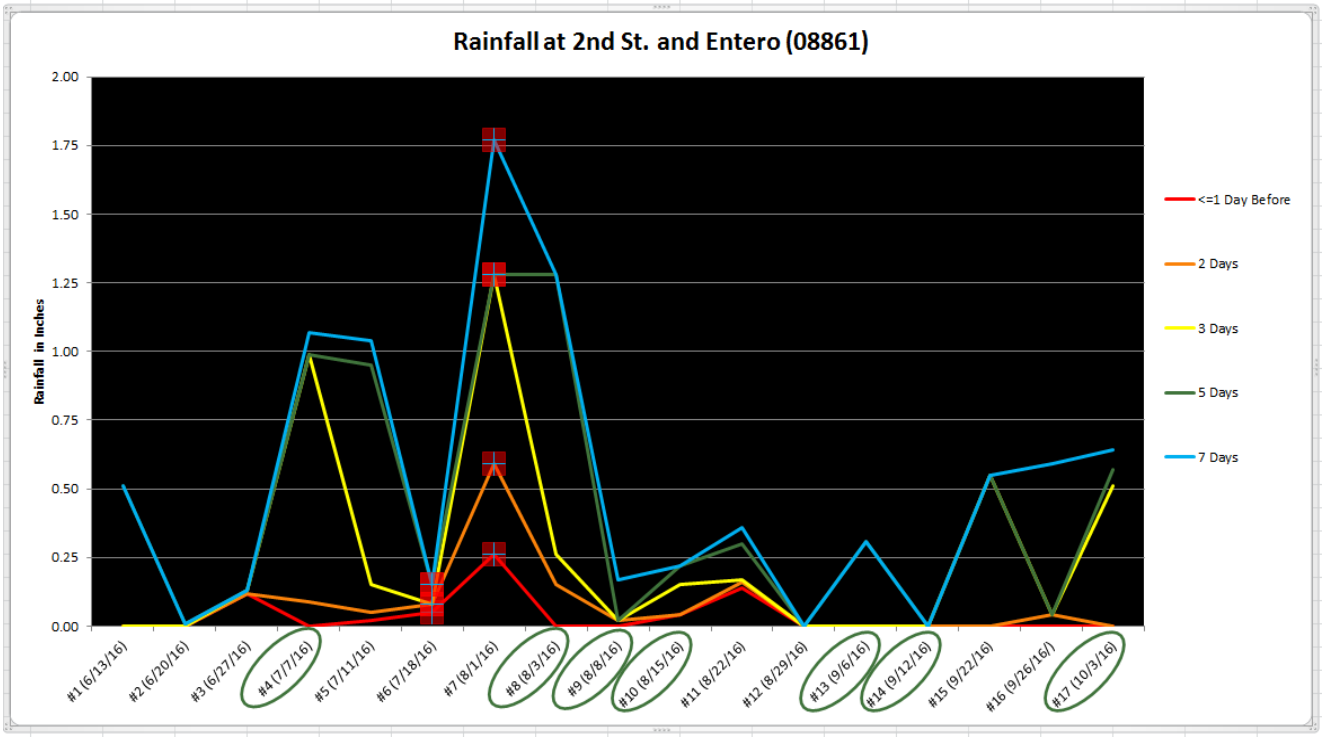

Figure 5: Enterococcus levels and rain events for beaches that had the highest levels of Enterococcus: Cliffwood Beach, Aberdeen (top), Route 35 Bridge, Perth Amboy (middle) and 2nd Street, Perth Amboy (bottom). Precipitation data was gathered from weather.com for each site.

Enterococcus levels were much higher immediately following precipitation. Each colored line represents how far out the rain event was prior to the sampling date. Red crosses represent what should be beach closures, had these beaches been bathing beaches. Sample dates circled in green show days where Enterococcus was present, but under the limit. The highest Enterococcus levels were found in Perth Amboy at the Route 35 Bridge and 2nd Street sites, both located next to CSO discharge pipes. Enterococcus levels at the eastern sample sites along the Bayshore remained low, even following rain.

Project evaluation:
The project (1) identified a watershed in need of water quality data, that would be positively impacted by the data conclusions (whether they be positive or negative), (2) used citizen scientists to gather water quality data and analyze results, (3) produced a final report analyzing results, and (4) provided these data to the proper state and federal agencies to be used as appropriate. The data gathered and produced via this project will be used: (1) by Baykeeper as part of the larger data file of water quality in the Hudson-Raritan Estuary, (2) to inform local and state agencies within the local watershed and (3) to educate constituents and the general public on local water quality through dissemination of information on the Baykeeper website, social media and presentations.

Conclusions and Recommendations:

Conclusions drawn from this project are higher levels of Enterococcus are found near CSO sites, especially after a rain event. Although Enterococcus was found at all sites, beaches were actually much cleaner than originally anticipated. When comparing Enterococci levels to rainfall, it was observed that it does not take much rainfall to trigger a CSO discharge and more research should be focused on this.

Usage at these non-bathing beaches is high, especially in Perth Amboy, where families rely on subsistence fishing. Although there is signage marking CSO discharge pipes, they are not obviously placed and there are language barriers. A public notification system implemented at these locations would be an important part of a water quality monitoring program to alert residents when they should avoid primary and/or secondary contact with the water to ensure their safety.

NJDEP issued new permits to all CSO municipalities in July 2015. Permittees are required to develop a Long Term Control Plan that addresses CSOs and are required to implement the plan over the course of 20-30 years. In the meantime, residents can decrease the amount of raw sewage and bacteria entering waterways by reducing the stress on municipalities combined sewer systems by installing a rain barrel, conserving water during rainfall, redirecting downspouts to a grassy area, and planting a tree or rain garden.

The data produced from this project represents a snapshot of water quality conditions in the area and are meant to inform the public, elected officials, agencies, and residents about their local water quality; including additional needs for more comprehensive water quality sampling. NY/NJ Baykeeper strongly recommends the public to avoid contact with waterways for at least 72 hours after rainfall.

Disclaimer

The data collected from this project is not intended to advocate for opening a bathing beach in any of the areas that were tested. The conclusions drawn from this project are to inform the public, elected officials, agencies, and residents about their local water quality. For those communities looking to better understand the conditions of their local waterways, NY/NJ Baykeeper strongly recommends working with the NJ Department of Environmental Protection (NJDEP) and the US Environmental Protection Agency (EPA) to develop water quality monitoring programs and obtaining further information to better inform decisions around water quality health and waterfront uses.

This project was funded by the New York-New Jersey Harbor & Estuary Program.

Works Cited:

Huggins, D.G., and J. Anderson. 2005. Dissolved Oxygen Fluctuation Regimes in Streams of the Western Corn Belt Plains Ecoregion. Report No. 130 of the Kansas Biological Survey. University of Kansas, Lawrence KS.

NJDEP Office of Science. 2014. Dissolved Oxygen Levels in Estuarine & Near Shore Waters Page 1. Environmental Trends Report. Retrieved from http://www.nj.gov/dep/dsr/trends/.

US EPA, 2016
Citizen Science QAPP.