STORMWATER ANALYSIS OF BEACHWOOD BEACH AND AVON ROAD WEST PINE BEACH

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ABSTRACT

This student grant program project concerning the water quality of locations on the Toms River was conducted during the months of June, July and August in the summer of 2011. The locations where the team sampled, Beachwood Beach and Avon Road West Pine Beach, were brought to attention by the New Jersey Department of Environmental Protection, along with members of the Save the Barnegat Bay committee. The areas of concern, regarding water quality include the amounts of *Escherichia coli*, *Enterococcus sp*., and Optical Brighteners within the storm water that is entering the Toms River. The student grant program team collected samples during rainfall, along with a baseline test done every other Monday. These samples were then assessed for the presence of the bacterium that would determine the cleanliness of the storm water. Another key factor determined while assessing the data, was the amount of human signature present in the storm water. This was highlighted by the amount of optical brighteners within the water. All of the sites the team concentrated on at the two locations produced astonishingly high numbers of the bacteria from the storm water, which proved to be dangerously higher than the health departments regulation for safe swimming water.

INTRODUCTION

On July 3rd-8th 2005, Beachwood Beach was hit with a rainstorm that produced high levels of *Enterococcus* that reached 10,000 cfu/100mL This amount is one hundred times the amount recommended for safe swimming water by the New Jersey Department of Health. One year later at the end of August the problem presented itself again. The amount of *Enterococcus* reached over 5,000 cfu/100mL. This same year Beachwood Beach was placed on the NRDC's Beach Bum list for exceeding the daily maximum bacterial standard with 30 percent of its 20 total sample. This trend continued over the next five years, but in 2010 instead of being 30 percent of 20 samples, these numbers skyrocketed to be 51 percent of its 47 total samples were exceeding the daily maximum bacterial standards (National Resources Defense Council). Pine Beach West has also been producing high numbers of *Enterococcus* notably since 2008 when on August 20th the bacterial levels reached 800 cfu/100mL. This also continued over the next five years, but not once has the beach received the title of a "Beach Bum" (National Resources Defense Council). The amount of *Enterococcus* being produced by these beaches over the past six years have surpassed the 104 cfu/100mL limit for safe swimming waters. Another concerning factor regarding these beaches would be that they are both located on the Toms River whose water eventually drains into the Barnegat Bay. Not only is this unhealthy, unsanitary water endangering those who expose themselves to this river, but it is also endangering the bay itself. With this in mind the locations, Beachwood Beach and Avon Road Pine Beach West, were ideal for us to concentrate our efforts and study on.

The *Enterococcus* is known to be found in the lower intestines and feces of humans and warm-blooded animals. This along with E.coli (*Escherichia coli*) is used as indicators to if there is sewage contamination presence and/or harmful pathogens within the water. In water exceeding the New Jersey Health Department standard for safe swimming water of 200cfu/100mL (E.coli) and 104cfu/100mL (*Enterococcus*), there is an increased chance of pathogens being present. Individuals exposing themselves to these

waters risk the pathogens entering the body through the mouth, ears, nose, and cuts. Diseases and illnesses that can be acquired in waters with high E.coli and *Enterococcus* levels include typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections. The water quality team was also testing for brightening agents known as optical brighteners. These are found in detergents and are used to make whites seem cleaner and whiter. If this is found in the water samples it will show that humans are negatively contributing to the storm water that is being drained into the Toms River.

METHODS

The study took place over seven sites located along the Toms River (Figure 1). There were four specific sites at Beachwood Beach, and three at Avon Road Pine Beach West. These sites were chosen due to their proximity to drainage pipes.

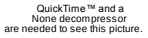
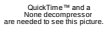


Figure 1. Map of testing sites along the Toms River. Yellow marker on left represents Beachwood Beach, and the most right one represents Avon Road West Pine Beach. The large body of water to the far right is the Barnegat Bay.

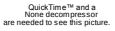
At Beachwood Beach our sites were all along the entire shoreline of the beach and surrounding area (Figure 2). Sampling from Site 1, Site 2, Site 3, and Site 4, were done near the mouth of storm drains. Site 1 did not have a visible pipe but the team had an understanding of the pipes general area. This area was off the boardwalk on the left side of the beach. Site 2 had a noticeable storm drainpipe that's mouth rested near the edge of the water. The pipe had a hole about six feet from the mouth, where we accessed water for a special in pipe sample along with the sample from the mouth of the pipe (Figure 4) (Figure 5). This pipe was located just to the left of the bathing area. Site 3 was located near the dock to the left of the bathing area, and Site 4 was located around to the far right of the beach.

Figure 2. The yellow pins represent each sampling site at Beachwood Beach.
Site 1: Lat.39°56'32.53"N- Long.74°11'8.07"W;
Site 2: Lat.39°56'32.53"N- Long.74°11'5.83"W;
Site 3: Lat.39°56'34.51"N- Long.74°11'3.42"W;
Site 4: Lat.39°56'30.46"N- Long.74°10'57.63"W



Avon Road West Pine Beach is located East of Beachwood Beach (Figure 1). Here we had three sites where we tested (Figure 3). Site 1 is towards the left of the dock and is along the boardwalk. The pipe is coming right form the boardwalk and the mouth is right on the shoreline. During storms we realized there was limited outflow in the pipe, and that it had a lot of sand filling the pipe. Site 2 is to the left of the swimming beach, and there is plan that there will be a second swimming beach developed at this location in the near future. Here the pipe was fully submerged, but that did not prevent the team from locating a hole in the pipe a few feet from the mouth were we could take an in pipe sample. Lastly Site 3 was located near a dock straight off from the Pine Beach sign. The pipe leading to this site was on the beach to the right of the dock, and often had a slow stream coming from it during rainstorms.

Figure 3. The yellow markers represent each site at Avon Road West Pine Beach.
Site 1: Lat.39°56'27.16"N- Long.74°10'21.48"W
Site 2: Lat.39°56'28.32"N- Long.74°10'17.34"W
Site 3: Lat.39°56'26.46"N- Long.&4°10'8.65"W



Accompanied by Danielle Donkersloot of the NJDEP, Cara Muscio of Rutgers Cooperative Extension, and John Wnek our advisor, we were able to establish a methodology that allowed us to have strong plan, and routine that would allow ourselves to be recognized as tier-B with the Department of Environmental Protection. Tier-B is described as a screening tier. Here scientists will identify issues that will be inspected in the future. (The New Jersey Watershed Watch Network) This was vital to our team because without the approval of our data and the way we collected it, it would be scientifically insignificant and possibly discredited.

One of the biggest challenges we had to over come was getting accurate information about the storm. To predict an estimate of storm arrival we used www.weather.com and www.weather.gov. Both sites proved to be fairly accurate through out the duration of the project. A minimum of 1/10 inches of rain was needed to create a significant flush. During a rain event our plan was to sample within the first thirty minutes since the storm has started, this will allow us to collect storm water from the first flush through the pipes, and then thirty minutes after the first sample we collected a second sample. Every other Monday we also collected a base-line sample. We chose Monday because this allowed us to compare our bacterial data with the Health Departments (Figure 9).

Figure 4-5. Pictured to the right is an image of Joe Convery sitting on the pipe located at Beachwood Beach, Site 2. As you can see to his left there is a small hole in the pipe, here we took the in pipe samples for this site. On the far right is a close up of the hole in the pipe at Site 2.

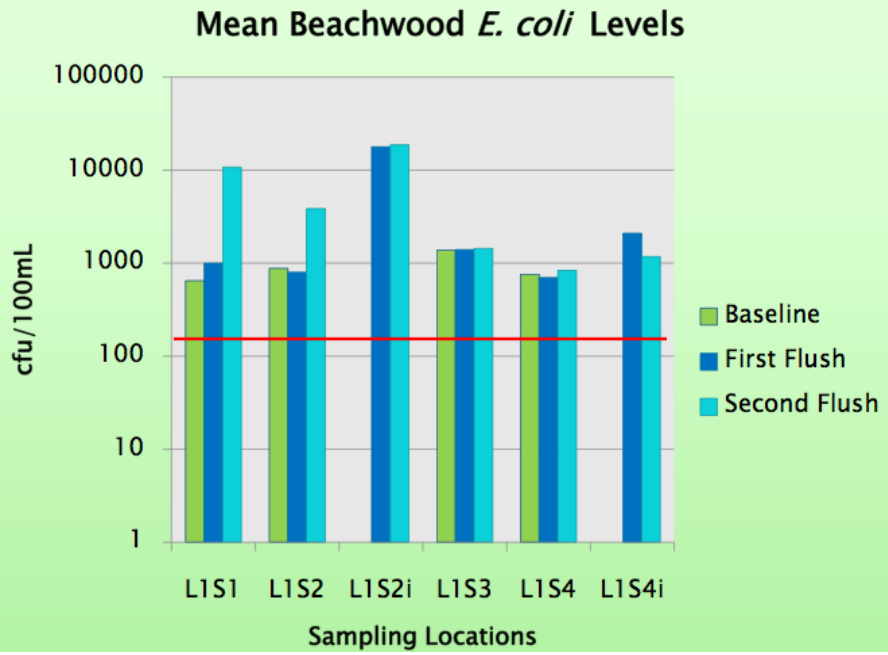
At each site we used a sample collection method set up by the NJDEPE for collecting samples directly in a sterile container. For this project we used WhirlPaks that were sodium thiosulfate-treated. The water samples were collected at a thigh-high depth, which was about eight to twelve inches submerged under the water's surface. The WhirlPaks were filled with a sweeping motion (downward/horizontally). These packs allowed us to have sterile containers every time we sampled, after using the bags we would dispose of them thus preventing any possibility of contamination. After the pack was closed, we refrigerated the samples in a large chilled cooler, and they remained in the container until we reached the laboratory in Dr. Wnek's garage. This site was chosen for the lab due to its convenience in location. Here we tested for water quality parameters using the YSI 85 and fluorometer, Turner Design handheld meter. The YSI 85 tested for the temperature, conductivity, salinity, dissolved oxygen, and percent saturation. The fluorometer was used to test for optical brighteners and turbidity. Each of these devices were calibrated before every sampling event, this provided accurate data. Another quality assurance procedure was the triple rinse, after every sample testing we would rinse the equipment three times with DI water to prevent any type of contamination between samples. Also to avoid contamination during the entire process we wore rubber gloves, and whipped down equipment with Kim wipes.

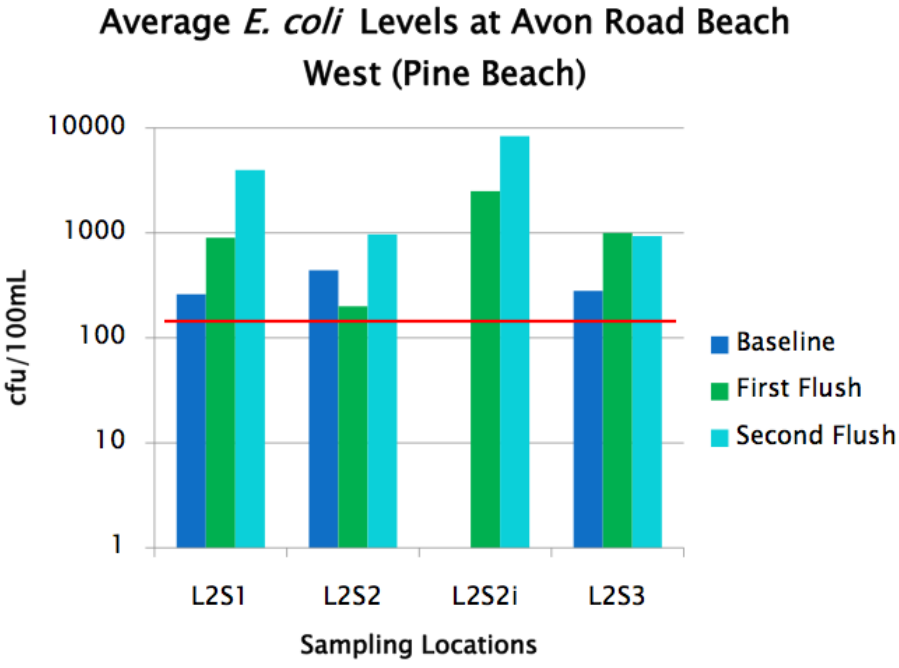
To test for E.coli present in the water the team used a Coliscan Easygel test. One mL of sample was collected from the WhirlPak with a pipet and added to Easygel media. This was then swirled and poured into a Petri dish. Once this was done with all of the samples we placed the Petri dishes into an incubator set at 35°C for twenty-four hours (Figure 6). With this test we were able to determine the amount of E.coli present. On the next day we identified the E.coli colonies by their distinct purple color, this number we then multiplied by one hundred, to produce the values per 100mL of sample.

Figure 6-8.
On the far left we have an example of the Petri dishes in the incubator. The center picture is of the two incubators and the IDEXX sealer. On the right there is a stack of IDEXX trays being incubated.

Next we used separated 10mL of the sample water in a graduated cylinder, which we then added 90mL of DI water to. You are required to dilute the marine water in this way. Enterolert was then added and swirled. This solution was poured into an IDEXX tray that we sealed and then incubated for twenty-four hours (Figure 7)(Figure 8). The next day we shined a black light over the IDEXX trays to identify how many colonies of *Enterococcus* there were present in the sample. What ever amount we saw we compared to the MPN numbers on the table, once we found our number we multiplied by ten because we diluted it, that way we were able to know how much *Enterococcus* would be present in 100mL.

As another part of our quality assurance with the NJDEP, we ran splits, and blanks along with the samples from each site. The splits were done for Beachwood Beach only and were sent to the NJDEP Leeds Point Laboratory and were used as a comparison (Figure 9). The blank was taken once every sampling event to meet the 1:20 ratio.





RESULTS

Beachwood Beach

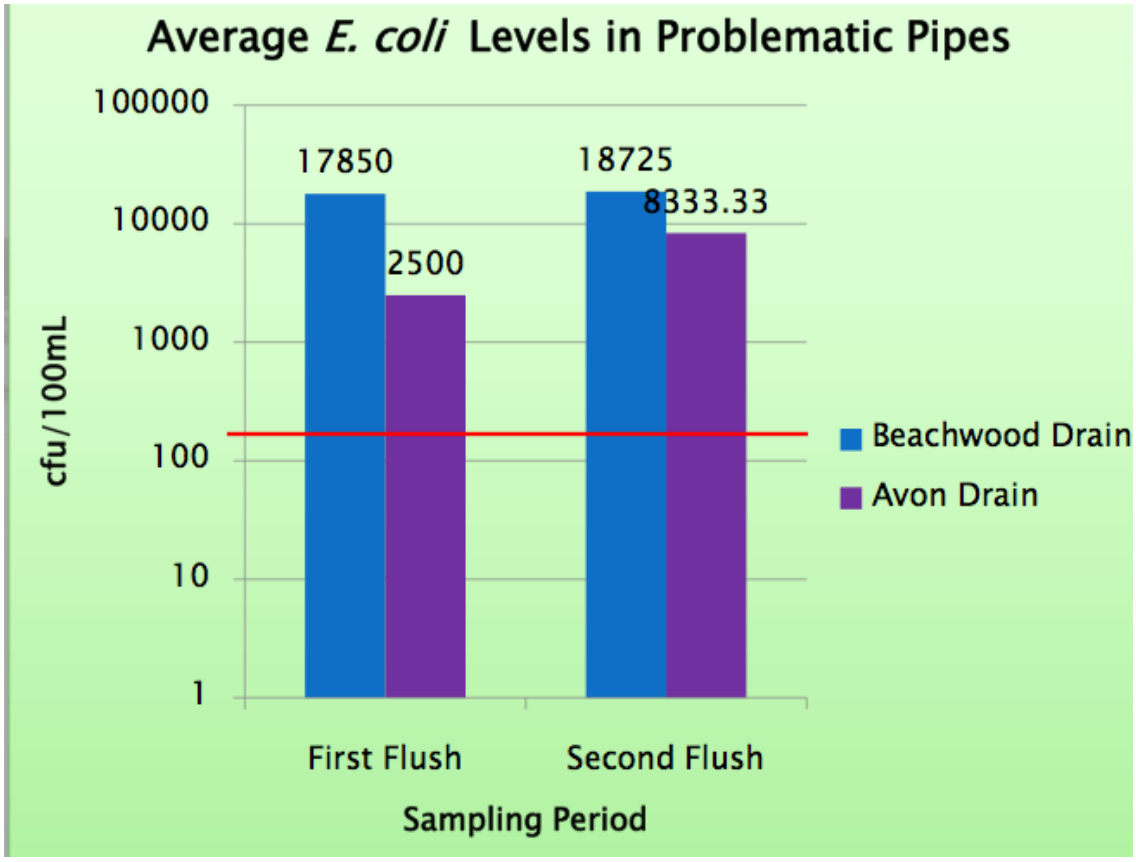
At Beachwood Beach we had five successful rainfall events on June 28th, July 3rd, July 8th, July 25th, and July 29th. The baseline was taken on June 27th, July 7th, July 18th, July 28th, and August 1st. All of the sites at Beachwood Beach during all flushes and even baseline have a mean that is substantially greater than the 200cfu/100mL recommended for the amount of E.coli in swimming water (represented by the red line). The samples from inside the pipe (L1S2i) have the highest amount of E.coli present.

Avon Road West Pine Beach

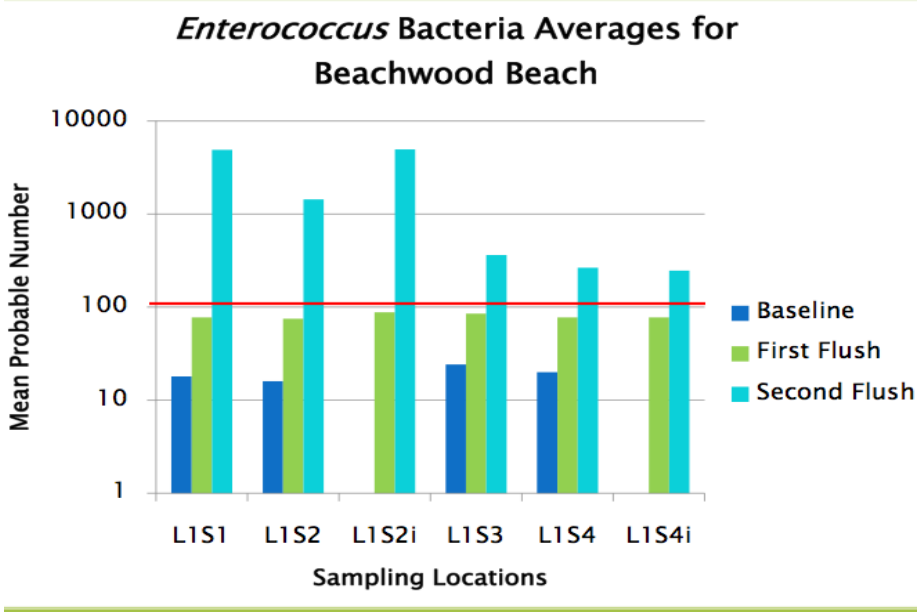
At Pine Beach we had three successful rainfalls on July 8th, July 25th and July 29th. The baseline was taken on June 27th, July 7th, July 18th, July 28th, and August 1st. We see a similar pattern to Beachwood in that the samples from in the pipe (L2S2i) is much higher in E.coli colonies

than the others and that all of the averages are drastically higher than the Health Department Swimming Standard for E.coli levels.

A common pattern seen in both graphs is that the second flush has greater levels than the first at a majority of the sites.

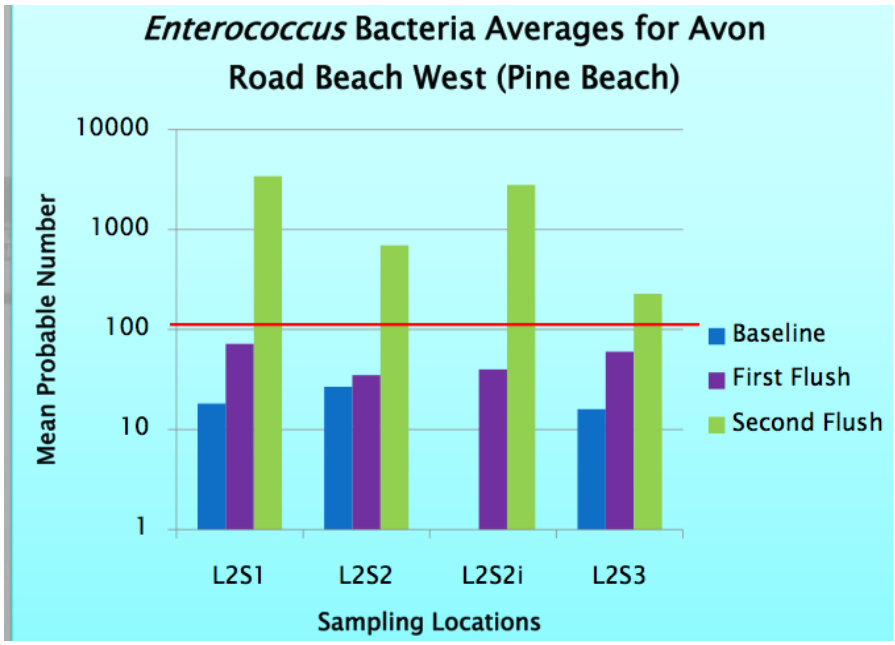


Here is a better look at the exact averages for the problematic pipes at Beachwood Beach and Avon Road West Pine Beach. These numbers are much higher than the standard for E.coli colonies. Beachwood Beach highest E.coli colony count was 41,900cfu/100mL on June 8th during the second flush of a storm and Pine Beach hit a high of 20,700cfu/100mL on July 29th.



Beachwood Beach

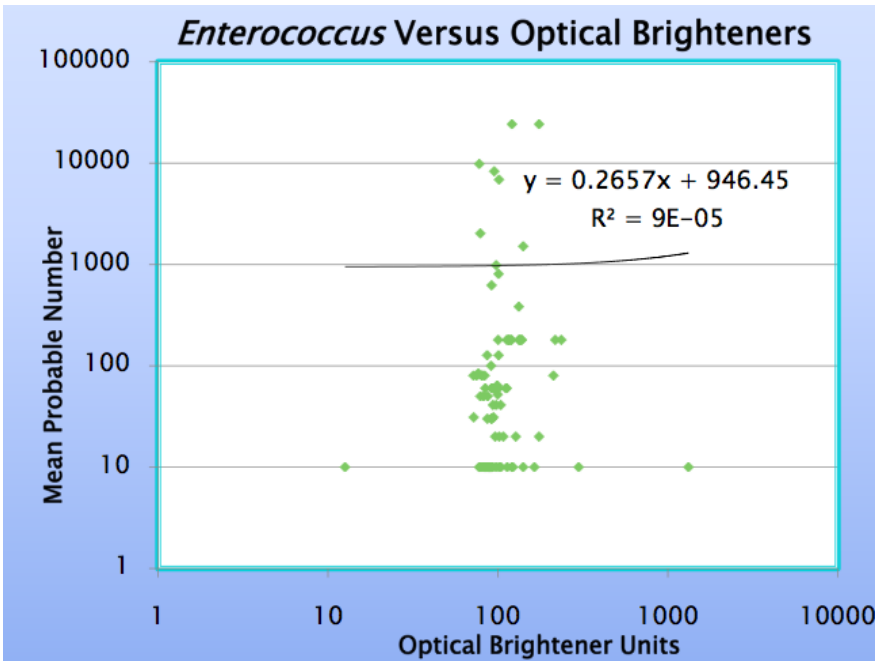
This graph shows the amount of *Enterococcus* on average found in water collected during the baseline, first flush and second flush. The graph perfectly shows the increasing amount of the bacteria found in the storm water as the rain continues. The highest amount of *Enterococcus* was present during the second flush of the storm on July 29th and this number was >24,196mpn.



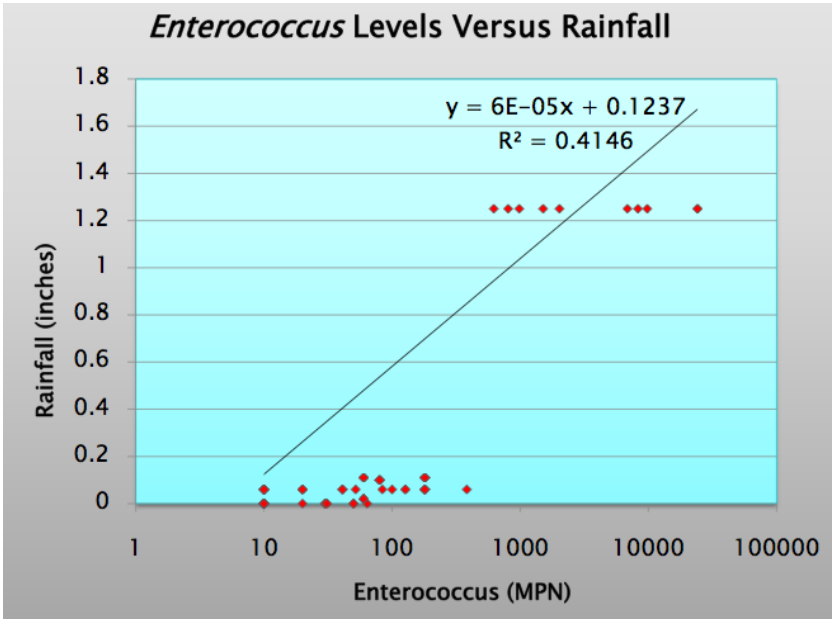
Avon Beach West Pine Beach

Once again one can see how the amount of bacteria present in the water increases as the storm continues. The highest amount of *Enterococcus* we recorded for Pine Beach was 20700mpn on July 29th.

All of the second flushes at both locations are above the standard for *Enterococcus*, 104cfu/100mL.



Above is a scatter plot representing the statistical relationship between optical brighteners and *Enterococcus*. The R-squared value is below .5 so it presents no statistical significance. We believe if we had more data to collect we would find a slight correlation between the two. We can also attribute the inaccurate data to tannins that may have interfered with our optical brightener readings



On the graph above *Enterococcus* Levels are compared to the amount of rainfall. The correlation between the two is statistically significant due to how close the R-squared value is to .5. This knowledge provides us with an understanding that when the amount of rain increases so does the amount of *Enterococcus* present.

Date	Beachwood (CFU/100 mL)		Avon (CFU/100 mL)	
	Health Dept.	Ours (Average)	Health Dept.	Ours (Average)
6/27/11	10	11.892	34.641	18.371
7/18/11	10	10	10	10
7/25/11	40	13.269	10	14.581
8/1/11	20	11.892	30	18.566

Location	Leed's (CFU/ 100 mL)	Ours (CFU/100 mL)
L1S1	30	10
L1S2	20	10
L1S3	37	10
L1S4	3	20

Figure 9. To the left there are the comparisons of our baseline data and other samples data to the data that prestigious organizations such as the New Jersey Health Department and Leeds Point have collected. As you can see our results are fairly close.

As stated before all of the samples from Beachwood Beach, and Avon Road West Pine Beach had large amounts of E.coli and *Enterococcus*, and even the averages/means proved to be over the recommended amount to be had in safe swimming waters. This was predictable for Beachwood Beach, a beach that is notoriously known for its beach closings and appearance on the Beach Bum list, to produce such dangerous levels of bacteria. I however was surprised with our findings in Pine Beach. Not once have I heard of it being a hot spot for unhealthy water, and whenever passing by I've observed crabbers, boaters, swimmers, and tanners always crowded the beach. Seeing so many people participating in recreational sports within the area made me believe that the water was actually safe.

At Beachwood Beach we encountered our highest numbers of E.coli. On the first flush of the storm on July 8th, we collected water that yielded 34,500 cfu/100mL. During the second flush, the amount raised to 41,900 cfu/100mL. The water tested was collected from the inside of the pipe located to the left of the beach. Possibilities to why these numbers are so high and increased from 1,300cfu/100ml (collected from July 7th) to the frighteningly large numbers before us include that this occurred during Fourth of July weekend. This week is known for crowded beach towns, the increase in population along with the fact that a storm occurred on the third clearing the storm pipes, allowed for all the rain from July 8th to pick up all the waste from the past four days. I believe had we not had the rain on the 3rd we would find that the amount of E.coli would be substantially larger than it was on the 8th. From our data we can also identify that site one has high levels of E.coli and *Enterococcus*. When these high numbers were produced we felt they could be caused by the pipe at site two, but the storm water exiting the pipe is being pulled eastward by the current. On the third this was noticeable because the debris that was discharged from the pipe at site two eventually floated over to site one when we were collecting samples. This highlights the concern that the storm water can also be pulled by the current West, where it would be even closer to the bathing area.

In regards to Avon Road West Pine Beach, there were not many connections between particular days or even outstanding patterns besides that there is a definite large amount of E.coli and *Enterococcus* present in the waters before and during a rainstorm. The numbers aren't nearly as large as Beachwood's but they still do present a problem. My main concerns with Pine Beach would be the pipe that produces consistently higher numbers in E.coli and *Enterococcus.*

RECOMMENDATIONS

Our data supports the idea that Beachwood Beach has elevated bacteria levels during/after rainfall. At the levels we counted, these bacteria present a potential health hazard for individuals exposing themselves to this water. These levels are greatly larger than the Health Department regulations for swimming water. At Avon Road West Pine Beach there is a threat that the high bacteria levels can potentially pose a problem, if the storm pipes are not properly addressed in an urgent manor. Our team recommends a 72-hour (three day) beach closing after a storm with .10 inches of rain; storms over .5 have been proven to consistently produce unhealthy increases in the bacteria levels. A direct way to prevent this bacteria level from escalading would be clean debris from the storm drains and to do this on a regular basis. When sampling we often saw still storm drains filled with murky water, and even a bag of dog waste was seen in one. Inspections of these pipes can be made with Ocean County Health Department's free, available storm drain cameras, which allow the town to inspect for debris and any sort of infrastructure problems in the pipes. I believe these issues should be addressed quickly, and these cautionary actions should be taken before a child gets sick from being exposed to these toxic waters.

The student grant project was a success, our team provided an accurate accumulation of data that we acquired through methods that were respected and recognized by the NJDEP. Our goal of increasing our knowledge of the water quality of the Toms River was readily accomplished through out the project. The team worked well together, and each of us brought our own special assets that we used and highlighted through this project. Working along side the NJDEP, and Rutgers Co Op. provided a great feeling of importance and scientific significance. If we had to replicate this project I would search for students living closer to the sites under question, that way there isn't a large amount of travel time. Having Beachwood Beach and Avon Road Pine Beach West located so close proved to be helpful when trying to get samples from both destinations. The only issues that we came across would be the unpredictable weather, and a lack of supplies. Often we found ourselves borrowing supplies from our resources.

As my first ever research experience I am proud of the results and the impact that they will have, if acknowledged by the towns. It was a great feeling to be contributing to research that had much substance value along with importance to the environment. It was an honor working along with the Save the Barnegat Bay committee, these scientists and experienced professionals, brought a sense of comfort to us when ever meeting with them regarding the project and they truly helped when it came to presenting our data. I would like to acknowledge and thank the following people who were particularly vital to my success: Dr. John Wnek, Danielle Donkersloot, Cara Muscio, the Save Barnegat Bay committee and of course the entire student grant water quality project team.

REFERENCES

"Cooperative Extension: Rutgers NJAES." *Rutgers New Jersey Agricultural Experiment Station*. Web. 11 Aug. 2011. <http://njaes.rutgers.edu/extension/>.

National Resources Defense Council. (2011). Testing the Waters: A Guide to Water Quality at Vacation Beaches.Retrieved July 28, 2011 from http://www.nrdc.org/water/oceans/ttw/ttw2011.pdf

National Resources Defense Council. (2009). Testing the Waters: A Guide to Water Quality at Vacation Beaches.Retrieved July 28, 2011 from http://abcnews.go.com/images/GMA/ht_tw_national_100727.pdf

National Resources Defense Council. (2009). Testing the Waters: A Guide to Water Quality at Vacation Beaches.Retrieved July 28, 2011 from http://cdn.publicinterestnetwork.org/assets/S4NeXuBF4nh0kw1QVrNEmA/NRDC-Testing-the-Waters-2009---NJ-fact-sheet.pdf

National Resources Defense Council. (2008). Testing the Waters: A Guide to Water Quality at Vacation Beaches. Retrieved July 28, 2011 from http://www.nrdc.org/water/oceans/ttw/ttw2008.pdf

National Resources Defense Council. (2007). Testing the Waters: A Guide to Water Quality at Vacation Beaches. Retrieved July 28, 2011 from http://www.nrdc.org/water/oceans/ttw/ttw2007.pdf

National Resources Defense Council. (2006). Testing the Waters: A Guide to Water Quality at Vacation Beaches. Retrieved July 28. 2011 from http://www.nrdc.org/water/oceans/ttw/ttw2006.pdf

"NJDEP New Jersey Department of Environmental Protection." *The Official Web Site for The State of New Jersey*. Web. 11 Aug. 2011. <http://www.state.nj.us/dep/>.

New Jersey Department of Environmental Protection. (2011). Ocean County Ocean Monitoring Results. Available from http://njbeaches.org/

Save Barnegat Bay. Web. 11 Aug. 2011. <http://www.savebarnegatbay.org/>.

"The New Jersey Watershed Watch Network." New Jersey Department of Environmental Protection, Division of Watershed Management. Web. 11 Aug. 2011. <http://www.state.nj.us/dep/wms/bwqsa/vm/docs/WatershedWatchFinal.pdf>.