



Making Waves Since 1986
www.savetheharbor.org

212 Northern Avenue - Suite 304 West - Boston, MA 02210
Telephone: 617-451-2860

2015 Beach Water Quality Report Card for the 2014 Swimming Season

Prepared by Bruce Berman, Ben Wetherill, Jingwei Zhang, and Yudan Jiang of Save the Harbor / Save the Bay.

Executive Summary

Save the Harbor / Save the Bay's annual **Boston Harbor Region Beach Water Quality Report Card** is based on an in-depth analysis of thousands of water samples taken by the Department of Conservation and Recreation (DCR) and the Massachusetts Water Resources Authority (MWRA). The samples are collected each year during the swimming season at 34 testing sites on 15 public beaches in 9 communities including Nahant, Lynn, Revere, Winthrop, East Boston, South Boston, Dorchester, Quincy and Hull. The report card is based on methodology developed by Save the Harbor/Save the Bay's **Beaches Science Advisory Committee (BSAC)**, Co-Chaired by Dr. Judy Pederson of the MIT Sea Grant Program and Dr. Jim Shine of the Harvard School of Public Health.

Water quality on the Boston Harbor Region's public beaches was very good in 2014 compared to previous years, with all 15 of the public beaches we studied from Nahant to Nantasket scoring between 87.5% and 100% for an average overall safety score of 96%, due in part to the unusually low rainfall during the 2014 swimming season.

The ranking of the beaches remains similar to previous years, with South Boston and Revere beaches showing the best water quality, and beaches in Dorchester and Lynn reporting the lowest scores. Only Tenean Beach changed rank significantly, with an overall beach safety score of 95%, compared to 63% in 2013, when there was more rainfall.

Water Quality Metrics

Save the Harbor uses quantitative metrics for assessing beach water quality and beach management at the Boston Harbor region beaches. *Enterococcus* is the current microbial indicator of gastro-intestinal (GI) illness used in marine waters, as established by the EPA. To assess and compare the water quality and conditions on each beach, we looked at the percentage of test samples below the state swimming standard of 104 colony forming units (cfu) of *Enterococcus* per 100 ml of water. This metric is called "Beach Safety," and is a metric that is independent of the flagging program. The inverse of this measure is referred to as "% Exceedances".

Another metric is the geometric mean (GM), which indicates the central tendency of a set of numbers, calculated from the root of the product of their values. Geometric mean is used to calculate averages for datasets that are exponential in nature. For our analysis, we calculated the GM based on bacterial counts from the previous five days without rain. A GM of 35 cfu/100 ml or greater is considered statistically significant in water quality analysis, and is included with bacterial exceedances when determining Overall Beach Safety.

The total number of samples collected varies across these beaches. Some are sampled weekly and others are sampled daily throughout the swimming season. Also, some beaches have as many as four sampling locations that are sampled simultaneously, while others have only one location. Protocols have been established by DCR and Save the Harbor’s BSAC defining how often beaches should be sampled and how many locations at each beach must be below the bacteria threshold for the beach to be considered swimmable. (**Error! Reference source not found.**) The “% Beach Exceedances” metric evaluates the percentage of days that each beach is considered above threshold according to this protocol.

Table 1
Overall Beach Safety 2014

Beach	2014 Overall Beach Safety	Test Frequency	# of sampling locations
City Point	100%	weekly	1
M Street	100%	weekly	1
Carson	100%	weekly	2
Pleasure Bay	100%	weekly	3
Revere	100%	weekly	3
Short	100%	weekly	1
Nahant	100%	weekly	4
Nantasket	98%	weekly	4
Constitution	96%	daily	3
Tenean	95%	daily	1
Winthrop	94%	weekly	1
Wollaston	94%	daily	4
Malibu	93%	daily	1
King's Beach	88%	daily	3
Savin Hill	87%	weekly	1

Overall Beach Safety for 2014 is presented in **Error! Reference source not found.**. Most of the weekly sampled beaches had no bacterial exceedances. Nantasket and Winthrop each had 1, and Savin Hill had 2 exceedances. All except Nantasket occurred immediately following large rainfall. Bacterial counts at daily sampled beaches were good in comparison with previous years (**Error! Reference source not found.**). See the Individual Beach Summaries section for a detailed description of each beach.

It is important to note the relationship between bacterial levels and precipitation. The summer of 2014 was a relatively dry season, with only 7.4 inches of rainfall during the June-August swimming season (Appendix). The average for the previous five years for these same months was over 13 inches. Beach water quality is strongly related to precipitation, as rainfall events tend to flush pollutants from sewer and storm water systems into water bodies. The lack of rainfall in 2014 is reflected in the water quality metrics, contributing to the relatively high Beach Safety scores.

Because rainfall amounts vary significantly from year to year, we have included this useful table, which compares overall beach safety from 2011 through 2014 for the metropolitan region’s public beaches from Nahant to Nantasket.

Table 2
Comparison of Overall Beach Safety – 2011 -2014

Beach	4-year Avg	2014	2013	2012	2011
City Point	100%	100%	100%	100%	99%
Carson	99%	100%	99%	99%	97%
M Street	99%	100%	99%	99%	99%
Nantasket	99%	98%	100%	98%	100%
Pleasure Bay	96%	100%	96%	94%	95%
Revere	96%	100%	94%	100%	88%
Constitution	94%	96%	97%	89%	93%
Short Beach	94%	100%	94%	100%	83%
Winthrop	93%	94%	94%	100%	85%
Nahant	92%	100%	91%	89%	89%
Savin Hill	92%	87%	100%	88%	92%
Wollaston	91%	94%	88%	93%	89%
Malibu	88%	93%	76%	89%	92%
King's Beach	83%	88%	83%	86%	73%
Tenean	80%	95%	63%	82%	80%
All Beaches	93%	96%	92%	94%	90%

Beach Flagging and Management

The metrics for assessing the Beach Management Flagging Program include Sensitivity, Positive Predictive Efficiency, Specificity, Negative Predictive Efficiency, and Overall Predictive Efficiency.

- **Sensitivity** tells us what fraction of the poor water quality days are correctly posted with a red flag. This can be expressed as, “When this beach is not safe for swimming, it is correctly posted with a red flag x% of the time.” A perfect score would be 100%.
- **Positive Predictive Efficiency** measures what fraction of the posted red flags are correct. A score of 100% would mean that all posted red flags were valid, regardless of whether or not red flags were posted on all poor water quality days.

- **Specificity** tells us what fraction of the good water quality days are correctly posted with a blue flag. This can be expressed as, “When this beach is safe for swimming, it is correctly posted with a blue flag x% of the time.”
- **Negative Predictive Efficiency** measures what fraction of the posted blue flags are correct. A score of 100% would mean that all posted blue flags were valid, regardless of whether or not blue flags were posted on all good water quality days.
- **Overall Predictive Efficiency** measures what fraction of the time the flags are in general correct. This metric can be expressed as, “The flags correctly indicate that the beach is safe or unsafe for swimming x% of the time.”

Beach flagging and management metrics are generally only available for beaches that are tested on a daily basis, because results cant be confirmed when there is only one test per week.

All Beach Metrics 2014

A summary of metrics, including flag accuracy is presented in table 3. A total of 51 red flags were flown in 2014, compared with 109 in 2013. Of these, only 11 were correct for the day they were posted (4 could not be verified) and 8 of the 11 correct flags were triggered by rainfall thresholds. Incorrect flags were triggered by both rainfall and bacterial samples, but previous day bacterial samples triggered less than 30% of the correct flags.

Table 3
Summary of all 2014 beach metrics.

	Test Freq.	Total # Samples	# Bacterial Exceedance ¹	Overall Beach Safety ²	% Beach Exceedance ³	# Red Flags ⁴	Positive Predictive Efficiency	Negative Predictive Efficiency	Sensitivity ⁵
City Point	weekly	16	0	100%	0%	1	0%		
M Street	weekly	16	0	100%	0%	1	0%		
Carson	weekly	32	0	100%	0%	1	0%		
Pleasure Bay	weekly	48	0	100%	0%	1	0%		
Revere	weekly	45	0	100%	0%	0			
Short	weekly	15	0	100%	0%	0			
Nahant	weekly	60	0	100%	0%	0			
Nantasket	weekly	60	1	98%	0%	0			
Constitution	daily	228	10	96%	3%	5	40%	92%	100%
Tenean	daily	80	4	95%	5%	14	29%	90%	100%
Winthrop	weekly	16	1	94%	6%	1	0%		
Wollaston	daily	314	18	94%	5%	10 ⁶	36%	96%	100%
Malibu	daily	74	5	93%	7%	6	17%	96%	20%
King's Beach	daily	228	28	88%	9%	10	0%	82%	0%
Savin Hill	weekly	15	2	87%	13%	1 ⁷			

1. # of Exceedances represents the number of individual samples that exceeded the 104 cfu threshold.
2. Beach Safety is calculated based on individual samples (total exceedances / total samples).
3. Beach Exceedance uses the beach multi-site protocol to define total beach quality (**Error! Reference source not found.**).
4. Flags are posted based on bacterial exceedances or rainfall.
5. Sensitivity can't be calculated for weekly sampled beaches.
6. Wollaston should have posted 11 flags. One was missed due to a flagging error.
7. Savin Hill should have posted 0 flags. One flag was posted due to a misreading of the back-to-back protocol.

In 2014, DPH, DCR, and BSAC decided to change the flagging protocol for beaches that have historically been considered clean so that only repeated back-to-back exceedances on successive days would result in a red flag. This decision covered Savin Hill, Nahant, Short, Revere, Carson, Pleasure Bay, M Street, City Point, and Nantasket. Because of good water quality, this decision had no impact in 2014 at any of these beaches, except Savin Hill. Savin Hill had two bacterial exceedance days, but neither of them resulted in a flag because neither was a back-to-back instance, so this new policy eliminated 2 inaccurate red flags in 2014. Winthrop also should have been included in this list, but was not, due to a beach mix-up. Including Winthrop would have eliminated a 3rd inaccurate red flag.

If this policy had been in place in 2013, which was a relatively wet year, 6 incorrect red flags across 5 of the beaches would have been eliminated. However, it is also worth noting that while this policy does reduce incorrect red flags, it doesn't necessarily improve the accuracy of red flags that are flown. A theoretical analysis at a subset of beaches with more frequent water quality exceedances does not show any consistent trend in Positive Predictive Efficiency when

protocol is changed from single exceedance to back-to-back. In both approaches, red flags would be accurate less than 50% of the time. There may be other more scientifically defensible ways to reduce wrong flags, such as predictive modeling using rainfall or by using long-term metrics.

Acknowledgements

Save the Harbor/Save the Bay would like to thank Dr. Jim Shine and Dr. Judy Pederson, Co-Chairs of our Beaches Science Advisory Committee, Kelly Coughlin and David Wu of the MWRA, DCR's Dennis Fitzgerald, and DPH's Vanessa Curran and Michael Celona for their help with the report card.

For more information on Save the Harbor/Save the Bay's Beaches Report Card, contact Bruce Berman on his cell at 617-293-6243 or email bruce@bostonharbor.com

You can find data and learn more about the methodology on which the report card is based at www.savetheharbor.org/Content/beachesreportcard/

Appendix A

2014 Individual Beach Summaries

City Point

City Point is located in South Boston and has one sampling location that is tested weekly for bacterial counts. (In previous years, City Point was tested daily.) In 2014, City Point received an Overall Beach Safety score of 100%, which was exactly the same as the previous year's score of 100%. There were no bacterial exceedances in the 16 samples taken.

City Point Beach Safety 2014	
Total # Samples	16
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

City Point posts a red flag when there is a bacterial count greater than 104 cfu on two consecutive days or rainfall is greater than 2 inches. In 2014, there was 1 flag posted due to rainfall, but no sample was collected on this day, so the accuracy of the flag cannot be verified.

M Street

M Street beach is located in South Boston and has one sampling location that is tested weekly for bacterial counts. (In previous years, M Street was tested daily.) In 2014, M Street received an Overall Beach Safety score of 100%, which was almost the same as the previous year's score of 99%. There were no bacterial exceedances in the 16 samples taken.

M Street Beach Safety 2014	
Total # Samples	16
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

M Street posts a red flag when there is a bacterial count greater than 104 cfu on two consecutive days or rainfall is greater than 2 inches. In 2014, there was 1 flag posted due to rainfall, but no sample was collected on this day, so the accuracy of the flag cannot be verified.

Carson Beach

Carson Beach is located in South Boston and has two sampling locations that are tested weekly for bacterial counts. (In previous years, Carson was tested daily.) In 2014, Carson received an Overall Beach Safety score of 100%, which was almost the same as the previous year's score of 99%. There were no bacterial exceedances in the 16 samples taken.

Carson Beach Safety 2014	
Total # Samples	16
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Carson posts a red flag when there is a bacterial exceedance at one or more of its sampling locations on two consecutive days or rainfall is greater than 2 inches. In 2014, there was 1 flag posted due to rainfall, but no sample was collected on this day, so the accuracy of the flag cannot be verified.

Aggregated Data for South Boston

The aggregated Overall Beach Safety score for the South Boston beaches (M Street Beach, Carson Beach, and City Point) was 100% in 2014, which was slightly higher than the previous year's score of 99%.

South Boston Beach Safety 2014	
Total # Samples	64
# Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Pleasure Bay

Pleasure Bay is located in South Boston and has three sampling locations that are tested weekly for bacterial counts. (In previous years, Pleasure Bay was tested daily.) In 2014, Pleasure Bay received an Overall Beach Safety score of 100%, which was higher than the previous year's score of 96%. There were no bacterial exceedances in the 48 samples taken.

Pleasure Bay Beach Safety 2014	
Total # Samples	48
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Pleasure Bay posts a red flag when there is a bacterial exceedance at two or more of its sampling locations on two consecutive days or rainfall is greater than 2 inches. In 2014, there was 1 flag posted due to rainfall, but no sample was collected on this day, so the accuracy of the flag cannot be verified.

Revere Beach

Revere Beach is located in Revere, MA and has four sampling locations that are tested weekly for bacterial counts. In 2014, Revere received an Overall Beach Safety score of 100%, which was higher than the previous year's score of 94%. There were no bacterial exceedance in the 45 samples taken in 2014.

Revere Beach Safety 2014	
Total # Samples	45
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Revere posts a red flag when there is a bacterial exceedance at two or more of its sampling locations on two consecutive days. In 2014, Revere posted no red flags.

Short Beach

Short Beach is located in Revere, MA and has one sampling location that is tested weekly for bacterial counts. In 2014, Short Beach received an Overall Beach Safety score of 100%, which was higher than the previous year's score of 94%. There were no bacterial exceedances in the 15 samples taken in 2014.

Short Beach Safety 2014	
Total # Samples	15
# Bacterial Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Short Beach posts a red flag when there is a bacterial count greater than 104 cfu on two consecutive days. In 2014, Short Beach posted no red flags.

Nahant Beach

Nahant Beach is located in Nahant, MA and has four sampling locations that are tested weekly for bacterial counts. In 2014, Nahant received an Overall Beach Safety score of 100%, which was higher than the previous year's score of 91%. There were no bacterial exceedances in the 60 samples taken.

Nahant Beach Safety 2014	
Total # Samples	60
# Exceedances	0
Test Frequency	weekly
Overall Beach Safety	100%
% Beach Exceedance	0%

Nahant posts a red flag when there is a bacterial exceedance at 2 or more of its sampling locations on 2 consecutive days. In 2014, Nahant posted no red flags.

Nantasket Beach

Nantasket Beach is located in Hull, MA and has four sampling locations that are tested weekly for bacterial counts. In 2014, Nantasket received an Overall Beach Safety score of 98%, which was lower than the previous year's score of 100%. There was 1 bacterial exceedance in the 60 samples taken.

Nantasket Beach Safety 2014	
Total # Samples	60
# Bacterial Exceedances	1
Test Frequency	weekly
Overall Beach Safety	98%
% Beach Exceedance	0%

Nantasket posts a red flag when there is a bacterial exceedance at two or more of its sampling locations on two consecutive days. In 2014, there were no red flags posted on Nantasket Beach.

Constitution Beach

Constitution Beach is located in East Boston and has three sampling locations that are tested daily for bacterial counts. In 2014, Constitution received an Overall Beach Safety score of 96%, which was almost the same as the previous year's score of 97%. There were 10 bacterial exceedances in the 228 samples taken in 2014.

Constitution Beach Safety 2014	
Total # Samples	228
# Bacterial Exceedances	10
Test Frequency	daily
Overall Beach Safety	96%
% Beach Exceedance	3%

Constitution Flagging Metrics	
Sensitivity	100%
Positive Predictive Efficiency	40%
Specificity	89%
Negative Predictive Efficiency	92%
Overall Predictive Efficiency	88%

Constitution posts a red flag when there is a bacterial exceedance at two or more of its sampling locations or if rainfall is greater than 1 inch. In 2014, there were 5 red flags posted on Constitution Beach due to exceedances and rainfall, but only 2 days actually qualified as beach exceedances. Both exceedances were captured by flags due to rainfall triggers.

Tenean Beach

Tenean Beach is located in Dorchester and has one sampling location that is tested daily for bacterial counts. In 2014, Tenean received an Overall Beach Safety score of 95%, which was higher than the previous year's score of 62%. There were a total of 4 bacterial exceedances in the 80 samples taken in 2014.

Tenean Beach Safety 2014	
Total # Samples	80
# Bacterial Exceedances	4
Test Frequency	daily
Overall Beach Safety	95%
% Beach Exceedance	5%

Tenean Flagging Metrics	
Sensitivity	100%
Positive Predictive Efficiency	29%
Specificity	80%
Negative Predictive Efficiency	90%
Overall Predictive Efficiency	79%

Tenean posts a red flag when there is a bacterial count greater than 104 cfu or rainfall greater than 0.25 inches. In 2014, Tenean Beach had 14 red flag postings due to exceedances and rainfall, but only 4 days actually qualified as beach exceedances. All 4 exceedances were captured correctly by flags – 3 due to rainfall triggers and 1 due to a back-to-back exceedance event.

Winthrop Beach

Winthrop Beach is located in Winthrop, MA and has one sampling location that is tested weekly for bacterial counts. In 2014, Winthrop received an Overall Beach Safety score of 94%, which was exactly the same as the previous year's score of 94%. There was one bacterial exceedance in the 16 samples taken in 2014.

Winthrop Beach Safety 2014	
Total # Samples	16
# Bacterial Exceedances	1
Test Frequency	weekly
Overall Beach Safety	94%
% Beach Exceedance	6%

Winthrop Beach posts a red flag when there is a bacterial count greater than 104 cfu. In 2014, Winthrop had one red flag posting. However, this flag did not correspond to an exceedance on the day of posting because the bacterial count on the following day was below threshold.

Wollaston Beach

Wollaston Beach is located in Quincy and has 4 sampling locations: Milton, Channing, Sachem, and Rice. Wollaston Beach is evaluated individually by location and in aggregate as a whole beach. In 2014, Wollaston received an Overall Beach Safety score of 94%, which was higher than the previous year's score of 89%. There were a total of 18 bacterial exceedances in the 314 samples collected in 2014.

Wollaston Beach Safety 2014	
Total # Samples	314
# Bacterial Exceedances	18
Test Frequency	daily
Overall Beach Safety	94%
% Beach Exceedance	5%

Wollaston Flagging Metrics	
Sensitivity	100%
Positive Predictive Efficiency	36%
Specificity	89%
Negative Predictive Efficiency	96%
Overall Predictive Efficiency	88%

Wollaston posts sites individually, but it posts red flags at all sites when there is a bacterial exceedance at two or more of its sampling locations or rainfall exceeds 0.5 inches. In 2014, Wollaston Beach should have had 11 red flag postings due to exceedances and rainfall (there were really only 10 flags due to a flagging error), but only 4 days actually qualified as beach exceedances. All 4 exceedances were captured correctly by flags – 2 due to rainfall triggers and 2 due to a back-to-back exceedance event.

Malibu Beach

Malibu Beach is located in Dorchester and has one sampling location that is tested daily for bacterial counts. (In previous years, Malibu was tested weekly.) In 2014, Malibu received an Overall Beach Safety score of 93%, which was higher than the previous year's score of 76%. There were a total of 5 bacterial exceedances in the 74 samples taken in 2014.

Malibu Beach Safety 2014	
Total # Samples	74
# Bacterial Exceedances	5
Test Frequency	daily
Overall Beach Safety	93%
% Beach Exceedance	7%

Malibu Flagging Metrics	
Sensitivity	20%
Positive Predictive Efficiency	17%
Specificity	86%
Negative Predictive Efficiency	96%
Overall Predictive Efficiency	80%

Malibu posts a red flag when there is a bacterial count greater than 104 cfu. In 2014, Malibu had 6 red flag postings due to exceedances and rainfall, but only 5 days actually qualified as beach exceedances. Malibu is not generally flagged for rainfall, but in 2014 beach managers chose to flag it for one particularly large rainfall. Only the rainfall flag correctly coincided with an actual beach exceedance on the same day as the exceedance.

King's Beach

King's Beach is located on the Lynn and Swampscott line. It has three sampling locations that are tested daily for bacterial counts. In 2014, King's received an Overall Beach Safety score of 84%, almost exactly the same as the previous year's 83%. There were 28 bacterial exceedances in the 228 total samples taken in 2014.

King's Beach Safety 2014	
Total # Samples	228
# Bacterial Exceedances	28
Test Frequency	daily
Overall Beach Safety	84%
% Beach Exceedance	9%

King's Flagging Metrics	
Sensitivity	0%
Positive Predictive Efficiency	0%
Specificity	78%
Negative Predictive Efficiency	82%
Overall Predictive Efficiency	71%

King's Beach posts a red flag when there is a bacterial exceedance at 2 or more of its sampling locations or if there is a CSO discharge on the beach. In 2014, King's had 10 red flag postings due to exceedances of the single sample maximum and the geometric mean, but only 7 days qualified as beach exceedances. Since there were no repeat exceedances on successive days, none of the flags actually corresponded to beach exceedances on the days the flags were flown.

Savin Hill Beach

Savin Hill Beach is located in Dorchester and has one sampling location that is tested weekly for bacterial counts. In 2014, Savin Hill received an Overall Beach Safety score of 87%, which was lower than the previous year's score of 100%. There were a total of 2 bacterial exceedances in the 15 samples taken.

Savin Hill Beach Safety 2014	
Total # Samples	15
# Bacterial Exceedances	2
Test Frequency	weekly
Overall Beach Safety	87%
% Beach Exceedance	13%

Savin Hill posts a red flag when there is a bacterial count greater than 104 cfu on two consecutive days. In 2014, there was 1 red flag postings on Savin Hill Beach, but there actually should not have been any, since the beach had no back-to-back exceedances.

Appendix B

Proposed Future Changes

In 2012, the EPA issued new Beach Water Quality Criteria, replacing the previous criteria that were issued in 1986. In order to continue receiving federal beach monitoring support, each state is required to comply with the new criteria by 2016. The new criteria include recommendations of different bacterial threshold values, and recommendations of new methods for bacterial sampling or bacterial modeling. Massachusetts has not decided yet exactly how it will implement the new criteria, but we have analyzed how this report card would change if the new bacterial threshold values were implemented exactly as recommended.

The current approach evaluates exceedances against two criteria: Single-Sample-Maximum (SSM) of 104 cfu, and a running 5-day Geometric Mean (GM) of 35 cfu. EPA's new recommended criteria would evaluate exceedances against three criteria: Beach Action Value (BAV) of 70 (or 60 for higher protection), a running 30-day GM of 35 (or 30), and a running 30-day Statistical Threshold Value (STV) of 130 (or 110) for 90% of samples. An analysis of 2014 data comparing scorecard metrics for the current and new recommended criteria shows that implementing the new criteria exactly as recommended would result in a decreased Beach Safety metric for most beaches (Table 4).

Table 4

2014 Overall Beach Safety - comparison of current and hypothetical new criteria

Beach	Current Overall Beach Safety	Overall Beach Safety with New Criteria
City Point	100%	100%
M Street	100%	100%
Carson	100%	94%
Pleasure Bay	100%	98%
Revere	100%	97%
Short	100%	93%
Nahant	100%	95%
Nantasket	98%	95%
Constitution	96%	94%
Tenean	95%	71%
Winthrop	94%	88%
Wollaston	94%	91%
Malibu	93%	89%
King's Beach	88%	82%
Savin Hill	87%	87%
All Beaches	96%	92%

Appendix C

Opportunities for Better Models

Current protocol flags beaches based on previous day samples and rainfall. If only previous day samples were used in 2014, only 12% of beach exceedances would be correctly flagged, and 88% of red flags flown would be incorrect. We have noticed similar performance in other years, and there have been many scientific studies concluding the same thing – that previous day bacteria samples have little relationship with current day water quality. Save the Harbor / Save the Bay is leading a study of opportunities to improve flagging performance with predictive modeling.

Many studies have noted better predictive performance from environmental variables, such as rainfall, streamflow, and tides. We have analyzed a range of environmental variables for predictive capability on Boston area beaches, and we have concluded that optimized rainfall thresholds would deliver between 10 and 30% improvements in Sensitivity and Positive Predictive Efficiency over models based on previous day samples. We have shown that rainfall models could have delivered over 50% Sensitivity and PPE over the last four years. And, our analysis has shown that combining rainfall and samples, as we are currently doing, actually makes predictive models worse by generating too many incorrect flags.

In the next years, Save the Harbor / Save the Bay will be advocating a transition away from the use of previous day samples to predictive modeling based on rainfall and other factors. The transition to the new EPA criteria in 2016 offers an opportunity to implement this change.

Table 5
Current Protocol for posting or analyzing beaches

Beach	Sampling Frequency	Post Red Flag When		Overall Beach Water Quality	
		Exceedance	Precautionary		
King's Beach	daily	2 or more >104 or GM >35		discharge of Lynn CSO#006	exceedances
Wollaston	daily	2 or more >104		Rain > 0.5 inches	exceedances
Tenean	daily	EC >104		Rain > 0.25 in	exceedances + GM
Malibu	daily	EC >104		no	exceedances + GM
Constitution	daily	2 or more >104		Rain > 1 in	exceedances + GM
Winthrop	weekly	EC >104		no	exceedances + GM
Nahant	weekly	2 or more > 104	back to back	no	exceedances + GM
Revere	weekly	2 or more >104	back to back	no	exceedances + GM
Short	weekly	EC >104	back to back	no	exceedances + GM
Pleasure Bay	weekly	2 or more EC >104	back to back	Rain > 2 in	exceedances + GM
City Point	weekly	EC >104	back to back	Rain > 2 in	exceedances + GM
M Street	weekly	EC >104	back to back	Rain > 2 in	exceedances + GM
Carson	weekly	1 or more >104	back to back	Rain > 2 in	exceedances + GM
Savin Hill	weekly	EC >104	back to back	no	exceedances + GM
Nantasket	weekly	3 or more >104	back to back	no	exceedances + GM

Appendix E

Comparison of bacteria and precipitation conditions for the past 4 years

Rainfall measurements are from the Blue Hills Observatory. Note that June 2013 was especially wet while the rest of 2013 was especially dry. This is important because weekly sampling starts in the beginning of June, but most daily sampling starts after June 20th.

