2021 RHODE ISLAND BEACH AND RECREATIONAL WATER QUALITY REPORT

RHODE ISLAND DEPARTMENT OF HEALTH

BEACHES ENVIRONMENTAL ASSESSMENT
AND COASTAL HEALTH PROGRAM

2021 RHODE ISLAND BEACH AND RECREATIONAL WATER QUALITY REPORT

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June 7, 2022

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Executive Summary

The Rhode Island Department of Health (RIDOH) is responsible for the licensing and regulation of bathing beach facilities in the State of Rhode Island, including both fresh and saltwater beaches. Funding for the RIDOH Beach Program for salt waters is provided by the United States Environmental Protection Agency (USEPA) through the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000, an amendment to the Federal Water Pollution Control Act (also known as the Clean Water Act) of 1972. These funds support primary programmatic activities including sanitary surveys, development and implementation of a risk-based monitoring plan, bacteriological testing at saltwater beaches, and a public notification system.

During the 2021 Beach Season (from June 1st through September 2st), RIDOH sampled and analyzed 1561 samples collected from 64 licensed saltwater beaches and two urban beaches which have been under consideration to become licensed beaches. RIDOH partner, Save the Bay, also collected samples from three other unlicensed urban beaches contributing to the total samples analyzed. Samples were tested for *Enterococcus* bacteria using the IDEXX *Enterolert* Method at the RIDOH State Laboratory (Budnick et al., 1996).

In the 2021 bathing season, the number of saltwater beach closure days was greater than in recent years. For the 64 monitored, licensed saltwater beaches, there were 98 closure days over 21 closure events at sixteen beech sites. Total rainfall during the 2021 season, at 18.69 inches, was more than any year since the monitoring program began in 2000 except 2013, when the total was 20.42 inches Working back through the record of the years with other rainfall totals > 15 inches, the number of closure days decreased from an all-time high of 427 in 2003 to 276 in 2006 and 178 in 2009. Ultimately the two most recent wet years, 2013 and 2021, with 111 and 98 days of closure, respectively, appear to be leveling to a new lower rate.

Despite the much higher seasonal rain total relative to Years 2017-2020, the number of advisory events in 2021 was less than the mean for those years, and the number of beaches affected was in the same range as those years. The only metric which exceeded the mean (and range) for prior years was days of closures, due to the persistence of adverse water quality in 2021.

The 2021 season was punctuated by an event that affected Scarborough Beaches (North and South) on August 30. The total 2021 closure days include 16 days attributed to the Scarborough Beaches (through Labor Day on September 7), although there were intermittent water quality problems documented at these beaches until October 7. The potential cause remains under investigation.

RIDOH research continues to seek methods that could allow advisories to close beaches closer to the time when risks of pathogen exposure are the greatest. Studies to establish the status of water quality at several “Urban Beaches” in upper Narragansett Bay are also ongoing.

During 2021, RIDOH was able to conduct limited freshwater beach monitoring, supported by a grant from the Centers for Disease Control (CDC), to supplement ongoing self-monitoring at those beaches. Methods generally followed those used for saltwater beaches and, along with results, are available upon request.

1.0 PROGRAM STANDARDS

1.1 Mission

The mission of RIDOH is to prevent disease and to protect and promote the health and safety of the people of Rhode Island. Within RIDOH, the Beach Program works to protect the public from illness associated with swimming in contaminated bathing waters. The primary means to provide protection is through routine monitoring and reporting when pathogens that constitute risks are present during the bathing season. The Beach Program also assists beach owners and managers by advising on approaches to find and eliminate sources of contamination.

1.2 History

RIDOH began monitoring beaches in the summer of 1995. Prior to 1995, the Rhode Island Department of Environmental Management (RIDEM) was responsible for monitoring recreational waters.

In 1999, RIDOH initiated a beach-monitoring program, "Bacterial Water Quality Monitoring at Upper Narragansett Bay Bathing Beaches" with USEPA funding from an Environmental Monitoring for Public Access and Community Tracking (EMPACT) grant. This grant enabled RIDOH to establish a public notification system including a website, telephone hotline, and beach signage system. RIDOH evaluated conditions in Upper Narragansett Bay, which has long been impacted by urban runoff, point source discharges, and combined sewer overflows (CSOs).

The EMPACT Program provided RIDOH with the resources to sample 23 stations in the Upper Narragansett Bay during wet and dry weather. The study concluded that additional sampling was necessary at the licensed Upper Bay beaches to adequately protect the public. In addition, due to identified contamination sources and analytical results, the areas north of Conimicut Point in Warwick and Nayatt Point in Barrington were deemed unsuitable to serve as licensed facilities.

In 2000, Congress enacted the Beaches Environmental Assessment and Coastal Health (BEACH) Act, an amendment to the Federal Water Pollution Control Act. The BEACH Act authorizes USEPA to distribute grants to eligible states, territories, and tribes to reduce the risk of disease and illness in the nation's bathing waters. Objectives under this program were published by USEPA in June 2002. The National Beach Guidance and Required Performance Criteria for Grants document promulgated by USEPA further stipulates several requirements of the BEACH Act funding

including: a tiered categorization of beaches according to risk, identification and mitigation of pollution sources, a risk communication plan, and specific beach monitoring information. National Recreational Water Quality Criteria were published in 2012.

Since 2000, USEPA has provided RIDOH with over $3.4 million in beach grants to manage Rhode Island's Beach Program. These grants have provided RIDOH with the resources to maintain critical continuity in monitoring Rhode Island's licensed bathing beaches for the purpose of characterizing risks, and how they change over time. Without this data, it would not be possible to understand which of our State's valuable beach resources need the most attention to identify and reduce sources (point and non-point) of contamination. Likewise, the monitoring data are critical in assessments that tell us how well management strategies are working to improve coastal water quality in Rhode Island.

1.3 Enacted Legislation

In accordance with the Rhode Island Regulation 216-RICR-50-10-3 (1/17/2018), and prior Regulation (R23-21-RF(A)(1.4 as amended January 2002) within the General Laws of Rhode Island, a "bathing beach" is defined as a natural area or tract of land that is used in connection with swimming and/or bathing in any waters of the state provided:

a) It is open to the public by permit and/or payment of a fee; or

b) It is maintained as a private club or association requiring membership fees or dues; or

c) It is maintained with or without charge for the recreation of groups of ten (10) or more children.

Please Note: Due to the important monitoring and protections provided by licensed beaches, RIDOH recommends only swimming at licensed bathing beach facilities.

Also per Rhode Island Regulation 216-RICR-50-10-3 (1/17/2018), and prior Regulation (R23-21-RF(A)(1.4 as amended January 2002), licensing of recreational facilities requires facilities to have electrical service; refuse storage and disposal; sewage disposal facilities; adequate toilets, showers, or lavatories with hot and cold running water; a drinkable water supply; and the water adjacent to a bathing beach must meet bacteriological standards. Specific requirements are dependent on the number of users. Reference to these requirements can be found within the Rules and Regulations for Licensing of Recreation Facilities within the General Laws of Rhode Island.

Per R23-22.5 Drowning Prevention and Lifesaving

Beach Rules and Regulations Promulgated in Accordance with Chapter 3343 of the Public Health Laws of 1954

1. All individuals employed as lifeguards after June 30, 1954 at bathing areas within the State of Rhode Island shall hold an active state lifeguard certification card as issued by the Division of Parks and Recreation, within RIDEM. Lifeguards holding surf cards may be employed at either surf or non-surf bathing areas. Lifeguards holding non-surf cards shall be employed only at non-surf bathing areas. All certification cards are active during the season of their employment and until the following June 30 unless suspended or revoked by the Division of Parks and Recreation.

2. All bathing areas shall provide lifeguard equipment and personnel according to the requirements of the Division of Parks and Recreation and shall provide such equipment and personnel whenever the facilities of the area are open for business.

3. All lifesaving equipment shall be maintained in good operating condition ready for immediate use.

4. All bathing areas shall post conspicuously the hours of duty of lifeguard personnel.

5. A telephone for emergency calls shall be readily accessible from every bathing area. Numbers of police, fire, and rescue units of the area shall be posted conspicuously beside the telephone.

6. No power boats shall be allowed within any bathing and swimming area. The management of each bathing area shall maintain his area free from driftwood and other objects which may cause injury.

7. No bathing area shall operate on any given day unless a state certified lifeguard is present during all hours which the facilities are being used.

8. During periods of severe surf, undertow and other emergency conditions the Recreational Safety Inspectors of the Division of Parks and Recreation shall have the authority to close any and all bathing areas whenever such action is deemed necessary in the interest of public safety. Whenever a bathing area has been closed because of the aforesaid conditions, lifeguards shall be retained on the beach to caution prospective bathers against entering the water.

9. The bathing season shall, for each year, last from May 30th until 6:00 PM of each Labor Day unless the Division of Parks and Recreation gives notice to the contrary.

1.4 Standards

Recreational water quality standards for Rhode Island saltwater bathing waters are under review. The State currently applies a single sample benchmark, EPA's recommended Beach Action Value (BAV) of 60 *Enterococcus* (measured in most probable number [MPN]) per 100 milliliters (ml) of water as a trigger to consider issuing a "no swimming" advisory. The Rhode Island Department of Environmental Management (DEM) regulations include an additional standard, a geometric mean of 33 *Enterococcus* (MPN). In practice, the DEM standard is applied across broad areas rather than the smaller areas that represent recreational waters adjacent to beaches.

The analytical method for monitoring for conformance with the BAV utilizes the IDEXX *Enterolert*© 1600, a USEPA-approved method to enumerate *Enterococcus*. *Enterolert*© provides a range of *Enterococcus* counts from less than 10 to greater than 24,192 MPN/100ml. The principal limitation of IDEXX *Enterolert*© is that it takes more than 24 hours from sample reception at the laboratory to reporting of analytical result. In other words, there is over a full day delay from when the sample is collected to when the results are received. Decisions to close and/or re-open a beach are generally made in the late afternoon on the day after sample collection. This translates to risk for beach-goers who may be exposed to contaminated water that will not be identified until the next day, with a management response a full two days after the sample was collected. In some cases, the delay may result in beach closures after the beach(es) may have become safe for swimming.

RIDOH is continuously reviewing promising new methods that would better meet the intent of standards to protect public health without unnecessary restrictions of use. These methods include new analytical methods and predictive modeling (see Section 4).

2.0 NATIONAL BEACH GUIDANCE AND REQUIRED PERFORMANCE CRITERIA FOR GRANTS, 2014 ED.

USEPA has developed 11 performance criteria for the implementation of monitoring, assessment and notification programs. To be eligible for a grant to implement a monitoring and notification program the state, tribal, or local government's program must be consistent with these performance criteria. These performance criteria are based on and incorporate other requirements of the BEACH Act as well. The 11 performance criteria listed below are quoted directly from the National Beach Guidance and Required Performance Criteria for Grants, 2014 Ed (US EPA 2014).

Performance Criterion 1: Risk-based Beach Evaluation and Classification Process

Performance criterion 1 requires a state or tribe to develop a risk-based beach evaluation and classification process and apply the process to its coastal recreation waters. The process must describe the factors used in the state's or tribe's evaluation and classification process and explain how the state's or tribe's coastal recreation waters are ranked as a result of the process. That process must result in a list of specific coastal recreation waters adjacent to beaches or similar points of access used by the public.

Performance Criterion 2: Tiered Monitoring Plan

Performance criterion 2 requires a state or tribe to develop a tiered monitoring plan. The plan must adequately address the frequency and location of monitoring and the assessment of coastal recreation waters on the basis of the periods of recreational use of the waters, the nature and

extent of use during certain periods, the proximity of the waters to known point and nonpoint sources of pollution, and any effect of storm events on the waters. EPA has added three new considerations to the basis for developing the tiered monitoring plan.

Performance Criterion 3: Methods and Assessment Procedures

Performance criterion 3 requires a state or tribe to develop detailed assessment methods and procedures. States and tribes must adequately address and submit to EPA methods for detecting levels of pathogens and pathogen indicators that are harmful to human health in coastal recreation areas. States and tribes must also provide documentation to support the validity of methods other than those that EPA validated or approved. Finally, states and tribes must identify and submit to EPA assessment procedures for identifying short-term increases in pathogens and pathogen indicators that are harmful to human health in coastal recreation areas.

Performance Criterion 4: Monitoring Report Submission

Performance criterion 4 requires states and tribes to develop a mechanism to collect and report monitoring data in timely reports. States and tribes must report their monitoring data to the public in a timely manner, including posting on a website. They must report their monitoring data to EPA at least annually or at a frequency required by the EPA Administrator. EPA encourages states to coordinate closely with local governments to ensure that monitoring information is submitted consistently. Reported data must be consistent with the list of required data elements.

Performance Criterion 5: Delegation of Monitoring Responsibilities

Performance criterion 5 requires a state to document any delegation of monitoring responsibilities that might have been made to local governments. If monitoring responsibilities are delegated to local governments, the state grant recipient must describe the process by which the state may delegate to local governments responsibility for implementing the monitoring program.

Performance Criterion 6: Public Notification and Risk Communication Plan

Performance criterion 6 requires that a state or tribe develop a public notification and risk communication plan. The plan must describe the state's or tribe's public notification efforts and measures to inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable Water Quality Standards (WQS).

The state or tribe must adequately identify measures to promptly communicate the occurrence, nature, location, pollutants involved, and extent of any exceedance or likelihood of exceedance of applicable WQS for pathogens and pathogen indicators. The state or tribe must identify how it will promptly communicate that information to EPA. States are responsible for identifying how

they will promptly communicate the failure to meet applicable standards to a designated official of the local government in the area adjoining the coastal recreation waters with water quality problems.

A state or tribal government program must describe procedures for posting signs at beaches or similar points of access, or for taking functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable WQS for pathogens and pathogen indicators.

Performance Criterion 7: Actions to Notify the Public

Performance criterion 7 requires that a state or tribe give notice to the public when coastal recreation waters are not meeting or are not expected to meet applicable WQS for pathogens and pathogen indicators.

A state or tribe must post signs at beaches or similar points of access or must provide functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable WQS for pathogens and pathogen indicators.

Performance Criterion 8: Notification Report Submission

Performance criterion 8 requires that states and tribes compile their notification data into timely reports. States and tribes must report to EPA the actions they have taken to notify the public when WQS are exceeded.

Performance Criterion 9: Delegation of Notification Responsibilities

Performance criterion 9 requires that states describe any notification responsibility they have delegated or intend to delegate to local governments. The state must describe the process by which the state may delegate to local governments responsibility for implementing the notification program.

Performance Criterion 10: Adoption of New or Revised WQS and Identification and Use of a Beach Notification Threshold

Performance criterion 10 is a new criterion, intended to focus on adoption of new or revised WQS as required by CWA section 303(i)(1)(B) and identification and use of an appropriate beach notification threshold. These requirements apply to states and tribes receiving grants under CWA section 406(b), and they will be implemented through conditions included in the grants.

Performance Criterion 11: Public Evaluation of Program

Performance criterion 11 requires that states and tribes provide the public with an opportunity to review the program through public notice and provide an opportunity to comment. This is not a one-time requirement; public input must be sought whenever a state or tribe makes significant changes to its beach program. If a state or tribe significantly changes its List of Beaches, beach ranking, or other elements of its monitoring and notification program, the public must have an opportunity to review the changes before implementation. Further, states and tribes should consult with the applicable EPA Region prior to making significant program changes.

The public evaluation can be accomplished through notice and public comment, meetings, forums, or workshops. For example, when classifying and ranking beaches, it is beneficial to gather input from members of the community regarding the recreational waters they would like monitored. Annual public or community meetings, surveys of the users at the beach, local newspaper articles, or other sources can provide insight into public opinion about the beach, including why the beach is or is not used (e.g., for sunning, running, swimming, or surfing); perceptions of water quality and health problems; and whether beach users desire a monitoring and notification program (if none exists) or how satisfied they are with the current program.

3.0 DATA SUMMARY

RIDOH reported water quality results for 1561 beach samples from June 1 through September 1, 2021, including stations at 63 licensed beaches throughout the state and five non-licensed urban beaches. An Additional 37 samples were collected during September to document conditions at Scarborough Beaches (North and South), following very high bacteria levels were reported on September 1st. The 2021 bathing season had 98 saltwater beach closure days (through September 7th) over 19 closure events at 16 beaches. This was a substantial increase from recent drier years. Total rainfall during the 2021 season, at 18.69 inches, was more than any year since the monitoring program began in 2000 except 2013, when the total was 20.42 inches. All metrics were higher in 2013, when there were 110 closure days on 35 events at 20 beaches.

Closure events are defined as each occasion when a closure recommendation occurs (on a per-beach basis). Closure days are the accumulation of all days when beaches were closed over one or more closure events. The number of closure days has been the standard tracking measure to capture variability in water quality related closures. However, unlike the number of closure events which has a direct association with water quality, the count of closure days is dependent on logistics and management at each beach, including the time needed to conduct follow up sampling required to affirm that it is safe to lift a closure advisory. The number of closure days may be the best representation of impact to beachgoers, while the number of events is a better expression of water quality conditions from year to year.

The 2021 season was punctuated by the extreme conditions that affected Scarborough Beaches (North and South) on August 31. The total 2021 closure days include 16 days attributed to the Scarborough Beaches (through Labor Day on September 7), although there were intermittent water quality problems documented at these beaches until October 7. Days after Labor Day were not included here in the total closure count days, because monitoring normally ends by Labor Day, when the official beach season ends in Rhode Island. The potential cause(s) for the adverse conditions at Scarborough Beaches remain under investigation.

There were two other beaches with particularly long closure events in 2021; Spouting Rock and Gooseberry Beach in Newport were each under advisory for 14 consecutive days in August. The average number of closure days per event in the ten years prior to 2021 was 2.4 days. In 2021, ten closure events lasted at least five days, for an average of 4.4 days (excluding the Scarborough Beaches end of season event).

During 2021, while some State Administrative Orders associated with the Covid19 epidemic remained in effect, licensed saltwater beaches were generally open.

Table 1 summarizes the number of advisory (closure) events, affected beaches and the sum of days under advisories, comparing 2021 with recent years. Information for 2020 is not included because closures related to Covid19 regulations skewed the data relative to other years. Despite the much higher seasonal rain total relative to Years 2017-2019, the number of advisory events in 2021 was less than the mean for those years, and the number of beaches affected was equivalent to prior years. The only metric which exceeded the mean (and range) for prior years was "Days of Closures", due to more persistence of adverse water quality in 2021.

Table 1. Number of events, sites affected and sum of advisory days per year.

	Year*				2017-2019 Summary		
Metric	2021	2019	2018	2017	Mean	StDev	CoV
Advisory events	21	37	20	27	28.0	8.5	0.3
Sites affected	16	23	11	15	16.3	6.1	0.4
Advisory days	98	74	67	73	71.3	3.8	0.1

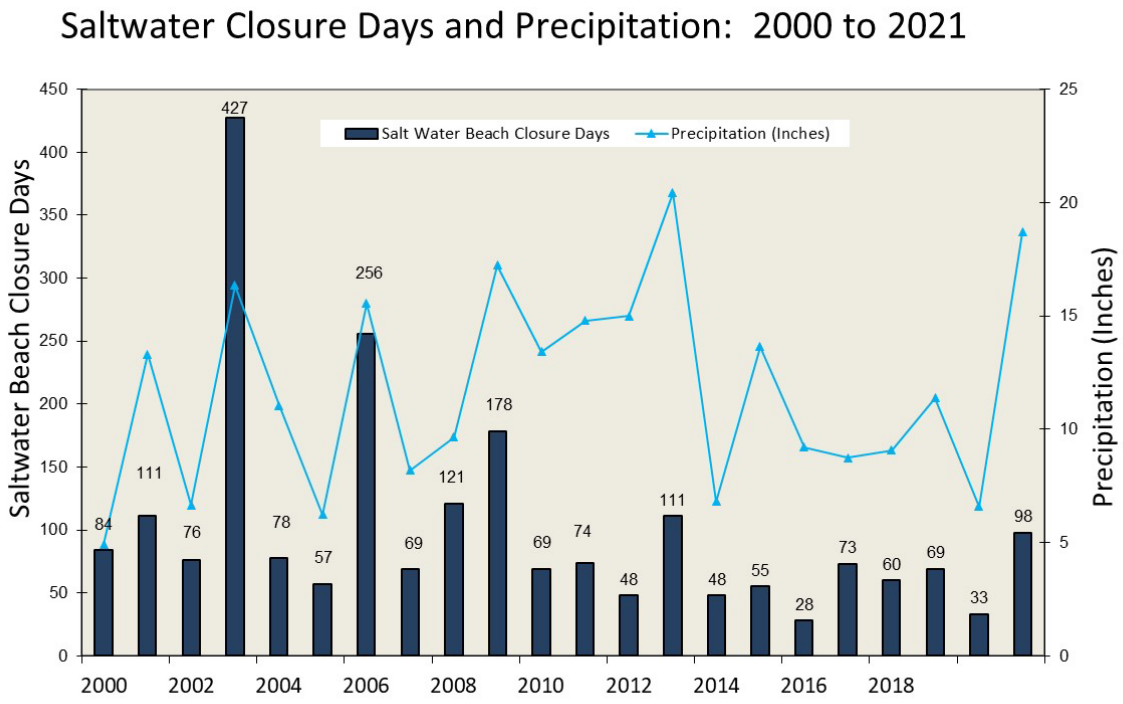
*2020 omitted due to Covid19-related management factors. StDev = Standard Deviation; CoV=Coefficient of Variation

Notably, in 2021 there were twelve occasions with greater than 0.5 inches of rain, including three events with greater than 2 inches of rain. Two of the extreme rain events occurred over weekends (when there was no water quality sampling) and did not result in any beach closures. However, fourteen (two thirds) of the closure events occurred when there was greater than 0.5 inches of rain within the prior two days.

Working back through the record of the years with other rainfall totals > 15 inches, the number of closures decreased from an all-time high of 427 in 2003 to 276 in 2006 and 178 in 2009.

Ultimately the two most recent wet years, 2013 and 2021, with 111 and 98 days of closure, respectively, appear to be leveling to a new lower rate.

Figure 1. Rhode Island Saltwater Beach Closure Days and Precipitation: 2000-2020



The trend towards fewer closure events occurring during heavy rain years is strong supporting evidence that beneficial changes correlate with a major sewage treatment plant upgrade initiative. Stormwater infrastructure introduced in 2008 at the state's largest treatment sewage treatment plant has reduced the volume of combined sewer and stormwater overflow from reaching Narragansett Bay. Upgrades to thefacility located on Narragansett Bay at Fields Point in Providence were phased, with the last stage completed in 2013. The number of beach closure days per inch of rain decreased from a mean of 13.3 for the period from 2003 (first year when *Enterolert* was used) through 2008 down to 5.7 for the period from 2009 through 2021. This difference is statistically significant (two tailed t test, p=0.05), while the average rainfalls over those periods were not significantly different (11.2 vs 12.7 inches, respectively). Still, there is considerable uncertainty in this analysis with respect to trends, particularly because it includes all licensed saltwater beaches in the state, including many outside of Narragansett Bay. Additional information about regional patterns in beach closures over time can be found in Chapter 23 of the State of Narragansett Bay and Its Watershed 2017 Technical Report prepared by the Narragansett Bay Estuary Program.

Table 2 shows the distribution of 2021 beach closure days across six Rhode Island towns. Newport led the list with 50% of all closures, while nearby Middletown had only 2% of the closures. The second highest percentage was Narragansett, primarily due to the Scarborough Beach closures. Warwick, with 14%, Tiverton, with 6% and Jamestown with 2% complete the list. The high percentage in Narragansett was atypical, as was the low percentage in Warwick. The low closure rate in Warwick was partially because poor conditions prior to June 19th were not cited, as the beach had not yet opened for the season. Newport, unfortunately, has been experiencing a high rate of water quality problems at Easton's Beach and at three private beaches on Ocean Drive in recent past years and 2021 was no exception. Of the Newport beaches, it is notable that only Easton's Beach is a Tier 1 beach with biweekly monitoring, although RIDOH has increased monitoring frequency at the three private beaches to weekly, given high levels of use. Other Tier II beaches that may warrant additional monitoring include the Upper Sakonnet Bay beaches in Tiverton and Mackerel Cove in Jamestown.

Table 2. Percentage of 2021 Saltwater Beach Closure Days by City/Town

Percent of Closures	City/Town	Closure Days	Beaches
50%	Newport	49	Easton's Beach, Gooseberry Beach, Hazards Beach, Spouting Rock (Bailey's) Beach, Kings Park, Fort Adams
22%	Narragansett	22	Scarborough (N&S), Bonnet Shores
14%	Warwick (UNB)	14	Conimicut, Goddard Park
6%	Tiverton	6	Grinnell's and Fogland Beaches
3%	South Kingstown	3	YMCA Camp Fuller
2%	Middletown	2	Third Beach
2%	Jamestown	2	Mackerel Cove Beach

UNB= Upper Narragansett Bay USB= Upper Sakonnet Bay

Analyses to determine exceedances of EPA 2012 Recreational Criteria were conducted on data from 2016 through 2021. This analysis, reported for the first time in the previous 2019 annual report, includes only Tier 1 beaches, for which the frequency of data collection (two times per week) is considered sufficient to meet EPA's recommendation for synthesis on a monthly basis. RIDOH's assessment relative to the Criteria was determined based on exceedance for more than one of the past three years.

Table 3a and 3b summarize results from the analysis, where Table 3a includes the Upper Narragansett Bay beaches of the Tier 1 category and Table 3b includes other Tier 1 beaches. In the analysis, every month with a geometric mean greater than 30 colony-forming units (cfu)/100 ml is counted as a single exceedance. Given the three months with sufficient data for analysis,

(June - August), the highest potential count for a given year is three. During the three-year period of 2019 - 2021, five licensed Tier 1 beaches exceeded the criteria. Only one Upper Bay licensed beach (Conimicut) failed the test. Sabin Point, the Urban Beach which has been monitored since 2010 by RODOH, is nearly meeting the Criteria, with only two months' failures in the past three years. Outside of the Upper Bay, Sandy Point Beach on Sakonnet Bay has also improved. In contrast, four licensed beaches in the southern part of the state (Easton's Beach, Third Beach, Scarborough Beach – North, and Scarborough Beach -- South) failed the criterion.

Table 3a and 3b. Exceedances of EPA's Monthly Geometric Means Criteria at Tier 1 Beaches

	Tier 1 Beaches (Upper Narragansett Bay) - Number of Monthly Geometric Means > 30 cfu/100 ml						
Beaches	2016	2017	2018	2019	2020	2021	Criteria Exceeded? *
Oakland Beach	1	2	0	0	1	0	NO
Conimicut Beach	1	1	1	0	2	1	YES
Goddard State Park	0	1	2	0	0	0	NO
City Park Beach	0	0	0	0	0	0	NO
Barrington Town Beach	0	0	0	0	0	0	NO
Warren Town Beach	0	0	0	0	0	0	NO
Bristol Town Beach	0	0	0	0	0	0	NO
Sabin Point Beach	1	2	3	1	0	2	YES
	Tier 1 Beaches - Number of Monthly Geometric Means > 30 cfu/100 ml						
Beaches	2016	2017	2018	2019	2020	2021	Criteria Exceeded?
Third Beach	1	0	0	2	1	0	YES
Peabody's Beach	0	0	0	0	0	0	NO
Easton's Beach	1	2	2	2	2	1	YES
Scarborough North	0	0	0	1	0	1	YES
Scarborough South	1	0	0	2	1	1	YES
Sandy Point Beach	0	1	1	1	0	0	NO

* US EPA's Criteria for monthly mean Fecal Indicator Bacteria is 30 Enterococcus cfu/100 ml. RIDOH applies the criteria on a three-year running average; criteria are exceeded when two of the latest three years include at least one monthly exceedance.
[1] 2021 Sabin Point geometric means were calculated from historic station ("-01"). New stations ("-03 and -04") to the east, farther from the stormwater pipe were tested for the first time in 2021, yielding only one month rather than two, exceeding the standard.

While not included in the table, there is a second criterion presented in EPA's 2012 Recreational Criteria document; a Statistical Threshold Value (110 cfu/100 ml) to be applied as an instantaneous exceedance in any month when it occurs. The counts for exceedences of this criterion at our Tier I beaches were much higher than the geometric mean metric, and all beaches had cases of exceedances in almost every year during the period. While both metrics are important, RIDOH considers the geometric mean to be a more reliable measure of chronic

impairment, and less subject to outlier data. It should be noted that the raw data (*Enterococcus* counts) used in the analysis only included results from RIDOH sampling. While additional samples are taken and analyzed by private laboratories for each beach, the inclusion of these additional data points would have resulted in substantially different outcomes (given that the number of samples collected by private laboratories varies by beach). It also would have introduced other quality assurance uncertainties.

The root causes of beach closures continue to be uncertain at most of Rhode Island's affected beaches. While data show that total closure days and closures per inch of rain are lower and more stable than in the early 2000's, it may be possible, by assembling data sets with many environmental variables, to develop better correlative predictors for specific high FIB count conditions. The Beach Program has been tracking meteorological data at weather stations throughout the state, as well as tidal data for each day during the beach season since 2009. The weather data includes precipitation, air temperatures and wind direction/speed. The program also records environmental observations at the time of sampling at each beach. These observations include local water temperature, prevalence of seaweed in the water and at the wrack line and current and wave observations, as well as numbers and activities of visitors and wildlife type and numbers (generally for birds). All of this information may contribute to statistical modeling to predict water quality conditions (See section 4.2, below).

During 2021, RIDOH was able to conduct limited freshwater beach monitoring, supported by a grant from the Centers for Disease Control (CDC), to supplement ongoing self-monitoring at those beaches. Methods generally followed those used for saltwater beaches and, along with results, are available upon request.

4.0 BEACH PROGRAM ACTIVITIES AND PROJECTS

4.1 Covid 19 Guidance

While the 2020 beach season was marked by many restrictive practices to reduce risks from the Covid19 pandemic, in 2021 capacity limits were lifted and Rhode Island beaches had largely returned to pre-pandemic operations.

Information to date continues to support the findings from 2020 research indicating that there is very low potential for contracting Covid19 from human feces/raw sewage carried into swimming waters. Laboratory data indicate that biochemical pathways likely inactivate the virus prior to excretion. Further, there were no indications that world-wide high attendance at beaches during 2020 and 2021 resulted in infections associated with recreational water activities.

4.2. Beach Season Kick-Off Meeting

Each year the Beach Program holds a topic-based meeting for beach owners/managers, cities/towns, state agencies, laboratories, and any interested stakeholders. Meetings may include guest speakers knowledgeable in the applicable topic as well as federal representatives to answer questions and concerns.

The 2021 Kick-Off Meeting was held on June 17, 2021, virtually, due to Covid19. Sherry Poucher, presented RIDOH data from 2020, described findings from tests with the alternative analytical method known as TECTA to quantify Enterococcus in beach water samples (see Section 4.4, below), and updated the group on Covid19 management guidance for the 2021 season. Julia Twitchell from the Narragansett Bay Estuary Program presented a new storymap tool depicting research findings from a study of recreational uses of Narragansett Bay. The study employed cell phone data to establish levels of use at over 400 public access points to the shores of the Narragansett Bay region (https://storymaps.arcgis.com/stories/b994fadc18bb4f1bb82dea62956c3139) .

4.3 Statistical Analysis and Predictive Modeling

During 2020, RIDOH continued work to improve our understanding of current marine beach water quality status and trends at Rhode Island beaches. These initiatives reach beyond the beach closure data to evaluate raw water quality monitoring data (*Enterococcus* concentrations) to better describe site conditions (e.g., as presented in Tables 1 and 3, above). For a special study that was supported by the New England Interstate Water Pollution Control Commission (NIEWPCC), we focused on two sites, Oakland Beach in Warwick and Easton's Beach in Newport. Our partner, the non-profit organization, Clean Ocean Access, led this effort. Using raw data from 2006 to 2018 we found that the data for most years did not meet either of EPA's specific water quality standards for recreational use, albeit conditions were acceptable for recreation more days than not in any given season. Analyses using R software and Mann-Kendall tests found that neither beach exhibited any significant trends in water quality. In 2020 we continued working with "Virtual Beach", a statistical modeling software package developed and supported by U.S. EPA, to find combinations of factors that predict water quality at individual sites.

For model development, data sets containing environmental variables that were temporally associated with *Enterococcus* concentration served as the input to predict counts of the bacteria. Statistical models were initially developed for Oakland Beach and Easton's Beach for the period 2015-2017, constituting the baseline, or training models. Subsequent years of data have been developed to see how well the models validate. If successful, the models could be used to predict water quality for more timely and appropriate management actions to better protect public

health. They might also, through inference, provide clues to better understand root causes of contamination.

An important finding was that the combinations of environmental variables that were statistically significant predictors of *Enterococcus* were different for each beach, and that no single variable was a good predictor. At Oakland beach, rain and tide variables along with depth to groundwater were statistically significant predictors. Easton's beach models did incorporate rain factors, but water temperature and operation of Newport's UV Disinfection Treatment Plant were also important factors. Although the models for both sites demonstrated strong relationships between the predictors and measured *Enterococcus* concentrations, they were not successful at predicting the limited number of elevated *Enterococcus* counts in 2018 or 2019. While the base models met statistical standards for acceptability, their predictive capacity would most likely improve if they were augmented with more years of data. Individual case study reports and the integrated final report are available on request (McLaughlin et al., 2019).

Since 2019, the data set developed for the Oakland Beach model was also applied toward the development of potentially predictive capabilities for six additional Upper Narragansett Bay beaches. Given the large time commitment required to develop model data sets, this work intended to test whether a single set of explanatory environmental data might be useful for multiple beaches located within close proximity. While the range of model fits was variable, the base year model fits did generally meet acceptability criteria. Again, we found that the predictive variables were unique to each beach. Unsurprisingly, the models seem to perform best for beaches with the highest counts of *Enterococcus*. Dr. Shuai Xie (PhD, Brown University, Chemical and Biochemical Engineering, 2020) led this effort, and the findings were presented at the virtual National Recreational Water Quality Criteria Workshop in April 2021.

4.4 Investigation of New Rapid Testing Technology (TECTA)

From 2019 through 2020, the Beach Program started to investigate the value of TECTA, a new technology that could provide an alternative to IDEXX *Enterolert*, allowing reportable test results in a shorter time frame. The technical basis for the test is similar to *Enterolert*, using similar selective media and an enzyme reaction that produces a fluorescent signal. TECTA's advantage is that it uses the relationship between detection time and concentration, allowing the quickest reporting for high concentrations. Compared with *Enterolert*, TECTA costs are roughly equivalent, and TECTA also has some automation advantages.

The Beach Program conducted a preliminary trial with TECTA (instrument on loan from the developer, Pathogen Detection Systems, Inc.) during the summer through winter of 2019-2020. RIDOH's methods for testing TECTA built on experience gained in our earlier studies with quantitative polymerase chain reaction (qPCR), another method with a relatively short test turn-around-time, but which proved more costly and logistically problematic (see Section 4.6, below).

Through our partnership with the State Health Laboratory, RIDOH conducted TECTA testing in parallel with the *Enterolert* (ENT) and Membrane Filtration (MEI) standard methods. We began with field samples spiked with *Enterococcus faecium* and *Enterococcus faecalis* over a range of relevant concentrations. However, the standard testing methods are based on data that show nearly all live cells in culture will produce an enzyme signal by the test endpoint. In contrast, the technical basis for TECTA is the relationship between the strength of the enzyme-mediated signal and time, where the predictability of time to detection vs concentration is dependent on the growth characteristics of the bacteria. Pathogen Detection Systems, Inc determined that reference cultures of *E. faecium* and *E. faecalis* did not necessarily have the same growth characteristics as *Enterococcus* species in natural environments. Therefore, spiked field samples were not as representative for TECTA as for other test methods with a single time endpoint.

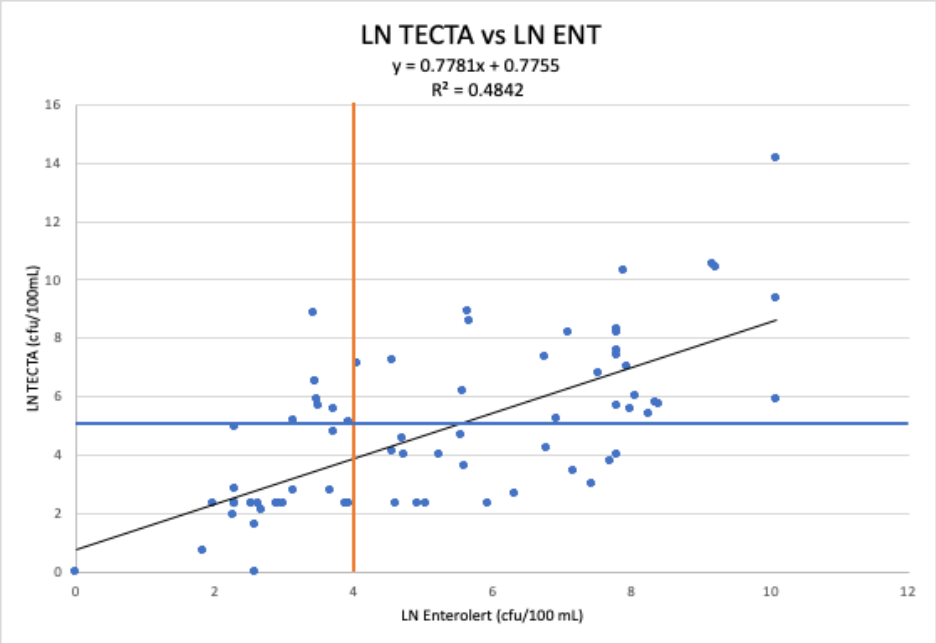
For this reason, RIDOH worked to obtain data by testing beach samples with elevated counts under summer conditions, to apply EPA's protocols for the development of Alternative Recreational Criteria and 'validate' the TECTA method. One problem encountered was the summer of 2020 was characterized by a record low number of high count samples.

We compiled Enterococcus final count and geometric mean exceedances over 60 cfu/100 mL for all three methods of TECTA, ENT and MEI for a total of 79 data points. The error rate of TECTA, detailing the occasions when TECTA did not match Enterolert in its determination of an exceedance, was 29% of exceedances by ENT results. The error rate for the total exceedance results of TECTA compared to ENT exceedance results was also 29%.

Using the total set of 79 data points, we established different subsets of data to complete a multi-parameter, comprehensive assessment. The discriminators were selected based on a hypothesis that each variable influenced the comparability of the methods. Through systematic inclusion or exclusion of specific qualifiers including: 1) samples analyzed the day after collection vs same day TECTA analysis, 2) spiked samples of both *E. faecalis* and *E. faecium* or only *E. faecium* dilutions, and 3) use of expired TECTA cartridges. We conducted linear regression analyses to estimate the relationship between the three methods, while including and excluding the above variations.

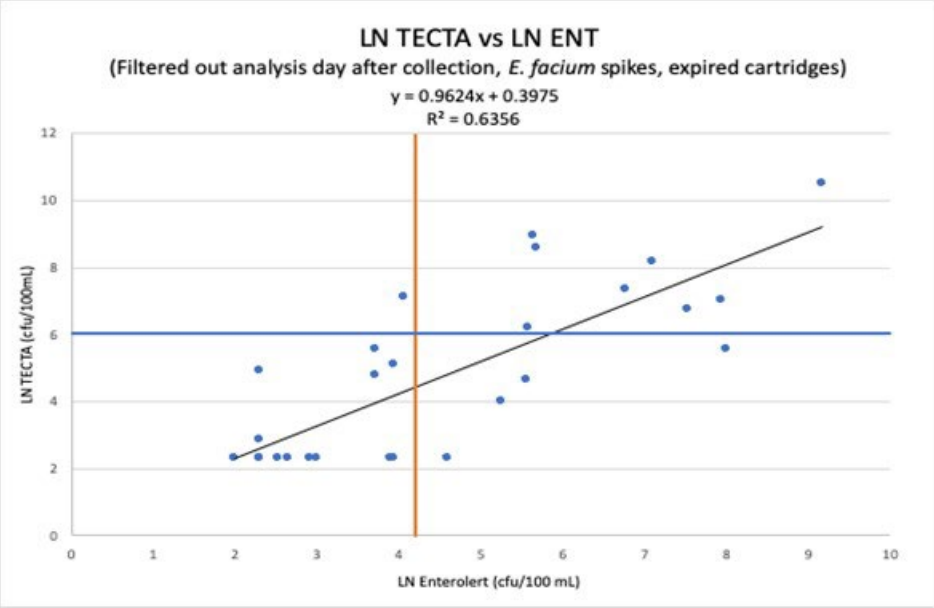
Figure 2 represents the relationship between the Enterococcus final count and geometric mean exceedances determined by TECTA and Enterolert, presenting an R^2 of 0.48. The regression analyses with the removal of results from samples held at 4 degrees C for one day prior to analysis also produced an R^2 of 0.48. Similarly, removal of spiked samples also resulted in an R^2 of 0.48. The removal of both day after samples and *E. facium* spiked samples produced an R^2 of 0.46. A similar comparison using the averages of Enterococcus instead of the geometric means presented a lower correlation in the relationship between TECTA and Enterolert. Through the exclusion of the same variables mentioned above, the R^2 values using simple averages varied from 0.41, 0.37, 0.32 and 0.39, respectively

Figure 2 Natural Logarithms (LN) of TECTA Results vs (LN) of Enterolert Results



In early September of 2020, we also encountered an issue of using testing cartridges that had expired by TECTA standards. Consequently, we conducted the analysis of final counts and geometric mean exceedances after the removal of "day after collection" TECTA analysis samples, *E. facium* spiked samples, and data obtained using expired cartridges. As shown in Figure 3, there was an improved relationship between TECTA and Enterolert (R^2 value of 0.64) with this data set.

Figure 3. LN of TECTA Results vs LN of Enterolert Results (Filtered out analysis day after collection, *E. facium* spikes, expired cartridges)



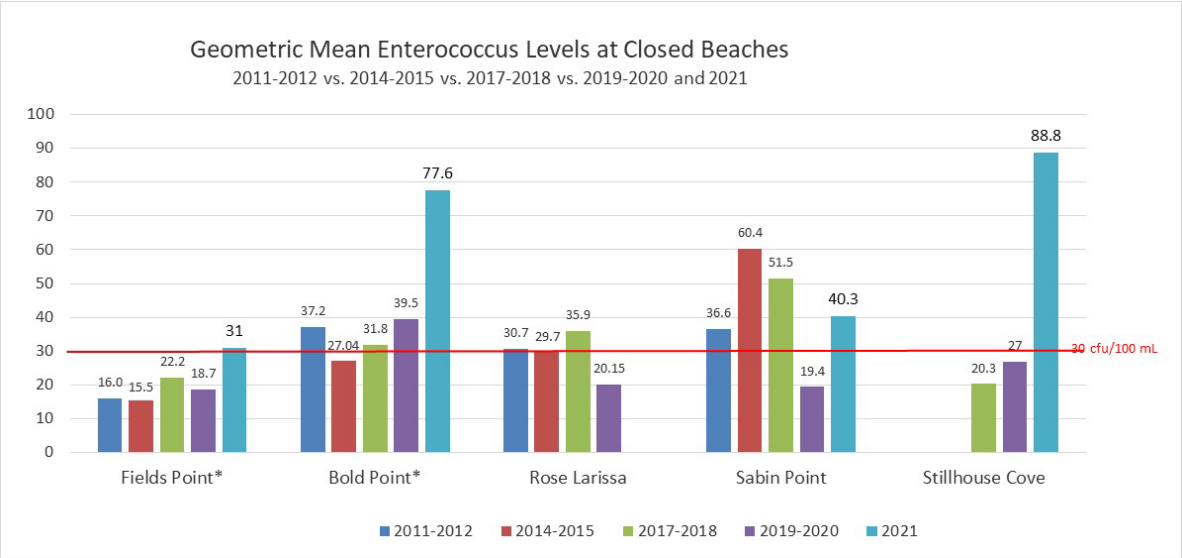
Ultimately, the findings from the TECTA trials showed promise, especially considering that differences between the methods were expected. One benefit of the TECTA method is that it concentrates bacterial cells to the bottom of the test chamber, and thereby avoids color interference in the sample (a potential drawback of the Enterolert method). However, the TECTA method still has a longer incubation period than would be optimal and would result in "next-day" advisories. In January 2021, RIDOH opted to discontinue trials with TECTA, given the eventual costs for instrumentation (~$20,000 per reader), and limited improvement in turn-around-time. Given the rapid changes in conditions at many beaches, it is incumbent on us to find a method more like a litmus test, where the public could be alerted to health risks as near as possible to the times when they occur.

4.5 Urban Beach Initiative

2021 marked the Urban Beach Initiative's twelfth season. In 2018, RIDOH completed the formal study to statistically examine status and trends of water quality at four areas in upper Narragansett Bay: RIDOH's partner, Save the Bay, has collected samples at Bold Point and Fields Point in Providence, and RIDOH has collected samples at Rose Larissa and Sabin Point in East Providence. The objective was to determine if these locations might prove to be suitable for primary contact recreation. The formal study was reported by John Snow Inc. (Coakley et al., 2016)). It included data from 2011 through 2015, but analysis consistent with original study continues with additional data collected through 2021. Due to the paucity of *Enterococcus* data (9 to 29 sample days per year), the Coakley et al. analysis grouped results from the years 2011 and 2012 to compare with results from 2014 and 2015. The years 2013 and 2016 were excluded from the analysis because only two beaches, Fields Point and Sabin Point, were sampled. Importantly, data from these years were neither the highest nor lowest over the study period. It is also of note that 2013 was a heavy rain year (20.4"), outside of the 99% normal distribution of the rainfall for the decade period. Beginning in 2016, Save the Bay added Stillhouse Cove in Cranston to their weekly monitoring effort. Since 2017, RIDOH has continued to evaluate the data in groups of two years. In Figure 4, which summarizes results, the year 2021 is added as a separate category because rainfall exceeded the range of all other years included in the figure.

While there is no overall pattern across years that applies to all sites, Fields Point stands out in having generally acceptable water quality. While conditions at Rose Larissa were relatively consistent, and approaching acceptable levels in all years, it was dropped from the study in 2021 due to the heavy erosion that has resulted in loss of usable beach and safety issues associated with an unstable bluff and stairways that provide access. Of the remaining beaches under evaluation, Sabin Point has a very favorable beach and neighborhood setting but has generally exceeded the benchmark for acceptable water quality, despite remedial actions designed to reduce runoff through improved infiltration which was expected to improve water quality.

Figure 4. Enterococcus at Non-licensed Urban Beaches (Geometric Mean Pooled by Year)



In 2021, RIDOH began to monitor additional stations to the east of the historic monitoring location at Sabin Point, given ample sandy beach and greater distance from the stormwater pipe. Notably, the geometric mean of *Enterococcus* counts dropped from 40.3 cfu/100 ml to 26.9 cfu/100 ml at the new stations. Bold Point had relatively stable, but marginal water quality until 2021, when there was a substantial spike in geometric mean *Enterococcus*, most likely attributable to the rainy summer. Similarly, the new site, Stillhouse Cove, also saw a large spike in 2021.

The City of Providence has achieved major improvements to the wastewater treatment plant with most of the upgrades completed by 2014. In contrast, at the Bucklin Point treatment plant in East Providence, located on the Seekonk River which enters Narragansett Bay near Bold Point, major improvements have lagged behind the Fields Point site. This may partially explain why Bold Point continues to experience worse water quality. Fields Point is an indication of what is possible, with water quality approaching conditions at three urban beaches that are open for swimming, Barrington, Warren and Bristol town beaches. At these town beaches, annual geometric mean concentrations are generally near 20 cfu/100 ml or less.

The urban beaches should be a priority for additional management actions, whether for the continued need for pathogen load reductions, or, where conditions have improved sufficiently, to develop the needed community infrastructure that would promote recreational use. During the hot summer months, many Rhode Islanders use recreational beaches as sanctuaries to escape the heat. Populations most in need are those living in Rhode Island's urban core, where buildings and pavement heat retention elevates temperatures through the "heat island effect". These populations are also some of the most at risk in the state for water-borne illness as social and economic restraints interfere with access to cleaner, more costly water bodies. Southern

Rhode Island waterbodies may also not be accessible to at-risk communities due to restrictions in public transportation. Working to create clean, healthy, and safe recreational outlets for at-risk communities is an integral part of the BEACH Program's mission.

Bristol Town Beach is a preeminent and nationally acclaimed example for how to re-claim an underutilized recreational water asset. The comprehensive program in Bristol demonstrated that combining best management practices to improve water quality with local initiatives such as camps and other promotions of recreational uses have leveraged the beach resource to develop an exceptional asset for the town.

4.6 Quantitative Polymerase Chain Reaction (qPCR) Rapid Testing

The qPCR study was successfully completed in 2018. The first objective was to build capacity to perform quantitative Polymerase Chain Reaction (qPCR; EPA Method 1609) to quantify fecal indicator bacteria, *Enterococcus,* in beach water samples. The State laboratory is now fully competent and practiced in this method. The other objective was to establish the utility of the method for beach water quality testing in Rhode Island. Unfortunately, the method, tested on two of the most severely impacted beaches in the state, did not prove to be a reliable surrogate for other EPA approved methods (*Enterolert* and Membrane Filtration). Nonetheless, the new qPCR capabilities at the laboratory can be used for enumeration and for targeting pathogenic strains of *Vibrio*, as well as for rabies confirmation and for various microbial source tracking functions. Having completed qPCR training and analysis of over 400 samples for this study, it is expected that additional applications would require little if any further training.

The project methods and findings are detailed in two reports, one completed through contract support for statistical analysis provided by the John Snow Institute (JSI). The second is a manuscript-style report which includes study background, information regarding experimental design, and a discussion of findings in the context of methodological uncertainties as well as practical application limitations of the method as a routine tool for beach water quality monitoring. The project was funded through USEPA's grants for research within Southeast New England Coastal Watersheds (SNEP).

4.7 Publication of the Beach Sands Study

In 2009 the Beach Program investigated bacterial contamination in sand at 10 coastal beaches throughout Rhode Island. Eight of the 10 locations have known sources of contamination and close due to high bacteria levels on a regular basis. Sand and water samples were collected along with data on wind speed, direction, wave intensity, and precipitation.

The study was published in the Journal of Environmental Health (Coakley et al., 2016). The study reported statistically significant gradients in *Enterococcus* concentrations among tidal zones, with dry (supra-tidal, or above high tide mark) sand having the highest level, followed by wet (intra-tidal, or below high tide mark) and underwater sand. There were two beaches without a statistically significant gradient (Easton's Beach and Conimicut Point); for these beaches, mean

levels were uniformly high in all three zones. Beaches with higher wave action had significantly lower *Enterococcus* count levels in wet and underwater sand compared to beaches with lower wave action. Results from the sand study are just a first step. Further investigation with respect to fate, transport and associated exposure risks is needed.

5.0 2022 PROJECTED ACTIVITIES

5.1 Monitoring Program

Beach interns will conduct sampling at coastal beaches from Memorial Day through Labor Day. Approximately 1600 samples will be collected, submitted, and analyzed for *Enterococcus* during the summer season.

5.2 Illness Tracking

The Beach Program will work with the Division of Infectious Disease and Epidemiology to research and develop standard operating procedures for tracking and responding to water-borne disease and illness.

5.3 Data Submission

The Beach Program will prepare both notification and monitoring data for submission to EPA's Environmental Exchange Network Services Center. Verification of the submittals, and updates and corrections in historic data will be accomplished using EPA's new Verification Tool, and with assistance from EPA contract staff.

5.4 Reporting

Annual Season Report

Reporting of previous year's data will be prepared and submitted to EPA Region 1 as required. The Season Report will include analysis and descriptions of data collected and trends affecting the beaches and water quality of Rhode Island.

5.5 Outreach

2022 Beach Season Kickoff

The Beach Program will hold a one-day meeting for beach owners, managers, and interested stakeholders to kick-off the summer season. Each year is a unique theme with presenters and take-home materials on the day's topic. The annual kick-off meeting also provides an opportunity for beaches to ask questions, sign up for summer training and events hosted by RIDOH and to network with other beaches and state officials.

Governor's Beach Day

The Beach Program conducts a summer education and outreach event during the annual Governor's Beach Day, generally held during the last weekend in July. Two sampling interns man a table for beach visitors interested in learning about water quality and healthy beaches. Some of the activities include an Enviroscape presentation, Beach Bingo, Beach Trivia, and Scavenger hunts. Other outreach activities can be scheduled for a "Beach Program at your Beach," on request, on Friday's when sampling does not occur. Beach managers and camp supervisors are required to oversee these events. Beaches are notified of this opportunity at the annual Kick-off meeting. 2022 will be the eleventh year for this option.

5.6 Risk Assessment

Sanitary Surveys and Modeling

The Beach Program will encourage and provide guidance to beach managers and municipal employees to conduct Sanitary Surveys upon request. Sanitary surveys identify potential sources of contamination, risks to public health, and environmental impairments leading to the evaluation and classification of beaches, particularly to rank priorities for frequency of sampling (Tier 1 through Tier 3). RIDOH will refer to new survey guidance and tools as they are published by EPA's Environmental Assessment and Coastal Health Act Program to perform these assessments. Beach Program staff will also work with any beach manager who expresses interest in developing and using Virtual Beach modeling predict and close and open their beach.

Rank Beaches by Tier

At the beginning of each season, RIDOH uses our risk-based beach evaluation and classification process to rank beaches by tiers. Using information and data gathered from evaluation of the prior year's beach data, along with sanitary surveys, tier rankings are adjusted needed.

Improving Risk Assessments with New Tools and Initiatives

Over the next three to five years, the Beach Program will work to develop an environmental assessment plan for Rhode Island Coastal beaches. This plan will refresh beach specific information/data such as sources of contamination, stormwater improvement projects, review water quality, and public access. This plan may include the following:

- Site-specific comprehensive assessments for coastal beaches
- Sanitary surveys using USEPA's new template and survey guidance recommended in the 2014 Beaches Environmental Assessment and Coastal Health Act Guidance Document
- Incorporate rapid testing methods, as appropriate
- Data collection to better characterize temporal and spatial variability
- Use of forensic dogs to identify sources and pathways of contamination

- Identification and characterization of the nature and extent of groundwater seepage
- Develop predictive models in areas with known sources of contamination that pose the greatest risk to public health.
- Incorporate predictive models into beach closures/advisories to better protect the public
- Hold stakeholder workshops, sampler training, etc.

5.7 New Recreational Water Quality Criteria Standards

The Beach Program will work to assist the Rhode Island Department of Environmental Management (RIDEM) as they review, and report on state-wide water quality data to meeting recreational water quality standards (RWQS) in Rhode Island. The Beach Program will also provide a beach-by-beach assessment of all beach water quality monitoring and notification data generated by RIDOH to characterize which beaches are meeting U.S. EPA recommended criteria.

6.0 REFERENCES

Beaches Environmental Assessment and Coastal Health Act of 2000, 33 USC § 1251 (2012).

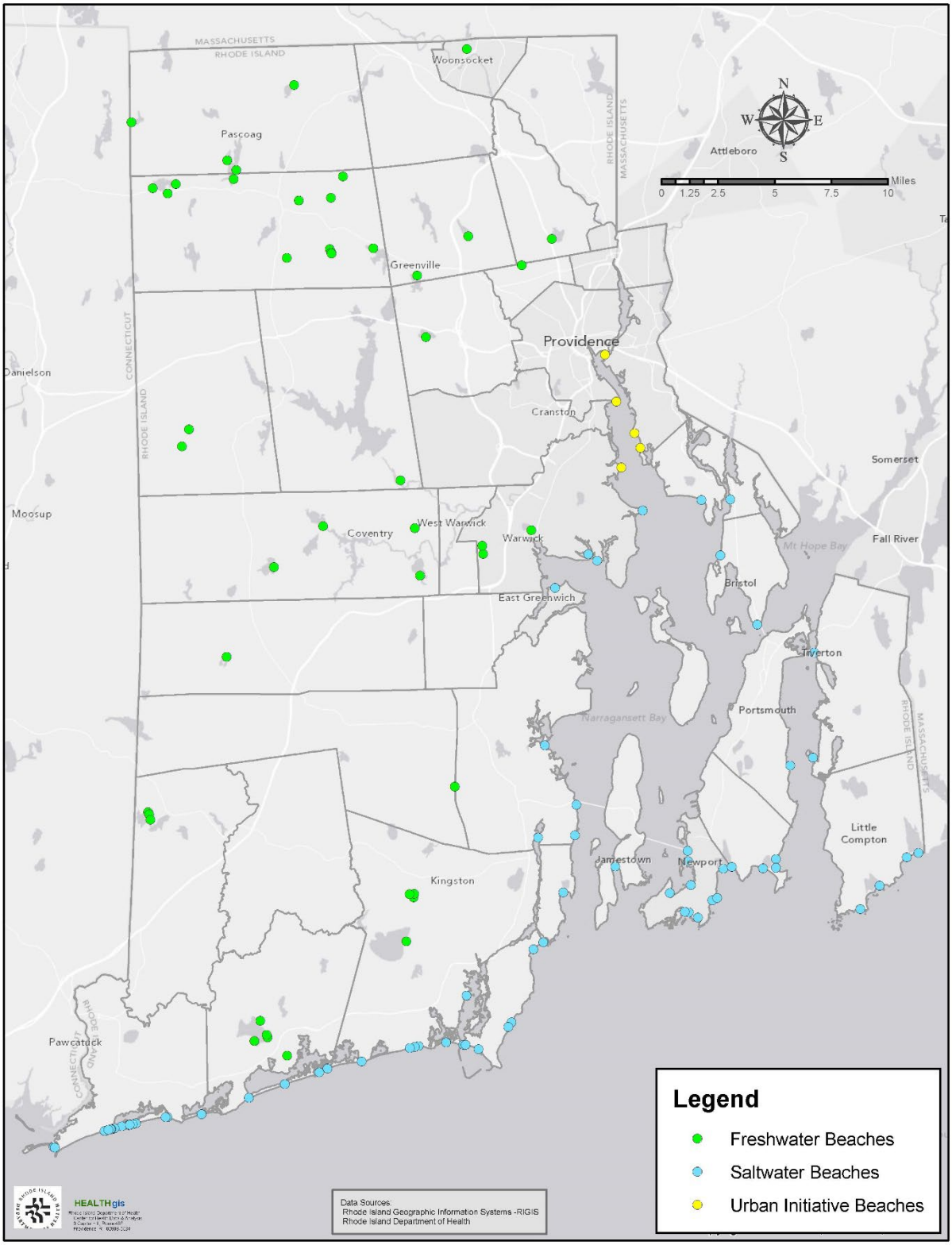
Budnick, G.E., R.T. Howard, D.R. Mayo. 1996. "Evaluation of *Enterococcus* for Enumeration of Enterococci in Recreation Waters". Applied and Environmental Microbiology. 62:3881-3884.

Coakley, E., A. L. Parris, Al Wyman, G. Latowsky . 2016. Assessment of *Enterococcus* Levels in Recreational Beach Sand Along the Rhode Island Coast, Journal of Environmental Health, Vol. 78, No. 8 (April 2016), pp. 12-17.

McLaughlin, D, S. Poucher, E. Touhey and J. Chopy and S. Pereira. 2019. Research Needs for Marine Beaches: Final Report, Federal Award Identification Number: CE00A00004
NBEP: Section 320 Funds, NEI Job Code: 318-001, Project Code: S-2018-005, 2018/2019 Grant Program, June 13, 2019

APPENDIX A

Map of Rhode Island Licensed and Urban Beaches


MASSACHUSETTS
RHODE ISLAND
Woonsocket
Pascoag
Greenville
Providence
Cranston
Somerset
Fall River
Mt Hope Bay
Bristol
Warwick
West Warwick
Coventry
East Greenwich
Tiverton
Portsmouth
Narragansett Bay
Little Compton
Jamestown
Newport
Kingston
Pawcatuck
Danielson
Moosup
CONNECTICUT
RHODE ISLAND
MASSACHUSETTS
Attleboro
N
W
E
S
0 1.25 2.5 5 7.5 10
Miles
Legend
Freshwater Beaches
Saltwater Beaches
Urban Initiative Beaches
HEALTHgis
Data Sources:
Rhode Island Geographic Information Systems -RIGIS
Rhode Island Department of Health

Appendix B

Closure Evaluation Spreadsheet

Rhode Island Department of Health Beach Monitoring Program

Closure Evaluation Spreadsheet

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Number of Monitored Freshwater Beaches	49	51	47	50	53	49	50	50	42	42	35	46	46	46	35	40	29	35	33
Number of Monitored Saltwater Beaches	70	72	71	69	69	69	74	68	72	70	76	69	69	69	69	69	69	69	67
Total Number of Monitored Beaches	119	123	118	119	122	118	124	118	114	112	111	115	115	115	115	115	98	104	100
Sample Count* (RIDOH - EPA Funded Sampling Only)	1,779	2,567	2,701	3,211	2,769	1,718	1,655	1,770	1,988	2,678	1,680	1,604	1,747	2,025	1,718	1,586	1,506	1,403	1561
Rainfall Total (Memorial Day - Labor Day)	6.65	16.34	11.04	6.24	15.54	8.18	9.64	17.24	13.42	14.8	15	20.42	6.8	13.65	9.21	8.79	9.08	11.38	18.69
Significant Rain Events (>0.5" in 24-hr)	6	12	9	4	7	6	6	13	11	9	5	13	7	8	7	7	6		12
S.W. Events	27	67	41	30	91	43	52	89	56	37	34	41	36	41	12	23	20	36	28
S.W. Closure Days	103	503	122	65	351	95	161	230	148	74	54	119	52	61	27	78	60	68	98

*Sample count estimates do not include approximately 1,000 samples submitted by Beach Operators on an annual basis, which are reviewed by RIDOH

notes: Significant Rain Events Calculated from Warwick RI - Central location of state

APPENDIX C
2019 Meteorological Data

Available on Request

APPENDIX D
Geometric Mean Data for

Tier 1 Beaches

Available on Request