State of Rhode Island and Providence Plantations

Water Monitoring Strategy

2019

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Rhode Island Water Monitoring Strategy

Table of Contents

1. Introduction

Rhode Island is fortunate to have abundant water resources that when properly managed can meet societal needs for drinking water, recreation and commerce and at the same time provide the foundation for healthy aquatic ecosystems. Water monitoring is an essential component of Rhode Island's framework for protecting and restoring its water resources. An effective water monitoring strategy allows managers to identify and prioritize waters for protection, restoration and management as well as protect public health. Implementation of the strategy will yield information that is intended to optimize the return on public and private investments in environmental protection, pollution control and natural resources management.

This strategy revises the existing RI Water Monitoring Strategy originally developed in 2005. It provides a framework to describe existing ambient monitoring and assessment programs - the who, what, where, when and why – of water monitoring in Rhode Island. It describes monitoring program elements consistent with guidance from the Environmental Protection Agency (EPA). It also identifies the actions and investments needed over the next five to ten years to address key data gaps or make needed enhancements to existing monitoring and assessment programs. It currently applies to all surface waters including coastal waters, rivers and streams, and lakes and ponds. It reflects monitoring and assessment programs pertaining to the chemical, physical, and biological characteristics of water quality. Strategies for monitoring and assessing groundwater quality and aquatic habitats, including wetlands, will be integrated in a future update.

It is intended through this strategy that ambient monitoring and assessment will function to support all state water resource programs in addition to its traditional role of characterizing water quality conditions and reporting on status and trends. Furthermore, this strategy is intended to be adaptive and evolve over time to incorporate new scientific understanding, reflect improvements and innovations in methods for ambient water monitoring, and be responsive to priority management needs including the impacts of a changing climate.

Throughout the strategy, the term "monitoring" is intended to address measurement or estimation of ambient physical, chemical and biological water quality status and conditions.

The term "assessment" refers to the determination of physical, chemical or biological condition from monitoring data and information. It also refers to the determination of whether various surface water uses designated under the Clean Water Act are supported by the condition. This assessment process is elaborated in the Rhode Island Consolidated Assessment and Listing Methodology prepared by Rhode Island Department of Environmental Management (RIDEM).

2. Goals and Objectives

2.1 Water Quality Management Framework

This Monitoring Strategy supports the goals articulated in the State Guide Plan Element *Water Quality 2035* (RIDOA, October 2016) which describes Rhode Island's water quality management framework. As a State Guide Plan Element, *Water Quality 2035* provides long-term perspective and policy direction for state programs engaged in the protection and restoration of water quality and aquatic habitats. The vision and overarching management goals articulated in *Water Quality 2035* are:

> Vision: Rhode Island's water resources will support healthy aquatic ecosystems and meet the needs of current and future generations by protecting public health, supplying high quality drinking water, providing bountiful recreation opportunities and supporting a vibrant economy.
>
> Water Quality Goal #1: Protect the existing quality of Rhode Island's water and aquatic habitats and prevent further degradation.
>
> Water Quality Goal #2. Restore degraded waters and aquatic habitats to a condition that meets their water quality and habitat goals.
>
> The full Water Quality 2035 document is available at:
> http://www.planning.ri.gov/publications/state-guide-plan.php

Rhode Island's water resources are described briefly in Table 1. *Water Quality 2035* further describes the following waters as protection and restoration priorities:

- Drinking water supplies
- Shellfish growing area waters
- Waters used for public recreation, including beaches
- High quality aquatic habitats

In *Water Quality 2035*, water monitoring and assessment are recognized as essential components of RI's overall framework for water resource management and core activities within state water quality programs. This strategy identifies the state as having the primary responsibility for carrying out ambient monitoring in a manner that will meet the diverse data needs of state water protection and resource management programs. It recognizes RIDEM as having the lead role in implementing water quality monitoring while noting the other state entities that also support or carry out water monitoring related activities including the RI Department of Health (RIDOH), RI Coastal Resources Management Council (CRMC), RI Water Resources Board (WRB), University of Rhode Island (URI), and Narragansett Bay Commission (NBC). These state programs work in collaboration with various partners including federal agencies, academia, watershed organizations and volunteer citizen scientists.

Table 1. Snapshot of Rhode Island Water Resources

	Freshwater Rivers and Streams: • 1,397 miles of rivers and streams • 86% are small headwater streams
	Freshwater Lakes and Ponds: • 20,749 acres of lakes, ponds and reservoirs • DEM estimates 75% of lakes 20 acres and larger are manmade impoundments • Many other small ponds
	Groundwater Aquifers: • 22 major stratified drift aquifers covering 190 square miles • 4 federally designated sole source aquifers
	Freshwater Wetlands: • An estimated 88,052 acres or approximately 12.8% of Rhode Island's land area is composed of freshwater wetlands including but not limited to swamps, marshes, bogs, and fens • Forested swamps are the most abundant wetland type in RI
	Estuarine Waters: • 159 square miles of estuarine waters including Narragansett Bay and its sub–embayments, and Little Narragansett Bay • Coastal lagoons (salt ponds) are located along the southern RI shore and on Block Island
	Salt Marshes: • About 3,800 acres of salt marsh located along RI's coastal shorelines
	Marine Waters: • Rhode Island Sound • Block Island Sound

The Rhode Island Environmental Monitoring Collaborative - Recognizing that various organizations are engaged in environmental monitoring, in 2004, Rhode Island state law established a body to coordinate and advance environmental monitoring - the Rhode Island Environmental Monitoring Collaborative (RIEMC). It is charged with developing a comprehensive environmental monitoring strategy to support management of Rhode Island's natural resources. Chaired by the University of Rhode Island Coastal Institute, monitoring is carried out by the members of the RIEMC that includes federal and state agencies, universities, non-governmental organizations and other monitoring practitioners. The RIEMC works to coordinate existing monitoring activities, establish statewide monitoring priorities and identify and address, as resources allows, critical gaps in data collection. It maintains a website at: http://www.rimonitoring.org and has an important role to play in facilitating communication among monitoring programs.

2.2 Water Monitoring Strategy Goals and Objectives

The overarching goal of the Water Monitoring Strategy is to provide representative data to support the protection and restoration of Rhode Island's water resources. This involves monitoring and assessing their physical, chemical, and biological condition. To achieve this goal a variety of monitoring activities are included in the strategy. The broad objectives for these programs include:

- Prevent risks to public health from environmental contaminants;
- Determine, with increasing confidence, the status and trends in the condition of RI's waterbodies and publicly share the results;
- Identify water pollutants and other stressors that threaten or degrade water quality and aquatic habitats;
- Support effective water resource management including planning, permitting, enforcement, and emergency response actions;
- Evaluate the effectiveness of water resource protection and restoration programs, including the need for adaptation to a changing climate;
- Expand access to monitoring and assessment information to facilitate use by governmental entities, academic researchers, interested stakeholders, and the public.

The objectives of this Monitoring Strategy are designed to meet the goals and intent of federal and state laws including but not limited to sections 106(e), 303(d), 304, 305(b) of the Federal Clean Water Act. Appendix A lists additional relevant state laws. These include requirements to report through EPA to Congress on the status of chemical and physical indicators of water quality, biological assemblages and habitats of all water resources to support environmental and human health assessments.

2.3 Progress Implementing the 2005 Water Monitoring Strategy

While not fully implemented, significant progress was made toward advancing the recommendations of the 2005 Water Monitoring Strategy. Several important monitoring programs were expanded. This occurred despite on-going RIDEM staffing limitations – a constraint that remains a priority to address. Key areas of progress are highlighted below:

- Expansion of the Narragansett Bay Fixed-Site Monitoring Network from 8 to 12 stations in RI and an additional 2 in Massachusetts waters. The network data has been used by researchers, managers and others to support a variety of data analyses.
- Reinstitution of regular water quality monitoring of RI's largest (non-wadeable) rivers via a Joint Funding Agreement with the United States Geological Survey (USGS). The resulting datasets are important for trend analysis.
- Built and equipped a sampling center at the RIDEM Promenade Street office complex that provides a base of operations for water monitoring field work.
- RIDEM adopted the rotating basin approach for water quality monitoring in freshwater wadeable rivers and streams. In 2020, the third rotational cycle will be completed.
- Reduced the gap in data on fish tissue contamination (mercury) in publicly accessible lakes through a cooperative effort among RIDEM Office of Water Resources, RIDEM Division of Fish and Wildlife, and the EPA-Atlantic Ecology Division. Between 2007 and 2018, thirty of 32 targeted lakes with boat

ramps have been sampled.

- Expanded collection of water clarity data in coastal waters by integrating secchi depth measurements into the ongoing RIDEM shellfish monitoring program.
- Expanded access to monitoring information on RIEMC, RIDEM, NBC and other websites.
- Engaged more citizen scientists through volunteer monitoring programs.
-

Looking ahead, further progress will be facilitated by building core capacity within RIDEM Office of Water Resources for ambient monitoring and assessment activities. Outside of the shellfish monitoring program, no fulltime state employees are dedicated to monitoring – a deficiency noted by EPA and others for over a decade. Staffing needs are further discussed in Section 8.

2.4 Water Monitoring Indicators

Monitoring data must be assessed or analyzed to translate it into meaningful information for state resource managers, other stakeholders and the public. This is accomplished using indicators or criteria that support data assessment at different scales tied to the management question or issue being addressed. In the case of water quality, one primary means of assessing data is via the use of criteria that are part of the state water quality standards established by regulation for both surface waters and groundwaters. For surface waters the process is well established, follows EPA guidance and is aimed at fulfilling mandates of the federal Clean Water Act.

RI Water Quality Standards: The Rhode Island Water Quality Standards (WQS) are the foundation for the surface water pollution control and surface water quality management efforts in the state. The standards specify the classification of rivers, streams, lakes, ponds, and coastal waters which establishes the management goals to be attained, maintained, and therein codified as "designated uses" for each class of water. See Table 2. All surface waters of the state are designated to support fish, wildlife and their aquatic habitat, which is interpreted as "Aquatic Life Use." Relative to this use, where data allows, RIDEM has further designated freshwaters waters as cold water or warm water fisheries, with the remaining unassessed. All surface waters of the state are also designated for recreation and fish consumption uses and subsets of waters are designated for drinking water supply or shellfishing/shellfish consumption use as appropriate. In Rhode Island, recreation use includes both primary (e.g., swimming, surfing) and secondary (e.g., boating, fishing) contact uses. The Water Quality Regulations may be accessed at: https://rules.sos.ri.gov/regulations/part/250-150-05-1.

The WQS establish narrative and numeric criteria to support designated uses that can serve as indictors of condition. The criteria relate to the essential chemical, physical, and biological elements of water resource integrity (Karr et al, 1986) and reflect the most basic components of all ecosystems (living biota, habitat and primary water quality). To make efficient use of limited resources, RIDEM uses a tiered approach to the sampling design that includes core and supplemental indicators. Core indicators are those biological, chemical, and physical parameters that are routinely measured in surface waters. Supplemental indicators are those that are measured to answer specific management questions that may arise for a waterbody that are not otherwise addressed by the core indicators; e.g. toxics. See Table 3.

Table 2. RI Water Quality Classifications

RI WATER QUALITY CLASSIFICATIONS

Designated Use	Applicable Classifications	Designated Use Definitions
Drinking Water Supply	AA	Supply safe drinking water with conventional treatment.
Primary Contact Recreation/Swimming	**All surface waters**	Swimming, water skiing, surfing or other recreational activities with prolonged and intimate contact by the human body with water.
Secondary Contact Recreation/Boating	**All surface waters**	Boating, canoeing, fishing, kayaking or other recreational activities with minimal contact by the human body with the water and the probability of ingestion of the water is minimal.
Aquatic Life Support/ Fish, other Aquatic Life and Wildlife	**All surface waters**	Waters suitable for the protection, maintenance, and propagation of a viable community of aquatic life and wildlife.
Shellfishing/ Shellfish Consumption	SA, SA{b}	Supports a population of shellfish and is free from pathogens that could pose a human health risk to consumers.
Shellfish Controlled Relay and Depuration	SB	Suitable for the transplant of shellfish to Class SA waters for ambient depuration and controlled harvest.
Fish Consumption	**All surface waters**	Supports fish free from contamination that could pose a human health risk to consumers.

Table 3. Designated Uses and Assessment Indicators

In the table above, conventional parameters include nutrients, dissolved oxygen, pH, conductivity, salinity,

DESIGNATED USES & ASSESSMENT INDICATORS

Designated Use	Indicator
Drinking Water	• Safe Drinking Water Act Standards (MCLs) • Finished drinking water restrictions • Treatment requirements more than conventional treatment • Fecal coliform bacteria (terminal reservoir)
Swimming/Primary & Secondary Recreation	• **Enterococci bacteria** • **Fecal coliform bacteria** • **Beach closure information for designated beach waters** • Water quality general criteria and aesthetics
Aquatic Life (fish, etc.) and Wildlife	• **Biological (macroinvertebrate) data with physical habitat** • **Conventional parameters** • Toxic parameters in water column • Toxicity data • Water quality general criteria and aesthetics
Shellfish Consumption/Depuration	• **Fecal coliform bacteria** • **RI Shellfish Growing Area Monitoring Program classifications** • Water quality general criteria and aesthetics
Fish Consumption	• **Fish consumption advisories**

* Core indicators are represented in BOLD lettering.

chloride, sodium, turbidity, solids, and temperature. Toxics may include metals and organic compounds.

The criteria are subject to periodic review and updating to incorporate new scientific understanding. A review of the current water quality standards is needed to support revisions to certain standards and criteria to align with EPA guidance; e.g. update standards for certain toxics, etc. RIDEM will initiate work to identify needed changes and formulate a plan for a triennial review. A schedule for updating water quality standards will be determined via the PPG process and is contingent on resources being available to support the work. In addition, RIDEM is continuing to work on development and refinement of numeric nutrient criteria. Short-term priorities over next 1-3 years include finalizing refined lake phosphorus criteria and completing work to develop criteria for wadeable rivers.

RIDEM is also interested in the further development of biological criteria, which may build upon indices of biological integrity (IBIs). Biological indicators offer advantages as they are reflective of the cumulative stress on a waterbody and its ecosystem. Improved understanding of biological conditions can allow for the development of a tiered aquatic life uses (TALU) framework that can be applied to more effectively identify threats and prompt actions to help prevent degradation of high-quality waters. RIDEM is collaborating on a regional project aimed at developing an approach for biological monitoring of low-gradient streams that are not appropriate to be sampled with well-established high gradient sampling methods (macroinvertebrates). Rhode Island has many such streams in the coastal areas of the state. A second priority is exploration of algae as a second biological assemblage for wadeable streams. This process will initially include completing diatom taxonomy on samples previously collected from streams, assessing additional data needs and data analysis. Longer term, the RIDEM will also work to update the classification of freshwaters fisheries habitats and continue to consider approaches to biological indicators for estuarine waters.

Water quality indicators are not limited to the RIDEM WQS. Other programs and researchers have developed indicators for various purposes. The Narragansett Bay Estuary Program (NBEP) developed its Status and Trends Report (NBEP, 2017) utilizing a variety of environmental indicators and associated metrics. For example, with respect to water quality, the NBEP worked with a researcher to develop metrics for characterizing dissolved oxygen and chlorophyll concentrations in estuarine waters. More details are available at: http://nbep.org/01/wp-content/uploads/2017/09/State-of-Narragansett-Bay-and-Its-Watershed.pdf

Recommended Program Enhancements - Indicators:

- Initiate review of RI WQS to support a needed updating of criteria.

- Support continued development of biological indicators This recommended work includes in priority order:

    - Work regionally to develop an approach to biological monitoring in low-gradient coastal streams that are not appropriate to sample with established high-gradient RBP methods. (Year 1-3)
    - Develop a second biological assemblage indicator for freshwaters. Investigate the use of algae for this purpose. (Year 2-5)
    - Evaluate the feasibility of TALU including assessment of any remaining data gaps. (Year 3-5)
    - Develop refined classification of freshwater fisheries habitats; e.g. warm water/coldwater. (Year 5-10).
    - Develop biological indicators for marine waters after assessing research and other state experience. (Year 7-10)

- Develop refined metrics for aquatic nuisance plants to improve application of such data in the water quality assessment process; e.g. apply to recreational uses.

- Continue refinement of numeric nutrient criteria for wadeable rivers and streams.

- Develop refined indicators to support drinking water assessments in collaboration with Department of Health (HEALTH).

3. Monitoring Design – Surface Waters

Rhode Island DEM uses targeted sampling to meet its water monitoring objectives. Given its small size, Rhode Island is able to collect representative data from a larger percentage of its waters that is generally not practical in larger states. The monitoring programs reflect three approaches that vary in spatial and temporal design: long-term fixed site networks, rotating basin assessments and targeted programs or projects. This combination of approaches has been modified but not fundamentally changed since the 2005 strategy. Long- term networks are utilized for trend analysis and increasingly important for understanding the effects of climate change on aquatic ecosystems. Rotating basin assessments provide a cost-effective means of characterizing water quality conditions on a periodic basis. Additional targeted monitoring programs are carried out to meet specific management needs. The design of all programs is subject to periodic review and adaptation to new scientific understanding, technological advancements, and changing management needs.

Monitoring programs with state involvement are described below and organized by resource type: coastal waters, rivers and streams, lakes and ponds.

3.1 Coastal Waters

Description of the Resource: Rhode Island has identified 159 square miles of coastal waters that are monitored for water quality assessment purposes. These include estuarine waters, comprised of Narragansett Bay, Mt. Hope Bay and the coastal ponds as well as the near-shore marine waters along the state's southern and Block Island shorelines. Eighty-five percent (85%) of these waters are designated for shellfishing use. (RIDEM, 2019) Rhode Island's coastal waters receive discharges directly from 13 major wastewater treatment facilities (non- industrial), including the state's largest WWTF operated by NBC. To abate pollution problems in the upper Bay, major upgrades to wastewater treatment facilities, including combined sewer overflow (CSO) controls, have been made and continue to be planned. As a result, water quality conditions in the upper Bay are expected to improve and there is a need to measure the effectiveness of the sizable investment being made in water pollution control infrastructure.

Monitoring Objectives– Narragansett Bay and Coastal Waters

- Characterize the presence and concentration of pathogens in all estuarine waters on an on-going basis.
- Characterize water chemistry and productivity in Narragansett on an on-going basis, including tracking the frequency and duration of hypoxia.
- Assess changes in the ambient water quality and ecosystem functioning resulting from pollution control measures to abate nutrient and pathogen pollutant loadings and a changing climate.
- Characterize water quality in RI coastal ponds and embayments on a periodic basis.
- Monitor to allow for early detection of potential harmful algal blooms.
- Characterize legacy and emerging contaminants of concern in coastal waters and sediments.

Monitoring Programs – Coastal Waters: Core monitoring programs for coastal waters include: (1) Narragansett Bay Fixed-Site Monitoring Network; (2) Dissolved Oxygen Surveys; (3) Shellfish Growing Area Monitoring; (4) Harmful Algae; (5) Saltwater Beach Monitoring; (6) Fish tissue contamination. Collectively,

these programs provide a sizable amount of data on water quality conditions in Narragansett Bay. However, there are gaps in the information needed to fully support desired modeling of bay processes including the ecological response to nutrient reductions or a changing climate. Accordingly, further evaluation of these needs is included as an action in this plan.

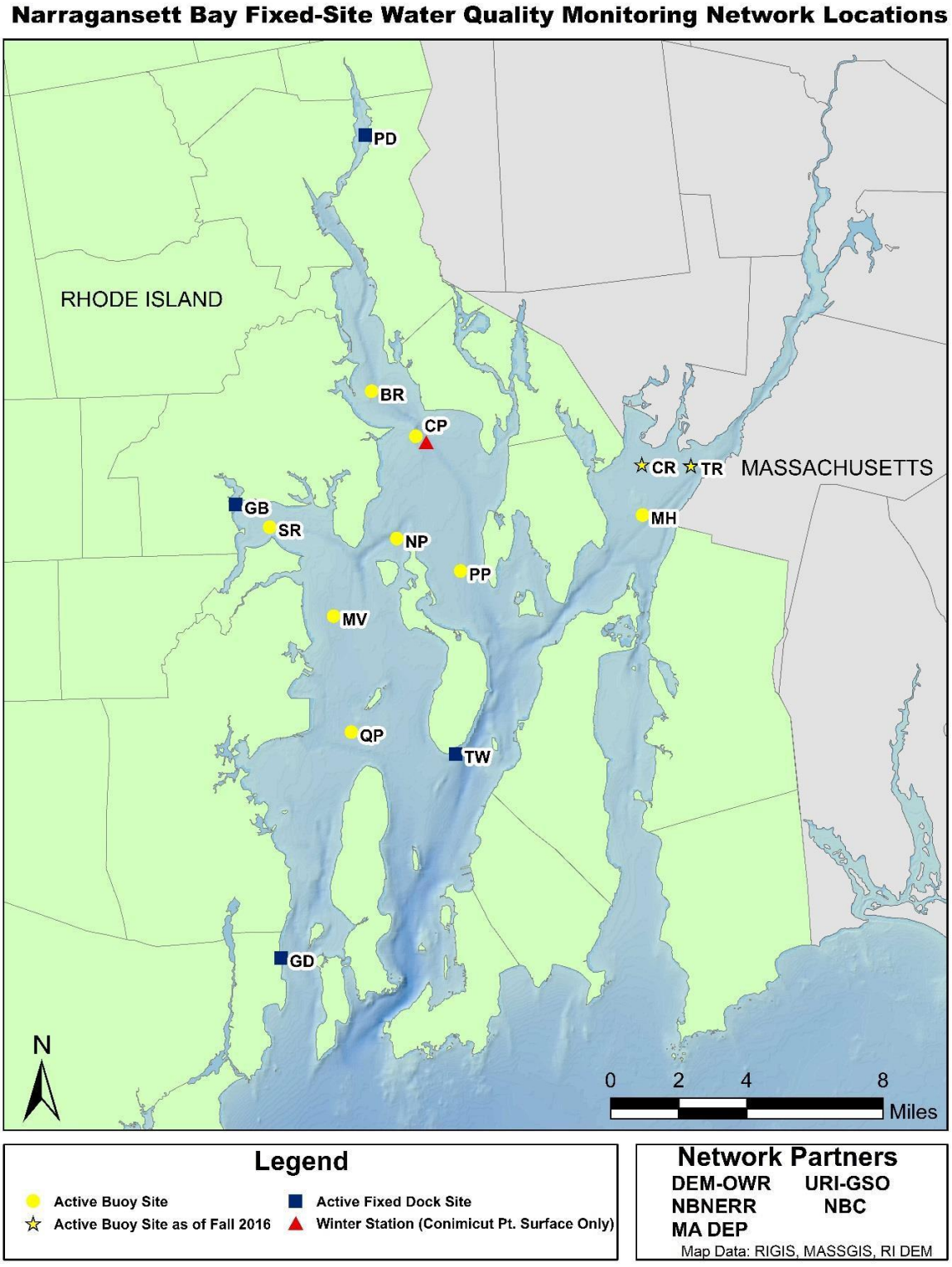
Narragansett Bay Fixed Site Monitoring Network (NBFSMN): The NBFSMN is a multi-agency collaborative, coordinated largely by RIDEM, that operates a network of 14 stations on docks or buoys in Narragansett Bay. Stations are arrayed along the north to south pollution gradient in the Bay with a majority monitoring in areas of known water quality degradation. Monitoring stations in the network are fitted with instruments that collect water quality data on a continuous basis (usually every fifteen minutes). Off-shore stations are on buoys, and near-shore stations are attached to structures, such as docks, that are accessible from land. Some stations operate year-round, but most are seasonal (spring to fall), with their instruments removed and stored for the winter. Each station measures water properties at particular depths, usually from the bottom and surface of the Bay. Data (temperature, chlorophyll, dissolved oxygen, salinity) are then transmitted to on-shore computers accessible to managers. Grab samples are also periodically collected at the stations and analyzed by URI-GSO for nutrients. The network was expanded in 2016 by the addition of two similar stations in the Massachusetts portion of Mt. Hope Bay that are supported by the Massachusetts Department of Environmental Protection. The Quality Assurance Project Plan for the NBFSMN is available on RIDEM website and is in the process of being updated.
http://www.dem.ri.gov/programs/emergencyresponse/bart/netdata.php

The existing network provides a denser coverage of the upper half of Narragansett Bay aligning with areas documented to be experiencing water quality degradation. Long- term, it would be desirable to also collect additional data from the lower bay and Sakonnet River which are currently gaps. There are projects underway by USGS and other researchers which could inform the siting of any additional stations in these areas. The fixed-station network serves as one of the primary sources of baseline data to characterize important aspects of Bay water quality. The collection of continuous data is aligned with Rhode Island's criteria for dissolved oxygen in estuarine waters which is assessed over a recruitment season. The network is maintained long-term to build datasets that will allow researchers and managers to discern trends from the natural variability that occurs in estuarine ecosystems. While operated efficiently, the network will require additional investment as equipment ages over time. In 2019, with the support of Southeast New England Program (SNEP) funding distributed via Restore America's Estuaries (RAE), RIDEM was able to upgrade three critical stations and restore near real-time access to data in collaboration with the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS). The three stations upgraded were North Prudence, Conimicut Pt, and Poppasquash Pt. Significant equipment upgrade needs remain. Additional description of the NBFSMN is at: http://www.rimonitoring.org/dissolved-oxygen/methodology/.

Table 4. Narragansett Bay Fixed Site Monitoring Network Stations

Label	Name and Location of NBFSMN Stations	Agency Operating the Station
BR	**Bullock's Reach -**downstream of Fields Point Wastewater Treatment Facility	NBC
CP	**Conimicut Point -** station just south of lighthouse	URI GSO DEM OWR
CR	**Cole Rive**r - Mouth of Cole River in Mt Hope Bay, MA	MADEP URI/GSO
GB	**Greenwich Bay - w**estern edge in a marina near the mouth of Apponaug Cove	URI GSO DEM OWR
GD	**URI GSO Dock –** URI Narragansett Bay Campus	URI GSO
MH	Mount Hope Bay –	URI GSO DEM OWR
MV	**Mount View -**mouth of Greenwich Bay	URI GSO DEM OWR
NP	**North Prudence -** representative of Upper Bay	URI GASO DEM OWR
PD	Phillipsdale (in Seekonk River-downstream of Bucklin WWTF)	NBC
PP	Poppasquash Point (Upper East Passage)	URI GSO DEM OWR
QP	Quonset Point	URI GSO DEM OWR
SR	Sally Rock (Mid-Greenwich Bay)	URI GSO DEM OWR
TR	Taunton River (Mouth of Taunton River in Mt Hope Bay)	MADEP URI/GSO
TW	T-Wharf (South of Prudence Island on East Passage)	NBNERR

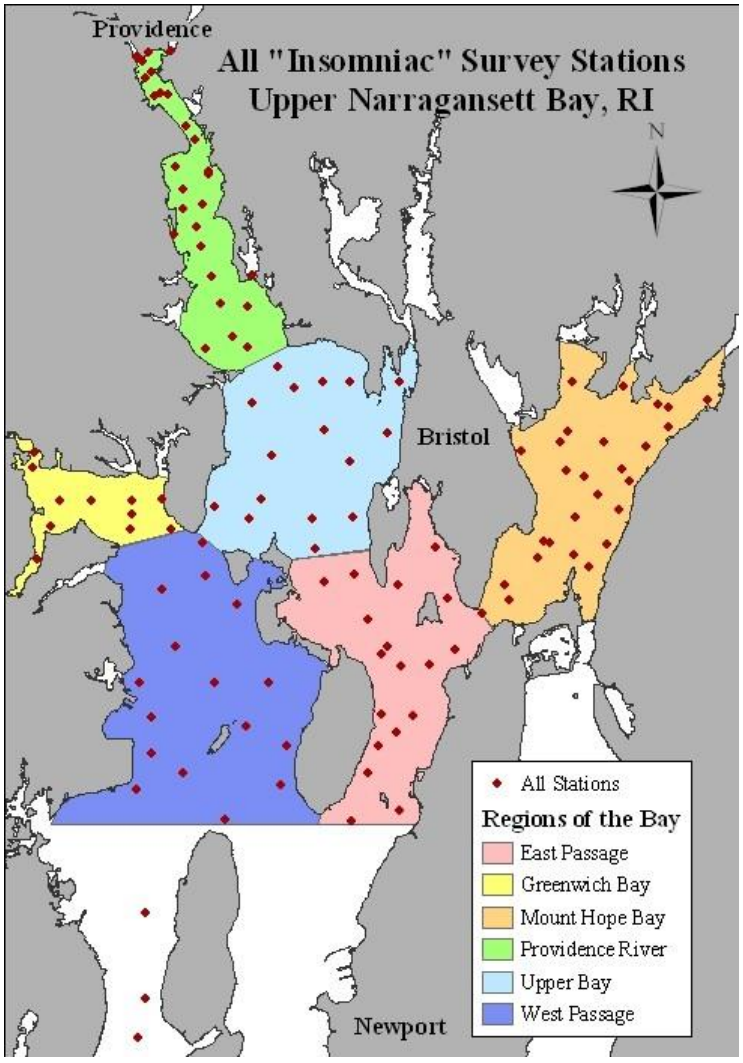
Figure 1.


Narragansett Bay Fixed-Site Water Quality Monitoring Network Locations
RHODE ISLAND
MASSACHUSETTS
PD
BR
CP
CR
TR
GB
SR
NP
MH
PP
MV
QP
TW
GD
N
0
2
4
8
Miles
Legend
Active Buoy Site
Active Fixed Dock Site
Active Buoy Site as of Fall 2016
Winter Station (Conimicut Pt. Surface Only)
Network Partners
DEM-OWR
URI-GSO
NBNERR
NBC
MA DEP
Map Data: RIGIS, MASSGIS, RI DEM

Dissolved Oxygen Surveys of Narragansett Bay- "Insomniac/Day Trippers": Complimenting the NBFSMN is an established program for surveying water quality in Narragansett Bay using equipment that profiles the water column (Sea-Bird SBE 19). The resulting data provides information on the spatial structure of hypoxia in the Bay. Brown University, RIDEM, the University of Rhode Island, Narragansett Bay Commission (NBC), and Save The Bay typically conduct the boat-based surveys 5-7 times every summer targeting neap tides when tidal mixing and dissolved oxygen may be at their lowest. Low tidal mixing in combination with phytoplankton and other plant diurnal respiration processes can cause low dissolved oxygen. The survey profiler collects data on temperature, salinity, DO and depth and uses additional sensors to measure chlorophyll-a (fluorescence) and turbidity at about 75 stations throughout the Providence and Seekonk Rivers, Greenwich Bay, and the East and West Passages of Narragansett Bay. At each station, a depth profile is taken, starting at one meter below the surface, and then going deeper, taking readings every five to six centimeters. Stable funding support for this program, including processing of the data, is a need.

More details at: http://www.geo.brown.edu/georesearch/insomniacs/.

Figure 2. Dissolved Oxygen Survey Stations



Shellfish Growing Area Monitoring: Among the state's coastal waters tracked for assessment purposes, all waters classified as SA and SA{b} are designated for shellfishing uses. This consists of 84,902 acres or about 85% of the total; which excludes the open waters of Rhode Island Sound and Block Island Sound. Within these shellfishing waters, the 2016 Integrated Report indicates 74% of the acreage is currently open to shellfish harvesting with 23.3% closed permanently or managed conditionally and about 2.6% unassessed. The RIDEM Shellfish Growing Area Monitoring Program provides an extensive dataset concerning pathogens in shellfish waters. The program, which assures compliance with the USFDA National Shellfish Sanitation Program Model Ordinance (NSSP MO), collects samples from 17 shellfish growing areas and routinely analyzes for fecal coliform bacteria. The growing areas encompass all of Narragansett Bay and its shellfish harboring tributaries, all of the south shore coastal salt ponds, Little Narragansett Bay and Block Island, and includes those state waters of RI Sound and Block Island Sound. There are over 315 fixed stations established in the program with 4 to 27 stations sampled in each growing area. See map on page 18. The frequency of sampling varies with the classification status of the growing area. All approved areas are sampled at least 6 times per year while those areas conditionally approved are sampled once a month when they are in their open status. Entire growing areas that are classified as prohibited are sampled when program resources allow or if reclassification of the area is currently being considered. Prohibited areas within growing areas that are routinely monitored are sampled at the same frequency as their encompassing approved or conditionally approved growing areas. Other parameters sampled during routine monitoring may also include, temperature, salinity, secchi depth, male-specific bacteriophage, and phytoplankton for identification and abundance. More details available at:
http://www.dem.ri.gov/programs/water/shellfish/shellfish- monitoring.php.

Harmful Algae in Coastal Waters: Rhode Island's coastal waters are occasionally impacted by harmful algae blooms (HAB) that have the potential to produce biotoxins that can sicken humans if they consume fish or shellfish contaminated by HAB toxins. The RIDEM Shellfish Monitoring Program has been monitoring for harmful algae that are known to cause public health concerns since 2000. Updated monitoring protocols are reflected in the "Harmful Algal Bloom and Shellfish Biotoxin Monitoring and Contingency Plan" (August 2017) jointly prepared by RIDEM and RIDOH following a major closure event in coastal waters involving *Pseudo- nitzschia* in October 2016 and March 2017. (Full plan available at: http://www.dem.ri.gov/shellfishclosure/habs-marine-biotoxin-monitoring.php). During its regular pathogen monitoring runs, RIDEM collects phytoplankton samples at fixed sites in the Bay and coastal ponds. See maps on pages 19-21. These samples are analyzed for HAB phytoplankton species abundance by the RIDOH laboratory as an initial step in the detection of biotoxins. If HAB phytoplankton abundance action levels are exceeded, shellfish meats are collected from the impacted area. Shellfish meats are then analyzed by the RIDOH laboratory to determine if levels of HAB phytoplankton biotoxins, including toxins responsible for Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP) and Diarrhetic Shellfish Poisoning (DSP), have exceeded FDA-established warning concentrations. If biotoxin levels in shellfish meats are elevated, shellfish grounds are closed. Continued monitoring documents the decline of the HAB phytoplankton bloom and the return of shellfish meats to safe, biotoxin-free levels. Shellfish closure events due to HABs have been rare in RI coastal waters with only two short-lived HAB closures since the year 2000. Routine secchi depth was added in January 2018 at HAB stations and is helping to address a data gap on water clarity identified by the NBEP Status and Trends Report (NBEP, 2017).

Figure 3. Shellfish Growing Area Monitoring Locations

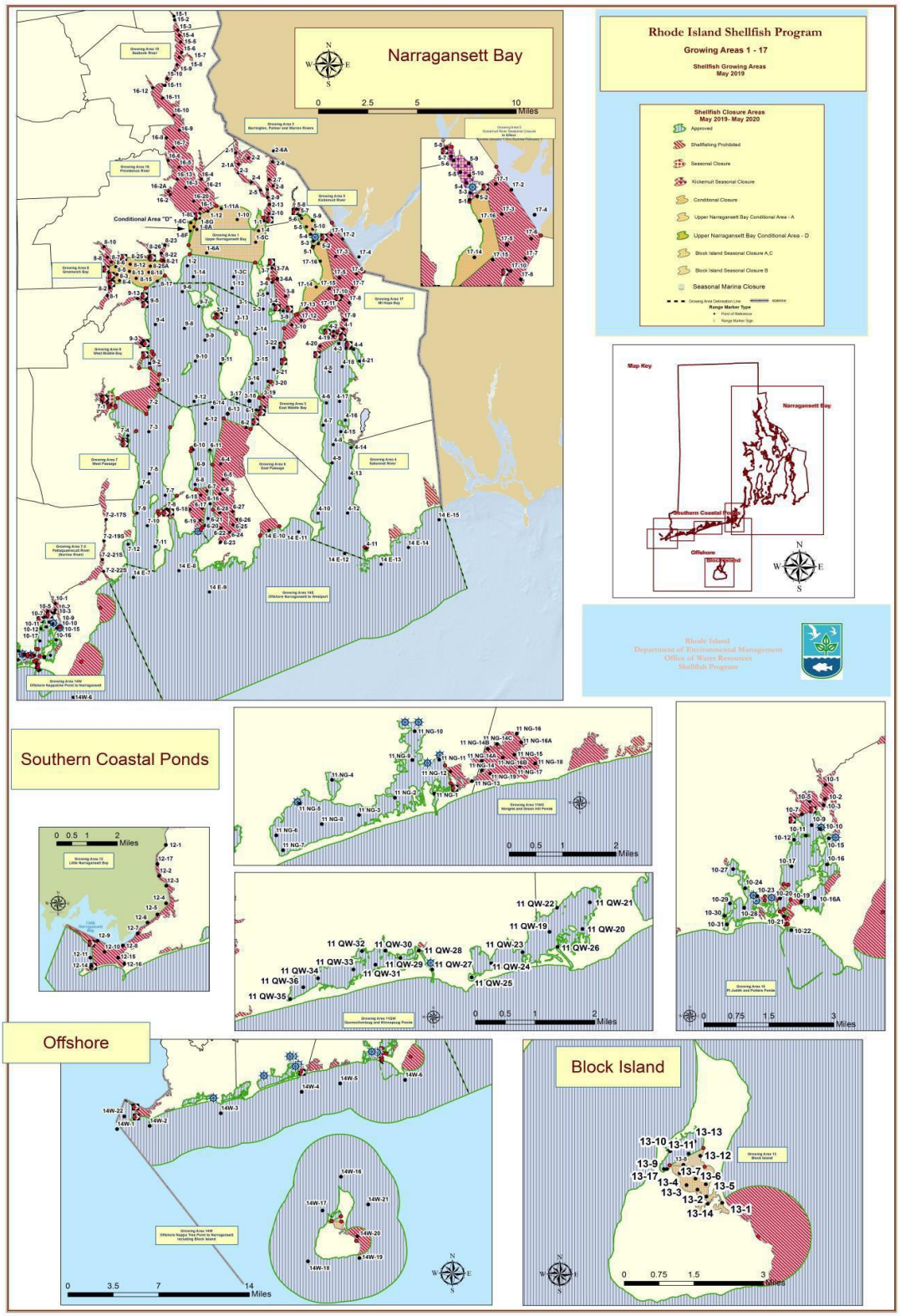


Figure 4-1. Shellfish Program HAB Sampling Stations – Upper Narragansett Bay

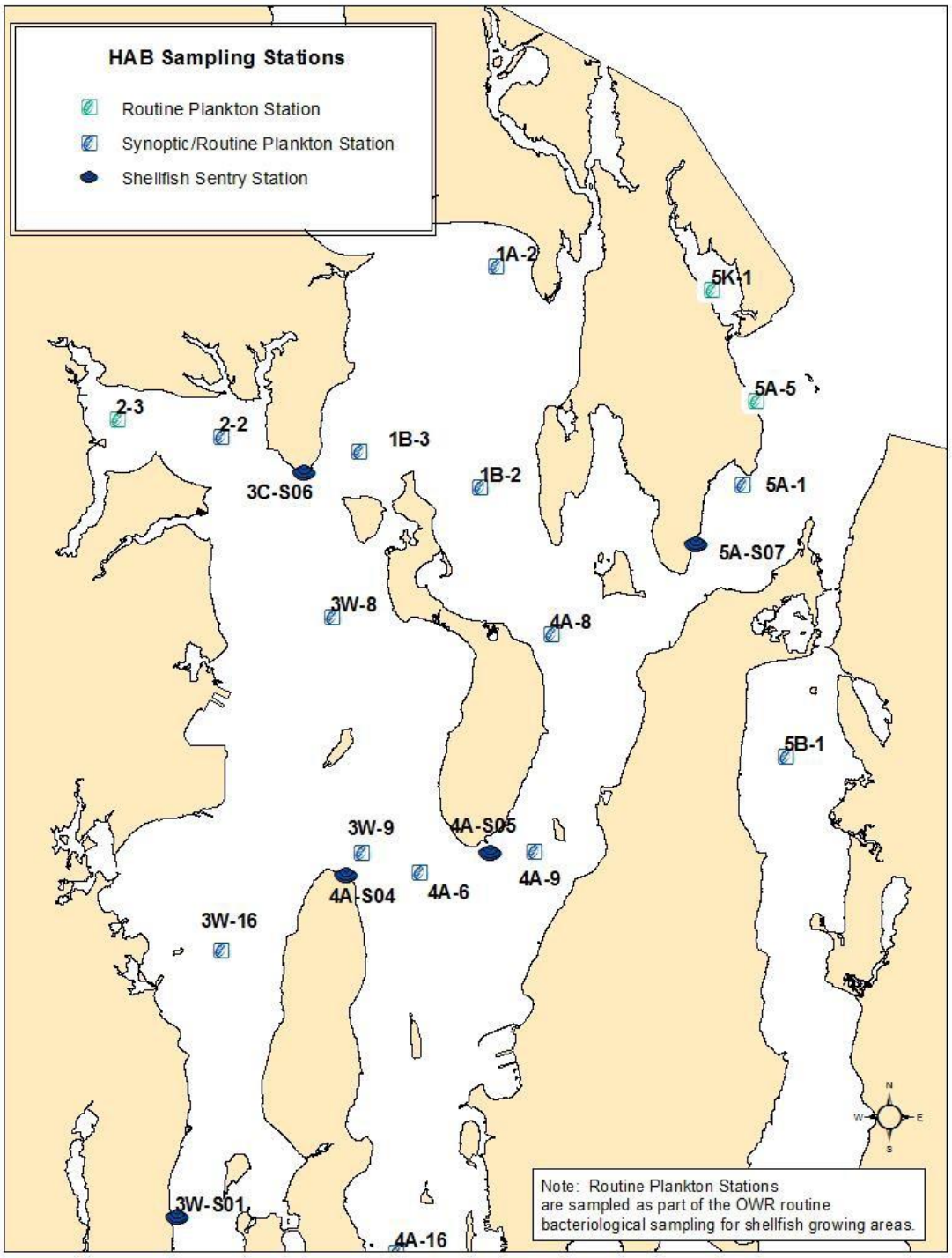


Figure 4-2. Shellfish Program HAB Sampling Stations – Lower Narragansett Bay

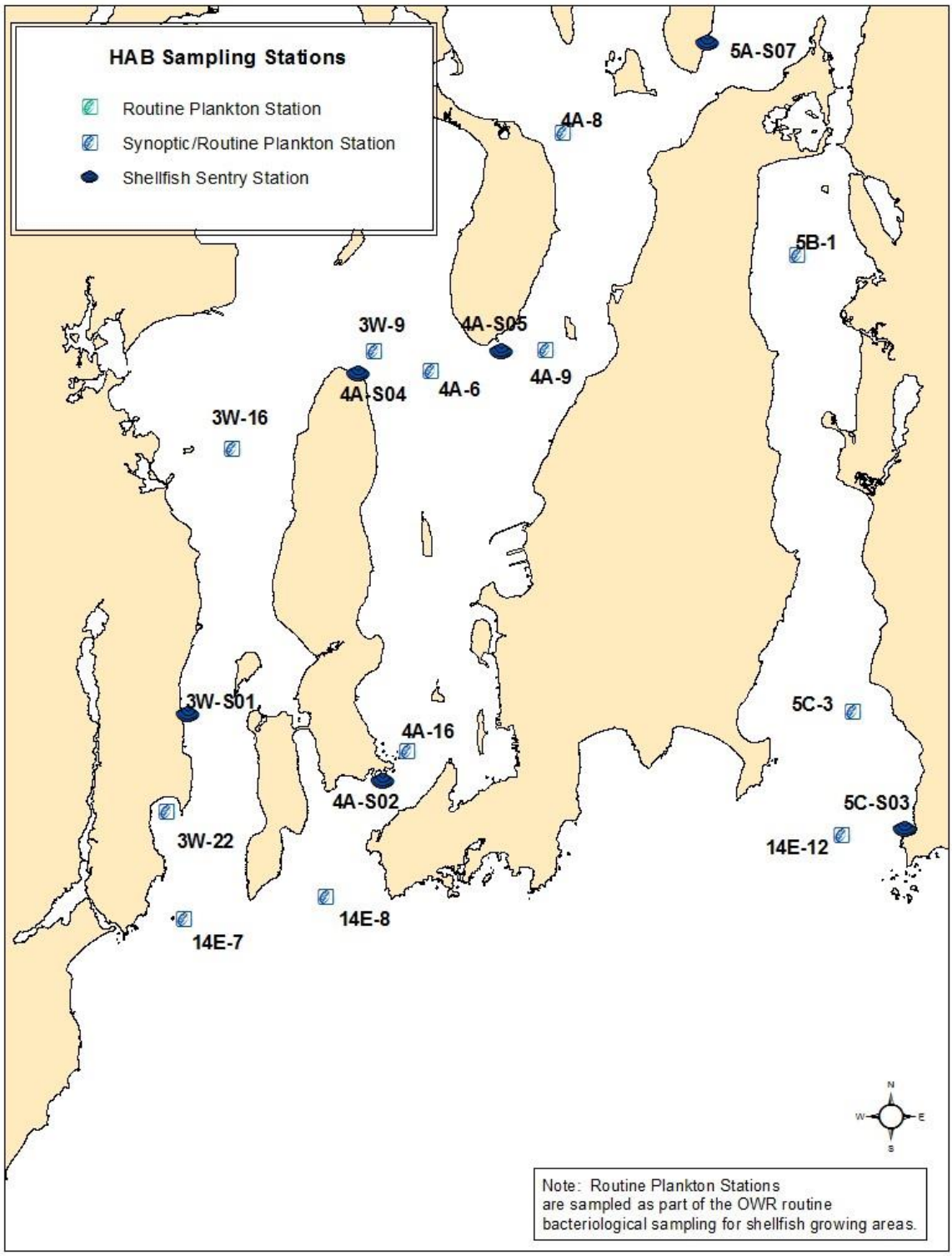


Figure 4-3. Shellfish Program HAB Sampling Stations - Coastal Ponds & Southern Shore

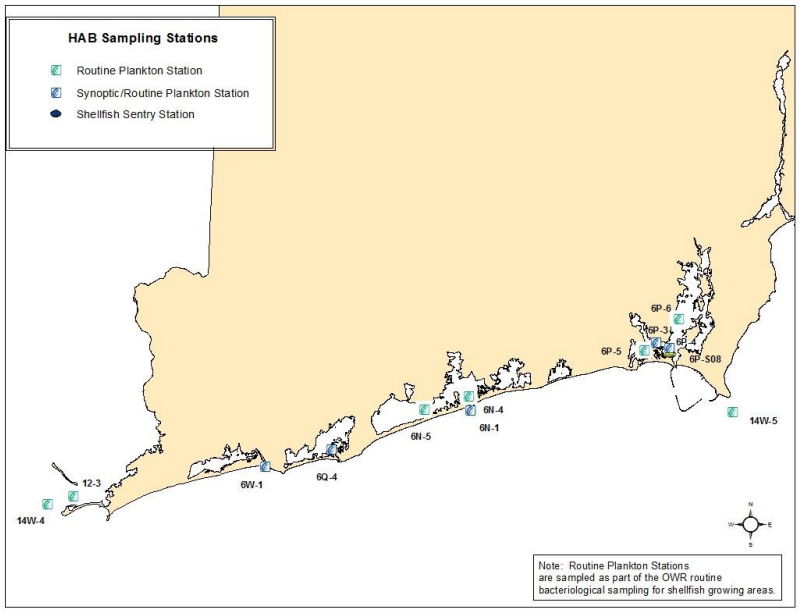
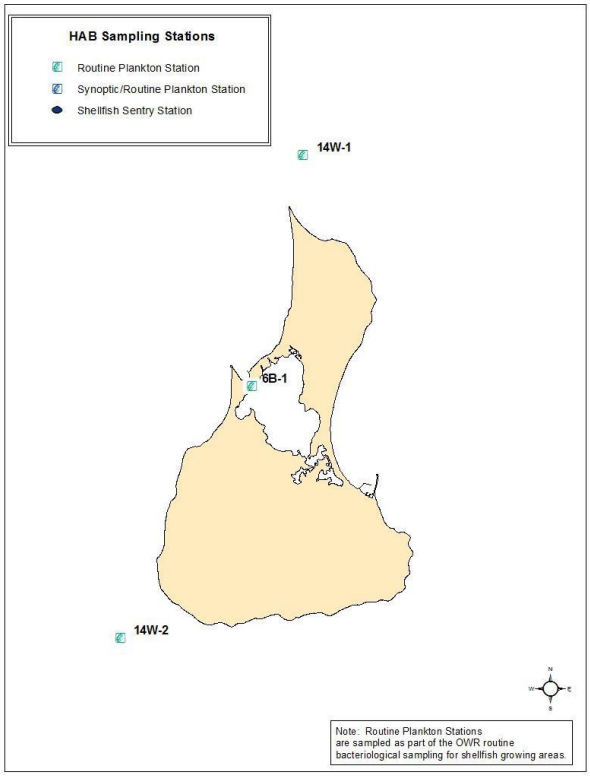


Figure 4-4 Shellfish Program HAB sampling stations -Block Island area



Saltwater Beaches: Rhode Island has over 400 miles of coastline and 70 licensed saltwater breaches which may be visited by thousands in a single day. Supported with EPA funding, the RIDOH Beach Program monitors licensed bathing beaches, identifies sources (point and non-point) of contamination, and works with Rhode Island's municipalities to eliminate those sources of contamination and improve coastal water quality. RIDOH uses a tiered, risk-based approach to sampling beaches for the bacterial indicator Enterococcus. When concentrations of bacteria are elevated above beach action values, the RIDOH issues public advisories recommending beach closures. Monitoring continues and RIDOH notices to reopen beaches are issued when water quality has sufficiently improved. More information at: http://www.health.ri.gov/beaches/.

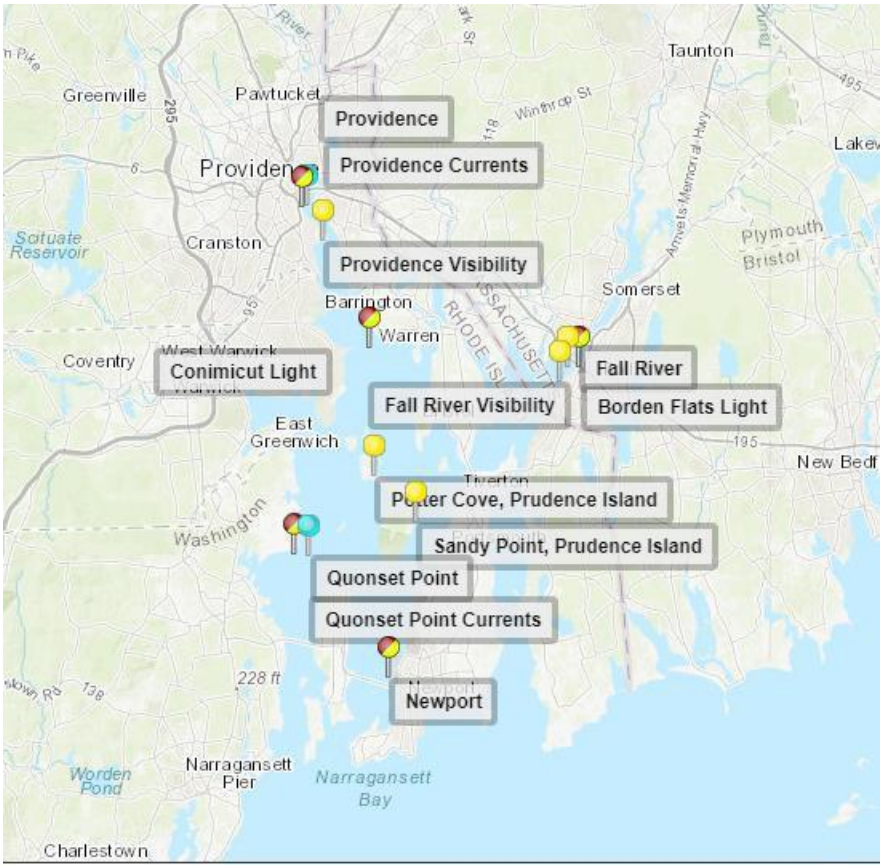
Fish Tissue Contamination: There is no established state level program for routinely monitoring the contaminants in fish tissue in coastal waters. RIDEM and RIDOH have compiled data collected by researchers and other entities. In the case of coastal waters, sources of data include work by David Taylor of Roger Williams University (RWU) and the EPA through its national surveys; e.g. National Coastal Condition Assessment (part of National Aquatic Resource Surveys). RIDEM is partnering with RWU to generate additional fish contamination data. RIDOH has reviewed existing data and articulated statewide public health advisories for fish consumption with respect to mercury. Details at: http://www.health.ri.gov/healthrisks/poisoning/mercury/about/fish/.

Rotating Assessment of Coastal Embayments: The fixed-station network provides a vital dataset for Narragansett Bay but is considered representative of its smaller, shallower embayments. In addition, data is needed for management of other coastal waters including the salt ponds and Little Narragansett Bay. The 2005 strategy recommended RIDEM establish a program to systematically monitor these areas on a rotating basis. It was envisioned instrumentation like the fixed–station network would be deployed on a temporary basis; e.g. 1-2 sampling seasons in specific areas. Limited resources prevented this program from being fully established, although project driven monitoring has partially filled the data need. RIDEM has collected some data from Green Hill Pond, Ninigret Pond, Point Judith Pond, Potter Pond, Quononchontaug Pond, the estuarine Pawcatuck River and Palmer River. Researchers and volunteer efforts active in these coastal waters are also generating water quality data. Given climate change, it will be increasingly important to routinely track conditions in near shore coastal waters to understand how their aquatic ecosystems are being affected.

PORTS: A primary source of data on the hydrodynamics of Rhode Island's coastal waters is NOAA. NOAA, through its Center for Operational Oceanographic Products and Services (CO-OPS) oversees the National Water Level Observation Network that provides data from tidal stations. CO-OPS operates the Physical Oceanographic Real-Time System (PORTS) which provides real-time water level, current, and other oceanographic and meteorological data for Narragansett Bay to promote navigation safety, economic efficiency and coastal resource protection. DEM contracts with NOAA to sustain the operation of PORTS in RI waters. In addition, the Town of Westerly has partnered with USGS to operate a tide gage in Watch Hill Cove since August 2014. Documentation of sea level rise reinforces the need to sustaining this type of monitoring.

Figure 5. PORTS Stations in Narragansett Bay (July 2019)

Legend: Red=Water levels (tides) Yellow=meteorological Green=Currents



Emerging & Legacy Contaminants: RI state agencies currently do not conduct routine monitoring for emerging or legacy contaminants in the water column or sediments. The NBEP has discussion of these topics in its Status and Trends Report which highlights available data based on work done by researchers. http://nbep.org/the-state-of-our-watershed/.

Recommended Program Enhancements – Coastal Waters:

- Sustain the Narragansett Bay Fixed-Site Monitoring Network by securing stable operational funding as well as funding to invest in the upgrade and replacement of aging equipment.
- Evaluate data needs relative to development of modeling tools for Narragansett Bay, identify key gaps and implement monitoring to address the gaps.
- Reassess the geographic gaps in the NBFSMN using data from recent and ongoing research activities.
- Secure funding for further assessment of estuarine fish tissue contamination.
- Secure stable funding for continuation of dissolved oxygen surveys.
- Build capacity for monitoring of coastal embayments.

3.1 Rivers and Streams

Description of the Resource

Rhode Island has 1,498 miles of rivers and streams mapped at a 1:24,000 scale which range from numerous small first order headwater streams to the large, well-known main stem rivers. The rivers are used for aquatic life habitat, fish consumption, and recreational activities. A subset of rivers are tributaries to drinking water supply reservoirs. In the northwest corner of the state, marked by rolling hills and higher elevations, the rivers have higher gradients and flow slightly faster than the streams in the coastal lowlands which cover more than half the mainland and the Rhode Island's islands. Except for small portions of the state bordering Connecticut, northern Rhode Island is drained by river systems that discharge into Narragansett Bay, while rivers in southern Rhode Island drain directly into Rhode Island Sound. Freshwater rivers in RI are the receiving waters for six major public WWTF discharges.

Monitoring Objectives– Rivers and Stream Water Quality

- Periodically assess the ambient water quality conditions in RI's wadeable rivers and streams on a statewide basis over a five-year period.
- Monitor water quality in the state's three largest rivers (Blackstone, Pawtuxet and Pawcatuck) on a regular basis for nutrients and other selected parameters to allow for estimates of pollutant loadings into coastal waters and long-term trends analysis.
- Reduce the gap in assessment of fish tissue contamination in rivers supporting fish of edible size.

Monitoring Programs- Rivers and Streams: Core monitoring programs for rivers and streams include: (1) Large River Long-term Network; (2) Ambient River Monitoring, (3) Biomonitoring, and (4) Stream Gage Network. Programs that need further development include (5) Cyanobacteria Surveillance.; (6) Fish Tissue Contamination and (7) Regional Climate Change Network.

Large River Long-term Water Quality Stations: RIDEM partners with the US Geological Survey (USGS) to routinely monitor water quality at six stations on Rhode Island's largest rivers: the Blackstone, Branch, Pawtuxet, and Pawcatuck. Several of the stations have lengthy periods of record of four decades or more which is valued for discerning long-term trends. (Table 5 and Figure 6) Stations are monitored for the parameters listed in Table 6. This work is carried out as part of a Joint Funding Agreement between USGS and RIDEM. Funding has constrained expansion of the number of sites monitored. Reevaluation of the need for additional stations should be undertaken during the next five years.

Table 5. Long-term Water Quality Stations in Rivers

USGS Station Name	USGS Station Number
Blackstone River at Millville, MA (near state border)	01111230
Branch River at Forestdale, RI	01111500
Blackstone River at Manville, RI	01112900
Blackstone River at Roosevelt St, Pawtucket, RI	01113895
Pawtuxet River at Pawcatuck, RI	01116617
Pawcatuck River at Westerly, RI	01118500

Figure 6. USGS Fixed Monitoring Stations on Large Rivers

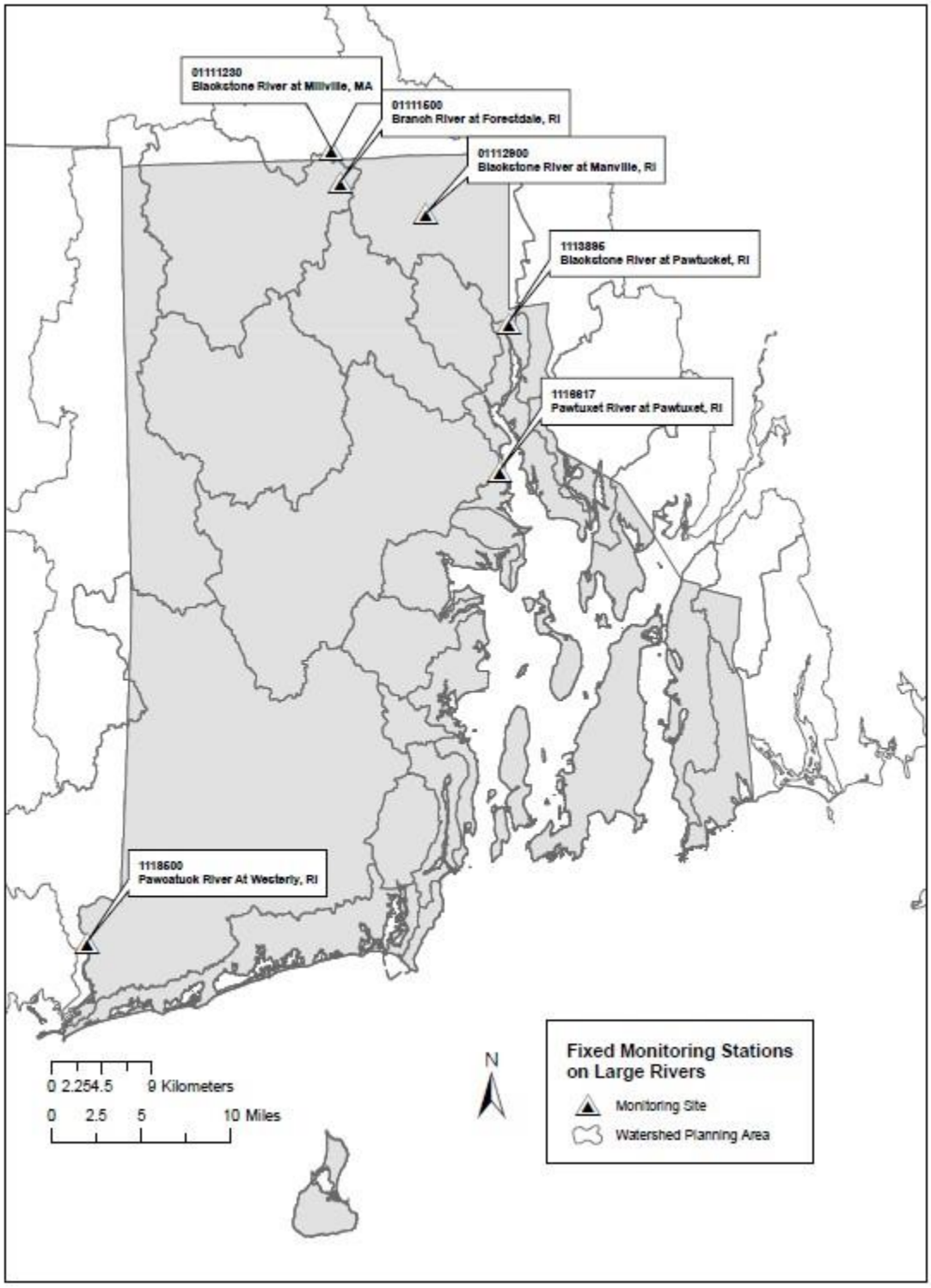


Table 6. Parameters measured by USGS at Long-term River Monitoring Stations

USGS

Table 2. List of analytes, parameter codes, reporting levels, and sample collection and analysis frequency

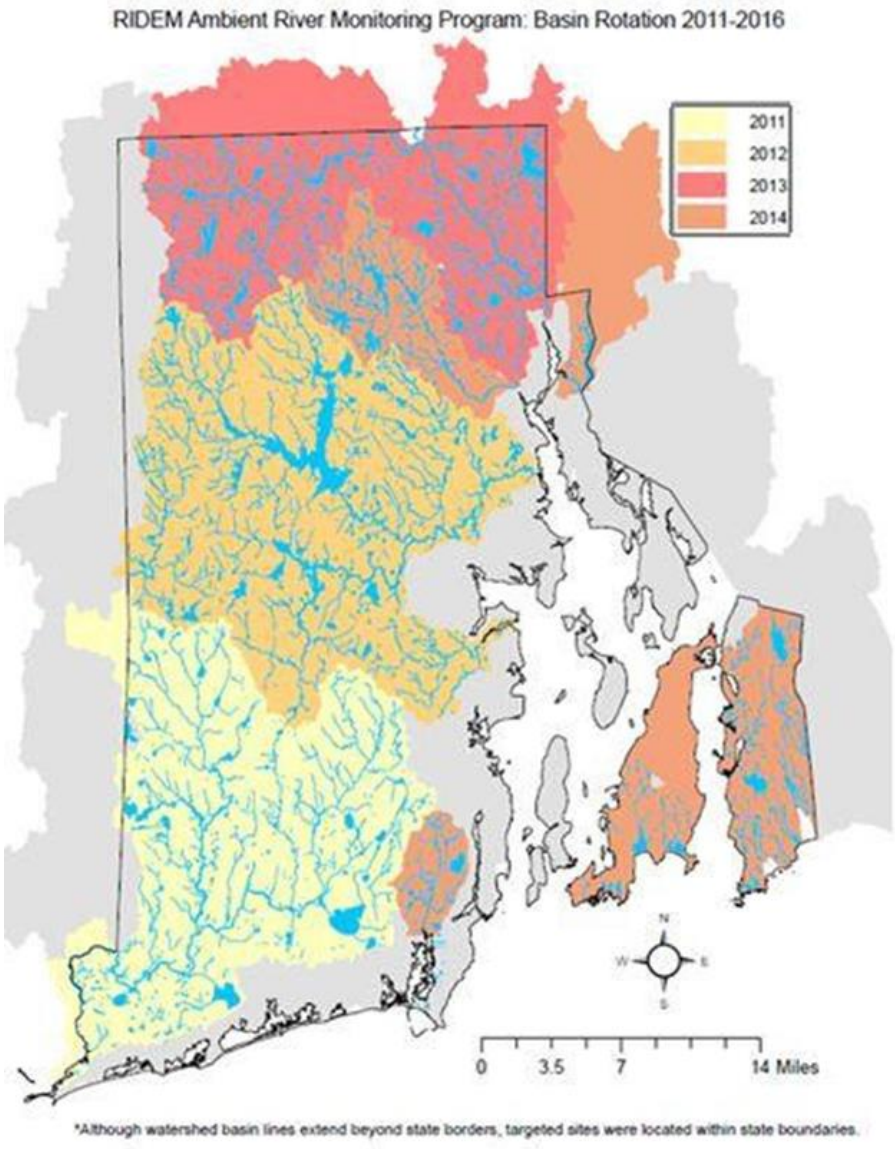
Analytes	USGS Parameter Code	Minimum Reporting Level	Monthly	Quarterly*
Field parameters				
Water temperature	00010	0.01 °C	✓	✓ (EWI)
Specific conductance	00095	1.0 uS/cm	✓	✓ (EWI)
Dissolved oxygen	00300	0.1 mg/L	✓	✓ (EWI)
pH	00400	NA	✓	✓ (EWI)
Turbidity	63676	NA	✓	✓ (EWI)
Nutrients				
Organic-N + ammonia-N, unfiltered	00625	0.07 mg/L	✓	
Organic-N + ammonia-N, filtered	00623	0.07 mg/L	✓	
Ammonia nitrogen	00608	0.010 mg/L	✓	
Nitrate + nitrite nitrogen	00631	0.04 mg/L	✓	
Nitrite nitrogen	00613	0.0010 mg/L	✓	
Total nitrogen, unfiltered	62855	0.05 mg/L	✓	
Total nitrogen, filtered	62854	0.05 mg/L	✓	
Total particulate nitrogen	49570	0.030 mg/L	✓	
Total phosphorus, unfiltered	00665	0.004 mg/L	✓	
Total phosphorus, filtered	00666	0.0030 mg/L	✓	
Orthophosphate phosphorus	00671	0.004 mg/L	✓	
Major ions				
Calcium, filtered	00915	0.022 mg/L	✓	
Magnesium, filtered	00925	0.011 mg/L	✓	
Sodium, filtered	00930	0.06 mg/L	✓	
Chloride, filtered	00940	0.06 mg/L	✓	
Suspended sediment				
Suspended sediment concentration	80154	1 mg/L	✓	
Trace metals				
Cadmium, filtered	001025	0.03 ug/L		✓
Cadmium, unfiltered**	001027	0.03 ug/L		✓
Chromium, filtered	001030	0.50 ug/L		✓
Copper, filtered	001040	0.20 ug/L		✓
Copper, unfiltered**	001042	0.20 ug/L		✓
Lead, filtered	001049	0.020 ug/L		✓
Lead, unfiltered**	001051	0.020 ug/L		✓
Nickel, filtered	001065	0.20 ug/L		✓
Zinc, filtered	001090	2.0 ug/L		✓
Zinc, unfiltered**	001092	2.0 ug/L		✓
Quality control samples				
Equipment blank (pre-field)				✓
Field blank				✓
Replicate samples				✓

* Quarterly samples are collected March, June, September, and December

** Collected only for Pawtuxet River at Pawtuxet, RI (site 01116617)

Wadeable Rivers and Streams-Rotating Basin Approach: RIDEM monitoring in Rhode Island's wadeable rivers and streams has two components: (1) an Ambient River Monitoring (ARM) program involving water chemistry, pathogens, and field measurements; and (2) a Biological Monitoring Program involving macroinvertebrate sampling and habitat surveys. Both components are typically implemented in accordance with a rotating basin approach in which a portion of the stations within one or more watersheds are sampled each year. The approach is designed to visit freshwater rivers and streams around the state over a 4 to 5- year rotating basin cycle. Since its inception, the ARM program has established over 200 river monitoring stations throughout the state. From 2004-2014, two sampling rotation cycles were completed; the third rotation was initiated in 2015 but disrupted due to loss of staffing. It is scheduled to be completed in 2020.
2004-2009 1st rotation 2011-2014 2nd rotation 2015-2016, 2019-2020 3rd rotation

Figure 7. RIDEM Ambient River Monitoring Program Basin Rotation 2011-2016



RIDEM is implementing ambient wadeable river monitoring with limited federal resources. A loss of contractual staff disrupted data collection during 2017-2018.RIDEM has reinstituted ARM monitoring in 2019 relying on seasonal employees and drawing upon staff time from other OWR programs. ***This arrangement is not sustainable, and it is a critical need to build staffing capacity for this work. A minimum, a fulltime person is needed to plan, carry out site reconnaissance, hire and train seasonal technical staff, coordinate field work and quality assure data.*** Ideally the program would be supported with two FTEs for redundancy. See Section 8 - Resource Needs for further discussion.

Ambient River Monitoring: The ARM typically includes sampling at 45 to 60 stations in a given year with the parameters sampled at each station tailored to both its situation and management information needs. Monitoring is conducted during the seasonal period of later spring to early fall. Water quality samples are collected for chemical and pathogen lab analysis for over a dozen parameters. Additional physical data is measured during field visits. Field staff also take note of the presence of aquatic invasive species as applicable. With respect to pathogen sampling, RIDEM is giving more priority to those rivers and streams that support public recreation or other uses; e.g. flow into shellfish growing areas and scaling back on other streams. Small streams with pathogen impairments will not be routinely resampled unless actions have been taken indicating a basis for a possible change in condition. Biological sampling occurs when conditions are suitable to collect specimens. Additional parameters, including metals, are sampled selectively based on need. The data generated allows RIDEM to assess water quality in rivers and streams, identify pollution problems and degraded aquatic habitat, and plan and track water quality management and restoration efforts. The data RIDEM collects is used to characterize general river and stream conditions, identify pollution problems and their causes, support development of water quality restoration plans (known as TMDLs), and contribute to environmental management decision-making.

Biological Monitoring Program – Aquatic Macroinvertebrates: The biological component of the rotating basin approach to monitor rivers and streams is the RI Wadeable Streams Biomonitoring and Habitat Assessment Program. This RIDEM program involves the collection and taxonomic identification of macroinvertebrate (aquatic insect) samples from riffle habitat in shallow, wadeable rivers and streams as well as habitat assessment. Aquatic macroinvertebrates include immature larval forms of many insects such as dragonflies and damselflies, or benthic (bottom dwelling) animals such as worms and snails, among other organisms. The objective of the program is to collect the macroinvertebrates in the stream with a net, identify them and characterize benthic communities and overall habitat in rivers and streams throughout Rhode Island. As resources allow, 30-45 stream locations are sampled once annually during a target period from August through the end of September using protocols specified in the program's USEPA-approved Quality Assurance Project Plan (QAPP). RIDEM utilizes contractual services for taxonomic identification. Field staff also document the presence of aquatic invasive species when applicable.

The macroinvertebrates sampled are good indicators of stream water quality and can be used to evaluate the biological integrity of a stream--its ability to support and maintain healthy aquatic communities, known as "aquatic life use." Because benthic macroinvertebrates are relatively sedentary within a stream and spend much of their life cycle in the water, information about community composition accurately reflects local ambient environmental conditions. These biological communities integrate the effects of different stressors providing a broad measure of aggregate impacts and also assimilate the effects of stressors over time, providing an ecological measure of fluctuating environmental conditions. Lack of macroinvertebrates that are sensitive to pollution or macroinvertebrate communities dominated by pollution tolerant organisms may indicate "impaired" waters that do not support healthy aquatic communities ("aquatic life use"). Integrating biomonitoring with basic water quality sampling is often regarded as a more cost-effective technique than

solely relying on intensive water sampling for multiple toxic pollutants that are highly variable over time. As noted in the indicator section on page 6, EPA recommends two biological assemblages be sampled to support assessments. RIDEM Biomonitoring should be expanded to a second assemblage; e.g. algae. As a refinement to the Biomonitoring Program, RIDEM is participating in a regional project with MA DEP to develop an IBI for low gradient streams that do not lend themselves to the existing macroinvertebrate sampling protocols. It is anticipated that the new methodology will reflect a multi-habitat sampling approach.

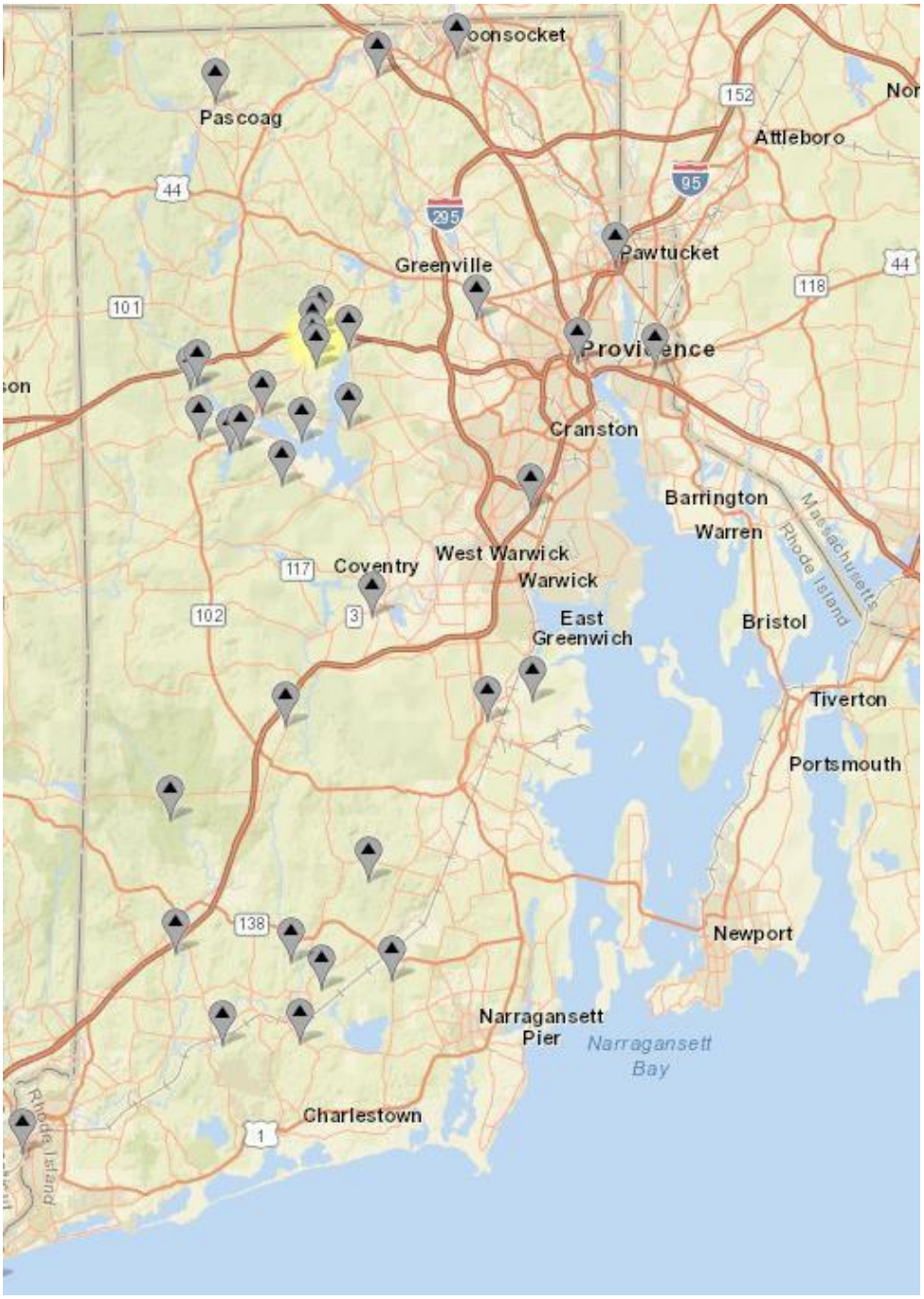
Stream Habitat Surveys: When macroinvertebrates are collected from streams, habitat quality is also visually evaluated, quantified, and categorized in accordance with the aforementioned QAPP. These habitat surveys help interpretation of the macroinvertebrate community data and prioritize restoration activities. It is expected that sites with good habitat quality will support healthy macroinvertebrates, whereas poor habitat quality can lead to poor macroinvertebrate health. However, sites that exhibit excellent habitat but show poor invertebrate health may indicate water quality problems such as nutrient enrichment or other pollution. Where habitat is marginal or poor, this indicates areas in need of habitat restoration. Integrating information from water chemistry samples, stream macroinvertebrate communities as well as habitat data in the surrounding environment helps strengthen confidence in water quality assessments and better focuses restoration planning.

Fish Tissue Contamination: Data on contamination in riverine fish tissue remains among the largest gaps in information needed to assess support of designated uses of rivers and streams with only 3.2% of river miles in RI assessed. Limited data is being generated by governmental programs and researchers. RIDEM a limited amount of one-time funding to target additional data collection through contractual services. Long-term additional investment will be required to reduce this data gap. Funding is needed to support data collection and sample analysis.

Stream Gage Network: The Rhode Island Stream Gage Network is comprised of 35 gages and provides continuous river and stream flow data from Rhode Island's largest rivers as well as the brooks and streams, with some flow records dating back to 1909. (Figure 8). These stream gages operate by measuring water pressure from which the elevation of the water can be calculated and then the water elevation can be used to determine stream flow or the volume of water flowing through in a certain period of time. The Rhode Island Stream Gage Network measurements are taken every 15 minutes and the data are then transmitted via satellite to the US Geological Survey (USGS). The data are publicly shared through USGS's National Water Information System (NWIS) at https://waterdata.usgs.gov/ri/nwis/current/?type=flow.

USGS operates and maintains stream gages under contracts with the RI Department of Environmental Management (RIDEM) and other entities, including the Providence Water Supply Board that supports gages in the Scituate Reservoir watershed. Two gages are part of the USGS National Streamflow Information Program, which, along with twenty other gages, are operated pursuant to a joint work plan between USGS, RIDEM, and the RI Water Resources Board. Certain gages are relied upon for flood forecasting models used by the National Weather Service. The data support a variety of statistics. Data include long-term statistical analyses specific to each gage in the network and are among the most widely used data in Rhode Island's water monitoring programs.

Figure 8. Stream Gage Network Locations in RI



Cyanobacteria: Within the last decade, RIDEM has documented confirmed cyanobacteria blooms in 2 rivers. Limited federal funding supported work to conduct surveillance and respond to public reports of potential blooms. Both RIDEM and RIDOH need to build capacity to address this public health concern that is expected to persist. Specifically, additional resources are needed to collect and analyze samples more frequently to track blooms during their duration. Additional staff capacity is needed to coordinate with RIDOH and other partners on public notification of blooms and related public outreach. Also see discussion under Lakes and Ponds.

Monitoring Network for High Quality Wadeable Stream and Lakes: A federally supported project was undertaken in New England to design a long-term monitoring program aimed at detecting changes in high quality wadeable stream conditions attributable to climate change and potentially other stressors. The sites selected were deemed least impacted by other stressors including land use. Two wadeable stream sites in Rhode Island have been included in the network and RIDEM is coordinating with EPA on implementation which has provided equipment to RIDEM for this purpose. Additional capacity will be needed for full implementation involving air, water, and biological stream monitoring. The sites are located in the Scituate Reservoir watershed.

Emerging and Legacy Contaminants: RI state agencies currently do not conduct routine monitoring for emerging or legacy contaminants in the water column or sediments. Past work has been conducted on a project basis including monitoring for TMDL development; e.g. metals. The occurrence of PFOA and PFAS compounds in RI groundwater has spurred interest in evaluating its potential to be in surface waters. RIDEM and DOH continue to collaborate on developing sampling protocols and laboratory capacity to support management actions related to PFOA/PFAS. Additional resources will be needed for broader surveys of such compounds in rivers and other surface waters.

Recommendations Program Enhancements - River and Stream Monitoring:

- Address critical RIDEM staff capacity need to sustain river monitoring programs (ARM and Biomonitoring).
- Ensure stable state funding for long-term river monitoring networks including stream gages in partnership with USGS.
- Seek resources to expand monitoring of fish tissue contamination in rivers giving priority to those likely to be utilized as food sources.
- Secure resources to increase capacity for tracking duration of cyanobacteria blooms in rivers.
- Secure resources to support full participation in Monitoring Network for High Quality Wadeable Stream and Lakes.
- Secure funding to address management information needs related to emerging contaminants in riverine systems, including PFAS/PFOA compounds where appropriate.

3.2 Freshwater Lakes and Ponds

Description of the Resource:
DEM has mapped 20,749 lake acres in Rhode Island at a scale of 1:24,000. This includes 148 lakes or reservoirs of 20 acres or more in size and hundreds of smaller ponds. Lakes in RI can be characterized as small and shallow, excluding the kettle holes that dot the state, and a number of lakes that are actually reservoirs or impoundments of riverine systems. Most of the impoundments were formed with the development of man-made dams. Among the reservoirs, 42 are designated as public drinking water supply sources, representing 7,813 acres or 37% of the total lake acreage. There are no major WWTF discharges into lakes in RI.

Monitoring Objectives:

- Assess all lakes of 20 acres or greater in size for aquatic life and recreational uses.
- Systematically identify and track of the extent of aquatic invasive plants in lakes and ponds.
- Enhance capacity to identify and track cyanobacteria blooms in lakes and ponds.
- Assess fish tissue contamination in all publicly assessible lakes 20 acres or greater.
- Provide data to allow measurement of water quality trends over longer periods of time.

Monitoring Programs – Lakes, Ponds and Reservoirs: Core monitoring programs for lakes and ponds include: (1) Volunteer-based Lake Monitoring; (2) Freshwater Bathing Beach Monitoring; (3) Cyanobacteria; (4) Fish Tissue Contamination

Volunteer–Based Lake Monitoring: Volunteer-based monitoring coordinated through the University of Rhode Island Watershed Watch Program is a primary source of baseline water quality data in lakes and ponds in RI. Founded in 1987, the program, operated seasonally from May through October, incorporates physical and chemical parameters (water clarity, chlorophyll-a, dissolved oxygen, temperature, alkalinity, pH, and nutrients as well as pathogens). The program developed a QAAP which is targeted for updating. The program generally provides adequate data from which RIDEM may make assessment decisions with respect to support of aquatic life and recreational uses. The sampling location is usually in the deepest portion of the lake. Given the biological response of lakes to variations in the weather, one year of data is not always considered representative of the general condition of the lake. Assessment decisions are enhanced when based on several years of data.

Using GIS, RIDEM has determined there are 148 lakes of 20 acres or more in size in the state. This group of lakes serves as the target for assessment with smaller lakes and ponds of interest added as resources allow. RIDEM believes there are currently 46 lakes of 20 acres or more that are not monitored regularly. To address this gap, RIDEM plans to work with URI-WW to continue to: (1) recruit volunteers for these lakes and (2) establish a two-person team to conduct monitoring in those lakes for which no volunteers are recruited. Where feasible, RI DEM will align the initiation of sampling in unassessed lakes with the rotating basin approach.

Bathing Beaches: The RIDOH Bathing Beach Program provides data that RIDEM may use to assess the recreational use of lakes. There are over 30 licensed freshwater beaches in RI. The program for freshwater beaches should be enhanced to be comparable to the level of activities conducted for the saltwater beaches by incorporating a risk-based approach to monitoring. This will improve the available data from which water quality assessments are made. More information at: http://health.ri.gov/beaches/

Cyanobacteria: Between 2010 and 2018, DEM documented cyanobacteria blooms of public health concern in 36 lakes or ponds. Certain lakes have experienced repeated blooms year to year. Using a limited grant from EPA, DEM, in coordination with RIDOH, URI-WW and other partners, refined its monitoring protocols and instituted a seasonal surveillance program to screen for and confirm cyanobacteria blooms. When appropriate, laboratory analysis is performed to measure levels of certain toxins When conditions meet certain thresholds, the agencies jointly issue a public health advisory that is generally applicable for the remainder of the summer/fall season unless additional sampling can be conducted. Resources limitations have prevented RIDEM from carrying out follow-up sampling despite public interest in having bloom conditions tracked more closely. Additional resources are needed to expand this program and adapt to the increase in detection of these blooms in RI freshwaters. Specifically, funding to collect and analyze samples more frequently to track the status of blooms is needed. Additional staff capacity is also needed to expand public outreach efforts and coordinate response actions with partners and affected local organizations; e.g. posting signage etc. More information at: http://health.ri.gov/healthrisks/harmfulalgaeblooms/

Fish Tissue Contamination: Over the last decade, with limited resources, RIDEM has still managed to be successful in collecting mercury fish tissue data in publicly accessible lakes through a collaboration among the RIDEM Division of Fish and Wildlife, RIDEM Office of Water Resources and researchers with the EPA - Atlantic Coastal Environmental Science Division in Narragansett RI. Of the 32 lakes publicly accessible via cement boat ramps, all but 2 have been sampled. Through this effort RIDEM has also been obtaining data from lake with light craft or beach access. Most lakes exhibit elevated concentration of mercury leading to statewide guidance from the RIDOH on fish consumption. Data on other contaminants such as PCBs, cadmium, lead, arsenic and pesticides remains a gap. More information at: http://health.ri.gov/healthrisks/poisoning/mercury/about/fish/

Aquatic Invasive Species: The growth of aquatic invasive plants is the second largest cause of impaired lake and pond conditions in RI. RIDEM has an established seasonal program for surveying AIS in lakes and ponds including collecting data on the success of management interventions. The program is coordinated with URI-WW and RINHS and has resulted in documenting one or more invasive plants present in over 60% of lakes surveyed since 2007. Given the widespread nature of the problem, additional monitoring capacity is needed to support both pro-active preventive management and ongoing activities to abate existing AIS infestations. http://www.dem.ri.gov/programs/water/quality/surface-water/aquatic-invasive-species.php

Bathymetry: The available bathymetry data for most lakes is considered out of date. Resources managers at the federal, state and local level need updated information to support the planning of conservation, water quality protection and restoration actions. Sound lake management decisions, such as treatment of aquatic invasive plants, require an accurate understanding of lake bathymetry. RIDEM has acquired equipment to support updated mapping of bathymetry but need additional staffing capacity to carry out this activity at a faster pace on more lakes.

Drinking Water Supply Reservoirs: RIDOH regulations require terminal reservoirs be sampled in accordance with drinking water program requirements. Upgradient reservoirs may not be routinely sampled by all suppliers. In terminal reservoirs, the monitoring entails a list of over 100 parameters that reflects the compounds for which maximum contaminant levels (MCLs) have been established for *finished* drinking water. Samples are usually collected from one location near the intake to the drinking water treatment plant. Further development of a protocol for assessing the drinking water use of tributaries to reservoirs is needed.

Recommended Program Enhancements - Lakes and Ponds:

- Acquire a boat and trailer to support lake monitoring activities.
- Develop capacity to periodically monitor currently unassessed lakes and ponds (20 acres or larger).
- Enhance capacity to monitor the extent of aquatic nuisance plants in lakes and ponds and track the outcomes of treatment or other management actions undertaken to abate nuisance plants. This should be undertaken in conjunction with establishing a lake management program in RIDEM.
- Expand capacity to monitor and track cyanobacteria blooms.
- Expand resources for the HEALTH Bathing Beach Program to allow improved assessments of water quality at freshwater beaches.

4. Supplemental Water Quality Monitoring Activities:

In addition to the core programs described in the above sections, there are additional monitoring activities which contribute to the overall goals of characterizing water quality conditions for protection and restoration. State agencies sponsor and oversee various short-term monitoring projects as part of water resources programs. Other organizations, including those engaging citizen scientists, produce data that is often shared with state managers. It is used as deemed appropriate based on the sampling design, level of quality assurance and relevance. Examples of these types of activities include but are not be limited to the following:

Water Quality Restoration Studies: In accordance with Clean Water Act requirements, RIDEM conducts targeted water quality studies to develop water quality restoration plans referred to as TMDLs (total maximum daily loads). Mandated by the Clean Water Act, TMDLs identify the total pollutant loading that a waterbody can assimilate and still meet water quality standards. Rhode Island's TMDL studies identify water quality goals, necessary pollutant reductions to achieve these goals, the sources of pollution found contributing to the pollution problems, and the necessary pollution control actions to achieve the required reductions and restore water quality. The studies typically involve 1-2 years of sampling effort targeting specific water quality parameters of concern. Field work may be carried out by RIDEM staff or its contractors. Larger studies, including the development of water quality models, are currently constrained by a lack of available RIDEM funding. On occasion, local governments may also pursue water quality studies either as part of implementing a TMDL; e.g. further evaluating the sources of water pollution within a sub-watershed, or to address an issue of high local concern. More information is available at: http://www.dem.ri.gov/programs/water/quality/restoration-studies/

Special Projects –Bathing Beach Program (RIDOH): RIDOH carries out specialized, short-term projects that include water monitoring aligned to their specific management objectives. Example projects have included evaluation of urban waters in the upper bay and further pollution source identification at Oakland Beach.

Public Water Suppliers: Several waters suppliers, including the Providence Water Supply Board, Pawtucket Water Supply Board and Newport Water Department carry out on-going monitoring related to management of their surface water reservoirs. Activities may include additional monitoring of source waters including streams that are tributary to the reservoirs along with special projects addressing management concerns; e.g. aquatic invasive species, sediments or other topics.

Narragansett Bay Commission: The Narragansett Bay Commission, a regional wastewater utility, carries out a variety of monitoring that provides additional data on conditions in the upper bay and tributary rivers. Their programs, which include the use of underwater benthic video surveys, are described at: https://snapshot.narrabay.com/

Citizen Science: Rhode Island is fortunate to have multiple organizations engaging volunteers in monitoring water quality in waters across the state. When shared with state managers, the data often provides additional information about a specific waterbody that RIDEM can use in planning, fostering, implementing and evaluating management actions. Citizen scientists are valued by the State as being knowledgeable about local conditions and alert to changes that may be occurring – both improvements as well as new threats of degradation. The utility to state management decision-making is determined by the

sampling locations, field sampling protocols, monitoring frequency, targeted parameters and documented quality assurance. As resources allow, RIDEM is willing to work with citizen science programs to strengthen quality assurance in their programs as a means to optimize the use of the data being produced.

The major professionally organized and supported citizen science programs monitoring water quality include:

URI- Watershed Watch Program: The University of Rhode Island Watershed Watch Program (URIWW) is a statewide volunteer monitoring program established in 1988. It focuses on providing current information on the water quality of surface water resources throughout Rhode Island, including lakes, ponds, reservoirs, rivers, streams and the marine environment. The heart of the program consists of weekly measurements taken by numerous trained volunteer monitors. The program emphasizes watershed scale monitoring because the water quality of a given body of water is a reflection of the activities in the lands and waters that surround it and lie upstream. In 2018, the program encompassed monitoring in 52 lakes, 292 river and stream locations and 197 coastal water sites in RI and nearby CT. Details on monitoring sites, methods and data results are at: https://web.uri.edu/watershedwatch/

Blackstone River Watershed Council/ Friends of the Blackstone: BRWC/FOB is one of the three core supporters (Blackstone River Headwaters Coalition, Blackstone River Watershed Association, and Blackstone River Watershed Council/Friends of the Blackstone) of the Blackstone River Coalition's bi-state Water Quality Monitoring (WQM) initiative. BRWC/FOB recently completed its 15th year testing program which involves volunteer sampling at 12 or more sites in RI. The overall program involves nearly 90 volunteers gathering water samples at 70 sites in the main stem and tributaries of the river in RI and MA on a fixed schedule from April to November. The samples are turned in at designated locations in the two states and lab tested according to pre-established criteria, gathering significant data on such matters as bacteria and nutrient levels in the water. The BRC produces annual report cards on water quality conditions based on this dataset. More information: http://www.thebrwa.org/water_quality.htm and https://blackstoneriver.org/

Clean Ocean Access: Clean Ocean Access, a non-profit organization, has carried out a monitoring program since 2006 focused on waters in and around Aquidneck Island. Samples from 10 locations are collected weekly year-round with a focus on assessing suitability for swimming. COA has also carried out targeted projects involving monitoring. More at: https://www.cleanoceanaccess.org/

5. Quality Assurance

Quality assurance is an important component of the monitoring programs relied upon by state water protection programs. It is important to ensure that the data generated by monitoring and used to support decision-making in water protection programs is valid and appropriate. All state monitoring programs have written quality assurance plans that address how the quality of data is assured.

RIDEM Quality Assurance Program - RIDEM maintains an approved quality management program (QMP) that is applicable to its water programs. RIDEM's program was initially approved by EPA in 2002 and has been revised periodically. The current QMP was effective in March 2017. EPA region 1 conducted an audit meeting with RIDEM staff in November 2019. The program outlines policies and procedures to ensure the scientific validity of data, including water quality data, collected via various programs. The plan, which is federally mandated, is available on the DEM website along with an archive of approved QAPPs. See: http://www.dem.ri.gov/data-maps/data.php#sops

Quality Assurance Project Plans - All monitoring programs or projects carried out in whole or part using EPA funds are subject to quality assurance planning and related documents. The process involves preparing a quality assurance project plan (QAPP) with thoughtful articulation of monitoring objectives and alignment of the sampling design and protocols (standard operating procedures) to the objectives. QAPPs are applicable to activities carried out by RIDEM staff and its contractors or sub-grantees; e.g. URI-Watershed Watch. For programs of an on-going nature, the QAPPs are prepared to cover multiple years of activity and positioned to be updated by addendum as needed. For targeted projects of limited duration, a project specific QAPP is prepared. All QAPPs are subject to EPA review and approval and as noted above are archived on an internal RIDEM website. Several QAAPs for on-going programs area being updated or amended. These include the QAPP for the NBFSMN which is being updated with partners including MA DEP and URI-WW program. In addition, new QAPPs for cyanobacteria and fish tissue sampling are being prepared.

With improved staffing capacity at DEM, the agency would be better positioned to assist outside organizations interested in more fully adopting quality assurance practices to improve the technical rigor of the monitoring program and quality of the resulting data. EPA Region 1 also offers resources to support QA/QC programs at: https://www.epa.gov/quality/managing-quality-environmental-data-epa-region-1

Recommendations for Quality Assurance:

Ensure QAPPs are up to date to reflect current and planned monitoring activities.

Assess the needs of citizen science programs relative to improving quality assurance and quality control to support utilization of data and develop technical assistance, possibly via regional approaches, to address the needs.

Table 7 Quality Assurance Plans in Monitoring Programs Used for Water Quality Assessment

Monitoring Program	Agency	Status of QAPP/Comment
Ambient River Monitoring (ARM) and Addendums	RIDEM	EPA Approved; Addendum through November 2014; New Addendum for 2019
Biomonitoring and Habitat Assessment in Wadeable Streams (Macroinvertebrates)	RIDEM	EPA approved; February 2015
Shellfish Monitoring Program	RIDEM-OWR	Compliant with NSSP and ISSC. (EPA approval not applicable). Standard operating procedures developed.
Narragansett Bay Fixed Site Monitoring Network	URI-GSO, DEM-OWR, NBNERR, NBC	EPA approved; July 2014; Being updated for 2020.
Bathing Beach Monitoring – Coastal beaches	RIDOH	EPA Approved
Bathing Beaches Monitoring-freshwater	RIDOH	EPA approval not applicable. Standard operating procedures developed.
Lake Monitoring	RIDEM	EPA Approved; August 2011
Volunteer Monitoring – Ambient Water Quality of Lakes	URI-Watershed Watch	QAPP approved in 2005. Requires an update; in process for 2020.
TMDL and Targeted Water Quality Investigations	RIDEM	Approved on a project basis.
Nonpoint Source Grant Program QAPP	RIDEM	EPA approved; November 2007; In process of being updated in 2019.
Cyanobacteria Bloom Screening Program	RIDEM & RIDOH	In process of being developed.

6. Water Quality Data Management

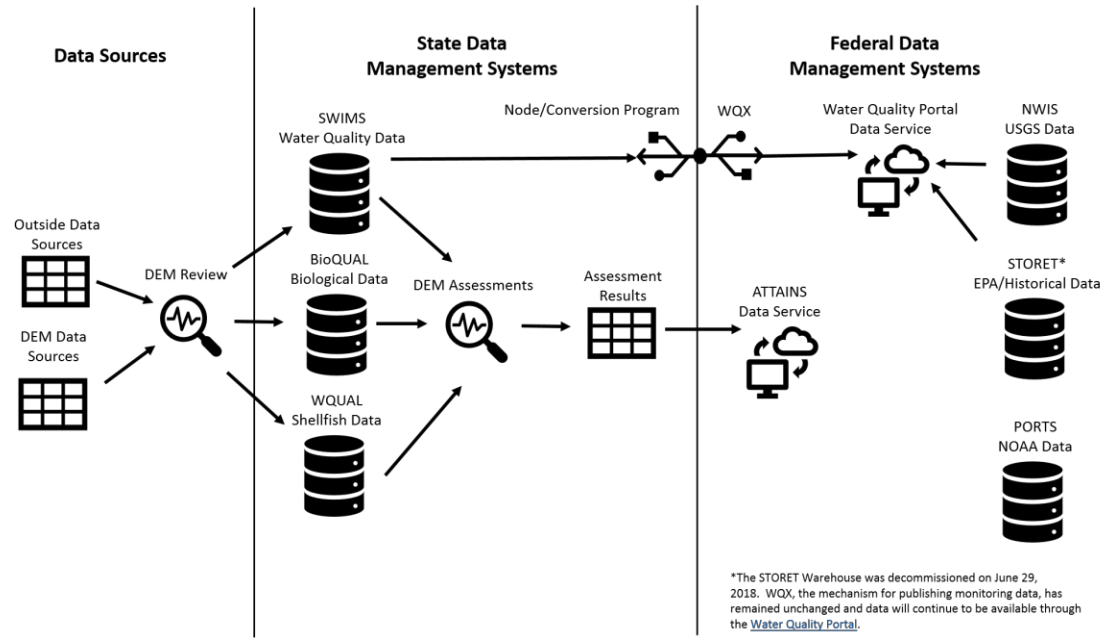
Data management must be an integral part of effective monitoring programs. It has been noted that all monitoring programs should "include plans and resources for ongoing data synthesis, analysis and reporting to all audiences in a prompt and reliable fashion" (GNBWPC, 2004). As highlighted previously, it is the critical task of analysis and interpretation that translates raw data into meaningful information. When this step is minimized or not even undertaken, it increases the likelihood that the data will not be made accessible or productively used and the investment of resources in collecting the data rendered a waste.

Overview of Current Data Management Practices

Data management and analysis activities are generally decentralized and dispersed among the agencies and entities engaged in monitoring in RI. Monitoring data is largely maintained in electronic formats ranging from simple spreadsheets to relational databases. Within state government, there is no organized system to systemically archive data over time although general procedures for backing up data within state networks exist. The data management practices across agencies are not standardized and electronic data sharing is limited by the compatibility of different agency data systems. With respect to the Clean Water Act, certain federal EPA are integrated within RIDEM information systems in support of program implementation. RIDEM has taken steps to enhance its data management capabilities regarding water quality data, but efforts continue to be constrained by available staffing resources and expertise.

The key components of the water quality data management infrastructure in RI are depicted below and further described. All systems are subject to changes as technological innovations proceed including shifts to more cloud-based data management. Within RI, the state agencies work with personnel from the RI Department of Administration Division of Information Technology to support existing systems and pursue system enhancements.

Figure 9. Key Components of Federal/State Water Quality Data Management Systems



Current RIDEM Databases:

SWIMS (State Water Information Management System) – RIDEM administers this relational database to manage ambient water quality data. It was designed to replace the Access database WQUAL. The system requires periodic updates and maintenance to remain fully functional. It was designed to support multiple users but has to date been deployed to a minimum number of users.

BIOQUAL – RIDEM administers this Access database to manage data associated with the biomonitoring of rivers and streams.

WQUAL – An Access database that continues to be relied upon for managing Shellfish Monitoring Program data. A plan to migrate to an up to date system is needed to fully retire WQUAL.

Rhode Island Geographic Information System (RIGIS) – Rhode Island's statewide geographic information system.

Federal Information Systems Support Water Quality Programs:

ATTAINS – The Assessment, Total Maximum Daily Load (TMDL) Tracking and Implementation System (ATTAINS) is an online system developed by EPA for sharing information about the conditions in the Nation's surface waters. The ATTAINS web reports provide users with easy access to view the information on the status of waters at the national, state and site-specific waterbody levels. DEM has successfully migrated from its prior Assessment Database (ADB) to ATTAINS in late 2018. ATTAINS is an EPA supported data system that is being utilized for the reporting of state water quality assessment results including the generation of 303(d) lists of impaired waters.

WQX/WQP: Recognizing that environmental managers and other users need access to timely and accurate data as well as the ability to draw various datasets together, the EPA and states have developed an environmental Information Exchange Network (Exchange Network) as an efficient solution to exchanging data. WQX Web is a newly-developed internet tool that allows any organization with a connection to the web to share its data nationally with others. Water Quality Portal (WQP) is the mechanism for anyone, including the public, to retrieve water monitoring data from EPA. The WQP uses the WQX data format for sharing data on a complete suite of water quality monitoring data (physical, chemical, biological and habitat) that are used to determine the condition of waters. DEM has developed a node to support exchanging data and is currently updating as needed to support data exchange. https://www.epa.gov/waterdata/water-quality-data-wqx

STORET: The National STORET Data Warehouse is a federally supported repository for water quality monitoring data collected by federal agencies, states and territories, tribes, volunteer monitoring organizations, and universities. It contains over 70 million records of water quality data from across jurisdictional boundaries. Data in the Warehouse are used by many agencies and scientists in water quality reporting, research, and decision making through tools such as mapping applications, water quality models or statistical software, and automated services. Overall, sharing data nationally opens opportunities for data access, reuse of data, and improved data quality.

NWIS: USGS maintains the National Water Information System (NWIS) which provides access to water resource data collected in all states. Data collected under joint funding agreements with RI agencies are publicly shared via NWIS. https://waterdata.usgs.gov/nwis

Recommendations –Enhancements for Data Management:

- Complete updated assessment of database needs and as resources allow, implement improvements to support efficient data management. This includes planned enhancements to SWIMS, the shellfish database and BIOQUAL.
- Build staffing capacity for effective data management by dedicating a person fulltime to data management tasks. (Requires new FTE).

7. Data Assessment, Reporting and Data Dissemination

Water Quality Assessment Process - As required by the Clean Water Act and EPA, RIDEM–OWR administers an on-going program to assess and report on water quality conditions. This is done by evaluating whether criteria in WQS established to protect designated uses of a waterbody are being met. The policies and procedures that govern the assessment process are documented in the RI Consolidated Assessment and Listing Methodology (CALM) which is periodically updated. The document is available at: http://www.dem.ri.gov/programs/water/quality/surface-water/integrated-water-quality-monitoring.php

To support each assessment cycle, RIDEM issues a request for data. Data received is reviewed along with all relevant data that RIDEM has acquired through its monitoring programs including contracts with partners. The process involves both automated and manual review of data to reach assessment decisions. In the case of estuarine dissolved oxygen, DEM utilizes a customized software program developed with EPA to assess compliance with the DO criteria which requires evaluation across a recruitment season (May – October). Biological assessments in rivers and streams include a habitat assessment and assessment of the macroinvertebrate community using a multimetric index (MMI) developed by RIDEM with technical assistance. RIDEM envisions further programming would allow additional automation of portions of the assessment process and provide program efficiencies.

RIDEM summarizes water quality assessment results in the State's Integrated Water Quality and Assessment Report (known as the Integrated Report) which is now submitted to EPA via the national ATTAINS data system. The Integrated Report includes a list of impaired waters that is used to prioritize water quality restoration planning; e.g. TMDLs. Full documents and more information are available at: http://www.dem.ri.gov/programs/water/quality/restoration-studies/index.php

Data Dissemination - As noted above, pursuant to the Clean Water Act, DEM reports water quality assessment results in the form of an Integrated Report. A number of prior reports are available on the DEM website at: http://www.dem.ri.gov/programs/water/quality/surface-water/integrated-water-quality-monitoring.php DEM communications staff assist in publicizing water quality information through the agency website, social media and other public outreach activities.

The State has not yet developed the data system capacity to host ambient water quality data in a web-based, searchable database. Until that capacity improves, certain datasets are being shared on-line in various formats; e.g. spreadsheet, etc. RIDEM accepts requests for quality assured data that may not yet be on posted to a website and responds to those on case by case. The RIDEM has launched a new website in 2016 which was considered Phase 1 of the needed improvements. As part of continuing refinements to the new site, referred to as Phase 2, RIDEM developed new descriptions of water monitoring programs that added content to the site about monitoring programs:

Bay monitoring: http://www.dem.ri.gov/programs/emergencyresponse/bart/index.php

River Monitoring: http://www.dem.ri.gov/programs/water/quality/surface-water/river- monitoring.php

Lake Monitoring: http://www.dem.ri.gov/programs/water/quality/surface-water/lake- monitoring.php

In addition, RIDEM coordinated with the URI Coastal Institute which updated its website for the RI Environmental Monitoring Collaborative. The re-designed RIEMC website has descriptions of a broader group of 18 environmental monitoring topics. It can be viewed at: http://www.rimonitoring.org/

Additional website providing real-time access to RI coastal water quality data are maintained by:

NBC - https://snapshot.narrabay.com/app/WaterQualityInitiatives/NutrientMonitoring

NERACOOS - http://www.neracoos.org/

Brown University – RI Data Discovery Center http://ridatadiscoverycenter.org/

NBNERR/NOAA – Centralized Data Management Office for National Estuarine Reserve System http://cdmo.baruch.sc.edu/

Recommended Enhancements to Assessment, Reporting and Data Dissemination:

- Periodically update the CALM to reflect new scientific understanding and development of new or refined assessment tools.

- Use information technology enhancements to automate additional aspects of the assessment process and facilitate greater public access to data.

- Utilize a variety of outreach tools including social media to raise public awareness of water quality assessment results and related information.

8. Program Evaluation and Resource Needs

Program Evaluation

A changing climate has reinforced the need for adaptive management. The RI Water Monitoring Strategy will be fully reviewed at minimum on five-year intervals and updated to ensure that it reflects the mix of monitoring programs needed to address the changing needs and priorities of state managers. Reviews will be coordinated with the RIEMC. Additional reviews occur annually as part of the state budget process which aligns resources to support planned work. On the individual program level, review also occurs annually as part of the planning cycle (fall to spring). This includes reviewing experience, identifying technical concerns and logistical issues and devising program modifications to improve operations. Any changes are reflected in QAPPs as needed and integrated into annual pre-season training. DEM also meets annually with USGS to review planned work being carried out under the agencies joint funding agreement. DEM will continue to report annually to EPA on its progress in executing its monitoring programs as part of EPA grant application and PPG processes. The annual review will note progress in implementing the strategy and explain any instances where planned monitoring program targets or milestones were not achieved.

Resource Needs

A core set of resources including personnel, equipment, facilities, and logistical support is needed to effectively implement the comprehensive monitoring and assessment programs envisioned by this strategy. DEM has long operated with minimal staffing support for water functions outside of the shellfish monitoring program. DEM has relied heavily on seasonal and contractual employees. EPA has long recommended RI retain a monitoring coordinator and the agency strongly concurs with this recommendation. Building a core staffing capacity, including for ambient river monitoring, has grown into a critical need. As noted above, resource planning for monitoring programs is considered in the annual state budget process. Given the vulnerability of funding support for several core programs, DEM will be exploring options and opportunities to stabilize the funding for water monitoring and reduce reliance on one-time allocations or unsustainable sources of funding. DEM will continue to advocate for funding as allowed. Unfortunately, recent attempts to add staffing have not been successful due to on-going state budget constraints and competing priorities within the state budget.

Equipping the staff is also important. DEM expects to procure a small motorized boat and trailer to support work on lakes. Field equipment will need to be replaced over time. A recent federal SNEP grant of $300,000 has supported important upgrades to the NBFSMN but not eliminated the need for annual funds for repairs and replacement parts. DEM and partners will continue to leverage federal funding opportunities to meet priority monitoring program needs.

Given the many gaps in the current programs, resource needs have been prioritized in order to target capacity building where it's most critically needed. The resource needs identify the additional investment that will be required to implement priority recommendations with estimates based on the assumption that the current level of existing support for monitoring will be sustained and not diminished. Both the 2005 Water Monitoring Strategy and the 2014 RIEMC Annual Report flagged unmet fiscal needs of over $1.9 million related to water quality monitoring. This strategy provides an updated estimate of needed resources to address the **priority needs** as highlighted in Table 8. It totals $1,790,000 in annual expenses and

$500,000 in capital equipment expenses. In the short-term, implementing the top six highest priorities would require $1,000,000 annually to support 4 new FTEs to build core staffing capacity, shift support for the NBFSMN to a more sustainable source and address priority equipment needs.

Table 8. Priority Resource Needs - Top priorities in BOLD

Priority /Gap	Recommended Program Enhancement	Estimated Funding Need Years 1-3
DEM Ambient Monitoring Programs	**Hire a fulltime monitoring coordinator (1 new FTE)**	**$140,000 annually**
Narragansett Bay Fixed Site Monitoring Network	**Secure sustainable funding for operations and funds to upgrade equipment**	**$250,000 annually & $425,000 in equipment upgrades over 1-3 years**
ARM (rivers) /Cyanobacteria in freshwaters	**Hire environmental scientist (1 new FTE)**	**$260,000 annually**
Cyanobacteria in freshwaters	**Expanded frequency of sampling**	**$150,000 annually**
Biomonitoring in rivers/AIS	**Create Limnologist job title; hire 1 new FTE**	**$140,000 annually**
Data management system enhancements	**Hire 1 new FTE dedicated to water quality data management & contracts for data system upgrades**	**$110,000 annually $50,000 - $100,000**
Streamflow gage monitoring	Secure sustainable funding	$220,000 annually
Dissolved Oxygen Surveys	Secure sustainable funding	$50,000 annually
Fish Tissue Contamination in Freshwaters	Funds to contract for collection and laboratory analysis	$100,000 annually
Water Quality Restoration Studies (TMDLs)	Contractual funds for laboratory analysis and modeling	$50,000-$100,000
Freshwater bathing beach program	Adoption of risk-based approach	$100,000 annually
Emerging Contaminants	Contractual funds for laboratory analysis	$50,000
Rotating Assessment of Coastal Embayments	Staffing (1 new FTE) & operating funds	$110,000 annually & $75,000 in equipment
Unassessed Lakes	Funds to organize volunteers or seasonal employees to monitor targeted lakes	$60,000 annually
TOTAL		$1,790,000 annually

Appendix A.

State Laws Pertinent to Water Monitoring Programs

State Law	Description
RIGL 46-23.2 (new) "The Comprehensive	• Establishes the Rhode Island Environmental Monitoring Collaborative (RIEMC).
RIGL 42-17.1 "Department of	▪ Establishes DEM and vests Director with broad authority for protecting and managing the state's
RIGL 46-12 "Water Pollution Control Act"	▪ Designates DEM as the state water pollution control agency for purposes of the federal Clean Water Act. ▪ Assigns duties to prevent, control and abate water pollution. ▪ Authorizes water quality standards and classification of surface waters (46-12-3(7)); water pollution studies, investigations or research (46-12-3(6)); collecting and disseminating information relating to water pollution (46-12-3(6))
RIGL 20.8.1 "Shellfish Grounds"	• Establishes the shellfish program in DEM.
RIGL 20-1 "Fish and Wildlife"	• Vests authority for managing fish and wildlife resources in DEM.
RIGL 23-21 "Licensing of Recreational Facilities"; RIGL 23-21.1	• Authority for the bathing beach monitoring program in HEALTH.
RIGL 46-13 "Public Drinking Water	• Authority for the public drinking water supply program in HEALTH.
RIGL 46-15 "Water Resources Board "	• Assigns duties to the Water Resources Board. Provides authority to regulate the proper development, protection, conservation and use of water
RIGL 46-15.7 "Management of the Withdrawal and Use of Water of the State"	• Requires an inventory of water resources. • Compilation of data.

Appendix B. References

Narragansett Bay Estuary Program (NBEP). 2017. State of Narragansett Bay and Its Watershed (Executive Summary, pages 3-6). Technical Report. Providence, RI.