Tiogue Lake

Bacteria Source Investigation

Town of Coventry, RI

AUGUST 2022

FUSS & O'NEILL

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Executive Summary

Routine water quality sampling is conducted at Tiogue Lake to monitor concentrations of the fecal indicator bacteria (FIB) enterococcus, which is used to indicate potential contamination of recreational water with pathogens capable of causing human illness. The Rhode Island Department of Health (RIDOH) has established threshold enterococcus concentrations for primary contact recreation, like swimming, in order to protect public health. Sampling conducted in June 2018 at Briar Point Beach on Tiogue Lake revealed concentrations of enterococcus exceeding the beach action value (BAV) established by the U.S. Environmental Protection Agency (EPA) and adopted by RIDOH for contact recreation. Accordingly, the Town closed the beach to swimming for several weeks until additional sampling showed waters were safe. The highest concentration recorded in 2018 for Tiogue Lake was 40 times higher than the RIDOH BAV, with additional exceedances documented before and since. Ingesting contaminated water while swimming can result in gastroenteritis, with symptoms such as vomiting, headache, and fever. Swimming in contaminated water can also cause skin rashes and ear, eye, and throat infections.

Common sources of enterococcus include stormwater runoff, non-permitted discharges to the stormwater drainage system, failing or leaking septic systems, and domestic animal and wildlife waste. Enterococcus is used as a proxy or indicator for other potential pathogens (i.e., bacteria and viruses) that are often present when enterococcus is present due to their common origin. This study focuses on identifying which of those potential sources, or other sources, are present for Tiogue Lake and makes recommendations on mitigating their impact.

To identify potential sources, Fuss & O'Neill staff conducted in-person investigations, including a sanitary survey and illicit discharge detection investigation at Tiogue Lake in March 2022, during the winter drawdown of the lake. These investigations used standard methods developed by the EPA. In addition, secondary data based on bacteria monitoring data, septic permitting and system use information were analyzed to identify patterns in observed data that indicate how additional sources of bacteria may impact the lake.

Data collected and reviewed as part of the project did not identify a single “smoking gun” bacteria source, instead indicating that the most likely sources of fecal indicator bacteria to Tiogue Lake are stormwater runoff, cesspools and septic systems, and pet and wildlife waste. To address these sources, we recommend the following measures:

- Increasing rainwater infiltration with green stormwater infrastructure
- Consider extending sewer service to unsewered areas around the lake
- Increasing the rate of cesspool removal and increasing septic system inspection and maintenance frequency
- Targeted public education campaigns

These methods also provide co-benefits by addressing the pollutants that may be linked to other recent beach closures due to harmful algal blooms.

1 Introduction

1.1

High Bacteria Concentrations

In June 2018, routine water quality sampling conducted at Briar Point Beach on Tiogue Lake revealed concentrations of the fecal indicator bacteria (FIB) enterococcus far exceeding the standards set by the Rhode Island Department of Health (RIDOH). These elevated FIB concentrations in Tiogue Lake in 2018 led the Town of Coventry to close Briar Point Beach to swimming for three weeks. The COVID-19 pandemic continued the beach closure, but FIB monitoring continued on a routine basis.

To protect beach users, RIDOH and the University of Rhode Island Watershed Watch (URI WW) regularly collect water quality samples to monitor for these and other substances that may pose health risks to humans. The standard for beach closure advisories, or Beach Action Value (BAV), set by RIDOH is 60 colony forming units per 100 milliliters of water (CFU/100mL). The highest concentration recorded in 2018 for Tiogue Lake was 40 times higher than the Beach Action Value, with additional exceedances documented before and since (*Figure 1*). The Town sought Fuss & O'Neill's assistance in identifying potential FIB sources to address these issues.

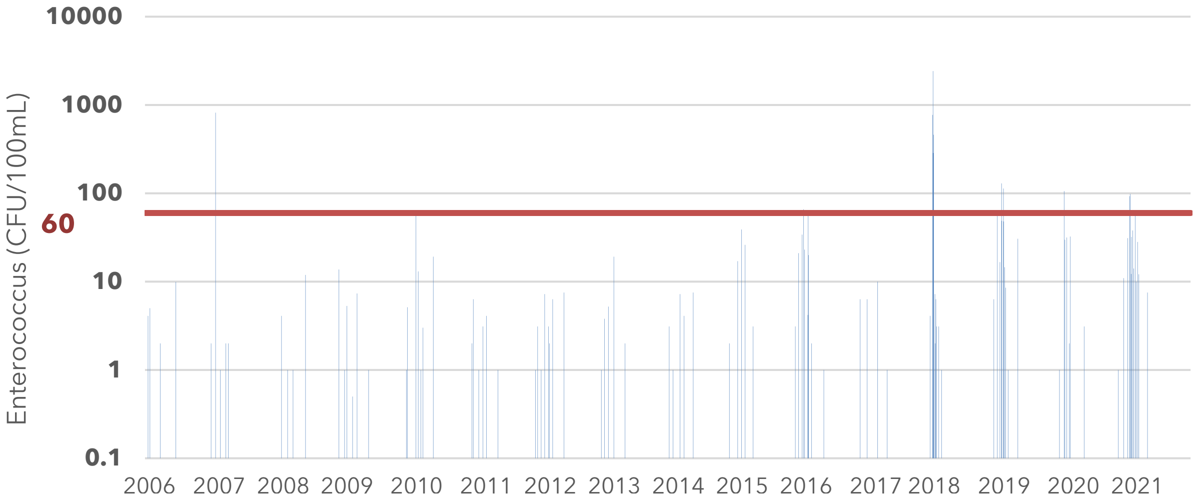

Figure 1: Enterococcus concentrations observed at Briar Point Beach, with beach action value of 60 CFU/100mL indicated by the bold horizontal line

Fecal indicator bacteria, such as enterococcus and E. coli, occur naturally in the digestive tract of humans and other warm-blooded animals. The presence of these bacteria indicates the presence of fecal matter in water. While enterococci are typically harmless to humans, their presence can indicate the presence of other viruses, bacteria, and protozoa that can cause disease in humans. Swimming or other primary contact recreation in waters with FIB concentrations exceeding the BAV can result in gastroenteritis, with symptoms such as vomiting, headache, and fever. Contact with contaminated water can also cause skin rashes and ear, eye, and throat infections.

1.2

Potential Enterococcus Sources

In developed watersheds, the most common sources of enterococcus include stormwater runoff and illicit discharges to the stormwater drainage system, failing or leaking septic systems, domestic animal and wildlife fecal waste, and improper manure storage. This study focuses on identifying which of those potential sources likely contribute to high enterococcus monitoring values at Briar Point Beach.

Rain water is generally clean. However, as soon as a raindrop hits the ground and starts flowing across surfaces, it begins collecting other materials. Stormwater runoff picks up surface pollutants like bacteria, nutrients, and sediment, carrying them into waterbodies, often without an opportunity for treatment and/or filtration. Separately, individual homes or businesses with improperly connected "gray water" lines, such as from dishwashers or laundry, or "black water" or sewage lines from septage disposal systems to the storm drain network can contribute substantial amounts of enterococcus to surface waterbodies through the storm drainage system, which should only convey stormwater runoff.

Failing or leaking septic systems can result from a number of factors, such as system age and use patterns. In particular, seasonal occupancy and system use has been shown to negatively impact septic system function for shoreline septic systems in Rhode Island (Postma et al. 1992). In addition, septic systems serving seasonally occupied homes, particularly those used as summer rentals, may have a greater potential to be overused. This overuse can occur when owners or renters have a greater number of people temporarily staying at the property, and using the septic system, than that system was designed to support. These situations can lead to septic system failure or inadequate treatment, potentially leading to enterococcus and pathogens from the system reaching a surface waterbody via groundwater.

Domestic animal and wildlife waste can also contribute to enterococcus levels if not properly managed. Pet waste that is not picked up and properly disposed of in a trash receptacle can be carried directly into waterbodies by stormwater. Wildlife, particularly wading waterfowl, wastes provide perhaps the most direct source of enterococcus and potential pathogens to a waterbody. If lake users feed waterfowl, that can create a learned behavior causing waterfowl to congregate around recreational areas. Anecdotal information provided by URI WW noted that waterfowl were historically prevalent because people fed waterfowl from the Arnold Road causeway. Indeed, bread trucks would reportedly drop off excess bread at this location. Since passage of a town ordinance against feeding wild fowl and posted signage, this behavior has been markedly reduced. Finally, though rare in the watershed, hobby farm animals generate enterococcus-containing wastes, which can be carried by stormwater runoff to surface waterbodies if not properly managed.

Although non-fecal sources of enterococcus and other FIB do exist, including plants, sand, soil, and sediments, they contribute to a background ambient level that varies with environmental and meteorological conditions, and are very unlikely on their own to result in the observed elevated concentrations.

1.3
Tiogue Lake and its Watershed Context

Tiogue Lake is a reservoir created in the 19th century by a stone dam to serve nearby mills along the southwest branch of the Pawtuxet River. The lake outlet flows north toward the Pawtuxet River under Tiogue Avenue. The watershed draining to Tiogue Lake is substantially built-out, with most development occurring between 1952 and 1972 (*Figure 2*). Based on available aerial imagery, many lakeside homes were constructed prior to 1952, and some prior to 1939. Conventional concrete tank septic systems were not developed until the 1950s and so may not be present on lots with these early constructions, which may be served by cesspools.

Different land uses contribute variable loads of enterococcus to downstream surface water bodies, depending on the intensity of the land use. Commercial and industrial land uses dominate near Interstate 95 at the southern portion of the watershed (*Figure 3*). Much of the remainder of the watershed is primarily comprised of single-family residential land uses, with minor institutional land uses from two elementary schools. All parcels in the Tiogue Lake watershed are served by the Kent County Water Authority (KCWA), which supplies water to the users from wells located outside the watershed. Parcels in the Tiogue Lake watershed are predominantly served by onsite wastewater treatment systems (OWTS), with minor areas in the western and southern parts of the watershed served by sewer.

Figure 2: Tiogue Lake in 1952 (left) and substantially built out (1972)

Much of the stormwater drainage network in the watershed are closed systems, comprised of catch basins and manholes connected to outfalls. Isolated locations around the lake are served by open drainage systems, where paved swales convey stormwater runoff to the lake. While most of the 26 outfalls discharging to the lake are owned by the Town of Coventry, the drainage from state Route 3 is under the jurisdiction of the Rhode Island Department of Transportation (RIDOT). Additional privately owned drainage systems, including some stormwater best management practice (BMP) installations intended to detain stormwater or remove pollutants from it, are present in the watershed. One stormwater treatment structure was identified during this study, at the intersection of East Shore Drive and Mohawk Street.

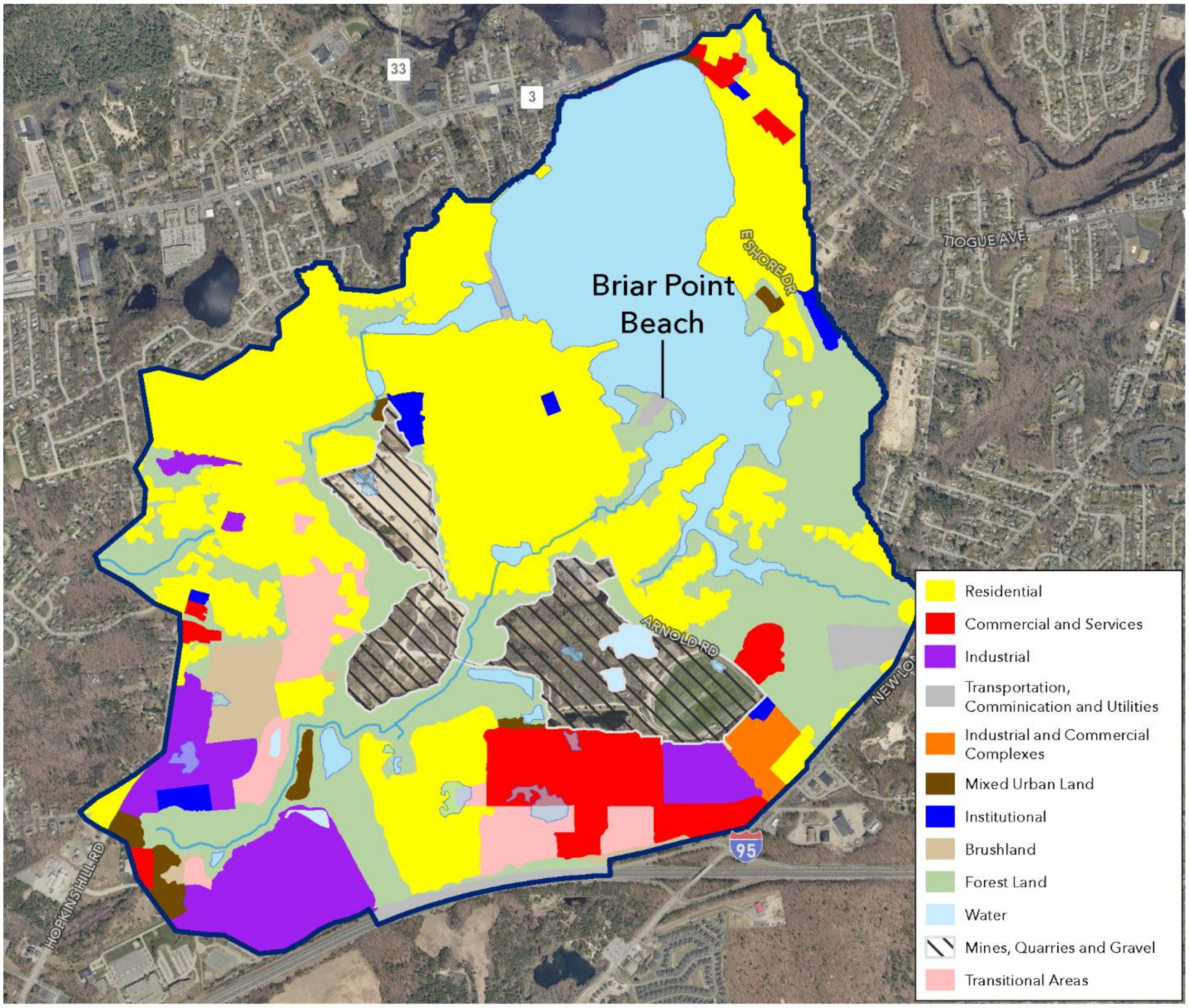

Figure 3: Current land uses in the Tiogue Lake watershed

2 Investigative Methods and Data Sources

Identifying various enterococcus sources requires different methods to determine their presence and impact on Tiogue Lake. The impact of some potential sources can be more easily quantified when sufficient information exists. Other potential sources can only be inferred from various data sources, and require additional information to determine their impact on enterococcus concentrations relative to other sources. This difference requires collecting additional data as part of this study, and analyzing existing secondary data collected by others.

2.1

In-person Investigations

To identify potential sources that could not be determined from secondary data, we conducted in-person investigations, including a sanitary survey and illicit discharge detection investigations at Tiogue Lake in late March 2022, during the winter drawdown of the lake. Fuss & O'Neill staff walked completely around the lake shore on March 16, identifying groundwater seeps not visible when the lake is at its higher summertime water level, and other observed potential sources of enterococcus, FIB, or pathogens. This sanitary survey followed procedures recommended by the EPA to visually identify potential sources of bacteria and other pathogens. Samples of flow from any identified groundwater seeps and stormwater outfalls with observed flow were collected during dry-weather conditions on a return visit on April 1.

Illicit discharge detection investigations occurred on March 16 and 23, 2022 during dry-weather conditions. The last rain event for these dates, as measured at the TF Green airport weather station, was 0.51 inches on March 12, and 0.28 inches on March 18. Where outfalls were observed to be flowing during dry weather, a sample of flow was collected and analyzed for the parameters listed in *Table 1*. Enterococcus samples were analyzed at New England Testing Laboratory in West Warwick, RI. All other parameters were analyzed using field test kits or calibrated meters, following all manufacturer instructions. All samples were delivered to the laboratory or tested in the field within specified hold times.

Table 1: Sampling parameters and illicit discharge detection action thresholds

Parameter (units)	Action Value
Temperature (°C)	None specified
Conductivity (µS/cm)	
Salinity (PPT)	
Ammonia (mg/L)	≥0.5 mg/L
Surfactants (mg/L)	≥0.25 mg/L
Chlorine (mg/L)	>0.02 mg/L
Enterococcus (MPN/100mL)	60 CFU/100mL[1]

[1] CFU and MPN are equivalent units and reflect a difference in measurement and reporting methodology only.

2.2

Secondary Data

2.2.1 Water quality monitoring data from RIDOH and Watershed Watch

The relationship between rainfall and enterococcus or other FIB concentrations can provide clues to help differentiate between localized point sources and more distributed non-point sources, in their contributions to enterococcus concentrations. If there is a temporal link between the timing of precipitation events and increased enterococcus concentrations, that may indicate a relatively larger contribution of stormwater to water quality. Conversely, if there is no temporal relationship, this indicates a non-point source of contamination, such as septic systems, wildfowl or pet waste.

To investigate the presence of this link, a cross-correlation analysis was performed on daily precipitation totals observed at the nearest National Weather Service station and the bacterial concentrations measured by RIDOH. Both data sets represent time series data, or collections of data points indexed in chronological order. A cross-correlation analysis examines the relationship between the individual time series with varying delays, or lags, between them (e.g., 0 days, ± 1 day, ± 2 days, etc.). The nearest weather station is located within the Tiogue Lake watershed, approximately 0.5 miles from Briar Point Beach, but this station has only been operational since August 2015. The nearest long-term weather station is located at TF Green Airport, approximately 7.1 miles from Briar Point Beach.

2.2.2 Septic System Failures

The Rhode Island Department of Environmental Management (RIDEM) is responsible for permitting septic systems across the state. Repairs to correct septic system failures require a permit from RIDEM, which also makes public all records related to septic system permits searchable by street address. These records include the dates of each phase of design, inspection, and approval, and so provide a timeline of when a failure is identified, a repair is approved, and the system once again conforms with the applicable regulations.

We reviewed all septic permits for streets adjacent to Tiogue Lake, with particular focus on properties abutting the lake with recent repair permit applications. These were manually categorized based on the type of work permitted, such as new system installation, failed system repair, and cesspool removal.

2.2.3 Sanitary System Use

In the absence of metered usage data from a sewer utility, we worked with KCWA to obtain metered water usage data. KCWA provides water to all homes around Tiogue Lake, which was assumed to be the source of water for sanitary flushing. Metered water use can be considered as a proxy for septic system usage, because water entering a home is discharged via the septic system. KCWA provided water usage data from summer 2016 to present from 28 properties near Briar Point Beach and seven immediately surrounding a groundwater seep on the east shore of the lake. Until 2021, KCWA billed users for water usage on a quarterly basis. After 2021, billing occurred on a monthly basis. Monthly billing data were aggregated into quarterly data to provide a consistent time series of water usage.

Because each KCWA account's water usage is measured at a set interval, the data represent a time series, or a chronologically indexed set of numbers. This time series can be analyzed by relatively simple statistical methods to identify both long-term trends as well as seasonal variation in water usage. The overall trend component was estimated using a moving average that removed seasonal and other unmeasured factors. The seasonal component was estimated by averaging each quarter of data (i.e. average of every year's first quarter usage, second quarter usage, etc.). Unmeasured factors include factors beyond the scope of this project, such as building footprint expansions and the exact timing of meter reading.

For each of the 35 properties, the results of each time series analysis for water usage data were plotted to graphically identify the extent of seasonal variation in water usage as well as any increasing, decreasing, or non-seasonally cyclical trends.

3 Findings

3.1

Sanitary Survey and Illicit Discharge Investigation

The sanitary survey identified several locations where flow was observed entering the lake, as well as potential locations where bacteria and other pollutants could reach the lake via overland flow (*Figure 4*). The most common observation during the sanitary survey was pipes located in retaining walls, none of which were flowing at the time of inspection, but which may represent weepholes or yard drains to provide an outlet for groundwater. Field notes and data sheets are included as Appendix A.

Figure 4: Potential enterococcus sources identified during sanitary survey

3.1.1 Groundwater Seeps

Three seeps were identified along the eastern shore of the lake during the initial sanitary survey and sampled during the follow-up visit. A seep indicates a hydraulic gradient pushing groundwater from subsurface to the surface. The presence of groundwater seeps indicates that depth to groundwater may be shallower in some locations than is indicated in the Rhode Island Soil Survey.

Two groundwater seeps showed enterococcus concentrations below the BAV. The seep in *Figure 5*, located between 95 and 107 East Shore Drive, had enterococcus concentrations over 400 CFU/100mL, or about 7 times higher than the BAV. This bacteria level suggests a source of bacteria to groundwater, such as a failing or poorly-sited septic system or cesspool. Because the sanitary survey occurred when the lake was drawn down and during the high groundwater season, it is difficult to determine if this groundwater seep contributes to enterococcus exceedances in the summer, when groundwater is typically lower. If this seep, and groundwater sources more generally, were substantially contributing to enterococcus levels at the beach, the water quality monitoring data would likely show this impact with more consistent BAV exceedances. Lake water samples collected nearer to the seep would be more likely to show elevated enterococcus concentrations.

Figure 5: Groundwater seep identified at 95-107 East Shore Drive, with high enterococcus concentration

3.1.2 Illicit Discharge Detection

The sanitary survey identified five of twenty-six stormwater outfalls exhibiting flow during dry-weather conditions, samples of which were collected during the return visit. All but one flowing outfall did not have a detectable enterococcus concentration; the outfall with detectable enterococcus was 20 CFU/100mL, below the BAV (*Figure 6*). The outfall on Twin Lakes Avenue was inundated, and during inspection of the first upstream drainage structure, a substantial amount of dog waste was observed on one private property on Twin Lakes Avenue (*Figure 7*).

Most other potential indicators of sanitary-related illicit discharge were similarly not detected, although two samples showed moderately elevated ammonia values of 1 mg/L. Ammonia is a component of human and animal wastes, potentially originating from sources such as leaking or failed septic systems and can also be found in fertilizer. The presence of ammonia without additional indicators of sanitary waste suggests that the ammonia found in the dry-weather flow samples may originate from groundwater influenced by fertilizer application or overapplication. Fertilizer overapplication can cause related problems in surface waterbodies, such as eutrophication and nuisance plant and algae growth.

Dry-weather flow with the observations and sampling results documented here (i.e., flow but lack of bacteria or other parameters listed in *Table 1*) indicate groundwater infiltration into stormwater pipes, and shallow groundwater depths, but not illicit discharges or cross connections to the stormwater drainage system. Shallow groundwater depths require careful design of OWTS to ensure adequate wastewater treatment by native soils.

Figure 6: Dry-weather Enterococcus sampling results from late March. Enterococcus concentrations in MPN/100mL, equivalent to CFU/100mL health standard

Figure 7: Seventeen dog waste piles were observed at time of inspection on one property along Twin Lakes Avenue

3.1.3 Other Potential Pollutant Sources

The sanitary survey visually identified other potential enterococcus and pollutant sources around Tiogue Lake. These sources necessarily rely on circumstantial evidence and may or may not represent actual enterococcus sources. In each instance we document the observed evidence (*Figures 8a-c*) and provide an explanation how that may indicate an enterococcus source.

Figure 8a: A suspected water intake located south of Tiffany Rd

Figure 8b: An unknown pipe in the retaining wall behind 62 W Shore Dr

Figure 8c: A drum containing an unknown liquid was observed in a waste pile at approximately 27 Harrington Rd

A corrugated metal pipe with a connected two-inch hose was identified along the shore south of Tiffany Road (*Figure 8a*). It is suspected that this is a water intake structure. While documenting this structure Fuss & O'Neill staff heard chickens nearby. The water intake and sound of chickens suggests a nearby hobby farm. Hobby farms and the livestock they contain generate animal waste. Proper management of this waste is important to prevent waste transport into surface waters via stormwater runoff.

Unknown pipes in retaining walls were the most frequent observation during the sanitary survey. This is likely a standard design component, i.e. a weephole, allowing groundwater to safely drain to the lake. One instance, believed to originate from 62 West Shore Drive, was observed to have a scour patch beneath the pipe (*Figure 8b*), possibly indicating greater flow, perhaps occurring only intermittently. If these pipes are connected as overflows for substandard septic systems, which may not be the case in this context, or are connected to gray water systems, they could discharge substantial quantities of enterococcus directly to the lake.

An unlabeled 55-gallon drum marked with Summit Industrial Products (*Figure 8c*) was observed to be stored along the lake shore on Harrington Avenue. Summit Industrial Products appears to produce chemical degreasers, industrial lubricants, and hydraulic fluids. While these are not sources of enterococcus bacteria, storage of such waste products or reuse of a container that may contain residual waste near the lake shore presents other risks that can be mitigated with adequate disposal in a permitted facility.

3.2
Secondary Data

3.2.1 Water Quality Monitoring Data

The cross-correlation analysis between precipitation and antecedent rainfall showed a moderate correlation between precipitation intensity and subsequent enterococcus concentrations with a lag between 4 and 5 days (*Figure 9*). This correlation (r=0.33) suggests that Briar Point Beach sees higher enterococcus values in the days after a rain event. Such a pattern is common in freshwater systems, though various temporal and spatial factors can introduce variation in beach monitoring data (EPA 2010), which may reduce the strength of the correlation.

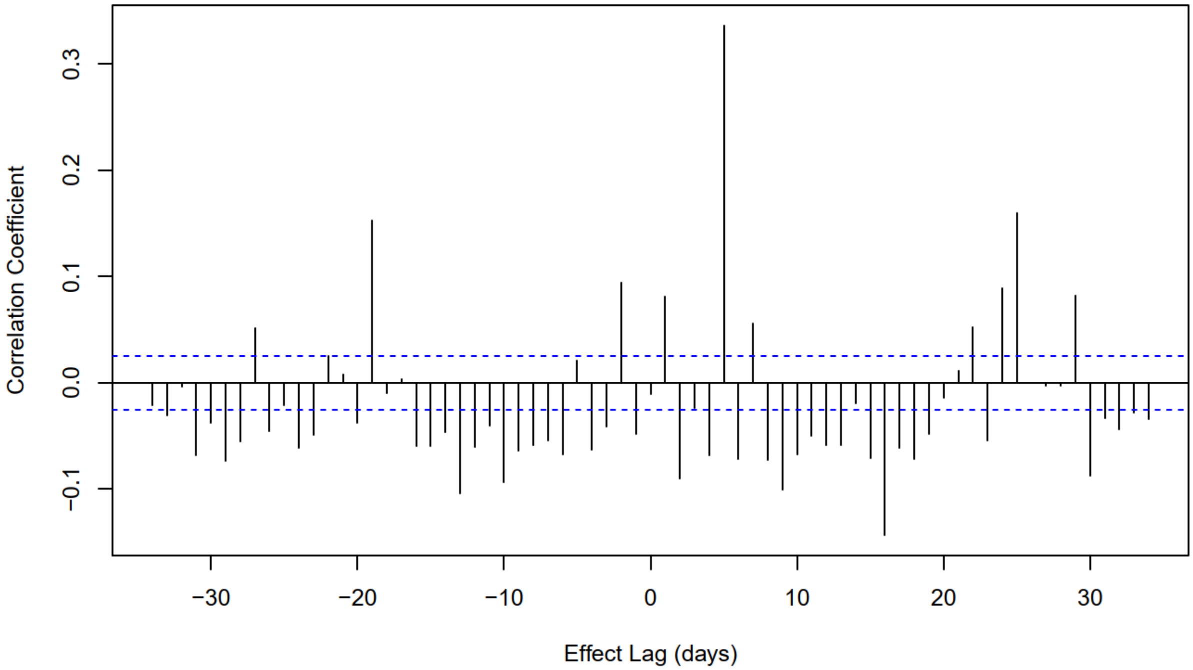

Figure 9: Correlation between rainfall with bacteria concentrations with lags and leads of ±30 days

These factors can interact in complex ways. For instance, the orientation of a beach relative to FIB sources, like stormwater outfalls and stream inlets that receive stormwater, can influence the temporal relationship between rain events and FIB concentration in a lake (Haack et al. 2003). In addition, longer gaps between prior rainfall events impacts the amount of enterococcus load on land available for runoff into Tiogue Lake. Shorter gaps between events may not leave sufficient time for enterococcus to increase between storms and become available to be washed into the lake. The exact timing of sampling relative to when rain fell may also play a role, for example when sampling occurs in the lag between rainfall and increased enterococcus concentration. Wind direction and speed can also impact how water moves through the lake, and when high-enterococcus water passes by the beach.

Plotting bacteria monitoring results against antecedent rainfall suggests not all rain events are necessarily followed by an increase in enterococcus concentration at Briar Point Beach. *Figure 10* indicates that enterococcus concentrations above the BAV most often occur after approximately 0.2 inches of precipitation have fallen in the preceding 3 days. Exceedances of the BAV do tend to follow particularly larger rain events (*Table 2*). This relatively low amount of rain indicates a brief window following a rain storm where exceedances of the BAV may occur. These exceedances may only be observed by chance in water quality monitoring data when water samples happen to be collected during that window.

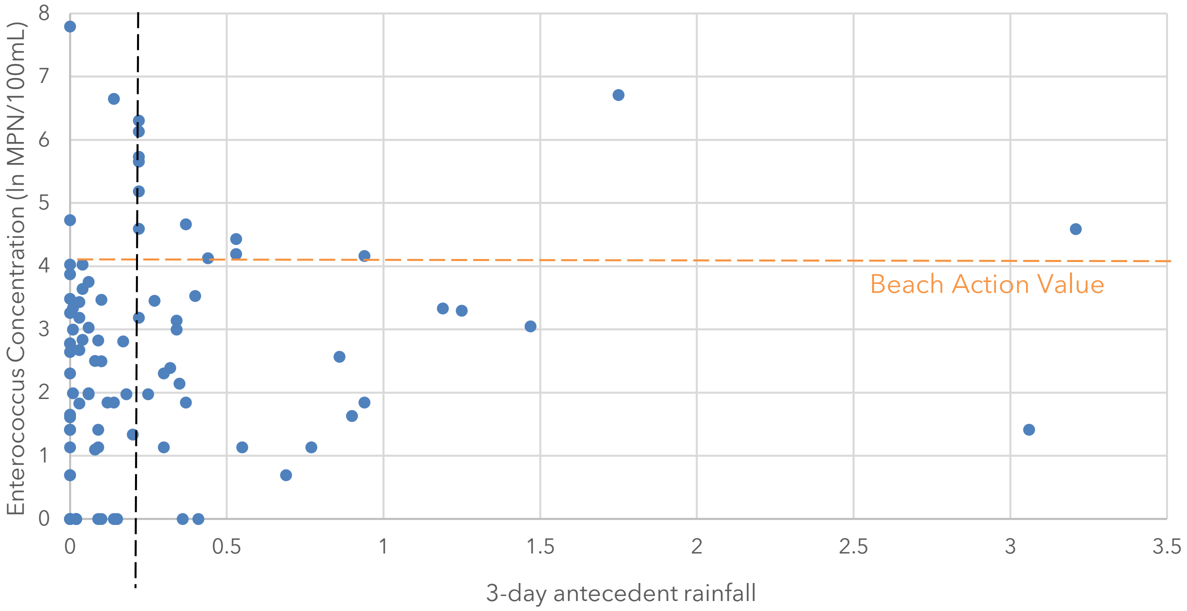

Figure 10: Antecedent precipitation and subsequent fecal indicator bacteria concentrations

Enterococcus in water quality monitoring data generally indicate the presence of human and other animal wastes, which also contain nutrients like phosphorus and nitrogen which are also found in stormwater runoff relating to land use practices. In freshwater systems, a lack of naturally occurring phosphorus often limits algal growth. The addition of phosphorus via stormwater runoff contributes to rapid algal growth, or blooms. These algal blooms can indicate the presence of certain co-occurring cyanobacteria that produce harmful toxins with the potential to cause gastrointestinal and neurological symptoms in humans. These harmful algal blooms have been recently documented by RIDOH in Tiogue Lake and caused closures at Briar Point Beach.

Table 2: Exceedances of Beach Action Value at Briar Point Beach and 72-hour antecedent precipitation

Sample Date	Enterococcus (MPN/100mL)	Rainfall in previous 72-hour period
2007-06-06	820	1.75
2016-07-01	84	0.21
2016-07-25	64	0.94
2018-06-21	770	0.19
2018-06-23	2,419	0.00
2018-06-26	285	0.22
2018-06-27	461	0.22
2019-06-26	62	0.44
2019-07-30	113	0.00
2020-07-07	106	0.37
2021-07-13	98	3.21

3.2.2 Septic System Permit Data

The review of RIDEM's septic system permit data around the lake show more than 60 septic system permit applications since 2012, 41 of which were identified as repairs. Six repair permits were open in June 2018 when the highest enterococcus concentrations were measured, two of which were near Briar Point Beach (*Figure 11*). While it is tempting to point to this geographic proximity and the open repair permits as definitive sources, all repairs have since been completed and RIDEM has issued letters of conformance indicating that these systems would not be ongoing sources of bacteria.

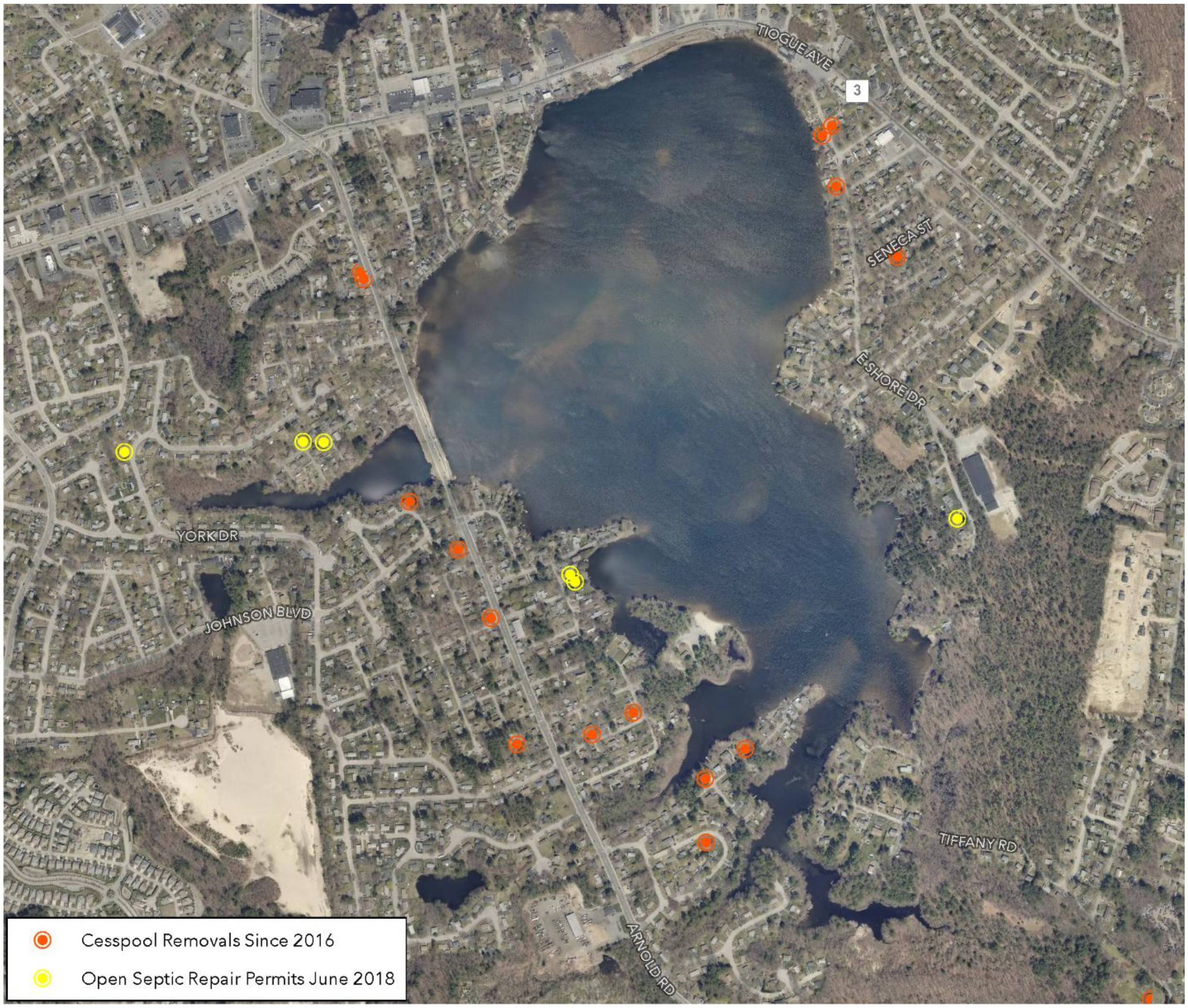

Figure 11: Septic system permit review results

A greater concern is the presence of cesspools in the parcels surrounding the lake. Based on RI Cesspool Act 2007 RIGL 23-19.15, as amended in 2015, all cesspools, including metal tanks, perforated concrete vaults, or covered hollows or excavations receiving sanitary sewage discharge, must be removed on a defined schedule. The Cesspool Act specifies that any cesspool must be removed and replaced with a RIDEM-approved septic system within one year of property transfer or when failing. Failure is defined in the Act when, among other conditions, a cesspool is shown to have contaminated a drinking water well or watercourse or the bottom of the cesspool contacts the groundwater table.

RIDEM records indicate removal of at least 16 cesspools since 2016. It is not documented how many parcels in the watershed are served by cesspools, but many likely remain given the age and type of development in the watershed. Removals were recorded for properties both near the lake shore in the first vacation homes constructed before 1952, but also further from the lake in areas developed later. This suggests a wider distribution of cesspools than those parcels abutting the lake, although those abutters are of greatest concern.

The presence of cesspools around the lake combined with the evidence of groundwater seeps with elevated enterococcus concentrations, and RI Soil Survey mapping indicating seasonal groundwater depths between 19-42", generates additional potential for remaining cesspools to meet the failure criteria. An expedited schedule for removal can apply if a failed cesspool creates a public health hazard, or if the property has a public sewer connection. The Cesspool Act specifically calls out drinking water intakes as a condition for a public health hazard, but proximity to a bathing beach may constitute sufficient basis to expedite cesspool removal.

3.2.3 Sanitary System Use

Time series analysis for the properties near Briar Point Beach indicated clear trend and seasonal components for each property. Summertime increases in water usage varied among properties, ranging from a 5% increase from winter baseline usage, suggesting year-round occupancy, to nearly 200% of winter baseline usage suggesting summer-only occupancy, with most properties increasing summer water usage around 25%. As noted above, seasonal septic system use can negatively impact septic system function during higher use months. In addition, based on the listed owner in some Town property records, it appears at least some waterfront homes on Tiogue Lake appear to be rental properties.

Where the trend component of a time series showed a clear increase in water use, this often corresponded to a property transfer or construction of an addition, as shown in the Town's property records. This increase may reflect different water use preferences (e.g., more intensive lawn watering) or increased occupancy and heavier septic system use. A decreasing trend at a property may also reflect lower usage following beach closure, and reduced water usage if seasonally occupied properties were less used during the COVID-19 pandemic.

While lawn watering practices likely contribute to seasonal variation in water usage, seasonal occupancy and overcapacity cannot be ruled out as contributing factors, since some short-term rental properties and seasonal septic system usage is evident from the available data. Because water usage can be used as a proxy for septic system usage, these patterns may show that septic systems contribute to enterococcus levels in Tiogue Lake. Multiple properties where water data was reviewed showed a decrease in water usage after the 2018 beach closure and COVID-19 pandemic. This decrease in water use, and associated reduction in septic system usage, may partly explain the improvement in water quality recently publicized in the Kent County Daily Times. The most recent water use data suggest that water usage and septic system use may be returning to pre-pandemic levels. If this trend is true and continues, we may expect to see additional exceedances of the BAV at Briar Point Beach in 2022 and 2023.

4 Recommended Next Steps

Based on the outcome of the sanitary survey investigation and secondary data review, multiple sources of bacteria likely contribute enterococcus to Tiogue Lake affecting exceedances of the BAV resulting in beach closures, including stormwater and wastewater sources. Additionally, while not directly indicated by the data available for this project, the continued removal of cesspools and elimination of OWTS will enhance protection of the lake. Addressing these relatively diffuse enterococcus sources is feasible, if challenging, given the built-out nature of the watershed.

Mitigating the impact of stormwater pollution and addressing bacteria loads from OWTS across the watershed is important but represents a long-term commitment, so it will be important to address other enterococcus sources in the short term by addressing seasonal OWTS loading and pet and wildlife waste through continued public education and outreach measures. Additional data collection efforts could also help refine the relationship between rainfall timing and BAV exceedances at Briar Point Beach.

The variety of these sources indicates a combination of infrastructure improvements and public outreach targeting bacteria reductions in the Tiogue Lake watershed may help address enterococcus concentrations at Briar Point Beach. The recommendations described below have the co-benefit of additionally addressing other pollutants that may be linked to the recent harmful algal blooms that have closed the beach in 2022.

4.1
Public Education

The Town has already taken steps to reduce bacteria from entering the lake, by enacting ordinances requiring dog walkers to pick up pet waste and forbidding park and public space users from feeding wildfowl. It has posted signage to those effects along the Arnold Road causeway, at Briar Point Beach, and the town boat launch on Tiogue Avenue. Pet waste bags and trash bins should continue to be made available in public spaces near the lake, and Town enforcement staff should continue to enforce those ordinances. Installing educational signage showing the link between pet waste, feeding wildfowl, and beach closures may encourage additional compliance with the ordinances.

Conducting targeted outreach to individual property owners on Twin Lakes Avenue can help reduce dog waste levels on private property at those lake side homes. Including pet waste informational materials with annual dog license renewals either town-wide or targeted to specific neighborhoods around TIogue Lake would provide additional benefits. These efforts would also count toward the Town's annual stormwater permit requirements for public stormwater education.

The Town should additionally continue to engage with residents' associations around the lake to conduct outreach to members and lake abutters about the importance of properly maintained septic systems and potentially advocate for public sewering. Additional outreach topics should include minimizing fertilizer application, maintaining buffer plantings at the lake edge, and conducting vista pruning of individual branches instead of cutting down entire trees. Maintaining a buffer between yards and the lake slows stormwater flows, allowing it more time to filter pollutants and infiltrate into the soil before reaching the lake. Removing trees near the shore can destabilize shoreline soils contributing to erosion and additional pollutant load. Vista pruning, by contrast, leaves trees and roots in place to limit erosion, while improving water views.

4.2
Stormwater Treatment

Removing pollutants from stormwater before it reaches the lake is the most effective way of mitigating its impact on Tiogue Lake. Allowing stormwater to infiltrate into the ground is the most cost-effective way of removing pollutants. Where this is not feasible, installing or constructing stormwater infrastructure that mimics the natural filtration and pollutant removal properties of soils is the next best option. In the built-out neighborhood around Tiogue Lake, identifying large areas for centralized stormwater retrofits is a challenge. Smaller, decentralized green stormwater infrastructure (GSI) practices may therefore represent the best alternative for future stormwater treatment.

GSI practices that rely on infiltration must be carefully sited because they rely on similar pollutant removal mechanisms as septic systems and if improperly sited will not function effectively to remove pollutants. These systems, which can be at surface level on a parcel or within a road right of way (ROW), or buried under roadways, sidewalks, and parking lots, typically have the highest bacteria removal efficiencies, exceeding 90% removal under ideal conditions. Where infiltration is not possible, biofiltration practices, such as bioretention planters, bioswales, and tree boxes are viable alternatives, and can remove up to 50% of bacteria loads from the stormwater they treat. The long-term success of GSI requires a commitment to maintenance, which is a critically important consideration when selecting the location and type of GSI.

Incorporating GSI installation into other planned infrastructure projects, such as road resurfacing or utility installation, can help decrease overall costs to the Town because the costs related to excavation and pavement removal and resurfacing are only paid once. Specific publicly owned locations in the Tiogue Lake watershed where GSI practices may be feasible include the elementary schools (*Figure 12*) and near Briar Point Beach (*Figure 13*). Further planning efforts would be necessary to identify additional locations where GSI components could be installed. A conceptual example of a potential GSI retrofit that can fit in space-limited ROWs around Briar Point Beach is shown in *Figure 14* as well as Appendix B. Because these areas are publicly owned, the Town would not need to coordinate access or easement agreements with private ownership interests, though outreach to nearby property owners can help with public acceptance of these systems. In addition to water quality benefits, GSI designs can provide both habitat and aesthetic benefits by incorporating native grass species into the design of these systems that allow them to better blend into the existing streetscape.

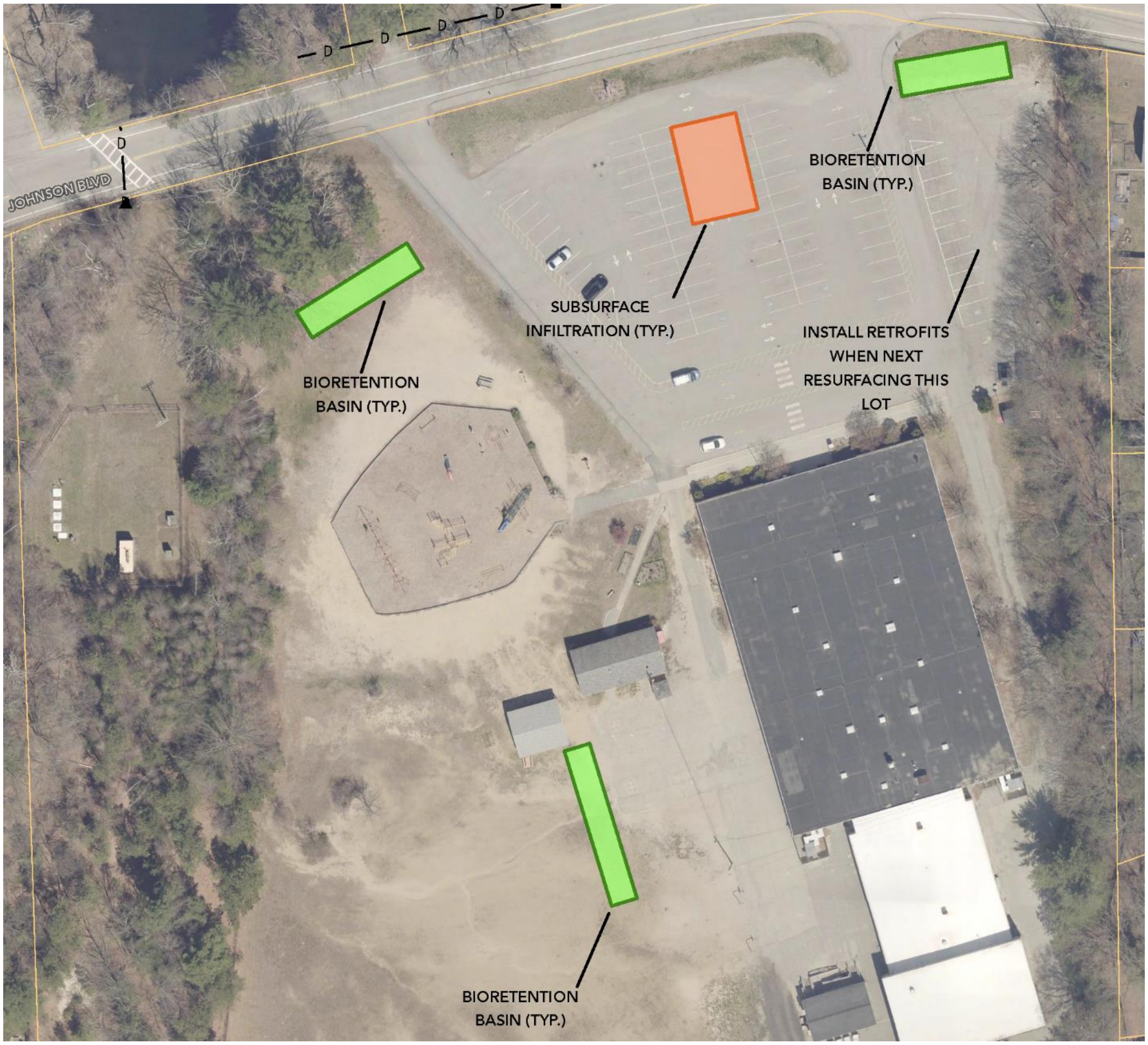

Figure 12: Potential GSI options at Hopkins Hill Elementary School. Aerial imagery and site visits indicate that channelized flow from the playground and impervious area near the pavilion discharges to a direct tributary of Tiogue Lake

Figure 13: Bioswales between roadway and sidewalk or private property

Figure 14: Potential GSI retrofit options within the ROW and on Town property near Briar Point Beach. An unmapped paved swale discharges surface flow from the southeast corner of West Shore Drive directly to Tiogue Lake

In addition, on the west side of the lake, a common development feature provides additional GSI opportunities. Holmes Road, Cove Road, Colonial Road, York Drive, Jade Road, and Lawnwood Road each have a partial cul-de-sac, also known as a street knuckle, with excess pavement that generates stormwater runoff and pollutant loading without the benefit of allowing through traffic (*Figure 15*). Removing some excess pavement and extending driveways and maintaining existing vehicle access and driveway width would reduce pollutant loading and stormwater runoff, while providing space in the ROW for additional GSI opportunities. This type of project may not change ROW boundaries or property lines, and so can likely continue to comply with the frontage requirements in the Town's zoning ordinance. Additional considerations for these types of solutions include identifying snow plowing and driveway repair responsibilities between the Town and individual homeowners. A similar project addressing recurring flooding is currently underway in Warren, RI (*Figure 16*) using funding from the Rhode Island Infrastructure Bank (RIIB).

Figure 15: Examples of partial cul-de-sacs on Holmes Road and Jade Road

Figure 16: Partial cul-de-sac pavement removal and GSI project example in Warren, RI

Existing programs in Rhode Island can help offset the costs of GSI installation. RIIB funds the Municipal Resilience Program (MRP) to help communities increase their resilience to the risks posed by climate change. GSI retrofit opportunities are one type of project that RIIB is able to fund through this program. Town participation in MRP allows access to additional grant funding currently capped at $250,000 per project, but which may increase in the coming years. There are additional funding sources for design and implementation of GSI. Programs such as the 319 Non-Point Source program, Southeast New England Program, and RIIB Green Infrastructure Acceleration program all allocate money to support GSI design and implementation. These programs should be considered when determining how to fund long-term investments in GSI in the Tiogue Lake watershed.

Based on aerial imagery, several commercial and industrial developments near Center of New England Boulevard appear to have some level of stormwater treatment, although it is not known if these practices address stormwater volume or remove pollutants from stormwater. Outreach efforts to amenable private property owners to identify opportunities to retrofit and upgrade stormwater infrastructure to remove pollutants would also help to reduce the bacteria load from the watershed.

4.3

Sewering

The Town of Coventry, with Fuss & O'Neill, is currently developing a new sewer facility plan, and a recommendation to extend sewer service to the unsewered areas around Tiogue Lake is anticipated. The sewer facility plan (FP) and the upcoming community comprehensive plan (CCP) process will coordinate with one another. Sewer planning areas identified and prioritized in the FP will incorporate demographic data such as long-term viability of onsite systems, environmental impetus for sewer extension, and affordability. The FP will consider the benefits and costs of providing public sewer around Tiogue Lake. One potential benefit of disconnecting properties from onsite septic systems and sending wastewater to a treatment facility outside the watershed, is reducing the risk of bacteria and other potential pollutants entering the lake from poorly sited or failing septic systems and cesspools.

Should the extension of public sewer to the Tiogue Lake neighborhood be deemed infeasible, alternatives exist to address pollutants from cesspool and septic systems. An important first step is identifying the location of remaining cesspools and failing septic systems. To assist this effort, the Town should assess the need to create a wastewater overlay district or including cesspools and septic systems in a Form Based Code to enforce their inspection and removal. Increasing the required inspection frequency provides a mechanism for the Town to identify system failures before property transfer, which may only happen every few decades. The Towns of Charlestown and Jamestown have adopted administrative overlay districts to address pollutants from septic systems.

The Town participates in the Community Septic System Loan Program (CSSLP), a loan program funded by the State Revolving Fund and administered by the Rhode Island Housing and Mortgage Financing Agency. Under this program, low interest loans are provided to homeowners, in participating towns, to help cover the costs associated with septic system repairs and upgrades.

4.4

Additional Data Needs

While this study identified several bacteria sources, several of the recommendations here may require a longer implementation timeframe. Until these recommendations can be implemented, Briar Point Beach remains at higher risk of additional closures due to bacteria loading. While the prior approximately monthly water quality sampling is effective at monitoring medium to longer term water quality trends, it is somewhat ineffective at capturing shorter term trends in water quality, such as stormwater-related bacteria exceedances. The Town should continue to address this gap by conducting its monitoring for bacteria during the swimming season and assess the feasibility of increasing the sampling frequency (i.e., weekly or greater frequency).

The Town might additionally consider collecting lake samples for conducting a focused, more intensive sampling program to refine the estimated storm intensity that causes BAV exceedances as well as the delay between rainfall and enterococcus levels. Such a study would allow the Town to predict when rainstorms could cause elevated enterococcus levels and use that relationship to make recommendations for preemptive beach advisories or closures based on rainfall. These short-term solutions do not address the underlying bacteria sources but do support additional public health measures while longer term fixes are pursued.

5 References

Haack, SK, LR Fogarty, and CC Wright. 2003. Escherichia coli and Enterococci at beaches in the Grand Traverse Bay, Lake Michigan: Sources, characteristics, and environmental pathways. Environmental Science and Technology, 37: 3275-3283.

Harvey, MC, DK Hare, A Hackman, G Davenport, AB Haynes, A Helton, JW Lane, Jr., and MA Briggs. 2019. Evaluation of stream and wetland restoration using UAS-based thermal infrared mapping. Water, 11: 1568.

Postma, FB, AJ Gold, and GW Loomis. 1992. Nutrient and microbial movement from seasonally-used septic systems. Journal of Environmental Health, 55: 5-10.

U.S. Environmental Protection Agency. 2010. Sampling and consideration of variability (temporal and spatial) for monitoring of recreational waters. EPA-823-R-10-005.

We gratefully acknowledge the data and information shared by the Rhode Island Department of Health staff, the Kent County Water Authority, and the University of Rhode Island Watershed Watch program and the many trained URI Watershed Watch volunteer water quality monitors who collected water samples for analysis at the state certified URI Watershed Watch Analytical Lab. For more information on the URI Watershed Watch program please visit http://web.uri.edu/watershedwatch/.

Appendix A

Field Data Sheets

20220316

LAKE TIOGUE SANITARY SURVEY

3/14 CAL

YSI pH	4	3.61		4
	7	7.40	CAL →	7.02
	10	10.74		10.04

Cl	0	0.00	
	1	0.22	✓
	2	0.95	
	3	1.65	

~~SAMPLE~~

SAMPLE ID	TIME	OUTFALL
01391220316-01	1335	LARCH DR
-01D	1335	"
02	1430	ARNOLD CAUSEWAY SOUTH

EPA United States Environmental Protection Agency

Freshwater Routine Sanitary Survey for Recreational Waters

EPA 820-F-20-004
March 2021

GENERAL INFORMATION

Name of beach (if applicable): **Briar Point Beach**

Date(s) of survey: **2022-03-16**

Beach ID:

Time(s) of survey:

Name of waterbody: **Lake Tiogue**

Waterbody type: **Freshwater**

Sampling station(s)/ID:

Surveyor affiliation: **Fuss & O'Neill**

WQX organizational ID:

Name(s) of surveyor(s): **SB/WG**

Sampling location Latitude: Longitude:

Dates of swim season Start: **June** End: **September**

QUALITY ASSURANCE

Will the data collected use an approved Quality Assurance Project Plan (QAPP)? yes [✓ no]

PART 1: WEATHER AND GENERAL WATERBODY CONDITIONS

Weather Conditions

Survey the weather using the method of your choice. You may use the National Weather Service as your source.

Air temperature: ______________ °C or °F

Method for temperature: (check one) ☐ Liquid-in-glass therm. ☐ Electronic thermometer ☐ Weather app ☑ Weather report: from airport or weather station? ☐ Other:__

Wind speed: __________ units: ______

Wind gust speed: ______ units: ______

Wind direction: ________

Is the wind: (circle one) Onshore or Offshore

Method for wind speed: (check all that apply) ☐ Wind vane for direction ☐ Weather app ☐ Wind sock for direction/speed ☐ Anemometer for wind speed ☐ Beaufort scale for wind speed ☐ Aerovane for wind direction/speed ☑ Weather report: from airport or weather station? ☐ Other (specify): [illegible]

If you collected wind speed from a local weather station, how far were you from the station: **1** [✓ mi] or km

How recent was the last rain event: (circle one) **2022-03-13**
0-24 hrs 24-48 hrs 48-72 hrs [✓ 72+ hrs]

Rain intensity: (circle one) Misting Light rain [✓ Moderate rain] Heavy rain Other:______

Total measured rainfall: **0.51"** in or cm

Distance to the gauge/station when recording rainfall amount: **1** mi or km

Method for rainfall: (check one) ☑ Rain gauge ☐ Weather report ☐ Weather app ☐ Other (specify): **Coventry 2 NOWData**

Sky condition/amount of cloud cover: (circle one) Sunny/ No clouds [✓ Mostly sunny/ 1/8 to 2/8] Partly sunny/ 3/8 to 1/2 Mostly cloudy/ 5/8 to 7/8 Cloudy/ Total coverage

Method for weather conditions: (check one) ☑ Visual observations ☐ Weather app ☐ Other (specify): __________

Waterbody Conditions

~~Water flow speed: ________ units: ________~~

~~Method for water flow speed: (check one) ☐ Stick with fishing reel with water balloon on end ☐ Ball and tether ☐ Other: ___~~

~~Direction from which the wave is coming (e.g., N, SW): ________~~

~~How tall are the waves: ________ m or ft~~

~~Is the wave height measured or estimated? (circle one) Measured Estimated~~

~~Method for measuring wave height: (check one) ☐ Visual examination of wave height ☐ Graduated stick and ranging pole ☐ Other (specify):__________~~

Is the stream bank/shoreline eroding? yes [✓ no]

Width of riparian vegetation on river/stream left (looking downstream) (circle one) none [✓ 0-25 ft] 25-50 ft 50+ ft

Width of riparian vegetation on river/stream right (looking downstream) (circle one) none [✓ 0-25 ft] 25-50 ft 50+ ft

Add additional comments for general waterbody conditions.

highly developed waterfront on most of lake shore
multiple SW outfalls
water @ ~115 mohawk more turbid than elsewhere

...tic Organism Passage Barrier

...is the outlet drop (e.g., 3.5ft)	Severity of barrier debris, sediment, or rock for the structure with the least amount of debris (None, minor, moderate, severe)	Location (lat/long)	Description

...nor = <10% open area of structure blocked; Moderate = 10-50% open area of structure blocked; Severe = 50% open area structure blocked

...ke images to document aquatic organism passage barriers and provide detailed descriptions where possible:

PART 2: WATER QUALITY

Bacteria

List bacteria samples collected at the beach. Potential pollution sources, if applicable, can be recorded in Part 4.

Sample Point	Sample Number	Location (lat/long)	Date & Time	Parameter (enterococci, E. coli, etc.)	Comments
SEE	NOTES				

General Water Quality

Water temperature: ______ [✓ °C] or °F

Water color: (circle one) Clear Blue [✓ Brown] Green Red Other: ______

Method for water temperature: (check one) ☑ Multiprobe ☐ Electronic meter ☐ Graduated thermometer ☐ Report from local radio station ☐ Report from NOAA weather band radio ☐ Other: ______

Has the water color changed since the last visit? yes no [✓ don't know] If yes, take photographs and describe:

Select the best description of the water smell: (circle one) [✓ None] Septic Algae Sulfur Other: ______

How did you measure turbidity? (check one) ☒ Observed: (circle one) [✓ Clear] [✓ Slightly turbid] Opaque
☐ Measured: NTU value: ______ Secchi disc depth: ______

What method was used to measure the turbidity of the water: (circle one) [✓ Simple visual observation] Visual test kit Titrimetric test kit Nephelometer/Turbidimeter Other: ______

Describe other measurements taken and report values: MORE SUSPENDED SED/ PARTICLES ALONG E SHORE

Additional water quality observations:
[illegible]

PART 3: PEOPLE

Are there recreators (swimmers, boaters, waders, etc.) present at the beach or waterbody? yes no

Total people in water: ______ + Total people out of water: ______ = Total people at the beach or waterbody: ______

Total number of boats: ______

Report activities observed at the beach or shoreline and in the water. Quantify and take photographs, if possible.

Activity (swimming, fishing, etc.)	0					
Approximate # of people participating						

Describe notable activities that could affect water quality (Example: babies in disposable diapers in the water):

Method for numbers of people participating in various activities: (check one) ☑ Counting by surveyor ☐ Photos
☐ Counting by lifeguard ☐ Turnstiles ☐ Other:__________

PART 4: POTENTIAL POLLUTION SOURCES

Identify visible sources of pollutants up to 500 feet from the beach or waterbody boundary. Quantify and photograph sources, if possible.

Type of Source	Discharge Source Name	Discharge Source Amount (H, M, L)	Discharge Flow Rate	Discharge Volume	Discharge Source Characteristics
Wetland drainage		H			
Outfall/Pipe (stormwater)					2 1 DOT x 2, Berkshire
Leaking pit latrines/septic					
Runoff (impervious surfaces)					Restaurant Parking
Homeless encampments					
Other (specify): GW					E Shore Dr

Did you collect samples and complete the Bacteria Samples section in Part 2? yes no
If no, describe why not:

How did you identify the source of discharge? (circle one) [✓ Visual observation] WWTP notification/report Other:______

How did you measure flow/velocity or volume? (circle one) Mechanical flow meter Electric flow meter
USGS gauging station WWTP notification/report Orange [✓ (float) and stopwatch] Other:______

Floatables and Debris

Are floatables present in the water? yes no If yes, select the types found: (check all that apply)

☐ Street litter (e.g., cigarette filters)
☐ Food-related litter (e.g., packaging/containers)
☐ Medical items (e.g., syringes)
☐ Sewage-related (e.g., tampons, condoms)
☐ Building materials (e.g., wood/siding)
☐ Fishing-related (e.g., fishing line, nets, lures)
☑ Household waste (e.g., household trash, plastic bags)
☐ Other: ______

Method for determining floatables presence: (circle one) [✓ Visual observation] Cleanup event results Other: ______

Is there debris or litter present on the beach or shoreline? yes [✓ no]

Select the amount (%) of debris/litter on the beach or shoreline: (circle one)
None [✓ Low (1% - 20%)] Moderate (21%- 50%) High (>50%)

Select the types of debris found? (check all that apply)

☐ Street litter (e.g., cigarette filters)
☑ Food-related litter (e.g., packaging/containers)
☑ Medical items (e.g., syringes)
☐ Sewage-related (e.g., tampons, condoms)
☐ Natural debris (e.g., driftwood, algae)
☐ Building materials (e.g., wood/siding)
☐ Fishing-related (e.g., fishing line, nets, lures)
☑ Household waste (e.g., household trash, plastic bags)
☐ Tar/Oil (e.g., tar balls)
☐ Oil/Grease (e.g., oil slick)
☐ Other: ______

Method for determining debris presence: (circle one) [✓ Visual observation] Cleanup event results Other: ______

Algae

Is algae present in the nearshore water, beach and/or shoreline? [✓ yes] no don't know If present, document with photographs.

Select the amount (%) of algae in nearshore water: (circle one)
None [✓ Low (1%–20%)] Moderate (21%–50%) High (> 50%)

Select the amount (%) of algae on the beach or shoreline: (circle one)
None [✓ Low (1%–20%)] Moderate (21%–50%) High (> 50%)

Method for determining amount and color of algae: (circle one)
[✓ Visual observation] Other: ____________

Circle the types of algae found: (check all that apply) ☒ Periphyton (attached to rocks, stringy) ☐ Globular (blobs of floating material)
☐ Free floating (no obvious mass of materials) ☐ Other: ____________

Algae colors: (circle all that apply) Light green Bright green [✓ Dark green] Yellow Brown Other:______

Is the nearshore water discolored? yes no don't know

If yes, specify the color: (circle all that apply) Clear Green Dark red Brown Yellowish Other:______

Harmful Algae Blooms

Is there presence of harmful algal blooms? yes [✓ no] don't know If yes, photograph and describe:

Method for identifying harmful algae blooms in nearshore water and beach: (circle one)
Field guide or internet site for taxonomic identification Other: ____________

Are there mats or scum in nearshore waters? (circle all that apply) Mats-floating Foam Scum [✓ None]

Are there dead fish or other dead wildlife deaths present with bloom? yes [✓ no]

Have any illnesses (e.g., itchy throat, cough, gastrointestinal) been reported by local or state health departments? yes was [✓ no]
If yes, describe: ?? septic? ?

Is algal toxin monitoring conducted? yes [✓ no] don't know If yes, have algal toxins been detected? ____________

Have algal species been identified? yes [✓ no] don't know If yes, specify the species: ____________

Presence of Wildlife and Domestic Animals

Are wildlife and domestic animals present? [✓ yes] no If yes, document with photographs.

Are dead birds found on the beach? yes [✓ no] If yes, specify the number and species of live ~~dead~~ birds.

Type	Number	Type	Number	Type	Number	Type	Number	Type	Number	Type	Number
Geese	20	Otters		Deer		Ducks	6	Rodents		Snakes	
~~Shorebirds~~	4	Turtles		Toads		Dogs		Beavers		Other	
~~Pigeons~~ Swans	2	Horses		Gulls	100	Frogs		Raccoons			

Method for determining presence of wildlife and domestic animals: (circle one)
Counting using hand-held counter and if necessary, binoculars Other (specify):____________

List the number and species of birds found dead on the beach

Type	# Dead	Type	# Dead	Type	# Dead	Type	# Dead
Common loon		Black-crowned night-heron		Long-tailed ducks		Ospreys	
Herring gulls		Double crested cormorants		Horned grebes		Common tern	
Ring-billed gulls		White winged scoter		Snowy egrets		Belted kingfisher	
Mallard ducks		Red-necked grebes		Great blue herons		Other: ______	

Method for determining the number of dead birds: (circle one)
Counting using hand-held counter and if necessary, binoculars Other:____________

Method for identifying dead birds: (circle one)
[✓ Field guide or internet site for taxonomic identification] Other:____________

Are dead fish found in the waterbody, on the beach or along the shoreline? yes [✓ no] If yes, specify the number of dead fish found on the beach or in/at the waterbody and take photographs:

Method for determining the number of dead fish: (circle one) [✓ Visual observation] Other:____________

Additional comments or observations on pollution sources, algae, or animals. Describe any photos taken.

FUSS & O'NEILL
(860) 646-2469 • www.FandO.com

☐ 146 Hartford Road, Manchester, CT 06040
☐ 56 Quarry Road, Trumbull, CT 06611
☐ 317 Iron Horse Way, Suite 204, Providence, RI 02908
☐ 1550 Main Street, Suite 400, Springfield, MA 01103
☐ 108 Myrtle Street, Suite 502, Quincy, MA 02171
☐ 540 North Commercial Street, Manchester, NH 03101
☐ 276 Newport Road, New London, NH 03257
☐ 205 Billings Farm Road, Suite 6B, White River Junction, VT 05001
☐ 5 Fletcher Street, Suite 1, Kennebunk, ME 04043
☐ 23046 Avenida de la Carlota, Suite 600, Laguna Hills, CA 92653
☐ Other ____________

CHAIN-OF-CUSTODY RECORD 43543

Turnaround

☐ 24-Hour* ☐ 72-Hour* ☐ Other ______ (days)
☐ 48-Hour* ☒ Standard (____ days) *Surcharge Applies

PROJECT NAME: COVENTRY
PROJECT LOCATION: RI
PROJECT NUMBER: 20190164.A10
LABORATORY: NET

REPORT TO: STEFAN BENGTSON
INVOICE TO: SAME
P.O. NO.:
Sampler's Signature:
Date: 3/16/22

Source Codes:
MW=Monitoring Well PW=Potable Water T=Treatment Facility S=Soil B=Sediment
SW=Surface Water ST=Stormwater W=Waste A=Air C=Concrete
X=Other ____________________

Item No.	Transfer Check 1	2	3	4	Sample Number	Source Code	Date Sampled	Time Sampled	Analysis Request: ENTEROCOCCUS								Containers: Soil VOA Vial, ☐ methanol	Soil VOA Vial, ☐ water ☐ Na(SO₄)₂	Glass Soil Container ( ) oz	Other:	Other:	Water VOA Vial, ☐ As is ☐ HCl	Glass Amber ( ) ml, ☐ As is ☐ H₂SO₄	Plastic - As is, ☐ 250 ml ☐ 500 ☐ 1000 ml 100mL	Plastic - H₂SO₄, ☐ 250 ml ☐ 500 ml	Plastic - HNO₃, 250 ml ☐ Filtered ☐ 0.45µ ☐ 10µ	Plastic - NaOH, 250 ml	Comments
1					01391220316-01	ST	3/16	1335	X															1				LARCH
2					↓ -01D	ST	↓	1335	X															1				LARCH
3					-02	ST	↓	1430	X															1				ARNOLD

Transfer Number	Relinquished By	Accepted By	Date	Time
1			3/16	15:38
2				
3				
4				

Charge Exceptions: ☐ CT Tax Exempt ☑ QA/QC ☐ Other ____________
1 Duplicates ____ Blanks (Item Nos:)

Reporting and Detection Limit Requirements: ☐ RCP Deliverables ☐ MCP CAM Cert.

Additional Comments:

20220323 Tiogue Lake
Sanitary Survey + IDDE

CAL CHECK
pH 4 4.01
7 7.04 ✓
10 9.99
COND 1000 998 ✓

DEP PVD 0830 TACOMA ODO 11337

RET PVD 1630 11379

42
mi

SAMPLE	TIME	LOCATION
01391220323		TRICKLE SEEP
-01	1000	1
-01D	1000	1D
-02	1020	2
-03	1105	3
-04	1130	W SHORE OR ~~LARGE OF #2~~ ~~DOG~~ ~~BY BEACH~~
-05	1205	DIXIE
-06	1230	MID LAKE
-07	1500	YORK CULVERT

EPA United States Environmental Protection Agency

Freshwater Routine Sanitary Survey for Recreational Waters

EPA 820-F-20-004
March 2021

GENERAL INFORMATION

Name of beach (if applicable): **Briar Point Beach**

Date(s) of survey: **2022-03-~~16~~** 23

Beach ID:

Time(s) of survey:

Name of waterbody: **Lake Tiogue**

Waterbody type: **Freshwater**

Sampling station(s)/ID:

Surveyor affiliation: **Fuss & O'Neill**

WQX organizational ID:

Name(s) of surveyor(s): **SB/~~WG~~** AJ

Sampling location Latitude: Longitude:

Dates of swim season Start: **June** End: **September**

QUALITY ASSURANCE

Will the data collected use an approved Quality Assurance Project Plan (QAPP)? yes [✓ no]

PART 1: WEATHER AND GENERAL WATERBODY CONDITIONS

Weather Conditions

Survey the weather using the method of your choice. You may use the National Weather Service as your source.

Air temperature: 45 °C or [✓ °F]

Method for temperature: (check one) ☐ Liquid-in-glass therm. ☐ Electronic thermometer ☐ Weather app ☑ Weather report: from airport or weather station? ☐ Other:__

Wind speed: 5 units: mph

Wind gust speed: ______ units: ______

Wind direction: N

Method for wind speed: (check all that apply) ☐ Wind vane for direction ☐ Weather app ☐ Wind sock for direction/speed ☐ Anemometer for wind speed ☐ Beaufort scale for wind speed ☐ Aerovane for wind direction/speed ☑ Weather report: from airport or weather station? ☐ Other (specify): [illegible]

Is the wind: (circle one) Onshore or Offshore

If you collected wind speed from a local weather station, how far were you from the station: 1 [✓ mi] or km

How recent was the last rain event: (circle one) **2022-03-~~13~~** 20
0-24 hrs 24-48 hrs 48-72 hrs [✓ 72+ hrs]

Rain intensity: (circle one) Misting Light rain [✓ Moderate rain] Heavy rain Other:______

Total measured rainfall: .25 ~~0.51~~" in or cm

Distance to the gauge/station when recording rainfall amount: **1** mi or km

Method for rainfall: (check one) ☑ Rain gauge ☐ Weather report ☐ Weather app ☐ Other (specify): **Coventry 2 NOWData**

Sky condition/amount of cloud cover: (circle one)	Sunny/ No clouds	Mostly sunny/ 1/8 to 2/8	Partly sunny/ 3/8 to 1/2	Mostly cloudy/ 5/8 to 7/8	Cloudy/ Total coverage

Method for weather conditions: (check one) ☑ Visual observations ☐ Weather app ☐ Other (specify): ______

Waterbody Conditions

~~Water flow speed: ______ units: ______~~

~~Method for water flow speed: (check one) ☐ Stick with fishing reel with water balloon on end ☐ Ball and tether ☐ Other: ___~~

~~Direction from which the wave is coming (e.g., N, SW): ______ How tall are the waves: ______ m or ft~~

~~Is the wave height measured or estimated? (circle one) Measured Estimated~~

~~Method for measuring wave height: (check one) ☐ Visual examination of wave height ☐ Graduated stick and ranging pole ☐ Other (specify):______~~

Is the stream bank/shoreline eroding? yes no

Width of riparian vegetation on river/stream left (looking downstream) (circle one) none 0-25 ft 25-50 ft 50+ ft

Width of riparian vegetation on river/stream right (looking downstream) (circle one) none 0-25 ft 25-50 ft 50+ ft

Add additional comments for general waterbody conditions.

Aquatic Organism Passage Barrier

What is the outlet drop (e.g., 3.5ft)	Severity of barrier debris, sediment, or rock for the structure with the least amount of debris (None, minor, moderate, severe)	Location (lat/long)	Description

* Minor = <10% open area of structure blocked; Moderate = 10-50% open area of structure blocked; Severe = 50% open area structure blocked

Take images to document aquatic organism passage barriers and provide detailed descriptions where possible:

PART 2: WATER QUALITY

Bacteria

List bacteria samples collected at the beach. Potential pollution sources, if applicable, can be recorded in Part 4.

Sample Point	Sample Number	Location (lat/long)	Date & Time	Parameter (enterococci, E. coli, etc.)	Comments
SEE NOTES					

General Water Quality

Water temperature: ________ [✓ °C] or °F

Water color: (circle one) Clear Blue Brown Green Red Other:______

Method for water temperature: (check one) ☑ Multiprobe ☐ Electronic meter ☐ Graduated thermometer ☐ Report from local radio station ☐ Report from NOAA weather band radio ☐ Other: ____________

Has the water color changed since the last visit? yes no [✓ don't know] If yes, take photographs and describe:

Select the best description of the water smell: (circle one) [✓ None] Septic Algae Sulfur Other: ____________

How did you measure turbidity? (check one)

☑ Observed: (circle one) Clear [✓ Slightly turbid] Opaque

☐ Measured: NTU value: ____________ Secchi disc depth: ____________

What method was used to measure the turbidity of the water: (circle one) [✓ Simple visual observation] Visual test kit Titrimetric test kit Nephelometer/Turbidimeter Other:____________

Describe other measurements taken and report values:

Additional water quality observations:

PART 3: PEOPLE

Are there recreators (swimmers, boaters, waders, etc.) present at the beach or waterbody? yes [✓ no]

Total people in water: 0 + Total people out of water: ________ = Total people at the beach or waterbody: ____

Total number of boats: ____________

Report activities observed at the beach or shoreline and in the water. Quantify and take photographs, if possible.

Activity (swimming, fishing, etc.)						
Approximate # of people participating						

Describe notable activities that could affect water quality (Example: babies in disposable diapers in the water):

Method for numbers of people participating in various activities: (check one) ☑ Counting by surveyor ☐ Photos ☐ Counting by lifeguard ☐ Turnstiles ☐ Other: ______________

PART 4: POTENTIAL POLLUTION SOURCES

Identify visible sources of pollutants up to 500 feet from the beach or waterbody boundary. Quantify and photograph sources, if possible.

Type of Source	Discharge Source Name	Discharge Source Amount (H, M, L)	Discharge Flow Rate	Discharge Volume	Discharge Source Characteristics
Wetland drainage	—				
Outfall/Pipe (stormwater)					→ YORK | WEST SHORE
Leaking pit latrines/septic	—				→ DIVE
Runoff (impervious surfaces)	—				
Homeless encampments					
Other (specify):________					

Did you collect samples and complete the Bacteria Samples section in Part 2? [✓ yes] no
If no, describe why not:

How did you identify the source of discharge? (circle one) [✓ Visual observation] WWTP notification/report Other:________

How did you measure flow/velocity or volume? (circle one) Mechanical flow meter Electric flow meter USGS gauging station WWTP notification/report [✓ Orange (float) and stopwatch] Other:______________

Floatables and Debris

Are floatables present in the water? yes no If yes, select the types found: (check all that apply)

☑ Street litter (e.g., cigarette filters)
☑ Food-related litter (e.g., packaging/containers)
☐ Medical items (e.g., syringes)
☐ Sewage-related (e.g., tampons, condoms)
☐ Building materials (e.g., wood/siding)
☐ Fishing-related (e.g., fishing line, nets, lures)
☑ Household waste (e.g., household trash, plastic bags)
☐ Other: ______________

Method for determining floatables presence: (circle one) [✓ Visual observation] Cleanup event results Other: ________

Is there debris or litter present on the beach or shoreline? [✓ yes] no

Select the amount (%) of debris/litter on the beach or shoreline: (circle one)
None [✓ Low (1% - 20%)] Moderate (21%- 50%) High (>50%)

Select the types of debris found? (check all that apply)

☑ Street litter (e.g., cigarette filters)
☑ Food-related litter (e.g., packaging/containers)
☐ Medical items (e.g., syringes)
☐ Sewage-related (e.g., tampons, condoms)
☐ Natural debris (e.g., driftwood, algae)
☐ Building materials (e.g., wood/siding)
☐ Fishing-related (e.g., fishing line, nets, lures)
☑ Household waste (e.g., household trash, plastic bags)
☐ Tar/Oil (e.g., tar balls)
☐ Oil/Grease (e.g., oil slick)
☐ Other: ______________

Method for determining debris presence: (circle one) [✓ Visual observation] Cleanup event results Other: ________

Algae

Is algae present in the nearshore water, beach and/or shoreline? yes no don't know If present, document with photographs.

Select the amount (%) of algae in nearshore water: (circle one)
None Low (1%–20%) Moderate (21%–50%) High (> 50%)

SAME AS 3/16

Select the amount (%) of algae on the beach or shoreline: (circle one)
None Low (1%–20%) Moderate (21%–50%) High (> 50%)

Method for determining amount and color of algae: (circle one)
[✓ Visual observation] Other: ____________

Circle the types of algae found: (check all that apply) ☐ Periphyton (attached to rocks, stringy) ☐ Globular (blobs of floating material)
☐ Free floating (no obvious mass of materials) ☐ Other: ____________

Algae colors: (circle all that apply) Light green Bright green Dark green Yellow Brown Other:______

Is the nearshore water discolored? yes no don't know

If yes, specify the color: (circle all that apply) Clear Green Dark red Brown Yellowish Other:______

Harmful Algae Blooms

Is there presence of harmful algal blooms? yes [✓ no] don't know If yes, photograph and describe:

Method for identifying harmful algae blooms in nearshore water and beach: (circle one)
Field guide or internet site for taxonomic identification Other:____________

Are there mats or scum in nearshore waters? (circle all that apply) Mats-floating Foam Scum [✓ None]

Are there dead fish or other dead wildlife deaths present with bloom? yes [✓ no]

Have any illnesses (e.g., itchy throat, cough, gastrointestinal) been reported by local or state health departments? yes no
If yes, describe:

Is algal toxin monitoring conducted? yes [✓ no] don't know If yes, have algal toxins been detected? ____________

Have algal species been identified? yes [✓ no] don't know If yes, specify the species: ____________

Presence of Wildlife and Domestic Animals

Are wildlife and domestic animals present? yes no SAME AS 3/16 If yes, document with photographs.

Are dead birds found on the beach? yes no If yes, specify the number and species of dead birds.

Type	Number	Type	Number	Type	Number	Type	Number	Type	Number	Type	Number
Geese		Otters		Deer		Ducks		Rodents		Snakes	
Shorebirds		Turtles		Toads		Dogs		Beavers		Other	
Pigeons		Horses		Gulls		Frogs		Raccoons			

Method for determining presence of wildlife and domestic animals: (circle one)
Counting using hand-held counter and if necessary, binoculars Other (specify):____________

List the number and species of birds found dead on the beach

Type	# Dead	Type	# Dead	Type	# Dead	Type	# Dead
Common loon		Black-crowned night-heron		Long-tailed ducks		Ospreys	
Herring gulls		Double crested cormorants		Horned grebes		Common tern	
Ring-billed gulls		White winged scoter		Snowy egrets		Belted kingfisher	
Mallard ducks		Red-necked grebes		Great blue herons		Other: _____	

Method for determining the number of dead birds: (circle one)
Counting using hand-held counter and if necessary, binoculars Other:____________

Method for identifying dead birds: (circle one)
[✓ Field guide or internet site for taxonomic identification] Other:____________

Are dead fish found in the waterbody, on the beach or along the shoreline? yes no If yes, specify the number of dead fish found on the beach or in/at the waterbody and take photographs:

Method for determining the number of dead fish: (circle one) [✓ Visual observation] Other:____________

Additional comments or observations on pollution sources, algae, or animals. Describe any photos taken.

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☐ 1550 Main Street, Suite 400, Springfield, MA 01103
☐ 108 Myrtle Street, Suite 502, Quincy, MA 02171
☐ 540 North Commercial Street, Manchester, NH 03101
☐ 276 Newport Road, New London, NH 03257
☐ 205 Billings Farm Road, Suite 6B, White River Junction, VT 05001
☐ 5 Fletcher Street, Suite 1, Kennebunk, ME 04043
☐ 23046 Avenida de la Carlota, Suite 600, Laguna Hills, CA 92653
☐ Other ______

CHAIN-OF-CUSTODY RECORD 43617

Turnaround
☐ 24-Hour* ☐ 72-Hour* ☐ Other ______ (days)
☐ 48-Hour* ☒ Standard (____ days) *Surcharge Applies

PROJECT NAME	PROJECT LOCATION	PROJECT NUMBER	LABORATORY
COVENTRY	RI	20190164.A10	NET

REPORT TO: STEFAN BENGTSON
INVOICE TO: SAME
P.O. NO.:
Sampler's Signature: Date: 3/23/22

Source Codes:
MW=Monitoring Well PW=Potable Water T=Treatment Facility S=Soil B=Sediment
SW=Surface Water ST=Stormwater W=Waste A=Air C=Concrete
X=Other ______

Item No.	Transfer Check 1	Transfer Check 2	Transfer Check 3	Transfer Check 4	Sample Number	Source Code	Date Sampled	Time Sampled	Analysis Request: ENTEROCOCCUS								Containers: Soil VOA Vial, ☐ methanol	Soil VOA Vial, ☐ water	Glass Soil Container ( ) oz ☐ Na(SO$_4$)$_2$	Other:	Other:	Water VOA Vial, ☐ As is ☐ HCl	Glass Amber ( ) ml, ☐ As is ☐ H$_2$SO$_4$	Plastic - As is, ☐ 250 ml ☐ 500 ☐ 1000 ml (200ML)	Plastic - H$_2$SO$_4$, ☐ 250 ml ☐ 500 ml	Plastic - HNO$_3$, 250 ml ☐ Filtered ☐ 0.45µ ☐ 10µ	Plastic - NaOH, 250 ml	Comments
1					0139/220323-01	SW	3/23	1000	X															1				SEEP 1
2					-01D	SW		1000	X															1				" 1D
3					-02	SW		1020	X															1				" 2
4					-03	SW		1105	X															1				" 3
5					-04	ST		1130	X															1				BEACH OF
6					-05	ST		1205	X															1				DIXIE
7					-06	SW		1230	X															1				MID LAKE
8					-07	ST	✓	1500	X															1				YORK

Transfer Number	Relinquished By	Accepted By	Date	Time
1			3-23-22	15:52
2				
3				
4				

Charge Exceptions: ☐ CT Tax Exempt ☒ QA/QC ☐ Other ______
1 Duplicates ____ Blanks (Item Nos:)

Reporting and Detection Limit Requirements: ☐ RCP Deliverables ☐ MCP CAM Cert.

Additional Comments:

Appendix B

Additional Stormwater Retrofit Option Concepts

Tree box filters next to roadway

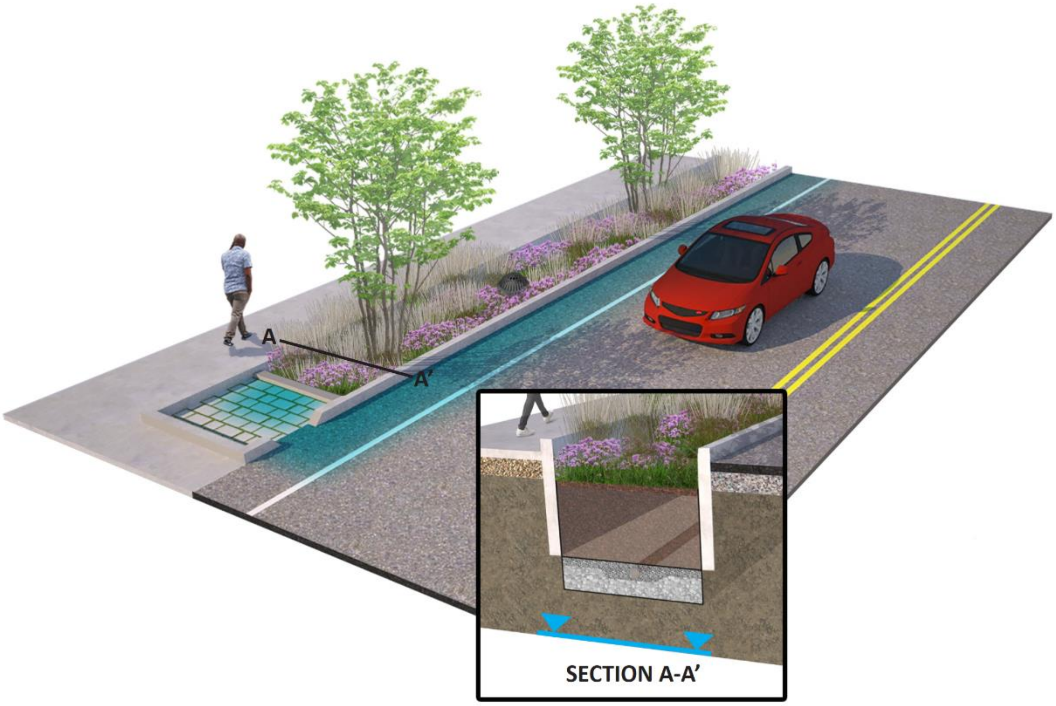

Figure 17: Curb inlet bioretention planter between sidewalk and roadway

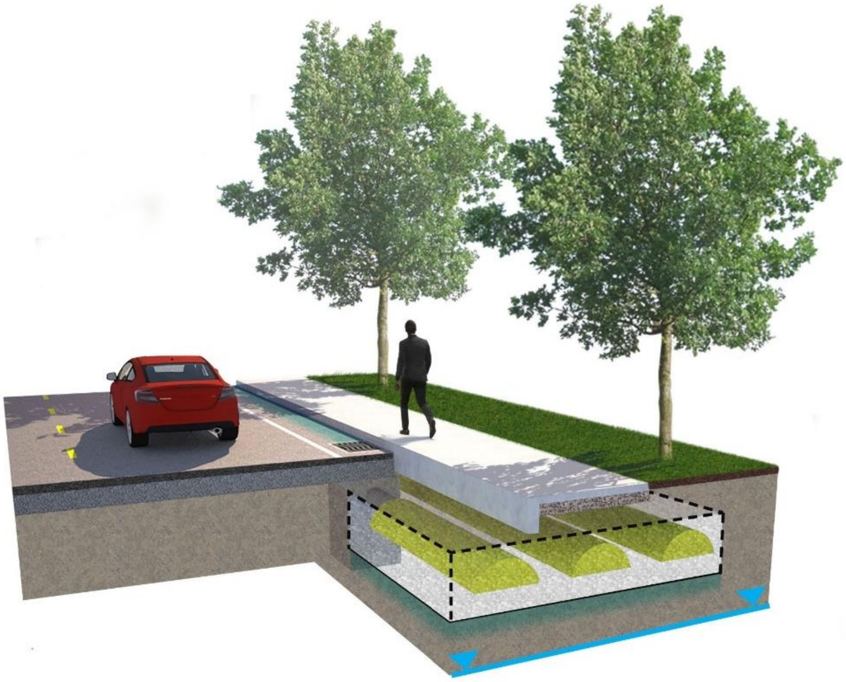

Figure 18: Subsurface infiltration chambers beneath sidewalk

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