Total Maximum Daily Loads for Phosphorus for the City of Newport Drinking Water Reservoirs

Nonquit Pond- Tiverton
Watson Reservoir- Little Compton
Lawton Valley Reservoir- Portsmouth
Sisson Pond- Portsmouth
St. Marys Pond- Portsmouth
North Easton Pond- Middletown, Newport
South Easton Pond- Newport
Gardiner Pond- Middletown
Paradise Pond- Middletown

Nonquit Pond 7/29/2015 (RIDEM)

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1.0 Introduction

Section 303(d) of the federal Clean Water Act requires states to prepare a list of surface waters in the state for which designated uses of the water are impaired by pollutants. Waterbodies placed on this list, known as the 303(d) List, require the preparation of Total Maximum Daily Loads (TMDLs) to identify and quantify sources of the impairments and establish acceptable pollutant loads from both point and nonpoint sources of pollutants which allow the impaired waterbody to meet water quality standards. A TMDL for a pollutant is the reservoir's loading capacity for that pollutant. A TMDL is the sum of the point source wasteload allocations (WLAs) and the nonpoint source load allocations (LAs) plus a margin of safety to account for the uncertainty in the relationship between the pollutant loads and the reservoir's water quality. TMDLs also include implementation strategies for reducing both point and nonpoint source pollutant loads.

The Rhode Island Department of Environmental Management (RIDEM) is responsible for ensuring that TMDLs are developed for impaired surface waters in Rhode Island. This Total Maximum Daily Load (TMDL) plan addresses total phosphorus (TP) and total organic carbon (TOC) impairments to nine drinking water reservoirs owned and operated by the City of Newport. These include Nonquit Pond, Watson Reservoir, Lawton Valley Reservoir, Sisson Pond, St. Marys Pond, North Easton Pond, South Easton Pond, Gardiner Pond, and Paradise Pond. These waters are listed on Rhode Island's 303(d) List of Impaired Waters and do not support the water quality goals, or designated uses, of drinking water supply and fish and wildlife habitat (aquatic life).

Using data collected in 2015, RIDEM evaluated the causal relationships between total phosphorus, algal growth and total organic carbon, which when brought into the drinking water treatment plants and chlorinated, results in formation of trihalomethane. Trihalomethanes (TTHMs) are associated with negative health effects, such as cancer and adverse reproductive outcomes. This evaluation resulted in the establishment of target phosphorus concentrations for the reservoirs such that algal growth and total organic carbon concentrations are reduced to a level that supports drinking water and aquatic life uses. The target phosphorus concentrations are the basis for development of the TMDLs.

Existing and allowable phosphorus loads to each reservoir were derived using well known methodologies, including spreadsheet-based land use modeling and application of nutrient load/lake response models. The existing phosphorus loads to each reservoir were estimated using available water quality data, application of nutrient load/lake response models, and land use-based watershed modelling. Allowable phosphorus loads were derived from the target phosphorus concentration applied to each reservoir. From these results, necessary reductions in phosphorus loading to each reservoir were then determined.

1.1 TMDL Study Area

The TMDL study area (Figure 1.1) includes the respective watersheds of the nine Newport Water Department surface water reservoirs mentioned above and located in the City of Newport and the Towns of Middletown, Portsmouth, Tiverton, and Little Compton, Rhode Island. This TMDL will supersede the TMDL completed for North Easton Pond as part of the Eutrophic Ponds Total Phosphorus TMDL completed by RIDEM in 2009 (RIDEM 2009).

1.2 Pollutants of Concern

Under the federal Clean Water Act, all states, territories, and tribes are required to comprehensively assess and report on the condition of their waters. Rhode Island's Water Quality Regulations classify all nine reservoirs as Class AA waters designated for use as a public drinking water supply source, primary and secondary contact recreational activities and fish and wildlife habitat. All nine reservoirs are listed as impaired for drinking water and aquatic life uses on the 303(d) List. The specific parameters (Table 1.1) causing these impairments are:

Total Phosphorus: impairs aquatic life use (contributes to frequent and excessive algal growth and cyanobacteria blooms).

Total Organic Carbon (TOC): impairs drinking water use (contributes to elevated levels of trihalomethanes in finished water).

Table 1.1. Newport Reservoir TMDL Impairment Information.

Waterbody	Location	Impairments	Waterbody ID	Waterbody Size (acres)
Nonquit Pond	Tiverton	Total Phosphorus Total Organic Carbon	RI0007035L-08	196
Watson Reservoir	Little Compton	Total Phosphorus Total Organic Carbon	RI0007035L-07	371
Lawton Valley Reservoir	Portsmouth	Total Phosphorus Total Organic Carbon	RI0007035L-06	81
Sisson Pond	Portsmouth	Total Phosphorus Total Organic Carbon	RI0007035L-10	69
St. Marys Pond	Portsmouth	Total Phosphorus Total Organic Carbon	RI0007035L-05	112
North Easton Pond	Middletown	Total Phosphorus Total Organic Carbon	RI0007035L-03	113
South Easton Pond	Middletown, Newport	Total Phosphorus Total Organic Carbon	RI0007035L-04	219
Gardiner Pond	Middletown	Total Phosphorus Total Organic Carbon	RI0007035L-01	92
Paradise Pond	Middletown	Total Phosphorus Total Organic Carbon	RI0007035L-02	29

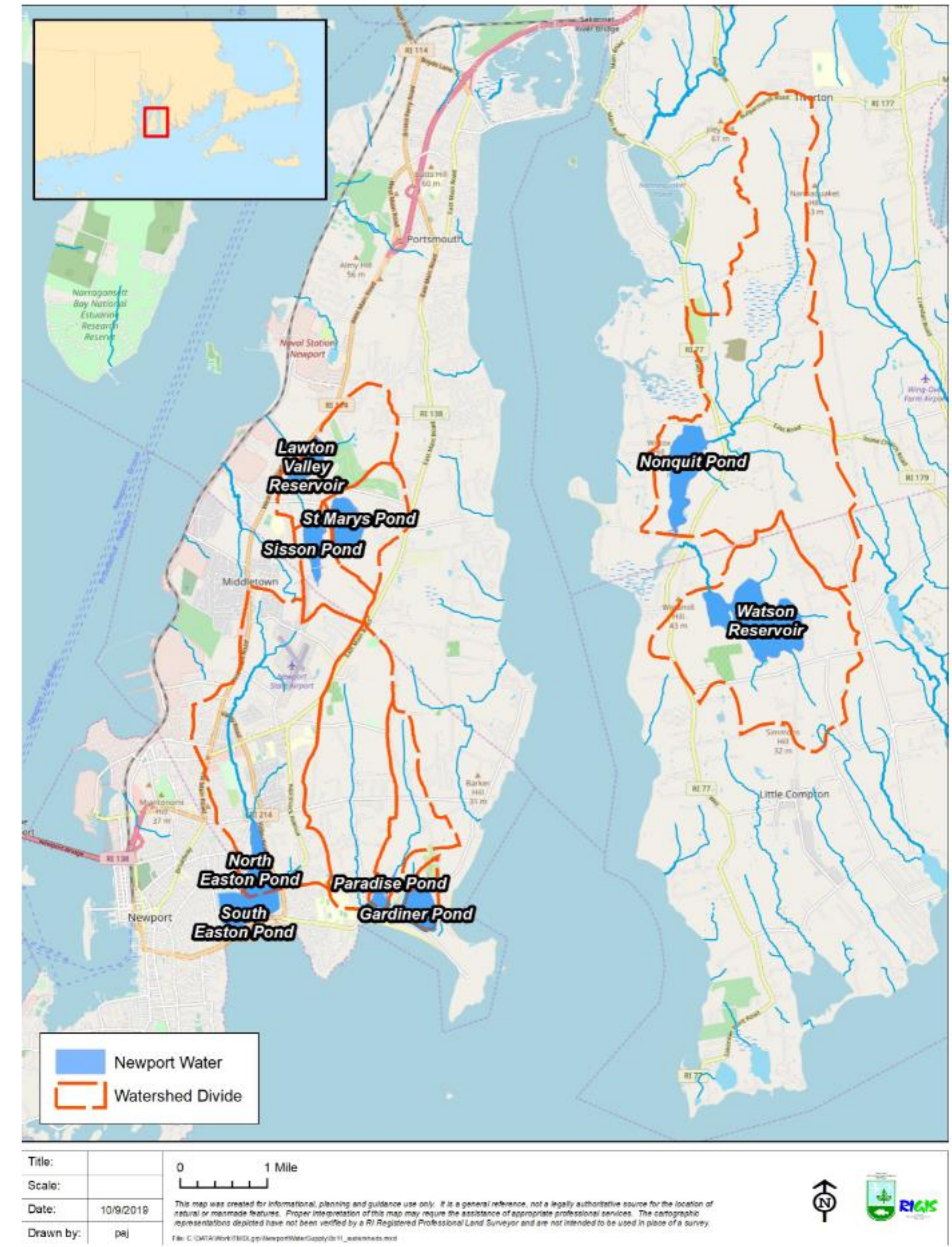


Figure 1.1 Newport Water Department Water Supply Reservoirs.

This TMDL has been developed for total phosphorus- the expectation being that reductions in total phosphorus loadings to the reservoirs will result in reductions in phytoplankton biomass, which in turn, will result in reduced levels of algal-derived organic carbon, addressing the total organic carbon impairment.

1.3 Priority Ranking

The 303(d) List identifies impaired waterbodies and a scheduled time frame for development of TMDLs. As such, it is used to help prioritize the State's water quality monitoring and restoration planning activities. Scheduling is not necessarily representative of the severity of water quality impacts, but rather reflects the priority given for TMDL development with consideration to shellfishing waters, drinking water supplies and other areas identified by the public as high priority areas.

1.4 Applicable Water Quality Standards

A water quality standard defines the water quality goals of a surface waterbody, or portion thereof, by designating the use or uses of the water and by setting criteria necessary to protect those uses. Water quality standards are intended to protect public health, safety, and welfare, enhance the quality of water and serve the purposes of the federal Clean Water Act. The most recent iteration of the State's Water Quality Regulations https://rules.sos.ri.gov/regulations/part/250-150-05-1 was completed in 2018 (RIDEM 2018a) and is the basis for setting water quality targets in this TMDL.

Water Use Classification and Designated Uses

Surface waters of the state are categorized according to the water use classifications of § 1.9(B)of Rhode Island's Water Quality Regulations (RIDEM 2018a) based on public health, recreation, propagation and protection of fish and wildlife, and economic and social benefit. Each class is identified by the most sensitive, and therefore governing, water uses to be protected. Surface waters may be suitable for other beneficial uses but are regulated to protect and enhance the designated uses. Water quality classifications represent the water quality **goals** for the waterbody, as described in § 1.9(B)of the regulations, not the present conditions. All nine of the reservoirs owned and operated by the Newport Water Division are Class AA waters, which are excerpted from RIDEM's Water Quality Regulations (RIDEM 2018a):

Class AA- These waters are designated as a source of public drinking water supply (PDWS) or as tributary waters within a public drinking water supply watershed (the terminal reservoir of the PDWS are identified in § 1.25 of this Part), for primary and secondary contact recreational activities and for fish and wildlife habitat. These waters shall have excellent aesthetic value.

Numeric and Narrative Water Quality Criteria

Existing numeric and narrative criteria for total phosphorus are provided in § 1.10(D)(1) of RIDEM's Water Quality Regulations (RIDEM 2018a) and are excerpted below.

Average Total phosphorus shall not exceed 0.025 mg/l in any lake, pond, kettlehole or reservoir, and average Total P in tributaries at the point where they enter such bodies of water shall not cause exceedance of this phosphorus criteria, except as naturally occurs, unless the Director determines, on a site-specific basis, that a different value for phosphorus is necessary to prevent cultural eutrophication.

None in such concentration that would impair any usages specifically assigned to said Class or cause undesirable or nuisance aquatic species associated with cultural eutrophication, nor cause exceedance of the criterion above in a downstream lake, pond, or reservoir. New discharges of wastes containing phosphates will not be permitted into or immediately upstream of lakes or ponds. Phosphates shall be removed from existing discharges to the extent that such removal is or may become technically and reasonably feasible.

Numeric Water Quality Targets applicable for this TMDL

This TMDL establishes site specific total phosphorus and chlorophyll-*a* targets to control phytoplankton growth and reduce total organic carbon concentrations. Analysis of existing reservoir data indicates that phosphorus is the primary driver of chlorophyll in the Newport Water Supply reservoirs, which is typically expected in freshwater lakes and reservoirs. Although recent research has shown that nitrogen can influence the formation and toxicity of freshwater cyanobacteria blooms, RIDEM does not believe the site-specific information collected for TMDL development concludes that nitrogen targets are needed to reduce 1) the eutrophic/hyper-eutrophic conditions found in the Newport reservoirs, 2) the frequent and long-lasting cyanobacteria blooms which affect the reservoirs, and 3) potential toxin production in the reservoirs.

In addition, Rhode Island lacks numeric criteria for total nitrogen in freshwaters. A separate process is underway, including a data analysis QAPP, to develop numeric nutrient criteria appropriate for Rhode Island's freshwater lakes. Rhode Island views that process as the best way to determine if and when nitrogen should be listed as an impairment requiring TMDL development in freshwater lakes. Development of nitrogen TMDLs outside of this process is not complementary to that approach and could potentially undermine the work that has already been completed but not finalized. Therefore, total nitrogen targets for the water supply reservoirs are not being pursued at this time.

Using data collected from all nine reservoirs in 2015 and data from twenty-one (21) reservoirs in New York State in 2103, RIDEM evaluated empirical relationships between nutrients, algal growth, total organic carbon, and the potential for total trihalomethane production. The findings from this study, presented in Section 5.0 of the TMDL, indicate that seasonal mean epilimnetic, or 1m below surface when not stratified, total phosphorus and chlorophyll-*a* targets of 18 ug/l and 11 ug/l, respectively, would be protective of the designated uses in Newport's drinking water reservoirs. The target total phosphorus concentration for the reservoirs, on which the allowable total phosphorus loads for these TMDL's are based is 18 ug/l. The target total phosphorus concentration of 18 ug/l is meant to be expressed and evaluated as a growing season epilimnetic, (or 1m below surface when not stratified), mean.

Antidegradation Policy

Rhode Island's antidegradation policy requires that, at a minimum, the water quality necessary to support existing uses be maintained (see § 1.20(B), Tier 1 in the State of Rhode Island's Water Quality Regulations). If water quality for a particular parameter is of a higher level than necessary to support an existing use (i.e. bacterial levels are significantly below Class B standards), that improved level of quality should be maintained and protected (see § 1.20(C), Tier 2 in the State of Rhode Island's Water Quality Regulations) (RIDEM 2018a).

2.0 Background

2.1 Water System and Reservoir Descriptions

The original water works in Newport started in 1876. The Newport Water Works Company was incorporated in 1881 and was succeeded by the Newport Water Corporation in 1929. Since 1936, the City of Newport has owned and operated the system. The Newport Water System is owned by the City of Newport and operated and maintained by the City's Department of Utilities, Water Division.

The Newport Water system consists of a complex network of nine surface water reservoirs, two treatment plants, four finished water storage facilities, in addition to clearwells at the treatment plants, booster pump stations for both raw and treated water, and close to 200 miles of distribution piping. The system serves approximately 14,700 retail customers across Aquidneck Island (Newport, Middletown, and a small section of Portsmouth) and sells water to the Portsmouth Water and Fire District (PWFD) and Naval Station Newport (10 connections) on a wholesale basis.

Source of supply can be obtained from nine (9) surface water reservoirs. The reservoirs are located in Newport, Portsmouth, Middletown, Tiverton, and Little Compton. The combined watershed area is almost 20 square miles, and only about 1 square mile is within the City of Newport. Sewer services are provided in three of the nine drinking water supply watersheds: North Easton Pond, Paradise Pond, and Gardiner Pond watersheds. Sewer services are also provided in the Maidford River watershed. Water from the Maidford River can be diverted into Paradise Pond or Gardiner Pond.

Physical characteristics of the nine reservoirs are summarized in Table 2.1. Reservoir function designation is based on the service use of the reservoir. All nine reservoirs are designated as storage reservoirs because they collect and store runoff from their respective watersheds. Several other reservoirs are designated as raw water distribution reservoirs because they can provide intermediate storage between another reservoir and one of the treatment plants. The reservoirs and ponds were all artificially built and are interconnected through a complex network of piping and pump stations allowing each reservoir to have multiple inflow and outflows (Table 2.2). These interconnections are graphically displayed in Figure 2.1.

Table 2.1. Various Physical Characteristics of the Newport Water Supply Reservoirs.

Reservoir	Surface Area (m^2)[1]	Mean Depth (m)[1]	Direct Watershed Size (km^2)	Reservoir Function Designation	Main Tributaries
Watson Reservoir	1,506,595	4.41	9.29	Storage	Various ephemeral unnamed
Nonquit Pond	808,940	2.65	17.96	Storage	Borden Brook Quaker Brook Various unnamed
Lawton Valley Reservoir	322,524	4.95	3.00	Storage and Distribution	Sisson Brook Various unnamed
Sisson Pond	253,325	1.75	0.92	Storage and Distribution	none
St. Marys Pond	430,976	1.80	2.21	Storage and Distribution	none
North Easton Pond	436,656	2.70	11.41	Storage and Distribution	Bailey Brook
South Easton Pond	605,005	2.71			
Gardiner Pond	403,863	3.99	0.59	Storage	Maidford River
Paradise Pond	125,853	3.02	2.22	Storage	Maidford River Paradise Brook

1 At full capacity

Table 2.2. Newport Water Supply Reservoir interconnection summaries.

Reservoir	Source of Inflow	Outflow Transfer Method	Destination of Outflow
Nonquit Pond	Watershed Drainage Quaker Brook Borden Brook Unnamed tributaries	Sakonnet Pumping Station and Pipeline	St. Marys Pond Lawton Valley WTP North Easton Pond via Bailey Brook
Watson Reservoir	Watershed Drainage Unnamed tributaries	Sakonnet Pumping Station and Pipeline	St. Marys Pond Lawton Valley WTP North Easton Pond via Bailey Brook
Lawton Valley Reservoir	Watershed Drainage Sisson Pond via Lawton Valley Brook Watson Reservoir St. Marys Pond Nonquit Pond	Pumping Station and Pipeline	Lawton Valley WTP
Sisson Pond	Watershed Drainage St. Marys Pond	Sisson Pond Stream Unnamed stream to	Lawton Valley Reservoir Bailey Brook
St. Marys Pond	Watershed Drainage Watson Reservoir Nonquit Pond	St. Marys Pumping Station and Pipelines Reservoir spillage to Sisson Pond	Lawton Valley WTP North Easton Pond via Bailey Brook
North Easton Pond	Watershed Drainage Bailey Brook St. Marys Pond Paradise Pond Gardiner Pond Sisson Pond South Easton Pond	Pumping Station and Pipeline South Easton Pond	Station 1 WTP (at North Easton Pond
South Easton Pond	Watershed Drainage North Easton Pond Paradise Pond Gardiner Pond	Pumping Station and Pipeline	Station 1 WTP (at North Easton Pond)
Paradise Pond	Watershed Drainage Paradise Brook Maidford River Gardiner Pond	Paradise Pump Station and Pipeline	Station 1 WTP Gardiner Pond North Easton Pond South Easton Pond
Gardiner Pond	Watershed Drainage Maidford River Paradise Pond	Paradise Pump Station and Pipeline	Station 1 WTP Paradise Pond North Easton Pond South Easton Pond

Figure 2.1. Graphic Display of Newport Water Supply Reservoir Interconnections.

2.2 Land Use- Land Cover

General land use in the watersheds of Newport's water supply reservoirs is displayed in Figures 2.2 and 2.3. As seen in these figures, a mixture of land uses exists in the nine reservoir watersheds with more rural land uses dominating in Watson Reservoir and Nonquit Pond. Significant amounts of agricultural land uses are also present in the watersheds of Watson Reservoir, Gardiner Pond, Nonquit Pond, and Paradise Pond. The combined watershed for all nine reservoirs contains approximately 26% urbanized land, 30% agricultural land, and 44% forested/wetland.

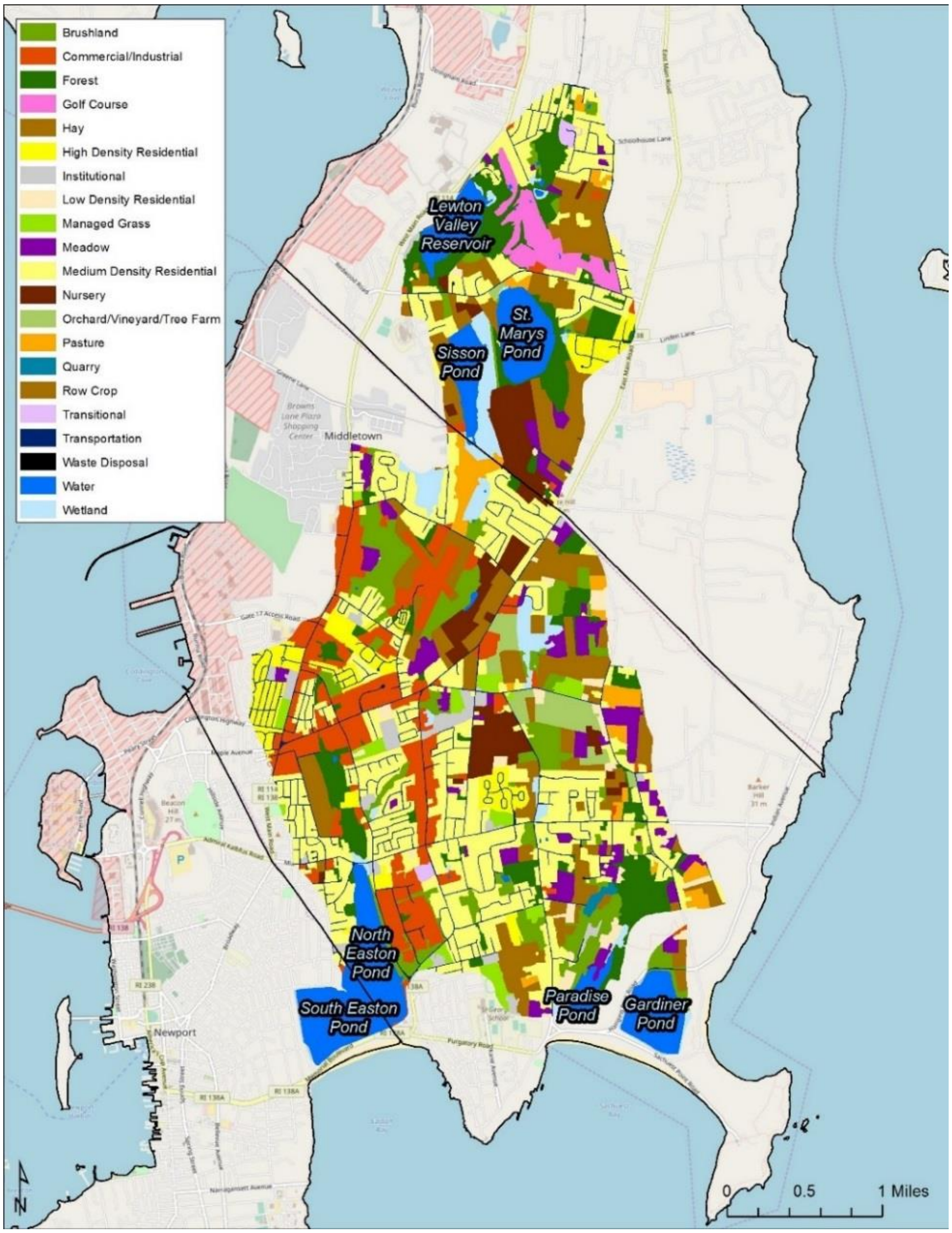


Figure 2.2. General Land Use in the Newport Watersheds- Aquidneck Island.

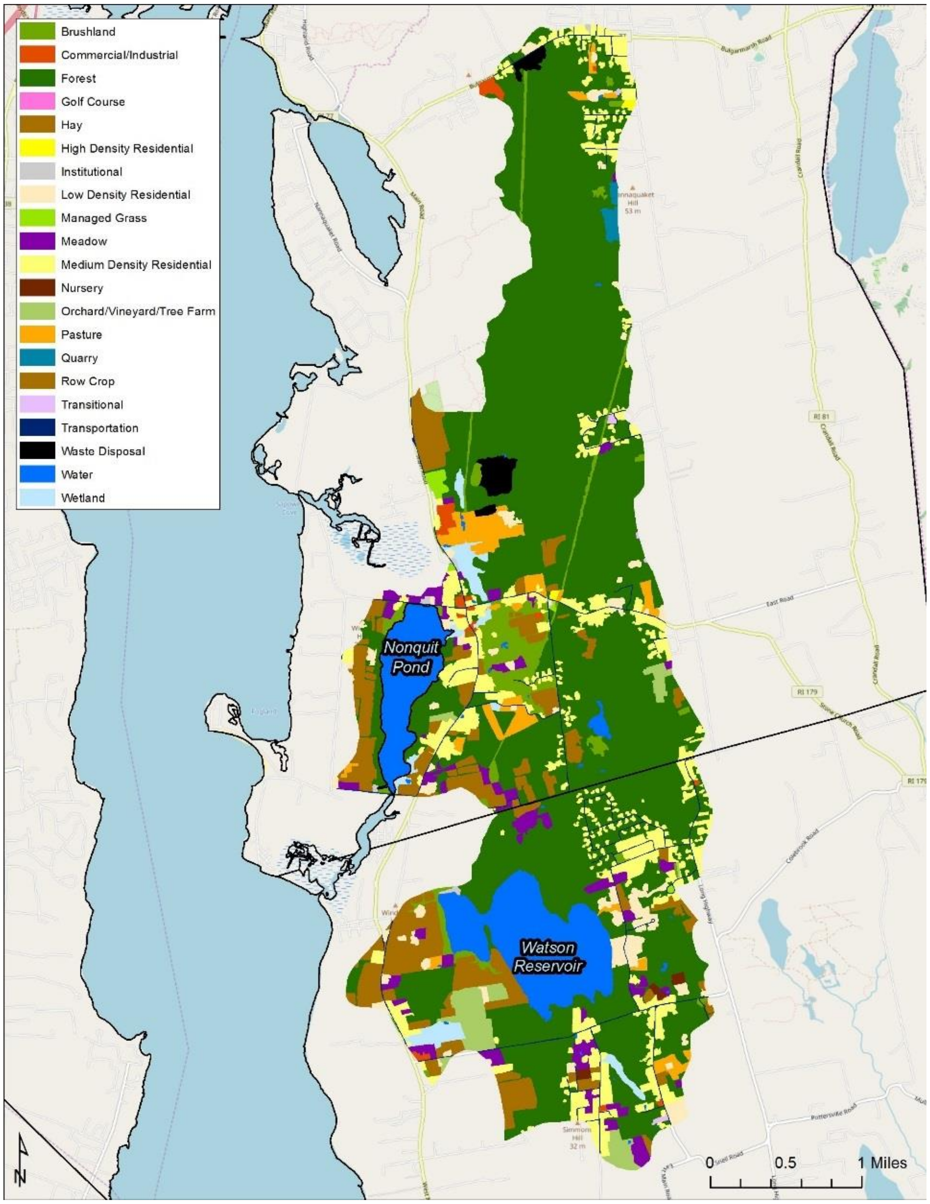


Figure 2.3. General Land Use in the Newport Watersheds- Tiverton and Little Compton.

2.3 Upgrades in Water Treatment Process

In 2004, the City of Newport completed a Water Treatment Plant Compliance Evaluation. The purpose of this evaluation was to assess current and future regulatory compliance as well as the physical condition of Newport's two water treatment plants – Station 1 Water Treatment Plant and Lawton Valley Water Treatment Plant (WTP). The most significant challenge that was identified was achieving compliance with new regulations (Phase II) for TTHMs (total trihalomethanes). The Compliance Evaluation concluded that the Lawton Valley WTP was beyond its useful life in terms of facilities and equipment and could not be cost-effectively upgraded and therefore should be replaced with a new plant. The study also concluded that the Station 1 WTP required upgrading to restore its reliable treatment capacity to 9 million gallons per day (mgd).

In 2008, the City of Newport entered into a Consent Agreement with the Rhode Island Department of Health under which improvements to the water treatment plants would be completed by December 2014. In 2009 and 2010, the City conducted detailed pilot testing studies to determine the optimal treatment method to reduce TTHMs. This included evaluation of "conventional" treatment as well as "advanced" treatment. The findings of the pilot testing studies showed that "conventional" treatment by itself did not achieve sufficient level of organics removal to control TTHMs and that it would be necessary to include "advanced" treatment in the new facilities.

In January 2012, the Newport City Council approved the award of a design build contract with a value of $67 million. The funding for the water treatment plant projects was provided by subsidized loans from the Drinking Water State Revolving Fund (DWSRF), administered by the Rhode Island Clean Water Finance Agency (RICWFA) and the Rhode Island Department of Health, Office of Drinking Water Quality (RIDOH). The design build contract included the design, permitting, and construction of the new Lawton Valley Plant and the upgrades to the Station No. 1 Plant. Also included was the required acceptance testing of the two plants, training of City personnel, and demolition of the existing Lawton Valley treatment facilities.

The new treatment process is standardized at both plants and consists of preoxidation (using chlorine dioxide), clarification (using dissolved air flotation or "DAF"), granular media filtration, advanced treatment, disinfection (using chlorine), and treatment (adjustment of the pH) to control the corrosivity of the water. For the method of advanced treatment, GAC (granular activated carbon) contactor to reduce TTHMs was incorporated. The GAC contactors offer additional benefits of more robust control of taste and odors, which were particularly suitable for addressing late-summer algae blooms that occur in the city's reservoir supplies. Newport Water anticipates that the advanced treatment will initially be operated only during the months of May through October and bypassed when not required to save operating costs. However, if required at some point in the future due to regulatory changes and or need, the advanced treatment process can be used year-round.

Construction activities at both facilities began in September 2012. The Phase 1 treatment improvements at the Station 1 facility went into service on May 30, 2013. The Phase 2 treatment improvements at Station 1 went into service on July 25, 2014. The new Lawton Valley facility went into service September 17, 2014. The Newport water treatment plants are the only facilities in Rhode Island to have advanced treatment.

2.4 Source Water Protection Initiative

Since construction of the new drinking water treatment facilities with advanced treatment processes was completed by the Newport Water System in 2014, Aquidneck Island residents and businesses are experiencing improved quality of water flowing from their taps. Though the "finished" water has improved, the quality of the raw water that necessitated these improvements has not changed. The nine source reservoirs continue to be nutrient enriched and experience frequent algal and cyanobacteria blooms – necessitating the continued use of copper sulfate and impacting the reservoirs' use for drinking water purposes as well as ecosystem health.

Controlling pollutants at their source (as opposed to removing them in the drinking water treatment process) can reduce potential human health risks, as well as reduce treatment costs. In terms of public health protection, good source water quality and development and implementation of source water protection programs are some of the multiple barriers that help ensure safe water. From an operations perspective, the higher the quality of the source water; the less money a drinking water utility will need to spend on treatment chemicals, equipment, and labor.

While drinking water utilities can treat contaminated water and make it safe to drink, the treatment process can be expensive and associated costs are passed on to the water system's customers. Treatment for some contaminants can also be technically difficult and potentially result in unintended consequences. For example, all drinking water utilities that use surface water must disinfect to ensure pathogens are inactivated, but high organic content in surface water can combine with certain disinfectants and lead to an increase in disinfection-by-products (DBPs), including TTHMs, that also pose health risks. Improved source water quality will also generally reduce customer complaints about taste and odor. Finally, compliance with drinking water regulations is made easier if source water concentrations of various bacteria, natural organic matter, nitrate, pesticides, metals, and other regulated contaminants are limited and controlled.

The ***Source Water Protection Initiative for Newport Water Supply Reservoirs***[1] is an effort initiated by the RI Department of Environmental Management, in coordination with the RI Department of Health, to improve the quality of the Newport Water System's (Newport Water) nine source reservoirs. Improvement to the water treatment facilities alone is not considered enough response to the degraded condition of the Newport source waters. Protection of a water supply's source waters is considered by the Department of Health as the frontline in protecting public health and is essential to the long-term viability of Aquidneck Island's water supply. The establishment of TMDLs for the water supply reservoirs is a major component of this effort.

[1] www.dem.ri.gov/programs/benviron/water/quality/rest/PDFs/nptstudy.pdf

3.0 Designated Use Impairments

3.1 Background

The quality of the raw water delivered from the reservoirs to the two treatment plants is of specific concern during summer and fall when environmental conditions favor peak phytoplankton growth and general community dominance by cyanobacteria. Based on data and/or observations in 2011, 2012, and 2015-2017, all nine of Newport Waters drinking water reservoirs exhibit elevated concentrations of phosphorus and experience frequent and long-lasting cyanobacteria blooms. Newport Water relies heavily on the use of copper sulfate in the surface water reservoirs, and in some reservoirs, aeration, to prevent/control these blooms; however, RIDEM staff observations and monitoring data confirm that these treatments have limited long-term effect on algal/cyanobacteria biomass in the surface water.

While phytoplankton play a key role in freshwater ecosystems, its excessive proliferation can become a significant problem for waterbodies used for drinking water supply. Available data from all nine reservoirs consistently indicate phosphorus limitation. Elevated levels of phosphorus are the primary cause of increased algal growth in the water supply reservoirs, although temperature, solar radiation, and other factors also play a role in algal growth. Excessive algal growth can lead to impairments in surface waters used for drinking water by: 1) contributing to total organic carbon (TOC) and turbidity (e.g., algae cells), 2) producing taste and odor compounds, and, 3) contributing precursors which form disinfection by-products (DBP) upon chlorination, such as trihalomethanes (THMs) and haloacetic acids (HAAs) (Nguyen et al 2005).

The primary goal of this TMDL is to reduce phosphorus loadings to the water supply reservoirs so that the designated uses are met. Reductions in phosphorus loadings are expected to result in decreased levels of phytoplankton, including cyanobacteria, as well as algal-derived total organic carbon content of the source waters. Understanding the links between nutrient enrichment and drinking water human health concerns is essential to 1) evaluating the existing drinking water use impairments and 2) developing phosphorus and chlorophyll a targets for the reservoirs that are protective of the drinking water use designation. These linkages are described further in Section 5.0 of this TMDL.

3.2 303(d) Drinking Water Use Impairment Listing

As part of the biennial Integrated Report assessment process, the Department of Health's Center for Drinking Water Quality (DWQ) works with DEM's Office of Water Resources to define and describe the methodology utilized to assess drinking water use status of public surface water systems. This methodology is published in DEM's Consolidated Assessment and Listing Assessment Methodology (CALM) for Section 305(b) and 303(d) Integrated Water Quality Monitoring and Assessment Reporting. The data utilized by DWQ to determine the drinking water use attainment status consists of ambient (source) water quality data, information about the level of treatment required, and finished water quality data. The use support status is based on violations of the maximum contaminant levels (MCLs), use restrictions, and/or best professional judgement by the DWQ staff.

The following criteria are used to evaluate drinking water designated use status:

- Compliance with SDWA standards (MCLs) in the finished drinking water,
- Finished Drinking Water Restrictions-use advisories associated with source water contamination,
- Treatment Requirements-contaminants in source water that requires more than conventional treatment,
- Finished water fecal coliform bacteria

Further, the guidance in the CALM states that surface source waters are considered impaired for drinking water use when there are violations of the MCLs, and/or requirements for more than conventional treatment, and/or frequent taste and odor problems, and/or contamination-based closures of the source water.

Prior to treatment plant upgrades, Newport Water and its consecutive wholesale water customers (Portsmouth and the Navy) have a history of violation of the MCL for disinfection by-products (trihalomethanes) and customer reported periodic taste and odor problems. Newport Water has upgraded its treatment facilities to include advanced treatment (beyond conventional treatment) to enable them to adequately treat the water for both of these issues; however, the Department of Health, Center for DWQ believes that these improvements alone are not sufficient response and that the first barrier protecting public health should be source water protection.

In 2014, the Department of Health determined that the Newport source water reservoirs should be listed as impaired with respect to their drinking water designated use. The cause of this impairment is high total organic carbon from excessive algal abundance fueled by excessive phosphorus loadings. When chlorinated, the high total organic content of the water has often resulted in violations of the MCL for trihalomethanes.

3.3 303(d) Aquatic Life Use Impairment Listing

The 2014 303(d) listings for aquatic life use impairment for total phosphorus for eight of the nine drinking water reservoirs originated from analysis of 2011 and 2012 datasets collected by the Newport Water Department. These data also confirmed the previously listed aquatic life use impairment for the ninth reservoir, North Easton Pond, that was first listed for total phosphorus in 2006 and for which a TMDL was completed by RIDEM and approved by EPA on Sept. 27th, 2007.

These listings were confirmed with additional data collected by RIDEM in 2015. All listings are based on comparison of the existing water quality criteria for total phosphorus (not to exceed 0.025 mg/l) to seasonal epilimnetic mean total phosphorus values obtained during 2011-2012 and 2015. These data are displayed below in Table 3.1 and confirm exceedances of the water quality criteria for total phosphorus in all nine reservoirs.

Table 3.1. Mean epilimnetic total phosphorus concentrations in the Newport reservoirs.

Reservoir	2011 Mean TP (mg/l)[1]	2012 Mean TP (mg/l)[1]	2015 Mean TP (mg/l)[1]
Nonquit Pond	**0.038**	**0.100**	**0.041**
Watson Reservoir	0.022	**0.058**	0.022[2]
Lawton Valley Reservoir	**0.030**	**0.036**	**0.042**
Sisson Pond	**0.054**	**0.103**	**0.088**
St. Marys Pond	0.023	**0.079**	**0.079**[2]
North Easton Pond	**0.068**	**0.048**	**0.057**
South Easton Pond	0.025	**0.034**	**0.037**
Gardiner Pond	**0.026**	**0.032**	**0.043**
Paradise Pond	**0.058**	**0.078**	**0.080**

[1] Annual Sample size (n=12) RIDEM samples only.
[2] Includes additional data collected in 2015 by contractors to the Newport Water Department.
Bold font indicates exceedance of aquatic life criterion value of 0.025 mg/l (expressed as seasonal mean).

3.4 Cyanobacteria Blooms in the Newport Reservoirs

Cyanobacteria, also known as blue-green algae, are photosynthetic bacteria naturally present in surface waters in low or moderate numbers. Cyanobacteria can occur as single cells or in groups, as colonies or filaments. They can be found in fresh, marine and brackish waters. Frequently occurring genera in freshwaters include *Anabaena, Aphanizomenon, Cylindrospermopsis, Lyngbya, Microcystis, Oscillatoria,* and *Planktothrix.*

One of the potential effects of excess nutrients in lakes and reservoirs is the prevalence and/or dominance of the total phytoplankton community by cyanobacteria. When the density of cyanobacteria leads to the presence of scum on the lake surface or significant discoloration of the water, they are known as harmful algal blooms (HABs). The frequency and severity of HABs has been linked to increased nutrient loading from human activities (Lopez *et al*. 2008), and cyanobacterial HABs are considered one of the clearest indicators of excess nutrient concentrations (Paerl and Fulton, 2006). Cyanobacteria can produce neurotoxins (nervous system), hepatotoxins (liver) and dermatoxins (skin), posing a threat to human health when blooms occur in drinking water supplies. Additionally, cyanotoxins in recreational waters can pose a danger to people, pets, and livestock when they come in contact with the water.

Since 2010, the Rhode Island Department of Health (Health) and RIDEM Office of Water Resources have worked cooperatively to detect and respond to the presence of cyanobacteria blooms in Rhode Island, evaluate the potential risks to the public, and, when necessary, issue health advisories notifying the public of health concerns. The agencies jointly issue recreational advisories when any of the following three guidelines are met:

- Evidence of a visible cyanobacteria scum or mat or lake/pond-wide cyanobacteria bloom.
- Cyanobacteria cell count exceeding 70,000 cells/ml.
- Toxin (Microcystin-LR) level of lysed cells meeting or exceeding 4 ppb (µg/l).[2]

Recreational advisories recommend that individuals avoid all recreational contact with the affected waterbody, including recreational activities such as swimming, boating, or fishing.

[2] Microcystin level has changed as USEPA guidance has developed

People are also advised to not eat fish from the affected waterbody or to allow pets to wade or swim in, or drink untreated water from the affected waters.

RIDEM became aware of the existence of cyanobacteria blooms in the water supply reservoirs in 2011 when they were documented by consultants contracted by the Newport Water Department to collect water quality data on the reservoirs during 2011-2012. Cyanobacteria blooms were also documented in 2012 and by RIDEM staff every year from 2015 to 2019. No reservoir sampling or surveillance by RIDEM staff occurred in 2013 and 2014, therefore no blooms were documented. It is noteworthy that despite frequent application of copper sulfate, all nine water supply reservoirs exhibit long lasting and severe cyanobacteria blooms. Observations and photographs by RIDEM staff documented these blooms, and various samples collected from raw water samples have shown the following cyanotoxin results:

- In 2015 a sample collected from Sisson Pond exhibited an anatoxin level of 80 ug/l. A visible orange-red bloom was evident on the pond with scum covering the entire shoreline.

- In 2016 a sample collected from Watson Reservoir exhibited a total microcystin level of 3.9 ug/l. A second sample, two weeks later, showed a microcystin level of 5.3 ug/l.

- In 2016 a sample collected from Lawton Valley Reservoir exhibited a microcystin level of 20.0 ug/l.

- In 2016 a sample collected from Paradise Pond exhibited a microcystin level of 1.0 ug/l.

- In 2017 a sample collected from Lawton Valley Reservoir exhibited a microcystin level of 42.0 ug/l.

- In 2017 a sample from Sisson Pond exhibited a microcystin level of 5.8 ug/l.

The aquatic life and drinking water use impairments for the water supply reservoirs are described above in Sections 3.2 and 3.3. 40 CFR section 130.7(b)(5) requires that "Each State shall assemble and evaluate all existing and readily available water quality related data and information to develop the 303(d) List" including what is referred to as 'observed effect(s)'. EPA (2006) defines "observed effect(s) as:

"Observed effect(s) Direct manifestations of an undesirable effect on waterbody conditions. For example, fish kills, fish lesions, depressed populations of certain aquatic species, cyanobacteria hepatotoxic microcystins, and bioassessment scores are observed effects indicating changes in aquatic communities. Major algal blooms, undesirable taste and odor in raw and finished drinking water, and increased incidences of gastroenteritis and other waterborne diseases among swimmers are also observed effects. Depending on a state's water quality standards and specific waterbody conditions, observed effects may form the basis of an impairment decision. For example, depending on the magnitude and cause of a fish kill, this observed effect may or may not result in an assessment of "impaired." Generally speaking, pollutants and pollution are not considered observed effects (e.g., lead, pesticides, phosphorus); rather, they are causes of observed effects."

For the 2018/2020 Integrated report cycle, RIDEM added 'Cyanobacteria Hepatoxic Microcystins' as an observed effect to all water supply reservoirs, excluding Nonquit Pond. This is a result of documented HABs in the reservoirs that have resulted in issuance of recreational/health advisories. This observed effect is associated with aquatic life and primary and secondary contact recreational uses.

In 2015, RIDOH's Center for Drinking Water Quality required all public water suppliers in the state to collect raw and finished water samples for cyanotoxin analysis. Samples from the water supply reservoirs collected between 2015-2017 were submitted to the State Health Laboratory in Providence, RI and were identified (on the genus level) and enumerated (using colony counts). The most common genus of cyanobacteria identified in the nine reservoirs were: *Microcystis*, *Anabaena*, and *Aphanizomenon*. Samples were also analyzed for various cyanotoxins including total microcystins, anatoxin, cylindrospermopsin, and nodularin. All finished water toxin levels were less than the detection limit (1.0 ppb for all toxins).

The RIDOH Center for Drinking Water Quality has recently updated federal requirements related to implementation of the Safe Drinking Water Act. These regulations were effective October 31, 2018 and are available at: https://rules.sos.ri.gov/regulations/part/216-50-05-1. These updates include changes related to improving public water system emergency response, resilience to storms, and managing the risk of algal toxins. The Treatment Optimization Protocol (TOP) is a document that requires all Public Water Systems under the Algal Toxin Rule to document and submit information about both a) their current treatment system and b) proposed treatment solutions under a variety of bloom conditions. The algal toxin rule requires that any systems that use surface water must submit their response and treatment plans (TOPs) to the RIDOH Center for Drinking Water Quality for approval, and those cover a wide variety of scenarios that include toxin detections. The Newport Water Division does have advanced treatment in place to remove cyanotoxins.

The Center for Drinking Water Quality provides assistance to public water systems in completing the TOP, including but not limited to:

- Reviewing current treatment systems, if any, for efficacy in algal toxin treatment/removal.
- Assessing source water vulnerabilities and methods of bloom management.
- Providing documentation (e.g. manufacturer's specification sheets, price quotes, installation and shipping time estimates, etc.) for any proposed treatment alterations.
- Exploring options for additional treatment designed for algal toxin treatment/removal.

4.0 Identification of Sources of Phosphorus to the Water Supply Reservoirs

Sources/source categories of phosphorus to the Newport reservoirs have primarily been identified utilizing a combination of land use modelling, field reconnaissance and targeted sampling to bracket suspected sources, and collection of continuous nutrient and flow data in several tributaries under baseflow and stormflow conditions. Much of this work has been conducted by RIDEM Office of Water Resources staff, but additional efforts at source identification/characterization (and pollution source control) have been undertaken by various entities, including the City of Newport, Town of Middletown, Aquidneck Land Trust, and the University of Rhode Island.

Land Use Modelling with the Watershed Treatment Model

The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection (http://www.cwp.org/pollution-calculators/), is a spreadsheet-based model used to calculate annual pollutant loads (total phosphorus, total nitrogen, total suspended sediment, and fecal coliform) and runoff volumes as well as estimate benefits from a wide range of stormwater runoff and pollutant removal practices. Recent watershed planning projects undertaken by the Town of Middletown and City of Newport included application of the WTM to the Maidford River, Paradise Brook, St. Marys Pond, and Watson Reservoir watersheds. To be consistent with these studies, RIDEM chose to apply the WTM as its watershed modeling tool for TMDL development. It has been re-applied to St. Marys Pond, Watson Reservoir, the Maidford River, and Paradise Brook and newly applied to Nonquit Pond, Lawton Valley Reservoir, Sisson Pond, Gardiner Pond, Paradise Pond, and Bailey Brook. The Bailey Brook watershed drains to North Easton Pond. South Easton Pond is entirely bermed and receives flow from North Easton Pond.

RIDEM's primary purpose for applying the WTM was to evaluate sources/source categories of phosphorus generated from various land uses within each watershed and acquire information as to the relative importance (i.e. magnitude) of each source. The WTM results were used to help apportion the allowable annual total phosphorus load to various source categories (i.e. urban, agricultural, etc.) within each reservoir's catchment (Section 5.0). Application of the WTM model also provided a secondary estimate of the annual total phosphorus load to each reservoir (corroborating primary estimates based on empirical lake models). Total suspended solids (TSS) and fecal coliform loads to the reservoirs were not modeled.

For the WTM applications to the Newport reservoirs, three workbooks were populated- the Primary Source workbook, Secondary Source workbook, and to the extent information was available, the Existing Management Practices Workbook. The primary source workbook evaluates nutrient sources from land use categories within the watershed using a combination of event mean concentrations and annual loading rates. The secondary source workbook evaluates sources of nutrients from onsite sewage disposal systems, stream erosion, sanitary and combined sewer overflows, illicit connections, livestock, road sanding, and other non-point related sources. The existing management workbook accounts for programs currently in place to control loads from urban land uses; these loads are then subtracted from the primary and secondary source load totals. A separate report containing the WTM setup and input files, assumptions, documentation of data sources, model results, and interpretation of model results is available at: http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/tdml-nonquit-wtm.pdf

An overview of results from the WTM applications to each reservoir and the Maidford River is presented in Tables 4.1-4.9. Predicted annual loadings of total phosphorus from various land use categories are included in these tables- as well as the contribution, expressed as a percentage, of the predicted total annual load. Table 5.9, in Section 5.0 of this TMDL, details the compartmentalization of land uses within each reservoir watershed into: 1) urban land uses, 2) agricultural land uses, 3) forest and wetlands, 4) contributions from confined livestock, 5) onsite wastewater treatment systems (OWTS), and 6) atmospheric. WTM results clearly show that a majority of the phosphorus generated in the reservoir watersheds comes from urban/residential and agriculture land uses.

Table 4.1. Nonquit Pond WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	752	38.1
Rural Land (Agriculture)	541	27.4
Natural Background[1]	583	29.5
OWTS (failure to surface water)	36	1.8
Total Annual Load	**1976**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.2. Watson Reservoir WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	718	51.7
Rural Land (Agriculture)	408	29.3
Natural Background[1]	249	17.9
OWTS (failure to surface water)	15	1.1
Total Annual Load	**1390**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.3. Lawton Valley Reservoir WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	582	69.9
Rural Land (Agriculture)	182	21.8
Natural Background[1]	43	5.2
OWTS (failure to surface water)	26	3.1
Total Annual Load	**833**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.4. Sisson Pond WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	99	34.1
Rural Land (Agriculture)	176	60.7
Natural Background[1]	14	4.8
OWTS (failure to surface water)	1	0.3
Total Annual Load	**290**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.5. St. Marys Pond WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	311	56.9
Rural Land (Agriculture)	176	32.2
Natural Background[1]	32	5.8
OWTS (failure to surface water)	28	5.1
Total Annual Load	**547**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.6. North and South Easton Pond (Bailey Brook) WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	3404	87.7
Rural Land (Agriculture)	390	10.1
Natural Background[1]	61	1.6
OWTS (failure to surface water)	25	0.6
Total Annual Load	**3880**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.7. Gardiner Pond watershed WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	5	11.1
Rural Land (Agriculture)	27	58.5
Natural Background[1]	14	30.4
OWTS (failure to surface water)	0	0
Total Annual Load	**46**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.

Table 4.8. Paradise Pond[2] WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	106	32.7
Rural Land (Agriculture)	179	55.3
Natural Background[1]	28	8.6
OWTS (failure to surface water)	11	3.4
Total Annual Load	**324**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.
[2] The immediate watershed of Paradise Pond not including the Maidford River inputs.

Table 4.9. Maidford River[2] WTM results.

Source Category	Predicted Total Phosphorus Load (lbs/yr)	Percent of Total
Urban land	1180	66.9
Rural Land (Agriculture)	565	32.0
Natural Background[1]	14	0.8
OWTS (failure to surface water)	4	0.2
Total Annual Load	**1763**	

[1]Natural Background includes combined load from forest, wetlands, and atmospheric inputs.
[2]The Maidford River can discharge to both Gardiner and Paradise Ponds and was included in the WTM.

Tributary Sampling as part of the National Water Quality Initiative (NWQI)

The National Water Quality Initiative (NWQI) was established in 2012 as a joint initiative with the NRCS and the Environmental Protection Agency (EPA) to address agricultural sources of water pollution, including nutrients, sediment, pesticides, and pathogens related to agricultural production and in priority watersheds. Priority watersheds are selected in collaboration with state agencies and facilitated by EPA and are generally associated with a waterbody that 1) is impaired, 2) has a TMDL, 3) is threatened (water quality data documenting an impairment, but is not documented in the Integrated Report), or 4) Is critical (i.e. upstream of an impaired segment that is determined to be a significant contributing source to a downstream impairment). The long-term goal of the NWQI is to achieve water quality improvements through accelerated conservation practice implementation.

Beginning in 2015, RIDEM OWR partnered with the Rhode Island Natural Resources Conservation Service (NRCS) to focus NWQI water quality investigations in several tributaries within the Newport reservoir watersheds. These included: 1) the Maidford River (tributary to Paradise Pond and Gardiner Pond), 2) Paradise Brook (tributary to Paradise Pond), and 3) Quaker and Borden Brook and two other unnamed tributaries (all tributaries to Nonquit Pond). This field investigations and water chemistry sampling occurred between 2014 and 2017. Between 2009 and 2013, four producers participated in the NWQI program in the Maidford River and Paradise Brook watersheds. Eleven conservation BMPs, having a potential impact on water quality, were initiated. It is not known if there were any producers participating in NWQI Program in the Borden or Quaker Brook watersheds.

Sampling was conducted under an EPA approved Quality Assurance Project Plan (QAPP) available online at: http://www.dem.ri.gov/data-maps/data.php#quapps. RIDEM established five sampling stations each on both the Maidford River and Paradise Brook - all bracketing agricultural areas. The streams were sampled for turbidity, total suspended solids, nutrients, and pathogens under both dry and wet weather conditions. Six surveys were conducted between 2014 and 2015- three wet weather and three dry weather surveys. Sampling station locations in the Maidford River and Paradise Brook are shown in Figures 4.1 and 4.2, respectively. Dry and wet weather sampling summaries are provided in Table 4.10. These results clearly indicate that both tributaries are significant sources of phosphorus under both dry and wet weather conditions to Paradise and Gardiner Ponds. A report summarizing the study design and monitoring/field results is available on the RIDEM website:
http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/maidford.pdf

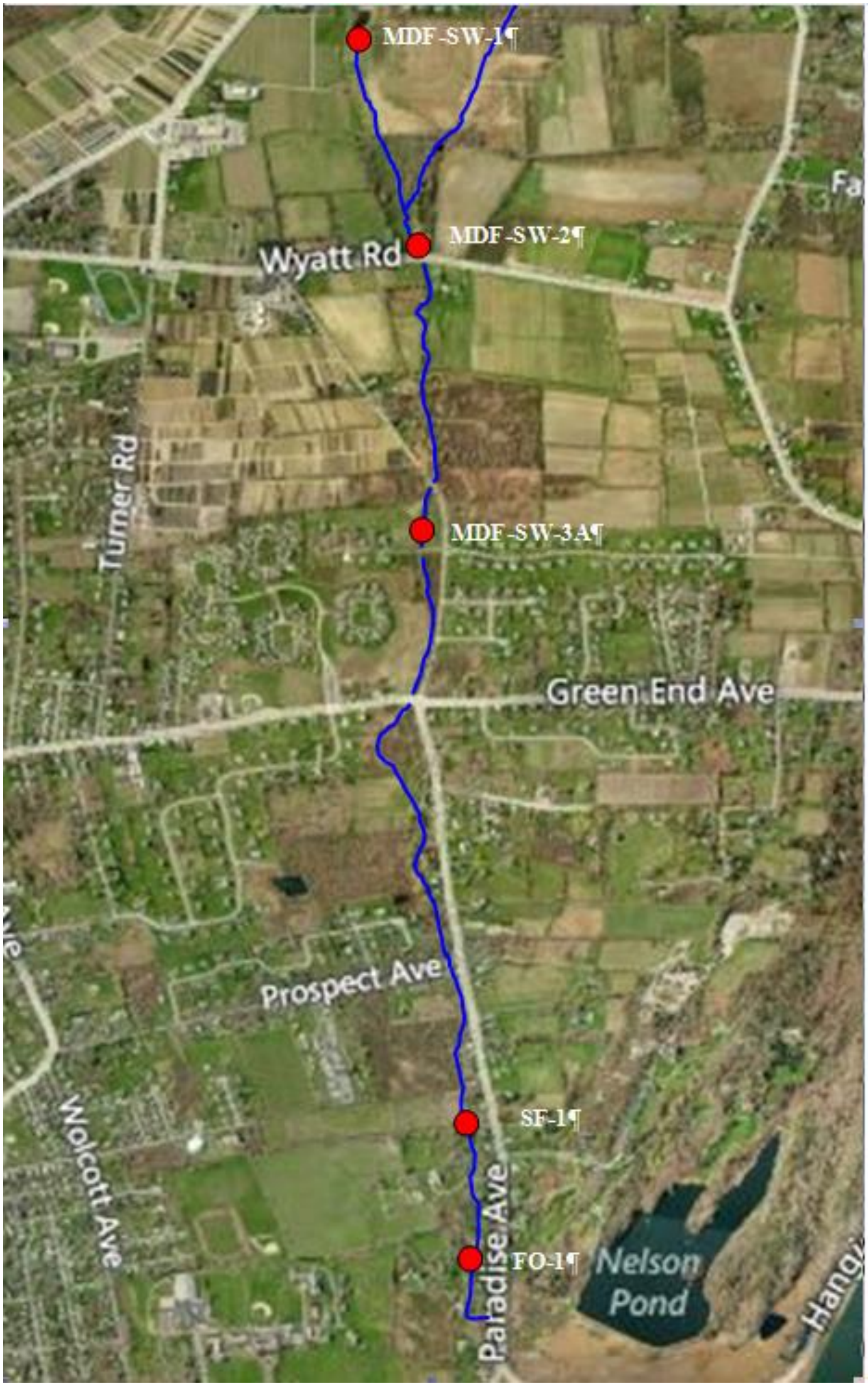


Figure 4.1. NWQI Sampling Stations in the Maidford River- Middletown, RI.

Figure 4.2. NWQI Sampling Stations in Paradise Brook- Middletown, RI.

Table 4.10. Maidford River and Paradise Brook NWQI Data Summaries.

Maidford River Dry Weather Summary			Maidford River Wet Weather Summary		
Station Name	Station Location	**Mean TP (ug/l)[1]**	Station Name	Station Location	**Mean TP (ug/l)[1]**
MDF-SW-1	Headwaters at Meadow Lane	**32**	MDF-SW-1	Headwaters at Meadow Lane	**241**
MDF-SW-2	Wyatt Road	**25**	MDF-SW-2	Wyatt Road	**702**
MDF-SW-3A	Berkeley Ave. Spur	**24**	MDF-SW-3A	Berkeley Ave. Spur	**2200**
MDF-SF-1	Reservoir Ave	**27**	MDF-SF-1	Reservoir Ave	**1100**
MDF-FO-1	Upstream of Maidford River Diversion	**19**	MDF-FO-1	Upstream of Maidford River Diversion	**1097**
Paradise Brook Dry Weather Summary			**Paradise Brook Wet Weather Summary**		
Station Name	Station Location	**Mean TP (ug/l)[1]**	Station Name	Station Location	**Mean TP (ug/l)[1]**
PDS-SW-3a	Headwaters at Fayal Ln.	**85**	PDS-SW-3a	Headwaters at Fayal Ln.	**500**
PDS-SW-1	Mitchells Ln.	**300**	PDS-SW-1	Mitchells Ln.	**1930**
PDS-SW-2	Green End Ave.	**128**	PDS-SW-2	Green End Ave.	**1560**
PDS-OCI-5	Third Beach Rd.	**77**	PDS-OCI-5	Third Beach Rd.	**1610**
PDS-OCI-6A	Downstream of Newport Equestrian	**52**	PDS-OCI-6A	Downstream of Newport Equestrian	**1493**

[1]Mean TP values were compared to EPA's 1986 Quality Criteria for Water ("the Gold Book) which recommends total phosphorus concentrations not to exceed 50.0 ug/l for any stream or river discharging directly to a lake or reservoir.

Between 2016 and 2017, six sampling events were completed at 11 stations in 4 tributary streams to Nonquit Pond. Figure 4.3 shows the location of sampling stations in Borden Brook, Quaker Brook, and two unnamed tributaries. Sampling was conducted under three dry and three wet weather conditions. Stations were selected to bracket agricultural areas as well as the Tiverton Landfill. All stations were sampled for turbidity, total suspended solids, nutrients, total organic carbon, and pathogens. For stations downstream of the landfill, samples were also analyzed for hardness, total iron, and dissolved cadmium, chromium, copper, lead, and selenium. Sampling was conducted under an EPA approved Quality Assurance Project Plan (QAPP) available online at: http://www.dem.ri.gov/data-maps/data.php#quapps

Dry and wet weather sampling summaries are provided in Tables 4.11. These results clearly indicate that both tributaries are significant sources of phosphorus to Nonquit Pond under both dry and wet weather conditions. As a result of this work, numerous sources of nutrients to Nonquit Pond were discovered, including the Tiverton Landfill, various agricultural-related activities, an equestrian center, and a pastured beef operation. These are discussed further in Section 4.0 below. A report summarizing the study design and monitoring/field results is available on the RIDEM website:
http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/tdml-nonquit.pdf

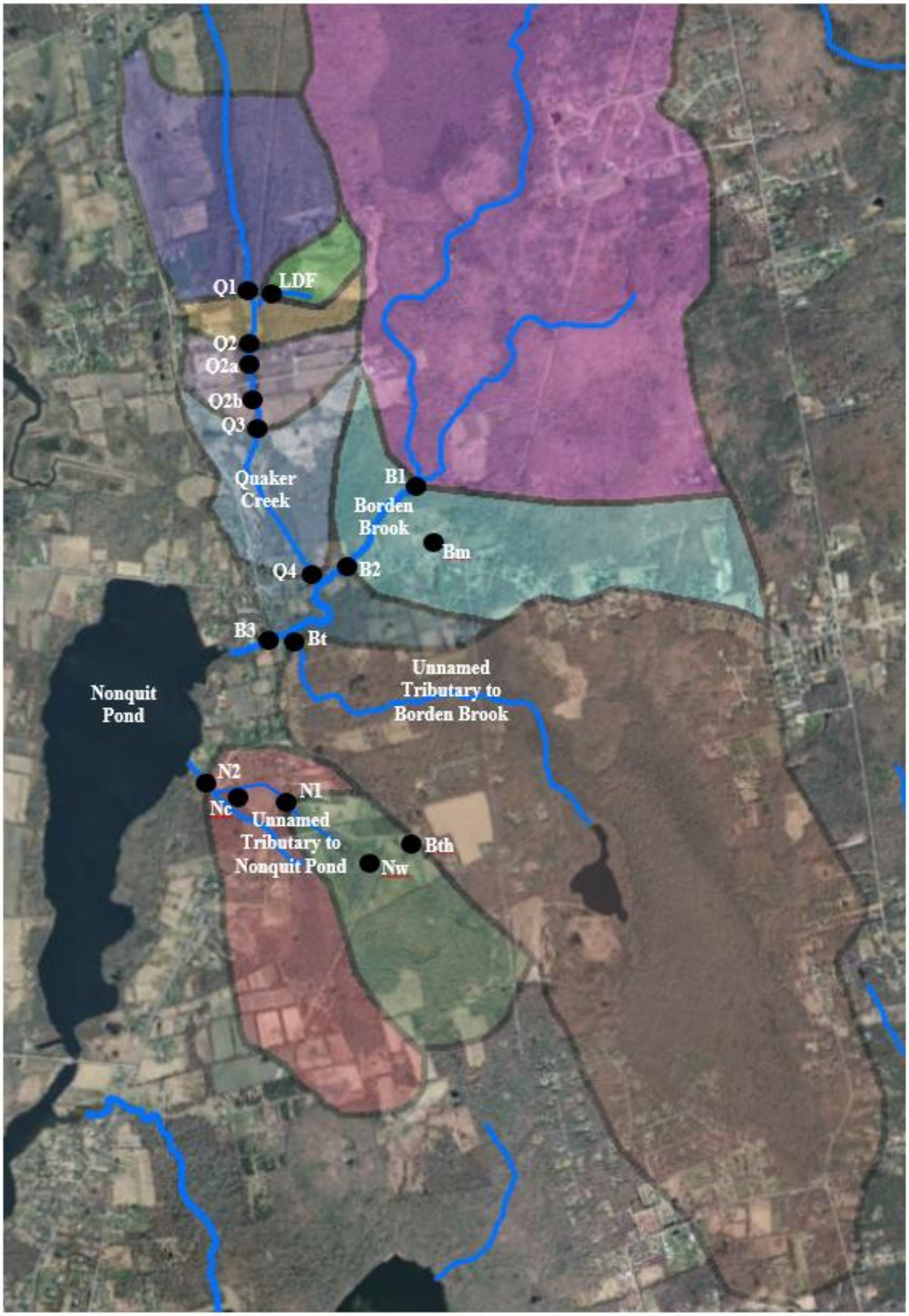


Figure 4.3. NWQI Sampling Stations in Nonquit Pond Tributaries.

Table 4.11. Nonquit Pond Tributaries Dry and Wet Weather NWQI Sample Results.

Quaker Creek Dry Weather Summary			Quaker Creek Wet Weather Summary		
Station Name	Station Location	**Mean TP (ug/l)[1]**	Station Name	Station Location	**Mean TP (ug/l)[1]**
Q1	Downstream of Tiverton landfill access road	**26**	Q1	Downstream of Tiverton landfill access road	**76**
LDF	Adjacent to landfill access road ~250 ft upstream of Quaker Creek	**83**	LDF	Adjacent to landfill access road ~250 ft upstream of Quaker Creek	**109**
Q2	Downstream boundary of landfill property and northern boundary of livestock area	**33**	Q2	Downstream boundary of landfill property and northern boundary of livestock area	**73**
Q3	Downstream of livestock area	**63**	Q3	Downstream of livestock area	**91**
Q4	Immediately upstream of East Road	**42**	Q4	Immediately upstream of East Road	**97**
Borden Brook Dry Weather Summary			**Borden Brook Wet Weather Summary**		
Station Name	Station Location	**Mean TP (ug/l)[1]**	Station Name	Station Location	**Mean TP (ug/l)[1]**
B1	Weetamoo Woods	**78**	B1	Weetamoo Woods	**52**
B2	South side of East Road and downstream of confluence with unnamed tributary	**11**	B2	South side of East Road and downstream of confluence with unnamed tributary	**62**
Bt (Unnamed Tributary to Borden Brook)	nr commercial area on Main Road ~ 100 ft upstream of confluence with Borden Brook	**64**	Bt (Unnamed Tributary to Borden Brook)	nr commercial area on Main Road ~ 100 ft upstream of confluence with Borden Brook	**100**
B3	At mill dam/footbridge ~ 60 ft upstream of Main Road	**71**	B3	At mill dam/footbridge ~ 60 ft upstream of Main Road	**74**
Unnamed Tributary Weather Summary			**Unnamed Tributary Wet Weather Summary**		
Station Name	Station Location	**Mean TP (ug/l)[1]**	Station Name	Station Location	**Mean TP (ug/l)[1]**
N2 (trib to Nonquit Pond)	Barnswallow Street	**333**	N2 (trib to Nonquit Pond)	Barnswallow Street	**310**
N3 (trib to Nonquit Pond)	Cul-de-sac of Peaceful Way	**21**	N3 (trib to Nonquit Pond)	Cul-de-sac of Peaceful Way	**197**

[1]Mean TP values were compared to EPA's 1986 Quality Criteria for Water ("the Gold Book) which recommends total phosphorus concentrations not to exceed 50.0 ug/l for any stream or river discharging directly to a lake or reservoir.

Tributary Sampling as part of the URI NSF Project

A University of Rhode Island (URI) National Science Foundation (NSF)-funded project began in June 2014 and included the collection of real-time water quality data on three stream systems in Rhode Island using in-situ sensors (Frazar et al. 2019). Two of the three stream systems selected for the study were Bailey Brook and the Maidford River. As part of the project, water quality sensors were deployed in each stream, as close to the outlet as possible. The sensors measured conductivity, temperature, dissolved oxygen, pH, turbidity, dissolved organic matter, nitrate-N and dissolved organic carbon concentrations. Water samples were also collected at regular intervals as well as during storm events (with an ISCO hourly sampler) and analyzed for Total Nitrogen (TN) and Total Phosphorus (TP). High frequency stage data (for use in calculating discharge) were obtained using water level sensors (Hobo Water Level Loggers) that were deployed alongside the water quality sensors.

URI staff provided quality assured data to RIDEM for the period from October 2014 through March 2017. These data were used to calculate dry (baseflow) and wet weather (event mean concentration) phosphorus and nitrogen loads, as well as to evaluate other water quality related trends. Nitrogen and phosphorus data from the Maidford River and Bailey Brook are summarized below in Tables 4.12 and 4.13. These data are separated into dry weather (baseflow) and wet weather-related stormflow. The Bailey Brook watershed contains more urban land uses while the Maidford River contains more agricultural and rural land uses.

Table 4.12. Dry Weather TN and TP Concentrations in Bailey Brook and Maidford River.

Timeframe	Bailey Brook		Maidford River	
	TN (mg/L)	TP (µg/L)	TN (mg/L)	TP (µg/L)
3 Year Mean Concentration	1.14	52.2	2.00	59.4
2014 (July-Dec)	0.81	58.8	1.40	51.8
2015	1.30	82.4	2.53	94.3
2016	1.18	30.2	1.93	40.2

The number of storm events sampled during the course of the field study were twenty-three for Bailey Brook and nineteen for Maidford River. Of these wet surveys, several could not be used to calculate the Event Mean Concentrations (EMCs) because either the TP or TN analysis was not done, the flows were not available or in error, or both in some cases. One of the Bailey Brook surveys on Dec 3, 2014 was not used because the sampling started thirty-six hours after the rainfall ended. As a result, EMCs for each watershed were calculated using the remaining sixteen storms available.

To calculate the EMCs, the instantaneous flow at the time the samples were collected was multiplied by the concentration associated with that flow. This was done for each sample collected during the storm event. These values were added together and divided by the total wet volume of that individual storm (volume under the storm hydrograph minus the base flow for the time period of runoff) associated with the sample set to get the EMC for that storm. All the EMCs for the individual storms were averaged together to get a single value. The table below shows the average EMCs for TN and TP for both systems.

Table 4.13. Mean Wet Weather TP and TN EMCs for Bailey Brook and Maidford River.

Timeframe	Bailey Brook			Maidford River		
	TN (mg/L)	TP (µg/L)	# of Storm Events	TN (mg/L)	TP (µg/L)	# of Storm Events
Survey Mean EMC	1.13	106.7	16	1.51	235.2	16
2014 Mean EMC	0.86	79.0	3	1.01	103.5	6
2015 Mean EMC	1.18	136.7	5	1.93	314.4	7
2016 Mean EMC	1.21	98.3	8	1.55	313.5	3

Several conclusions can be drawn from analysis of these data:

- Both the Maidford River and Bailey Brook are a significant source of phosphorus to North and South Easton Ponds and Paradise and Gardiner Ponds.

- Total phosphorus concentrations under baseflow conditions in both the Maidford River and Bailey Brook are elevated and exceed Rhode Island water quality criteria and when compared to EPA's 1986 Quality Criteria for Water ("the Gold Book) which recommends total phosphorus concentrations not to exceed 50.0 ug/l for any stream or river discharging directly to a lake or reservoir.

- Wet weather total phosphorus EMC values in the Maidford River range from 2 to 8 times the dry weather baseflow values. In Bailey Brook the wet weather EMC values are 1 to 3 times the dry weather baseflow values.

- Baseflow total nitrogen concentrations in both the Maidford River and Bailey Brook are elevated compared to EPA's recommended reference condition (Table 3.a) (based on the 25th percentile (for Level III Ecoregion 59 streams and rivers) of 0.57 mg/l (EPA 2000). Baseflow total nitrogen concentrations in the Maidford River were higher than wet weather EMC values, reflecting the elevated levels of total nitrogen in the groundwater and the influence of dilution during wet weather.

Additional findings from analysis of data from the Maidford River (**MR**) and Bailey Brook (**BB**) were provided to RIDEM from URI Staff and are listed below within specific categories of study. In general, analysis of the data suggests that wet weather events account for a majority of the orthophosphate and nitrate into the system which enhances and confirms RIDEMs findings regarding wet weather sources of nutrients in the Bailey Brook and Maidford River watersheds. Further, the effects of storm events on orthophosphate flux were much more pronounced in the agricultural dominated Maidford River than in the more urbanized Bailey Brook watersheds. In addition, it is noted in both the URI study as well as RIDEM fieldwork and site investigations in the Maidford River watershed that many of the agricultural fields abut the drainage network without buffers which creates the potential for high phosphorus delivery to the stream.

General NO3-N and PO4-P flux patterns:

- Total cumulative NO3-N flux was 2.6 times higher in Maidford River watershed than Bailey Brook (BB) watershed for the 313 days.
  - MR cumulative NO_3-N flux: 4.403 kg/ha, or load = 1,950 kg
  - BB cumulative NO_3-N flux: 1.672 kg/ha, or load = 1,091 kg

- Total cumulative PO_4-P flux was 12 times higher in Maidford River watershed than Bailey Brook watershed for the 313 days.
  - MR cumulative PO_4-P flux: 0.494 kg/ha, or load = 218.79 kg
  - BB cumulative PO_4-P flux: 0.040 kg/ha or load = 26.11 kg

NO3-N and PO4-P flux from high-flow events

- A disproportionate amount of discharge and flux occurred during the highest flow events:

  - In Maidford River, 26% of the total discharge, 14% of the total NO_3-N flux and 40% of the total PO_4-P flux occurred during the highest 2% of daily flows.

  - In Bailey Brook, 13% of the total discharge, 7% of the total NO_3-N flux and 17% of the total PO_4-P flux occurred during the highest 2% of daily flows.

  - The highest daily discharge events had a dampening effect on NO3-N flux in both watersheds (the highest 2 and 5% of daily flow events accounted for a higher percentage of the total flow than the total NO3-N flux).

  - The highest daily discharge events had an amplifying effect on PO4-P flux in the Maidford River watershed (the highest 2 and 5% of daily flow events accounted for a higher percentage of the total PO4-P flux than the total discharge, the highest 2% of daily flow events accounted for 40% of PO4-P flux but only 26% of the total discharge).

NO3-N and PO4-P flux from storm events

- Findings come from analysis of the impact of 16 storm events that generated more than 13 mm of rain during the 313 analyzed days on total discharge and dissolved nutrient flux.

- The 16 storms accounted for 30% of the total discharge in MR and 22% of the total discharge in BB.

- The 16 storms accounted for 14% of the total NO_3-N flux in the Maidford River watershed and 15% of the total NO_3-N flux in the Bailey Brook Watershed.

- The 16 storm events accounted for 44% of the total PO_4-P flux in the Maidford river watershed and 29% of the total PO_4-P flux in the Bailey Brook watershed.

- The single largest storm event during the study period occurred from 12/23/15 to 12/24/15 (62.74 mm of rain) and generated the highest daily discharge values of the study period on 12/24/15 at both sites. This storm accounted for 4% of the NO_3-N flux and 15% of the PO_4-P flux in the Maidford watershed and 2% of the NO_3-N and 6% of the PO_4-P flux in the Bailey watershed.

4.1 Source Categorization and Identification

Similar sources/source categories of phosphorus impact a majority of the nine Newport Water supply reservoirs. Because of the interconnections between reservoirs, nutrient sources to one reservoir may, via water transfers and/or stream diversions, impact other reservoirs. Table 4.14 summarizes the primary sources of phosphorus to the Newport reservoirs, the primary method(s) of identification, and the relevant section where these sources are discussed. In many areas the lack of adequate/effective buffers along many of the reservoir tributaries, as well as the reservoirs themselves, hastens the delivery and decreases the attenuation (loss) of phosphorus from many of these sources. Lack of riparian buffer along the reservoirs also allows for access to resident geese.

Table 4.14. Summary of Phosphorus Sources to the Newport Reservoir Watersheds.

Sources of Phosphorus to the Newport Reservoirs	Method(s) of Identification	Section
Urban and Residential Runoff	WTM results, Field Observations, Outfall Information	4.2
Agricultural Runoff and other agricultural-related activities	WTM results, Field Observations, NWQI investigations	4.3
Loss or Riparian Buffer Streambank/Streambed Erosion.	Field Observations, Previous Investigations, NWQI investigations	4.4
Excessive populations of resident geese utilizing reservoir shorelines	Field Observations	4.5
Onsite Wastewater Treatment System (OWTS) Contributions	WTM results	4.6
Internal Cycling of Nutrients from Reservoir Sediments	Sediment sampling, Water column sampling, Oxygen-Temperature Profiles	4.7
Natural Background Sources	Literature Review, WTM Results	4.8
Tiverton Landfill*	RIDEM staff observations, NWQI Investigations	4.9

*The Tiverton Landfill drains to Quaker Creek, which flows into Nonquit Pond.

4.2 Urban and Residential Runoff

Many studies confirm that the first flush of urban stormwater runoff is highly enriched in phosphorus (P) and contributes to the eutrophication of downstream waterbodies and impairment of aquatic ecosystems (Alias, N., et al. 2014, Kim, L.H., et al. 2007). Lee and Jones-Lee (1995) stated that urban stormwater runoff contains about 100 times the total concentrations of phosphorus that are typically derived from stormwater runoff from forested areas. Major sources include urban landscape runoff containing fertilizers, pet and other animal waste, detergents, and lawn/yard debris.

Storm water runoff from urbanized areas is generated from many sources in the nine reservoir watersheds including residential areas, commercial and industrial areas, and roadways- even rural roadways. Essentially, any land surface lacking the capability to pond and infiltrate water will produce runoff during storm events. An important indication of the degree of urbanization in a watershed is the level of impervious surfaces. As the level of imperviousness increases in a watershed, more rainfall is converted to runoff rather than infiltrated into the ground. Impervious cover percent, by direct reservoir watershed, ranges from 1% in Gardiner Pond to 30% in Bailey Brook. Studies by the Center for Watershed Protection (CWP 2003) and others (ENSR 2005) have documented water quality and habitat impacts at watershed impervious levels in the 10% and above range.

As described previously, the Watershed Treatment Model (WTM) was used to estimate nutrient loads from the varying land use activities in the water supply reservoir watersheds. Overall contributions from urban runoff to the annual total phosphorus load to each reservoir are presented in Tables 4.1-4.9. WTM loading results show that, with the exception of Gardiner Pond and Sisson Pond, runoff from the urbanized portions of reservoir watersheds dominates annual total phosphorus loads to the individual reservoirs. These results are corroborated by earlier land use based nutrient modeling completed in the water supply reservoir watersheds including:

- Rhode Island Department of Health (RIDOH) Division of Drinking Water Quality (DWQ) Source Water Assessment (2003) (https://web.uri.edu/nemo/publications/swa-reports/).

- Town of Middletown Maidford River Watershed Assessment and BMP Design (2015) (http://publicworks.middletownri.com/maidford-river-watershed-assessment/).

- City of Newport Source Water Phosphorus Reduction Feasibility Study (2016) (http://www.cityofnewport.com/departments/utilities/water/water-shed-protection),

With the exception of the Town of Little Compton, all municipalities within the Newport reservoir watersheds are regulated under the RIDEM Phase II Municipal Separate Stormwater Sewer System (MS4) General Permit. In Rhode Island, Newport, Portsmouth, Middletown, Tiverton, and the Rhode Island Department of Transportation have applied for coverage under the Rhode Island Phase II Stormwater General Permit (issued in 2003) and have prepared the required Phase II Stormwater Management Plans (SWMPP). Little Compton is not covered by the general permit, because of the town's rural character, none of its census blocks had population that met the threshold requiring the town to obtain coverage.

As part of the Phase II MS4 requirements, municipalities and RIDOT have confirmed ownership, mapped outfalls and catch basins, among other information required by the general permit, and submitted this information to RIDEM. However, there is little information, other than pipe diameter, that would allow for evaluation of accurate water quality impacts from specific outfalls. It should be noted that information related to these outfalls has not been independently confirmed by RIDEM staff.

Figures 4.4 and 4.5 show the location of municipal and RIDOT owned stormwater outfalls within the reservoir watersheds located on Aquidneck Island and Tiverton and Little Compton. RIDEM has not found that any of the outfalls discharge directly to the reservoirs. The majority of outfalls are owned by the Town of Middletown and RIDOT, and drain to Bailey Brook, Paradise Brook, and the Maidford River. Additional information regarding outfall ownership, number, and size is presented in Table 4.15 below.

Table 4.15. Summary of stormwater outfalls discharging to reservoir tributaries.

MS4 Permit Holder	Outfall Information
Newport	No outfalls discharging to reservoirs or tributaries
Portsmouth	A single 24" outfall discharging to St. Marys Reservoir A single 24" outfall discharging to Lawton Valley Reservoir
Middletown	11 outfalls ranging in size from 12-36" discharging to Bailey Brook and tributaries 2 outfalls ranging in size from 12-24" discharging to a tributary to North Easton Pond 22 outfalls ranging in size from 12-36" discharging to the Maidford River 8 outfalls ranging in size from 12-30" discharging to Paradise Brook
Tiverton	2 outfalls discharging to headwaters of Borden Brook A single outfall discharging to an unnamed tributary to Nonquit Pond
Little Compton	5 outfalls ranging in size from 12-18" discharging to Watson Reservoir via tributaries
RIDOT	5 outfalls ranging in size from 18-36" discharging to Bailey's Brook 7 outfalls ranging in size from 12-36" discharging to a tributary to North Easton Pond 6 outfalls ranging in size from 18-24" discharging to North Easton Pond 2- 24" outfalls discharging to Lawton Valley Reservoir via Sisson Pond Brook 1 outfall discharging to Quaker Creek 2 outfalls discharging to Borden Brook 2- 24" outfalls discharging to an unnamed tributary to Nonquit Pond

Figure 4.4. Schematic of municipal and RIDOT outfalls in Newport Reservoir Watersheds-Aquidneck Island.

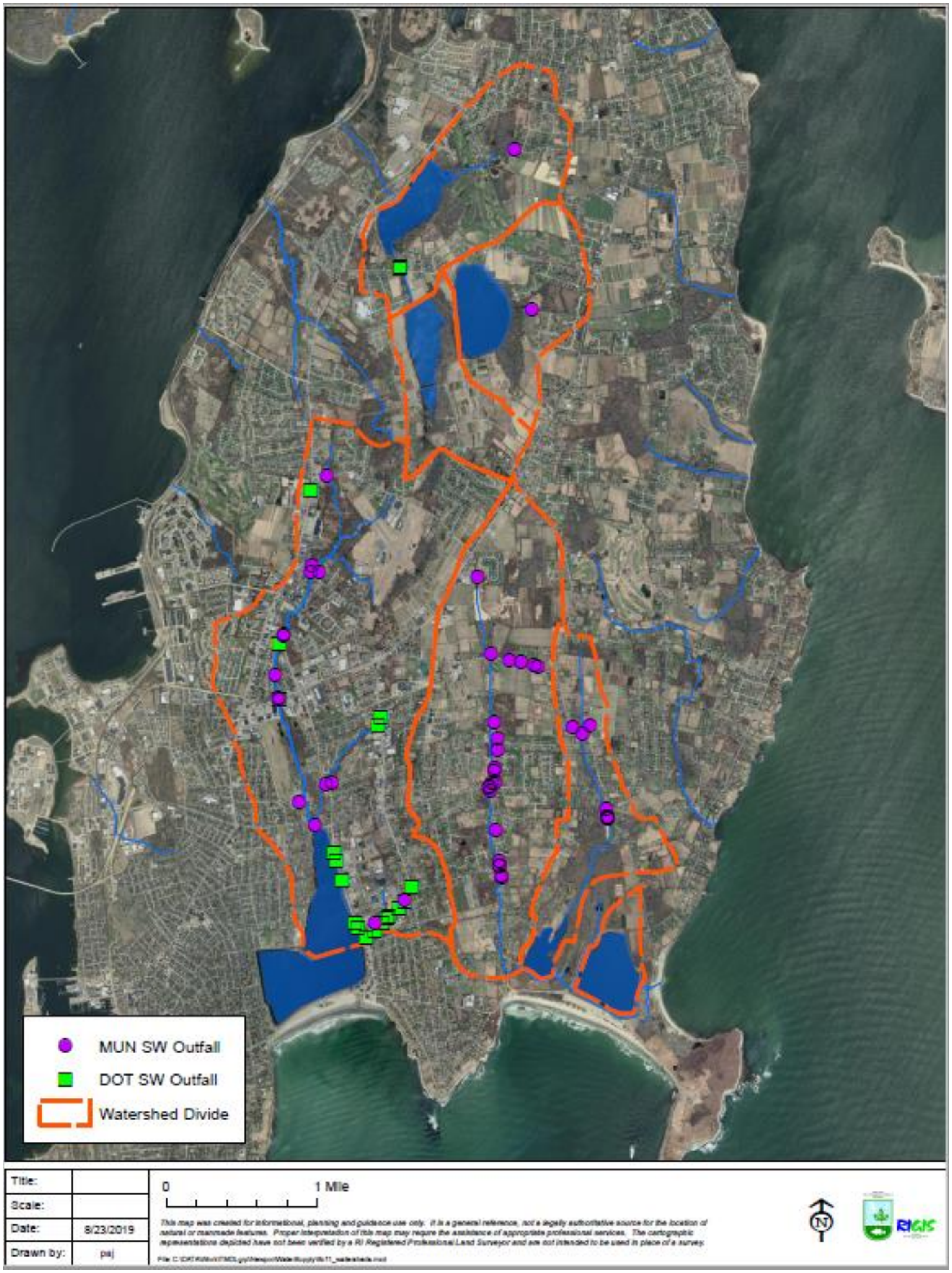
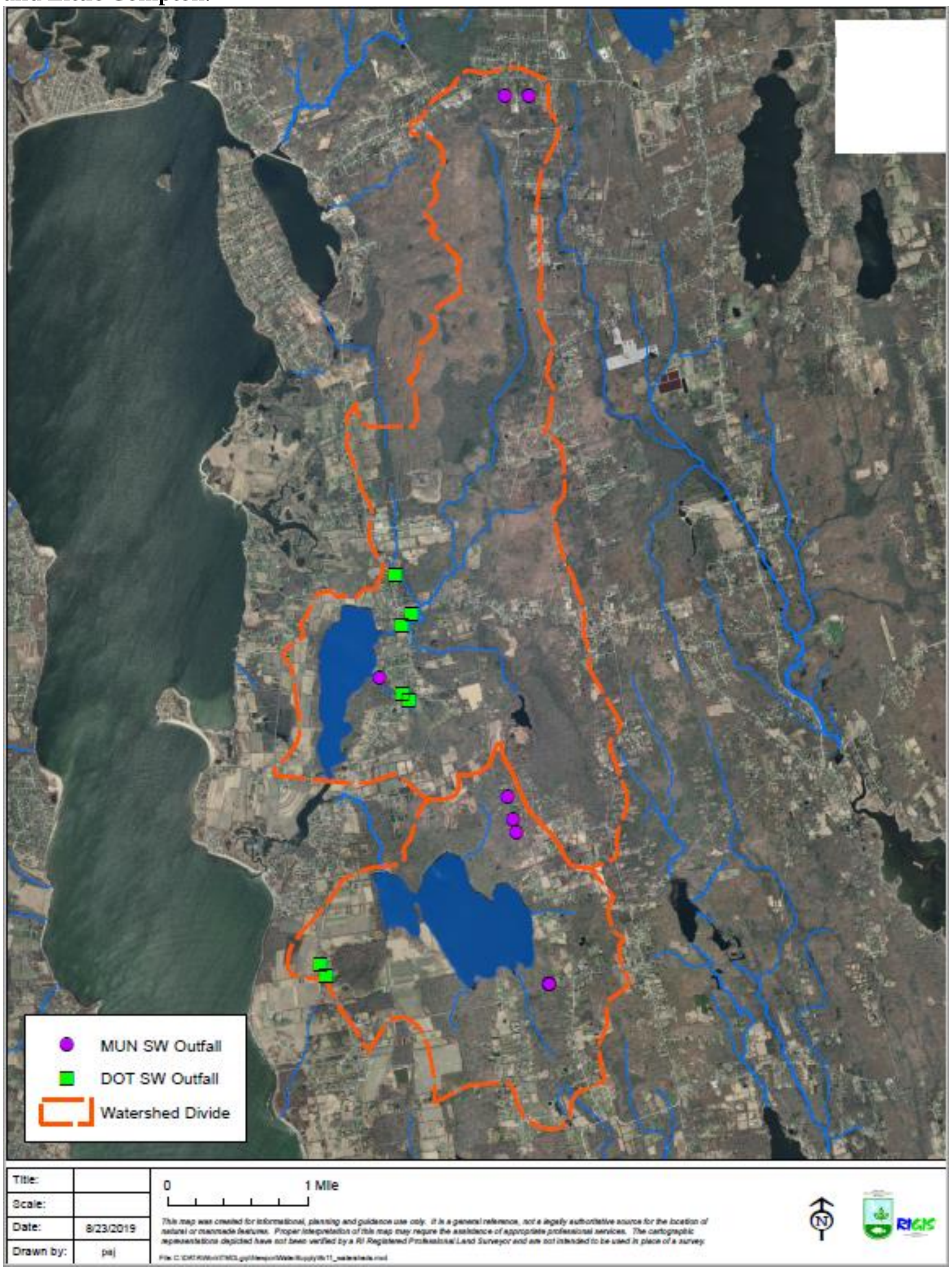


Figure 4.5. Schematic of municipal and RIDOT outfalls in Newport Reservoir Watersheds-Tiverton and Little Compton.



4.3 Agricultural Runoff and Agricultural-Related Activities

It is widely recognized that agricultural operations contribute to nutrient pollution when not properly managed. Fertilizers and animal manure are the primary sources of nutrient pollution from agricultural land uses. Agricultural runoff is generally defined as water leaving agricultural operations because of rain, melted snow, or irrigation and may be associated with soil erosion. Agricultural runoff in the Newport reservoir watersheds includes that originating from soil erosion, feeding operations, grazing, plowing, animal waste, application of pesticides, irrigation water, and fertilizer. Agricultural sources in the Newport reservoir watersheds include landscaping and nursery operations, vineyards, orchards, hobby farms, equestrian/riding centers, and pastured beef operations.

The Watershed Treatment Model predicts that agricultural land uses contribute from 10% to 61% of the annual total phosphorus loads to the Newport reservoirs (Tables 4.1 to 4.9). The model was used to provide a general sense of the overall contribution of nutrients generated from agricultural-related land uses in the water supply watersheds, but the most valuable information regarding source identification was collected by RIDEM staff as part of the NRCS National Water Quality Initiative (NWQI) investigations that included detailed site investigations and targeted sampling of these sites under various weather conditions.

Tables 4.16 and 4.17 summarize the agricultural-related sources of nutrients in both the Maidford River and Paradise Brook that were discovered as part of the NWQI investigations. Table 4.18 summarizes nutrient sources in Quaker Brook, Borden Brook, and two other unnamed tributaries to Nonquit Pond. As documented in these tables, agricultural runoff and erosion have been documented at many sites within the sampled watersheds. The impact of these observed pollution sources on water quality are confirmed by the results of bracketed sampling conducted at these sites.

Table 4.16. RIDEM NWQI Prioritization of Nutrient Sources in the Maidford River.

	River Reach	Downstream Station	Potential Sources	Evidence	September 13, 2017 Limited Field Inspection
Maidford River	MDF-SW-1 to MDF-SW-2	**Wyatt Road**	Cattle Farm	Cattle Access to Stream	Apparently no longer any cattle on property, no sign of disturbance near stream despite open gate from pasture
			Vineyard	Proximity	
			Nursery at 736 East Main Road	Possible Connection via Road Storm Drain System	
	MDF-SW-2-MDF-SW-3A	**Berkeley Av. Spur**	Nursery at 408 Turner Road	Documented major erosion and uncontrolled runoff	Stormwater basin in place on Town-leased property; many lower fields planted in grasses, some erosion but reduced from 2015
			Crop Field	Documented Turbid Runoff Manure Spreading?	
			Berry Farm at 915 Mitchells Lane	Documented Turbid Runoff Manure Spreading?	
			Hay Fields	Manure Spreading?	
	MDF-SW-3A to MDF-SF-1	**Reservoir Av.**	Mainly Residential Area	Streambed/Streambank Erosion Documented Turbid Runoff Leaky sewer Lines? Pet & Wildlife Waste? Lawn fertilizers?	
			Cattle Farm	Cattle may have Access to Tributary to Stream (Unconfirmed)	Cattle have access to quarry across tributary from barn; access to farm difficult
			Hayfields	Manure Spreading?	
	MDF-SF-1 to MDF-FO-1	**Newport Water Intake**	Mainly Residential Area	Lawn Fertilizer?	

Table 4.17. RIDEM NWQI Prioritization of Nutrient Sources in Paradise Brook.

	River Reach	Downstream Station	Potential Sources	Evidence	September 13, 2017 Limited Field Inspection
Paradise Brook	PDS-SW-3A to PDS-SW-1	Mitchell's Ln.	Mixed Livestock Farm	Livestock Have Access to Stream Documented Turbid Runoff	No livestock visible, field recently mowed but no sign of animal traffic or bare soil
			Nursery at 736 East Main Road	Documented Turbid Runoff Manure Spreading?	
			Cattle Farm	Cattle in Wet Area next to Stream	
			New Cattle Farm	Cleared to Stream (access?)	No cattle; same cleared condition; land for sale
	PDS-SW-1 to PDS-SW-2	Green End Av.	Nursery at 736 East Main Road	Documented Turbid Runoff (via Culvert)	
			Berry Farm at 915 Mitchells Lane	Documented Turbid Runoff	
	PDS-SW-2 to PDS-OCI5	Third Beach Rd.	Residential Area	Streambed and Streambank Erosion Underperforming Septic Systems?	
	PDS-OCI5 to PDS-OCI-6A	Downstream of Newport Equestrian	Equestrian Center at 237 3rd Beach Road	Horses in Frequently Flooded Area Adjacent to Stream	Lower paddock west of stream is mostly wetland; manure in paddock (no piles), horses have access to stream on lower paddock east of stream, log/substrate obstructions of downstream of N.E.

Table 4.18. RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
Tiverton Landfill Swale	Specific Conductance pH Turbidity Total Nitrogen Ammonia Organic Nitrogen Nitrate Dissolved Organic Carbon Enterococci Total Iron	Specific Conductance Turbidity Total Phosphorus Total Nitrogen Ammonia Organic Nitrogen Nitrate Dissolved Organic Carbon Enterococci Total Iron	Prominent Iron Flocculent Turbid Stormwater with Petroleum Sheen Swale is a Stormwater BMP not a Water of the State	Tiverton Landfill
QUAKER CREEK (RI0010031R-04)	Dissolved Oxygen pH Total Nitrogen Organic Nitrogen Dissolved Organic Carbon Total Iron	Dissolved Oxygen Total Phosphorus Total Nitrogen Organic Nitrogen Dissolved Organic Carbon Enterococci Total Iron	Downstream of Stagnant Wetland with Organic Soils Prominent Iron Flocculent	Tiverton Landfill Decay of organic material within Wetland Town Recreational Fields Pasture
	Total Nitrogen Ammonia Nitrate	Specific Conductance Turbidity Total Nitrogen Ammonia Organic Nitrogen Nitrate Enterococci	Reach is a Marsh/Swamp area Landfill Swale Discharges to this Reach	Tiverton Landfill

Table 4.18(cont.). RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	**Wet Weather**		
QUAKER CREEK (RI0010031R-04)	Enterococci	Dissolved Organic Carbon	Flooded Paddocks of Two Equestrian Centers Livestock have Access to Stream from at least One Equestrian Center and Cattle Farm Turbid Runoff from Shell Parking Areas of Equestrian Center, Artist's Cooperative, Landscaping Business, and Bus Depot Turbid Runoff from Gravel Mining Area	Stormwater from Parking Areas Stormwater from Gravel Mining Area Two Equestrian Centers Cattle Farm
		Turbidity Total Phosphorus	Targeted Wet-Weather Sampling Observations Above	Stormwater from Parking Areas, except Bus Depot Upper Equestrian Center
		Turbidity Total Phosphorus Enterococci	Targeted Wet-Weather Sampling Observations Above	Stormwater from Bus Depot Lower Equestrian Center

Table 4.18 (cont.). RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
QUAKER CREEK (RI0010031R-04)	Organic Nitrogen	Total Phosphorus	Cows have access to Western Farm Pond Turbid Runoff from Main Road to Farm Pond Church, Hay Field, Residences and Commercial Properties with Inadequate Vegetated Buffer (0-50 ft.) Adjacent to Wetland Corridor	Cow Farm Roadway Runoff Church Residences Commercial properties Transformation of Nitrogen Species to Organic-N in Wetland Corridor Phosphorus Release from Flooded Wetland Areas
Unnamed Tributary to Borden Brook (RI0010031R-01)	Total Nitrogen Organic Nitrogen Dissolved Organic Carbon	Total Nitrogen Organic Nitrogen Dissolved Organic Carbon Enterococci	Large Silage Pile and Cow Access at Headwaters of Southwest Fork Livestock have Access to Stream (a Few Animals) Near Confluence of Forks Six Residences with Inadequate Vegetated Buffer (0-30 ft.) Two Hay Fields with Inadequate Vegetated Buffer (25-50 ft.) A Commercial Shop with no Vegetated Buffer	Cow Farm Small Livestock Farm Six Residences Two Hay Fields Commercial Property Wetlands

Table 4.18 (cont.). RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
Unnamed Tributary to Borden Brook (RI0010031R-01)		Turbidity Total Phosphorus Ammonia Organic Nitrogen Enterococci	Wet-Weather Targeted Sample Taken Immediately Downstream of Silage Pile Adjacent to Stream Dense Growth of Filamentous Algae with White Scum Downstream of Silage	Silage
Borden Brook (RI0010031R-01)	Total Nitrogen Organic Nitrogen Dissolved Organic Carbon	Total Nitrogen Organic Nitrogen Dissolved Organic Carbon Enterococci	Reach Located in Weetamoo Woods with Extensive Wetlands Development is Located on Periphery of Extensive Forest with no Development Near Stream	Wetlands

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
Borden Brook (RI0010031R-01)	No Significant Pollutant Increases	No Significant Pollutant Increases	Stormwater from East Road Draining Residences, an Equestrian Center, a Pasture, Hay Field, and Crop Field Manure Pile adjacent to East Road Chicken Coop adjacent to East Road Ditch Small Cow Farm with Livestock Access to Stream Hayfield with Inadequate Vegetated Buffer (20 ft.) Seven Residences with Inadequate Vegetated Buffer (0-30 ft.)	East Road Stormwater Manure Pile Chicken Coop Small Cow Farm Hay Field Seven Residences
Borden Brook (RI0010031R-01)		Enterococci	Targeted Wet-Weather Sampling of Stormwater from Manure Pile Flows to Quaker Creek via Roadside Ditch	Manure

Table 4.18 (cont.). RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
Borden Brook (RI0010031R-01)	Total Phosphorus Total Nitrogen Organic Nitrogen Lead	Total Nitrogen Organic Nitrogen Lead	Both Quaker Creek and an Unnamed Tributary Discharge to this Reach Small Farm with Livestock Access to Stream Manure Pile 30 ft. from Stream Three Commercial Shops including Metal Working Shop near B3 Strong Orange Color of Stream Flow at Mill Dam at B3 (Possibly Natural Tannins) Very Small Ponded Area Immediately Upstream of B3	Quaker Creek Unnamed Tributary Small Livestock Farm Commercial Shops Metal Shop (Lead-Unlikely-Downstream of B3) Contaminated Sediment in Small Ponded Area, Ultimately from Land Fill (Lead) Stormwater from East Road (Lead)
Unnamed Tributary to Nonquit Pond (RI0010031R-20)	Total Phosphorus Total Nitrogen Organic Nitrogen Dissolved Organic Carbon	Total Phosphorus Total Nitrogen Organic Nitrogen Dissolved Organic Carbon Enterococci	Cows Have Access to Flooded Areas Adjacent to Stream and Stream Itself One Residential Lot with No Vegetated Buffer	Cow Farm One Residence Wetlands

Table 4.18 (cont.). RIDEM NWQI Prioritization of Nutrient Sources in Nonquit Pond Tributaries.

	Exceedances of Criteria/Guidance (Most Upstream Station) or Significant (>20%) Pollutant Increases (Downstream Stations)		Field Observations	Potential Sources
	Dry Weather	Wet Weather		
Unnamed Tributary to Nonquit Pond (RI0010031R-20)		Enterococci	Wet-Weather Targeted Sample Sample Taken in Wetlands at Extreme Headwaters Apparently Upstream of any Direct Stormwater Runoff from Cow Farm	Wetland
	Nitrate	Turbidity Total Nitrogen Organic Nitrogen Enterococci	Western Fork: Bisects Crop Field with Inadequate Buffer (15 ft.) and 6-acre Residential lot with no Buffer Eastern Fork: Flows along Border of Hay Field and Crop Field and Six Residential Lots with No Vegetated Buffer	Crop Field Seven Residential Lots Hay Field Wetland Stormwater From Main Road
		Turbidity Total Phosphorus	Wet-Weather Targeted Sample Sample Taken at Northwest Corner of Corn Field Turbid Flow in Eroded Swale at Northern end of Corn Field	Crop Field

Other agricultural-related activities that have been documented to impact various reservoir tributaries include: 1) flooding paddocks at two equestrian centers and 2) horses and cattle having direct access to certain tributaries. These activities were documented by RIDEM staff as part of the NWQI field investigations. Paddock flooding was observed at both the Newport Equestrian Center in Middletown which impacts Paradise Brook and PJM Equestrian in Tiverton which impacts Quaker Brook. Flooding at these sites was observed by RIDEM staff on many occasions. In both cases- heavy rainfall caused flooding of the channels of Paradise Brook and Quaker Brook which overflowed into the paddocks. RIDEM staff observed horse manure directly exposed/submerged within these flooded areas.

There were several areas within the NWQI tributaries where RIDEM staff observed that horses and cattle had direct access to watercourses. One of the largest sites observed was a pastured beef operation located adjacent to Quaker Brook. This property is located south of the PJM Equestrian Center and adjacent to a school bus storage facility. No fencing of the riparian area exists and there were extensive piles of cow manure along portions of the creek and in the stream channel. Trammeling of the riparian area was also observed. RIDEM staff estimated approximately 40 dairy/beef cows at this site in the Spring of 2018 and Fall of 2017. This number was later confirmed by RIDEM Department of Agriculture staff.

Livestock that have free access to watercourses may impact both the water quality of the receiving water and the riparian area itself. Impacts can include such things as: direct deposition of urine and manure into the water; deposition of manure onto low land that is seasonally flooded or where it can be washed into a watercourse; streambank trampling and siltation of the water; and removal of riparian vegetation. Livestock impacts are usually related to the duration and timing of use, the livestock density, and the nature of the watercourse. RIDEM staff routinely observed sheet and gully erosion from cultivated fields flooding downstream areas including local roads, driveways, and lawns causing sediment deposits (including deposits observed to contain pelletized fertilizer/pesticides) in streams as well as local roads- portions of Berkeley Avenue in Middletown must be cleared with a backhoe after significant/intense rainfall and resulting erosion from an adjacent nursery operation.

4.4 Loss of Riparian Buffer and Streambank and Streambed Erosion

A riparian buffer is a vegetated area (a "buffer strip") near a stream, usually forested, which helps shade and partially protect a stream from the impact of adjacent land uses. Riparian buffers protect water resources from nonpoint source pollution and provide bank stabilization and aquatic and wildlife habitat. When surface water (runoff) from the surrounding catchment runs through the riparian area, contaminants (sediments, nutrients) contained in the runoff are trapped by its vegetation and allow the water to infiltrate into the soil. Healthy native forest riparian vegetation usually consists of a canopy of trees accompanied by a thick undergrowth of shrubs and grasses.

Loss of riparian buffer can cause increased bank erosion - the loss of roots decreases the stability of the bank, increasing its vulnerability at times of flooding. Streambank and streambed erosion can contribute nutrients, primarily phosphorus to downstream reservoirs. Erosion in naturally stable streams (i.e., streams that are in equilibrium condition) is evenly distributed and therefore minimized along the stream channel. Acceleration of bank erosion processes is the result of channel instability, likely caused by the combined actions of sediment accretion from erosion of disturbed upland areas (including agricultural fields), altered watershed hydrology, and the subsequent change and removal of riparian vegetation.

Significant and widespread streambank and streambed erosion has been documented in Bailey Brook, Maidford River, and Paradise Brook. As part of the NRCS National Water Quality Initiative (NWQI) investigations, RIDEM staff have observed significant channel erosion in portions of the Maidford River and Paradise Brook. Much of this appears to be a direct result of the lack of riparian buffer. There are also areas in Quaker and Borden Brook where lack of riparian buffer and channel erosion have been identified. These areas are described in more detail in the individual reports available on the RIDEM website (http://www.dem.ri.gov/programs/water/quality/restoration-studies/).

The Aquidneck Land Trust (ALT) contracted a consulting firm to evaluate individual stream reaches in both the Maidford River and Paradise Brook as part of development of the Maidford River and Paradise Brook Watershed Conservation Plan (ALT 2017a). The evaluation included assessments of stream buffer and stream channel integrity, as well as information regarding stormwater outfalls and agricultural-related observable impacts.

The stream reach surveys documented many impacts to both the Maidford River and Paradise Brook. These include impacted buffers, significant erosion problems, agricultural-related impacts, and stormwater impacts. The central portions of both the Maidford River and Paradise Brook were found to have the highest proportion of erosion impacts. It was also noted that these areas also had the highest instance of both residential land use and impervious surface cover-which is often associated with higher peak flows and ‘flashier’ runoff characteristics. Summaries of reach assessments are presented in Figure 4.6 (Figure 2.5 in the Maidford River and Paradise Brook Watershed Conservation Plan (ALT 2017a).

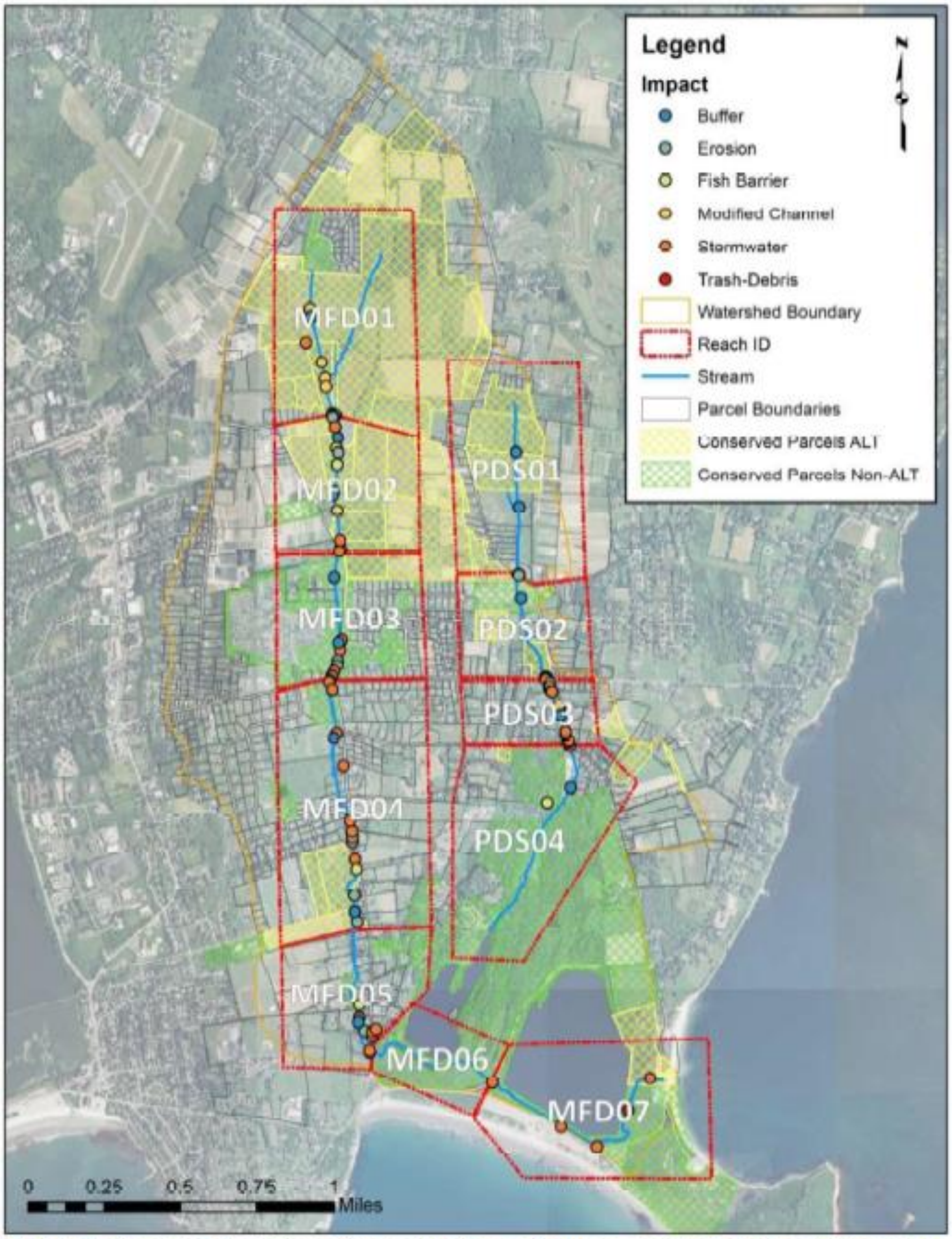


Figure 2-5 Reach delineations with various Reach Impacts observed during stream walks.

Figure 4.6 Maidford River and Paradise Brook stream reach summaries.

Stream assessment surveys were conducted in 2004 in first order tributaries of Bailey Brook as part of the Bailey Brook Watershed Plan, prepared for the Natural Resources Conservation Service (NRCS) (NRCS 2005) by GeoSyntec Consultants. These assessments applied both the Unified Stream Assessment (USA) methodology (USACOE 2007) and the low gradient Rapid Bioassessment Protocol (Barbour et al. 1999) to five segments of first order tributaries in the Bailey Brook Watershed. Figure 4.7 displays the stream reaches and Table 4.19 summarizes the stream assessment survey results for Bailey Brook. As seen in Table 4.19, nearly all stream reaches surveyed showed evidence of: 1) sediment deposition, 2) inadequate buffer, 3) bank scour and erosion, and 4) moderate channel erosion.

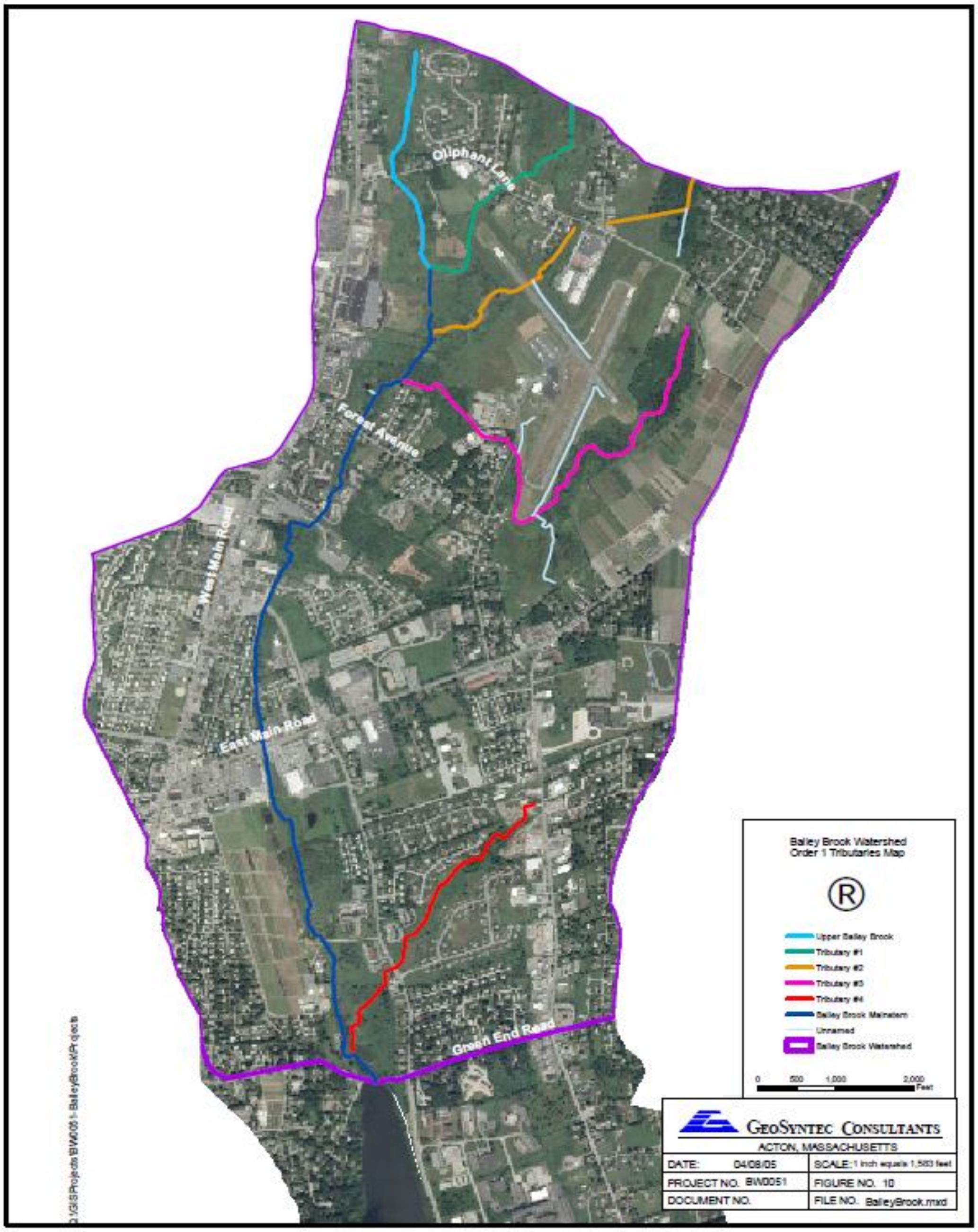


Figure 4.7. Bailey Brook NRCS Stream Assessment Reaches.

Table 4.19. Bailey Brook NRCS Stream Survey Summaries

Tributary	Water Quality Issues/Threats	USA Reach Assessment*		
		In-stream	Buffer/ Floodplain	Total
Upper Bailey Brook *(summary on page 4-5)*				
Reach 1	▪ No significant problems identified.	68	60	128
Reach 2	▪ Sewer main adjacent to (and crosses) stream. ▪ A portion of Reach 2 has been widened and relocated. ▪ Large piles of unprotected fill are actively eroding in "Skater Island" area adjacent to wetland at stream headwaters. ▪ Sediment deposition in stream channel.	54	46	100
Tributary #1 *(summary on page 4-7)*				
Reach 1	▪ Stable wetland channel. No problem areas identified.	77	68	145
Reach 2	▪ Moderate sediment deposition. No significant problems observed.	50	53	103
Reach 3	▪ Possible illegal floor drain connection requiring further investigation. ▪ Area of inadequate vegetated buffer (mowed lawn adjacent to stream).	63	51	114
Tributary #2 *(summary on page 4-9)*				
Reach 1	▪ Small, stable wetland channel. No problem areas noted.	74	67	141
Reach 2	▪ Moderate channel erosion, bank scour, sediment deposition. Stream is deeply entrenched. ▪ Marginal buffer zone (10-25'), with significant floodplain encroachment from adjacent development.	28	18	46
Reach 3	▪ Reach 3 appears to have been widened and relocated.	58	69	127
Tributary #3 *(summary on page 4-11)*				
Reach 1	▪ Downstream section of Reach 1 was altered (widened, bank alteration) with a bulldozer to increase storage capacity. ▪ Inadequate buffer (mowed law to stream edge) along Champlin Terrace. ▪ Odor (sulphur/rotten egg) and orange film at several in-stream locations.	63	61	124
Reach 2	▪ Odor (sulphur/rotten egg) and orange film at several in-stream locations. ▪ Odor and buildup of highly flocculent material in channel, at confluence with drainage ditch (*additional investigation recommended*). ▪ Piles of unprotected fill are eroding from property of H. Lacerda Jr. Landscaping & Construction, adjacent to wetland at stream headwaters.	47	26	73
Tributary #4 *(summary on page 4-13)*				
Reach 1	▪ In general, Reach 1 is stable and has extensive vegetated buffers. ▪ Minor area of inadequate buffer (mowed grass to stream edge) and rip-rap bank stabilization just downstream of Valley Road.	68	65	133
Reach 2	▪ Small area of bank scour and channel erosion upstream of Valley Rd. ▪ Piles of debris (stone, logs, gravel) in stream at area adjacent to sand/gravel operation off of Aquidneck Avenue. Significant sediment deposits found downstream of this area. ▪ Headwaters pond off Aquidneck Ave. is filling with sediment and should be excavated to provide additional stormwater storage capacity.	51	43	94

* USA score based on a maximum total of 160 points (80 in-stream, 80 buffer/floodplain), which represents the highest quality stream conditions for this region.

More recent riparian buffer assessments in Bailey Brook were conducted by ALT in 2016 (ALT 2017b). The riparian buffer was assessed through a combination of on-the-ground site visits and examination of aerial imagery and GIS analysis. The stream was delineated into 7 reaches for classification purposes and was scored according to evaluation of the following criteria: land use, undisturbed vegetation width, vegetation composition, percent hydric soils, topography, proximity to roadways, and floodplain restoration potential.

Results from this evaluation showed that the healthiest levels of riparian buffer in Bailey Brook are at the headwaters and at the main branch at North Easton Pond. Poor buffer quality corresponded with the heavily urbanized areas of residential and commercial land uses in Middletown along West Main Road.

The above studies clearly document that stream channel erosion and lack of adequate/effective riparian buffer exists in the three largest tributaries to the drinking water reservoirs on Aquidneck Island. Stream channel erosion transports sediment and nutrients, namely phosphorus, to the receiving reservoirs. Lack of riparian buffer along portions of both the stream channel and reservoir shoreline allow for direct transport of nutrients from various nonpoint sources of pollution impacting the reservoirs.

4.5 Excessive Populations of Resident Geese Along Reservoir Shorelines

Another source of nutrients (both phosphorus and nitrogen) is the excessive amounts of Canada Goose feces observed by RIDEM staff on the reservoir shorelines and bermed areas. A significant number of papers have been published examining how nutrients from both migratory and resident bird populations can affect water quality and speed the process of cultural eutrophication (Manny et al, 1994; Moore et al. 1998; Purcell, 1999; Portnoy, 1990; Kitchel et al., 1999, and Bland et al., 1996).

Manny et al. (1994) estimated that an individual goose contributed approximately 8.2×10^{-3} kg/yr of phosphorus to a lake in southwestern Michigan, mostly during their migration. This was estimated to be equivalent to 70% of all P that entered the lake from external sources. Migrating geese were found to increase the total phosphorus loading rate in some wetland ponds at the Bosque del Apache National Wildlife Refuge in New Mexico by as much as 75% (Kitchel et al. 1999). Chlorophyll levels also increased in proportion to bird densities. J.K. Bland (1996) reported that 52% of the annual phosphorus budget of Green Lake in Seattle could be traced to resident waterfowl. Although the water supply reservoirs have small populations of waterfowl relative to typical wildlife refuges, most of the waterfowl is resident and not just present a few weeks a year.

In urban and suburban areas throughout Rhode Island, including the Newport reservoir watersheds, shoreline home development with widespread lawns on lakes and ponds (and in the case of Newport's reservoirs-grassed embankments), lack of natural predators, limited hunting, and supplemental feeding have created a surge in resident waterfowl numbers- mainly geese. Based on observations by RIDEM staff, most of the nutrient loadings from waterfowl to the Newport reservoirs comes from excessive populations of resident Canada Geese. These observations include: vast quantities of goose droppings along a majority of reservoir shorelines as well as certain reservoir tributaries. Table 4.20 lists the reservoirs, in order of those with most often observed of goose droppings, in the 4 years-worth of field observations made at various times of the year by RIDEM staff. Riparian buffer strips of natural vegetation, especially bushes, can greatly lessen the attractiveness of a pond by physically impeding movement from land to water and providing the threat of harboring potential predators. Trees surrounding smaller ponds also make landings and take-offs more difficult.

Reservoir levels fluctuate fairly rapidly, particularly in the summer and fall months when demand is higher and inter-reservoir water transfers are more common. RIDEM staff regularly observed fecal material along shorelines that was completely submerged on the next visit. This problem is exacerbated by a lack of buffer on the berms around these reservoirs. Much of these grassy bermed areas are kept free of tall vegetation of any kind and are frequently cleared by the Newport Water Department to maintain the berms' integrity. Unfortunately, this results in ideal habitat for resident geese. In areas that cannot have tall vegetation, Canada Geese can also be deterred by installation of predator decoys (e.g. owls, coyotes) or reflective/shiny items that move, such as temporary streamers or pinwheels.

Table 4.20. Observed goose waste adjacent to water supply reservoirs.

Reservoir	Relative Magnitude of Problem[1]
Lawton Valley Reservoir	High
North Easton Pond	High
South Easton Pond	High
Watson Reservoir	High
Paradise Pond	High
Sisson Pond	High
St. Marys Pond	Medium
Gardiner Pond	Medium
Nonquit Pond	Low

[1] Based on RIDEM staff observations of goose populations and amounts of waste.

4.6 Wastewater Contributions

Failing septic systems may be a source, albeit minimal, of phosphorus to the Newport reservoirs. Although there are few houses sited directly along the reservoir shorelines, there are numerous houses located along several of the tributaries. Phosphorus from failing individual septic systems is typically adsorbed to soil particles within proximity of the failing system and is not generally found dissolved in groundwater. However, failing systems adjacent to waterbodies, particularly those with surface breakouts, could be a significant source of phosphorus. Illicit tie-ins to storm water systems are probably the most significant potential source of phosphorus associated with failed systems. Annual total phosphorus loads predicted by the WTM in all reservoir watersheds were generally less than 2% of the total annual load.

Sanitary sewer overflows are discharges of untreated wastewater from sewer systems. These overflows can be caused by clogged or cracked sewer pipes, by excess infiltration and inflow, by undersized sewer systems (piping and/or pumps), or by equipment failure. This untreated wastewater can find its way to surface waters. In addition to surface releases, cracked sewer pipes may contaminate groundwater and ultimately surface waters.

A query of DEM bypass event records for the Town of Middletown shows that five bypasses occurred between 2007 and 2013 with discharges to Bailey Brook and tributaries ranging from 500 to less than 20,000 gallons. All five bypasses were due to grease and/or debris blockages. At present, it does not appear that this is a continuous or significant source of nutrients in the watershed. However, as the collection system ages, the frequency and severity of bypass or sanitary sewer overflows could also increase and become a more significant source.

There are no discharges from wastewater treatment facilities (WWTF) to any of the nine reservoirs.

4.7 Internal Cycling of Nutrients from Newport Reservoir Sediments

The release of phosphorus from sediments, is referred to as 'internal cycling or internal loading' and can be a significant source of phosphorus in lakes and reservoirs waters. Internal phosphorus loading originates from a pool of phosphorus accumulated in the lake sediment. <u>The ultimate source of most of the sediment-bound phosphorus is external (i.e. watershed sources such as stormwater).</u> Under certain conditions this sediment-bound phosphorus can be released into the water column resulting in elevated phosphorus concentrations, and consequently, algal blooms, and low dissolved oxygen conditions. Internal loading is generally more significant in deeper lakes, where no or low oxygen levels (anoxic conditions) favor the release of sediment-bound phosphorus.

In deep lakes (>5 m), phosphorus concentrations at the surface and at depth are typically similar in the spring, reflecting the physical water column mixing that occurs in the spring. When deep ponds become thermally stratified in the summer and early fall, oxygen at depth typically becomes depleted because of the decay of organic matter in the sediment and from the decay of recent senescent phytoplankton. The bottom waters of deep ponds are typically isolated from more oxygen rich surface waters in the summer and early fall, with little occurrence of vertical mixing. When the bottom waters become anoxic in the summer, the chemical state of metals (such as iron) changes, resulting in release of phosphorus into the water column. Unlike under aerobic conditions when phosphorus is typically retained in the lake sediment, bound to metals such as iron and manganese. Phosphorus concentrations at depth tend to increase dramatically in the summer and early fall, in deep eutrophic ponds. Søndergaard et al. (1993) found that in a Danish lake phosphorus release mainly occurred from April to October, with little or no phosphorus release occurring during the winter.

While shallow lakes are generally well mixed, they may become weakly or intermittently stratified, resulting in anoxic conditions in the bottom waters. Riley and Prepas (1984) studied two shallow intermittently-stratified lakes in Alberta and found that during periods of stratification water directly overlying sediments was anoxic and total phosphorus increased in deep water, with the sediments being the major source of total phosphorus. After eight of nine mixing events that immediately followed stratified periods, total phosphorus in the surface water increased by 3-52%.

Although the release of sediment-bound phosphorus is enhanced by anoxic bottom conditions, phosphorus is also released from lake sediments to well aerated water more typical of shallow lakes. Holdren and Armstrong (1980) per Fricker (1981) quoted literature values of sediment phosphorus release rates from several lakes in the United States for aerobic (0 to 13 mg/m^2/day) and anaerobic conditions (0 to 50 [max. 150] mg P mg/m^2/day). Welch and Cooke (1995) reported very high internal loading rates (20-50 mg/m^2/d) in shallow lakes characterized by wind mixing/resuspension. Søndergaard et al. (1999) measured the seasonal phosphorus concentrations of 265 shallow, mainly eutrophic Danish lakes and found that total phosphorus concentrations during summer were two to four times higher than winter values in lakes with a mean summer total phosphorus concentration above 200ug/l. Søndergaard et al. (1992) reported that the rate of phosphorus release from the undisturbed sediment of a shallow eutrophic Danish lake during the summer was 4-12 mg/m^2/day. This rate increased to 150 mg/m^2/day during simulated resuspension events. Phillips et al. (1994) recorded sediment phosphorus release rates as high as 278 mg/m^2/d, in very shallow lakes in the United Kingdom.

The level of phosphorus concentrations in the water column influences the length of time that phosphorus is released from the sediment. Søndergaard et al. (1999) found that in shallow eutrophic Danish lakes, with total phosphorus concentrations below 100 ug/l, phosphorus was retained in lake sediments for most of the year, except July and August when mean internal loading accounted for 10-30% of external loading. In lakes with total phosphorus above 100 ug/l, phosphorus was retained in lake sediments during the winter but released from April to September. It is noted that mean total phosphorus concentrations in the nine water supply reservoirs are well below 100 ug/l.

Based on information collected in 2014 and 2015, each of the nine Newport reservoirs has exhibited some circumstantial evidence of internal loading (the release of phosphorus from lake sediments). The circumstantial evidence includes hypoxic bottom waters, elevated levels of phosphorus in the bottom waters, increases in chlorophyll-a concentrations after fall turnover, elevated lake sediment-phosphorus concentrations, and/or increases in reservoir phosphorus mass during the growing season.

RIDEM estimated internal loading for Newport's nine reservoirs using two well-established methodologies: (1) assessing in-situ increases in reservoir phosphorus, and 2) estimating a sediment-phosphorus release rate based on sediment-phosphorus concentrations. The in-situ method appeared to be the better method for quantifying the internal load from these reservoirs, since the in-situ method assumptions more closely match reservoir water quality conditions (i.e. the occurrence of harmful algal blooms). The data used to estimate internal loading for the reservoirs consisted of single sediment cores collected in each of the reservoirs in 2014 and water quality data (including phosphorus and DO data) collected biweekly from May through October 2015.

The analysis documented evidence of internal phosphorus cycling within Newport's Water Reservoirs; however, because of the confounding influence of intra-reservoir water transfers, tributary inflow and hypolimnetic water withdrawals, the estimations of internal load are only approximate in nature. A more accurate estimation of internal loads would require flow measurements and phosphorus sampling of intra-reservoir water transfers, major tributaries, and

water withdrawals into the North Easton and Lawton Valley Water Treatment facilities. The internal loading evaluation is available on RIDEMs website at:
http://www.dem.ri.gov/programs/water/quality/restoration-studies/
While the focus of this TMDL's Implementation section is on the control of external loading of phosphorus to the reservoirs, attention should also be given to better evaluating the internal loading, as it may become a more significant source of nutrients to the reservoirs once external sources are controlled.

4.8 Natural Background Sources

There are many 'natural' sources of phosphorus in aquatic systems. Natural sources include native waterfowl and wildlife waste, atmospheric deposition, tributary inputs of organic material, and biological decomposition. These sources are difficult to evaluate and quantify.

The Watershed Treatment Model (WTM) was used to evaluate watershed-derived natural background loads of phosphorus to each reservoir. The total natural background phosphorus load was calculated as the sum of loads from atmospheric sources and forest/wetland land use categories. Forest and wetland land use categories assumed zero percent impervious and turf cover. All estimates are based on literature-derived annual loading rates. Natural background phosphorus loads (expressed as a percentage of the total load) ranged from 3% in the Bailey Brook watershed to 30% Nonquit Pond.

4.9 Tiverton Municipal Landfill

The Tiverton Landfill, also known as the Tiverton Town Landfill #2, is located on the east side of Main Road (Route 77) in Tiverton, Rhode Island. Currently, the landfill serves the solid waste management needs of the residents of Tiverton. The Landfill property encompasses approximately one hundred twenty-five (125) acres, of which approximately thirty-three (33) acres are permitted for solid waste landfilling activities. The remainder of the property is used for the collection and transfer of recyclables, records and equipment maintenance, runoff control, and a wooded buffer. Also located within the property boundaries is a public recreation area situated approximately one-quarter (¼) mile west of the active Landfill, adjacent to Main Road. A swale/ditch drains portions of the upper landfill and flows directly into Quaker Creek, the main tributary to Nonquit Pond. The landfill swale was specifically constructed to convey stormwater and leacate from the landfill to Quaker Creek.

The Town of Tiverton has been operating the Tiverton Sanitary Landfill for over sixty (60) years. The landfill was originally opened in 1952 and was used as an unregulated open burning dump. In 1977, the State instituted regulation of the Landfill by issuing the Town a permit to operate. In 1982, the State implemented the solid waste operating guidelines entitled, "Rules and Regulations of Solid Waste Management Facilities" and the Town received an Administrative Order to comply with Rule 10.12. As a result of this Order, the Town established a two-hundred foot (200') buffer within the property boundary where no landfilling could occur. Prior to the 1982 guidelines, some landfilling occurred in what was delineated as the southern buffer.

Numerous field investigations by RIDEM staff during wet weather documented uncontrolled runoff from the landfill roadway and landfill property containing sediment, litter, and petroleum hydrocarbons flowing into the drainage swale that discharges directly to Quaker Creek and eventually Nonquit Pond. As part of pollution source reconnaissance done in support of this TMDL, RIDEM OWR staff observed uncontrolled runoff from various portions of the landfill containing sediment, litter and petroleum hydrocarbons flowing into the main landfill drainage swale (identified as 'LD') (Figure 4.8). Runoff from the site was a dark brown color and had a petroleum odor and sheen. These observations corroborate the findings of OWR's NWQI monitoring of Nonquit Pond tributaries that Tiverton Landfill operations are contributing to water quality impairments of Quaker Creek, and possibly Nonquit Pond.

The landfill swale is a stormwater conveyance to Quaker Creek and is therefore considered to be a point source to a water of the state. As part of the National Water Quality Initiative project, samples were collected from the landfill swale as well as locations just upstream on Quaker Creek (Station Q1) and downstream of the swale (Station Q2) (Figure 4.8). It is noted that station Q1 likely receives groundwater flow originating from the landfill as well as inputs from other land uses upgradient of the landfill. The landfill swale was documented to convey leachate containing TSS, ammonia, and dissolved organic carbon (DOC) during dry weather. Stormwater runoff from the upper portions of the landfill during wet weather is elevated in TSS, total phosphorus, total nitrogen (primarily as ammonia), DOC, and Enterococci.

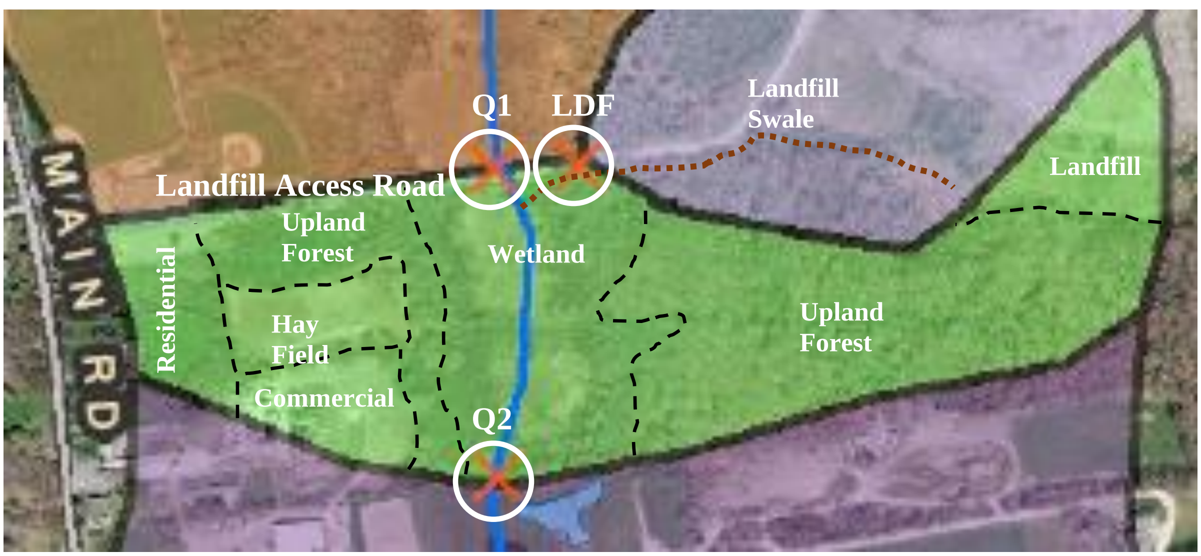


Figure 4.8. RIDEM NWQI Tiverton Landfill Stations.

Pollution Source Overview

In summary, utilizing water quality sampling results, direct observation from pollution source field investigations and watershed modeling, RIDEM has documented a variety of actual and potential pollution sources contributing to the water supply reservoirs observed and documented water quality impairments. The major sources of both phosphorus and nitrogen to the water supply reservoirs, not necessarily in order of importance to each individual reservoir, include: 1) urban and agricultural runoff, 2) other agricultural-related activities including flooding of livestock and equine paddocks and direct access of animals to water courses, 3) excessive populations of resident geese, 4) internal cycling of nutrients from reservoir sediments, 5) onsite wastewater treatment systems (OWTS), 6) natural background sources (forest and atmospheric), and 7) Tiverton Landfill (as a source of nutrients and other pollutants to Nonquit Pond).

5.0 TMDL ANALYSIS

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The TMDL is often defined as the sum of loads allocated to point sources including stormwater from urbanized areas subject to Rhode Island Pollutant Discharge Elimination System (RIPDES permitting) (i.e. waste load allocation, WLA), loads allocated to nonpoint sources, including natural background sources (i.e. load allocation, LA), and a margin of safety (MOS). The loadings are required to be expressed as mass per time, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]).

Determining the TMDL that a lentic waterbody can assimilate without exceeding WQS is challenging and complex for the following reasons: (1) Many lakes receive a significant portion of their nutrient load from diffuse landscape or nonpoint sources, which are highly variable and difficult to quantify without a substantial data set. Internal loading of nutrients, which is retention and cycling of nutrients within a lake, can also play a significant role but can also be difficult to quantify without adequate water quality data. (2) Lakes generally respond to nutrient loading on a seasonal time scale, rather than a daily time scale. (3) Nutrient loading capacity is typically determined through water quality modeling, which is often expressed on an annual basis, targeting the time of year when nutrients are likely to be transported to the lake and affect water quality. (4) Additionally, water quality response to nutrient loading in lakes depends on several factors, including weather patterns (drought, storm events), lake morphology, and nutrient forms. Therefore, it is most appropriate to quantify a lake TMDL as an annual load and evaluate the results of that annual load on seasonal conditions from April through October, which is most critical to supporting designated uses.

5.1 Margin of Safety (MOS)

The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly allocate a portion of the TMDL as the MOS. A ten (10) percent explicit margin of safety was applied to the 20 ug/l total phosphorus target concentration resulting in a final total phosphorus target concentration of 18 ug/l. Allowable loads were then derived using the 18 ug/l total phosphorus target concentration. The resulting allowable loads calculated from an 18 ug/l total phosphorus concentration target are 10-12 % less than loads calculated with a total phosphorus concentration target of 20 ug/l. Section 5.4 describes the development of numeric phosphorus targets applied to this TMDL.

5.2 Critical Conditions and Seasonal Variation

Critical conditions for phosphorus loadings to Newport reservoirs occur between May and October when the occurrence and frequency of nuisance algal and cyanobacteria blooms are usually greatest. The application of copper sulfate, necessary to control the cyanobacteria blooms, to various reservoirs typically occurs from late June through October. Data collected during the growing season (May-Oct) in 2011, 2012, and 2015 revealed that all nine reservoirs experience moderate to severe nutrient enriched conditions, including elevated levels of phosphorus, nitrogen, and chlorophyll-*a*, low water clarity, low levels of dissolved oxygen, and frequent algal and cyanobacteria blooms. Since these TMDLs are based on information collected during the most environmentally sensitive period (i.e., the growing season) and were developed to be protective of this critical time period, they are expected to be protective of water quality during all other seasons.

5.3 Numeric Water Quality Targets

The primary objective of these TMDLs are to address the water quality impairments in the Newport reservoirs that are associated with elevated phosphorus loadings. These impairments include excessive levels of phytoplankton (predominantly cyanobacteria) and total organic carbon (TOC). Reducing phosphorus concentrations in the reservoirs is the most effective way to reduce phytoplankton abundance, because their growth in freshwater environments is constrained by the availability of phosphorus.

In 2015, RIDEM completed a water quality study of the Newport reservoirs with the goal of collecting data to support establishment of specific phosphorus and chlorophyll-*a* concentrations to control phytoplankton growth and reduce total organic carbon concentrations to a level that supports drinking water and aquatic life uses. Using the data collected in 2015, RIDEM evaluated empirical relationships between the limiting nutrient phosphorus, algal growth (measured as chlorophyll-a), total organic carbon, and the potential for total trihalomethane production. The findings from this study, presented in Section 5.4 below, indicate that seasonal mean epilimnetic total phosphorus and chlorophyll-*a* targets of 18 ug/l and 11 ug/l, respectively, would be protective of aquatic life use in Newport's water supply reservoirs and their use as drinking water sources. More specifically, reductions in algal/cyanobacterial-derived organic carbon will result in reduced risk of disinfection by-product formation and reductions in cyanobacterial dominance of the phytoplankton communities in the reservoirs-with associated reductions in the potential for cyanobacterial toxin formation.

5.4 Development of Total Phosphorus and Chlorophyll-a Targets for the Newport Reservoirs

Development of the TMDLs for the Newport water supply reservoirs required the establishment of numeric phosphorus and chlorophyll-*a* targets that are protective of the more stringent use classification of drinking water supply sources. The TOC drinking water impairment is addressed via the total phosphorus TMDL. The goal of the TMDL is that the quality of the reservoirs is such that the Safe Drinking Water Act (SDWA) requirements (for trihalomethanes specifically) can be met with conventional treatment alone.

The derivation and adoption of numeric nutrient and chlorophyll-*a* targets that are protective of drinking water supply sources has been slow to develop at both the state and federal levels. Rhode Island is re-evaluating its current numeric nutrient criteria in lakes but has specifically targeted non-drinking water lakes, due to the complex nature of management at drinking water source supplies. To date, the States of Colorado, Oklahoma, and Kansas have developed chlorophyll-*a* targets for drinking water supply reservoirs, and New York State has developed chlorophyll-*a* and phosphorus targets that would apply to all potable water supplies in the state. Although the chlorophyll-a targets derived in NY have yet to be formally adopted they have been used as TMDL endpoints for several Class A waterbodies which, by NY's classification, are waterbodies suitable for use as drinking water sources following conventional treatment.

RIDEM's technical approach for deriving nutrient and chlorophyll-*a* targets for the Newport water supply reservoirs was largely patterned after a study conducted by the New York State

Department of Environmental Conservation (NYSDEC) (Callinan 2009). Additionally, some aspects of RIDEM's study have incorporated elements of a somewhat similar study completed by the state of Colorado Water Quality Control Division (WQCD 2011). NYDEC has proposed phosphorus and chlorophyll-*a* thresholds for the protection of water supply lakes and reservoirs by establishing relationships between nutrients, algal abundance, dissolved organic carbon, and trihalomethanes (Callinan et al. 2013). In 2015, RIDEM initiated a water quality study of the Newport reservoirs similar in scope and purpose to the one conducted by NYSDEC (Callinan 2009). A summary of major findings from this study, as well as the technical approach to defining the phosphorus and chlorophyll targets for the nine reservoirs is detailed below.

5.4.1 Water Quality and Trophic Status of the Newport Reservoirs

Data collected in 2011 and 2012 by consultants to the City of Newport revealed that all nine reservoirs experience moderate to severe nutrient enriched conditions, including elevated levels of phosphorus, nitrogen, and chlorophyll-*a*, low water clarity, frequent algal and cyanobacteria blooms, and low levels of dissolved oxygen. Additional data collected in 2015 by RIDEM confirmed the eutrophic conditions in the reservoirs. Table 5.1 provides a summary of trophic state related parameters, as well as the Trophic State Index (TSI) calculations in the Newport reservoirs from the 2015 dataset. The trophic status of each reservoir is calculated according to Carlson (1977).

The TSI, developed by Carlson (1977) utilizes three variables-total phosphorus, chlorophyll-a pigments, and Secchi depth to express the condition of the waterbody. Phosphorus, chlorophyll-a (algae concentration) and Secchi depth are related. When phosphorus increases, there is more 'food' available for algae, so algal concentrations increase. When algal concentrations increase, the water becomes less transparent and the Secchi depth decreases. Table 5.1 presents seasonal epilimnetic mean concentrations of total phosphorus, chlorophyll-*a*, and Secchi disc depth data. Epilimnetic means for each parameter are generally based on 12 samples. The Carlson trophic state indices calculated from the data are also presented in Table 5.1 for informational purposes regarding the condition of the waterbody.

Table 5.1 Calculated Trophic Condition of Newport Reservoirs.

Reservoir	Mean TP (ug/l)	Mean Chl-a (ug/l)	Secchi (meters)	Calculated Carlson Trophic State Index			Trophic State
				TSI (TP)	TSI (Chl-a)	TSI (Secchi)	
Nonquit	41.3	16.2	1.0	57.8	57.9	60.0	Eutrophic
Watson[1]	17.2[1]/22.0[2]	14.4	1.47	45.2	56.8	54.5	Eutrophic
Lawton Valley	41.7	35.1	1.08	57.9	65.5	58.9	Eutrophic
Sisson	87.7	55.9	0.81	68.7	70.1	63.0	Eutrophic
St. Marys[1]	71.1[1]/79.0[2]	38.2	1.16	65.6	66.3	57.9	Eutrophic
North Easton	57.2	44.7	0.77	62.5	67.9	63.8	Eutrophic
South Easton	37.1	31.0	0.78	56.3	64.3	63.5	Eutrophic
Gardiner	43.1	36.7	1.15	58.4	65.9	58.0	Eutrophic
Paradise	79.6	37.3	0.86	67.3	66.1	62.2	Eutrophic

[1] Mean TP values do not include data collected by outside contractors for the City of Newport during the same time period because no concomitant chlorophyll-a data were collected. These mean TP values for Watson and St. Marys were used solely for purposes of evaluating TP criteria for the water supply reservoirs, as described in Section 5.4.4.

[2] Mean TP values for Watson and St. Marys include data collected by outside contractors for the City of Newport to better reflect mean TP concentrations in the reservoir. These mean values were used to evaluate existing TP loads (Section 5.5.1)

5.4.2 Nutrient Enrichment and Drinking Water Supply Reservoirs

While phytoplankton plays a key role in aquatic systems, its excessive proliferation can become a significant problem for waterbodies utilized as a source of drinking water. Elevated nutrient concentrations are the primary cause of increased algal growth although temperature, solar radiation, predation, and other factors also play a role. Excessive algal growth can lead to impairments in surface waters used for drinking water by: 1) contributing to total organic carbon (TOC) and turbidity (e.g., algae cells), 2) producing taste and odor compounds, and, 3) contributing precursors which form disinfection by-products (DBP) upon chlorination, such as trihalomethanes (THMs) and haloacetic acids (HAAs) (Nguyen et al 2005).

Callinan et al. (2013) provide an excellent conceptual model showing the theoretical linkages between nutrient enrichment and drinking water human health concerns. This conceptual model (excerpted from Callinan et al. (2013) is presented below in Figure 5. 1 and provides additional insight for examining the relationships between nutrients, algal abundance, natural organic matter, and disinfection by-product formation (specifically, total trihalomethanes (TTHM)) in the Newport reservoirs. Below is a description of the linkages in Figure 5.1, as they are described by Callinan et al. (2013) and as applied in the context of the Newport Reservoirs.

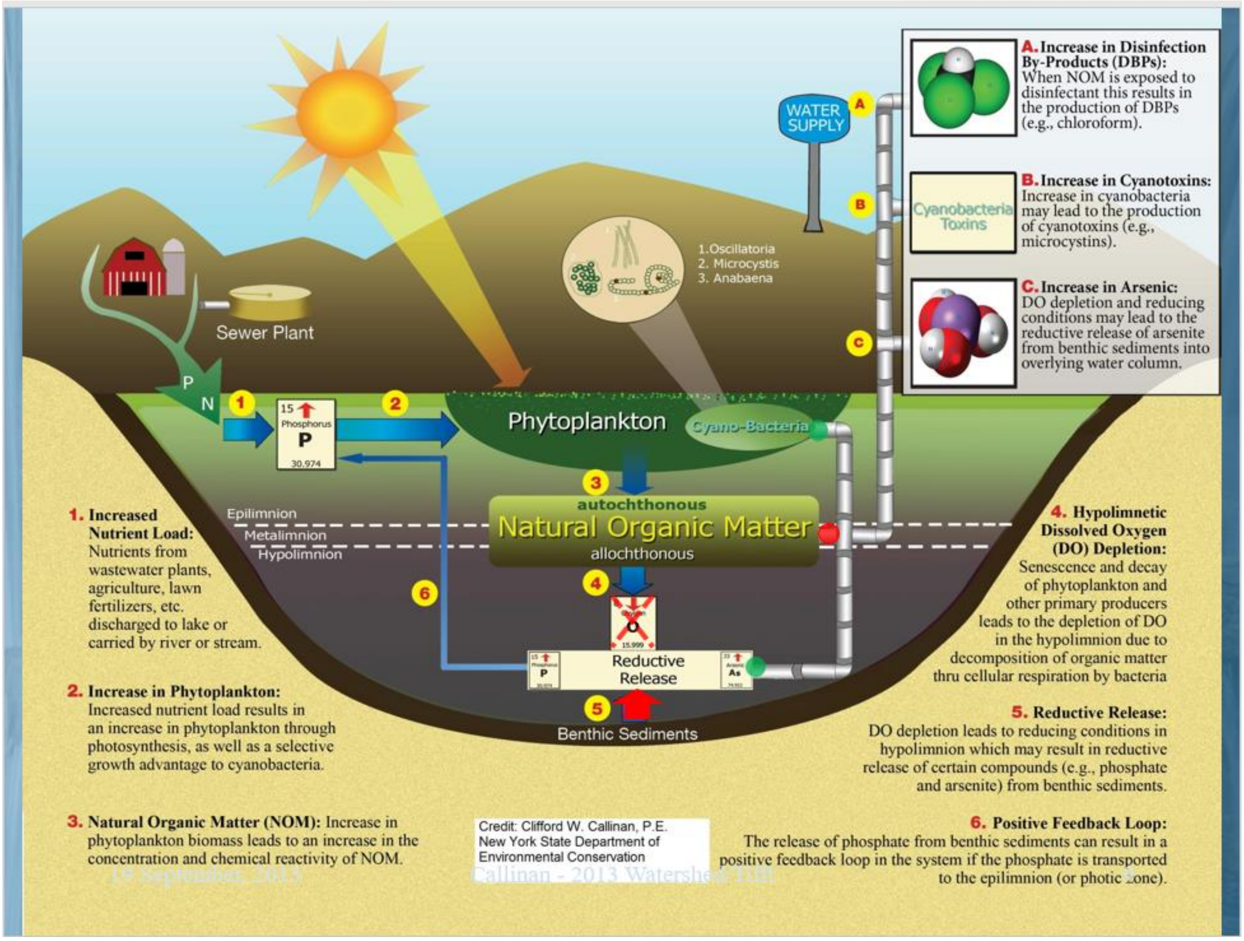


Figure 5.1. Conceptual Model of Theoretical Linkages between nutrient enrichment and drinking water health concerns (taken from Figure 1. Callinan et al. 2013).

Linkage 1- **Increased nutrient loads:** Elevated nutrient (phosphorus and nitrogen) loads to the reservoirs comes from agricultural, commercial, and urban-residential land uses in the watersheds and are transported via tributaries, most significantly from Baileys Brook, Paradise Brook, and the Maidford River. This has been documented via investigation by RIDEM, URI, and the City of Newport. Nutrient loads (namely phosphorus) also come from internal cycling from reservoir sediments (see Linkages 5-6). A substantial portion of the internal load may also come from anthropogenic legacy phosphorus loads. Increased nutrient loads results in elevated levels of nutrients in the reservoirs (documented in Table 5.1).

Linkage 2- **Increase in phytoplankton:** Increases or elevated levels of nutrients results in increases in phytoplankton as well as selective growth advantage to cyanobacteria. Results from 2011-2012 and 2015 sampling efforts document elevated levels of chlorophyll-*a* during the growing season as well as dominance (and early dominance) of the phytoplankton community by cyanobacteria in a majority of the reservoirs. Newport Water has been applying copper sulfate to control algal and cyanobacteria growth in the reservoirs for over 60 years (City of Newport Department of Utilities public meeting Oct 13th, 2016). Cyanobacteria blooms have necessitated the issuance of recreational/non-contact advisories with untreated water by the Rhode Island Department of Health in 2011, 2012, and 2015-2017.

Linkage 3- **Natural Organic Matter (NOM):** Increases in phytoplankton biomass can lead to increases in both the concentration and reactivity of NOM, which then form disinfection byproducts when the raw water is treated with chlorine. Figure 5.2 displays the mean TTHM (Summers et al. 1996), and chlorophyll-a concentrations for all nine Newport reservoirs from early May through mid-October. Figure 5.2 shows the tendency of TTHM formation potential to increase as primary productivity (as measured by chlorophyll-a) increases within the reservoirs.

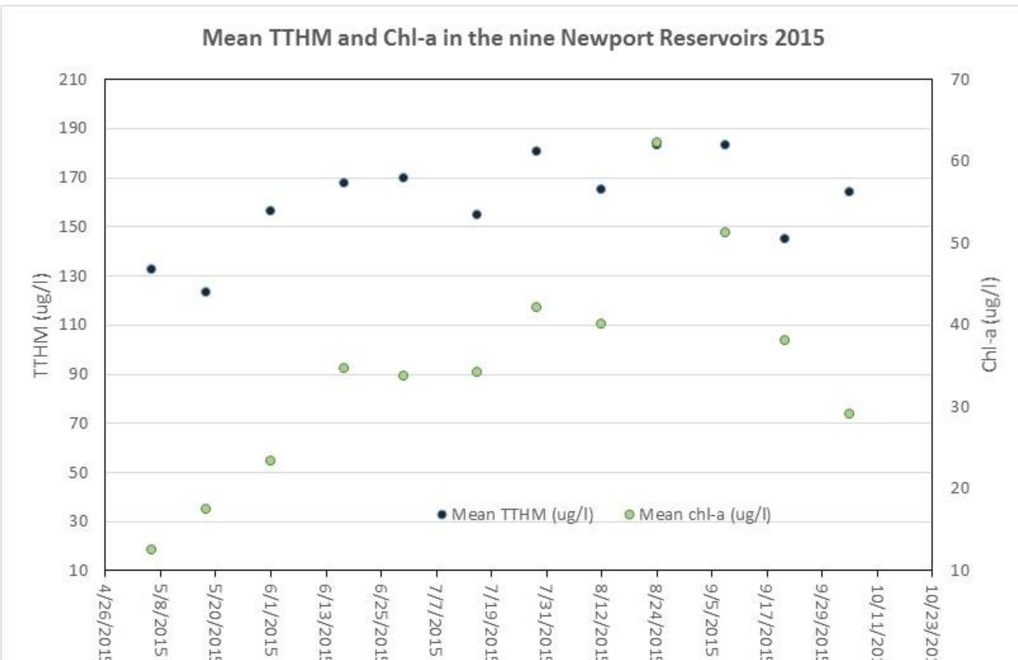


Figure 5.2. Plot of seasonal changes in reservoir-mean TTHM and chlorophyll-a concentrations in the Newport Reservoirs-2015.

Linkage 4- **Bottom Water DO Depletion:** Decay of organic matter (primarily phytoplankton) through cellular respiration by bacteria causes depletion of oxygen in the hypolimnion of stratified reservoirs. The same mechanism causes oxygen depletion in the bottom waters of the shallow, non-stratified reservoirs. Low oxygen levels were observed in a majority of the reservoirs in 2011, 2012, and 2015.

Linkage 5 and 6- **Reductive Release and Internal Loading of Nutrients:** Oxygen depletion in the hypolimnion or bottom waters of the reservoirs leads to reducing conditions and reductive release of nutrients (nitrogen and phosphorus) from the benthic sediments, which is available to further increase phytoplankton abundance. Results from the 2011-2012 and 2015 sampling efforts confirm elevated levels of both nitrogen and phosphorus in the anoxic portions of reservoirs during periods of the growing season.

Linkage A- **Increase in DBPs:** While disinfectants are effective in controlling many harmful microorganisms, they react with organic and inorganic matter in the water to form disinfection by-products (DBP), some of which pose health risks at certain levels. Prior to the advanced treatment processes becoming operational in the fall of 2014, Newport Water had a history of periodic violations of the TTHM MCL of 80 ug/l.

Linkage B- **Increase in cyanotoxins**: Increases in cyanobacteria abundance increase chances of cyanotoxins in raw water. Both microcystins, a hepatotoxin, and anatoxin-A, a neurotoxin, have been detected in several of the raw water samples from Newport's reservoirs. A water sample from Sisson Pond collected on August 12, 2015 had a measured anatoxin concentration of 80 ug/l.

5.4.3 Natural Organic Matter-Sources, Properties, and Significance

As stated earlier, control and reduction of the algal-derived component of organic matter in the reservoirs via reduction of nutrients is one of the major goals of the TMDL and thus it is useful to evaluate the likely source of DOC in each reservoir. The focus on algae is important because algal-derived precursors are difficult to remove during conventional water treatment (Saunders et. al 2015). Natural Organic Matter (NOM) is widely accepted as the primary precursor of disinfection by-product compounds (USEPA 2001). NOM is usually measured and reported in terms of either dissolved organic carbon (DOC) or total organic carbon (TOC).

The primary source of DOC in a waterbody can either be (or a combination of) external (allochthonous) or internal (autochthonous), depending on the waterbody and watershed characteristics as well as season or year. External inputs tend to consist of humic substances originating from terrestrial and wetland/littoral higher plant tissues (Wetzel 2001) while internal sources are derived from internal primary productivity and include algal/cyanobacteria biomass, extra-cellular products, and products of cell lysis (Veum 2006). Differences in the properties of external and internal-derived DOC are often used to interpret the composition of DOC in a waterbody. The type of DOC, external versus internal-derived, can influence the production of disinfection by-product compounds.

Optical properties are used to infer the source of DOC. Organic matter tends to absorb light strongly in the ultraviolet (UV) range and UV absorbance is sometimes used as a surrogate for DOC concentration (Edzwald et al. 1985). DOC source can be determined by what is called 'specific UV absorbance' or SUVA. SUVA is calculated as the ratio of UV absorbance (UV 254) to the DOC concentration and is expressed in units of L/mg-m. SUVA is useful for generalizing about sources because internal and external DOC are at opposite ends of the SUVA spectrum (CO WQCD 2011). DOC composed of larger and more complex molecules (external) absorb UV light more strongly than DOC composed of simpler molecules (internal) (Weishaar et al. 2003). DOC of external origin tends to have a high degree of aromacity because it consists mainly of larger molecules like humic and fulvic acids.

The SUVA for external DOC is likely to be more than 3.0 or 3.5 L/mg-m (Mash et al. 2004) while algal-derived, or internal DOC is composed of small molecules such as carbohydrates and amino acids with a SUVA value less than 2 L/mg-m (Mash et al. 2004, Nguyen et al. 2005). The carbon to nitrogen ratio (C/N ratio) can also be used to discern internal versus external sources of organic carbon. Internal, algal-derived sources of carbon are indicated by C/N ratios less than 8 while external organic matter has C/N ratios greater than 20 (Hein et al. 2003).

Table 5.2 provides a summary of chlorophyll-*a*, dissolved organic carbon, UV-254, SUVA, C-N ratio, Specific Yield, and TTHM levels from the 2015 sampling of the Newport Reservoirs. In addition to DBP concentrations (as represented by TTHM levels), specific yields are useful for further evaluating the reactivity of the DOC pool and better understanding of the TTHM precursor material. Specific yields represent the concentration of TTHM normalized to the DOC for a water sample (µg DBP/mg C). This allows for determining a specific water sample's yield of a particular DBP per unit carbon, or essentially its reactivity to chlorine. The final column in Table 5.2, the likely predominant source of DOC for each reservoir, was determined based on the above information as well as ancillary information such as watershed size and knowledge of tributary inputs. Rows highlighted in blue, green, or brown denote primary DOC source from watershed, in-pond, or combination thereof, respectively.

Table 5.2. Organic Matter characteristics of Newport Reservoirs based on 2015 Sampling Results.

Reservoir	Direct Watershed Size[2]	Chl-a ug/l[1]	DOC mg/l[1]	UV 254 nm(cm-1)[1]	SUVA L/mg-m[1]	C:N ratio[1]	TTHM ug/l[1]	Specific Yield ug TTHM/mg DOC	Likely Predominant DOC source
Nonquit	4436	16.2	11.3	0.5	4.2	19.0	434.2	38.4	Watershed - Derived
Watson	2295	14.4	5.17	0.10	2.01	8.7	119.63	23.1	Phytoplankton-based
Lawton Valley	742	35.1	4.68	0.08	1.84	4.5	96.85	20.7	Phytoplankton-based
Sisson	225	55.9	8.52	0.16	1.98	6.8	137.08	16.1	Phytoplankton-based
St. Marys	546	38.2	5.64	0.11	2.01	4.5	103.93	18.4	Phytoplankton-based
North Easton	2812	44.7	5.09	0.12	2.48	5.9	133.67	26.3	Combination
South Easton	2850	31.0	5.36	0.11	2.13	5.4	136.92	25.5	Combination
Gardiner	146	36.7	6.23	0.09	1.51	5.2	91.89	14.7	Phytoplankton-based
Paradise	2049	37.3	7.97	0.20	2.58	6.7	186.92	23.4	Combination

1Expressed as seasonal mean epilimnetic value. [2] Direct watershed size is the contributing watershed to each reservoir in the 'conventional sense', however water from each reservoir can and is transferred.

5.4.4 Methodology for Development of Chlorophyll and Phosphorus Targets

The data used to support this analysis was collected in 2015 and involved sampling of the nine reservoirs on a bi-weekly basis from May through October. Mean TP values calculated for St. Marys Pond and Watson Reservoir in this analysis do not include data collected by outside contractors for the City of Newport during the same time period, because no concomitant chlorophyll-a data were collected.

Sampling was conducted at a location corresponding to the deepest location in each reservoir and included in-situ vertical profiling of temperature, conductivity, pH, and dissolved oxygen. Water samples were obtained from the surface, and, if present, from within the thermocline and hypolimnion of each reservoir. Samples were analyzed for total and dissolved phosphorus, total nitrogen, nitrate and nitrite nitrogen, total Kjeldahl nitrogen (TKN), ammonia nitrogen, dissolved organic carbon, chlorophyll-*a*, ultraviolet absorbance (UV 254), and total trihalomethanes (utilizing the UFC method developed by Summers et al. 1996). Surface samples were also analyzed for phytoplankton identification and enumeration as well as algal toxins (on a monthly basis). All data were collected according to a US EPA approved quality assurance project plan developed by RIDEM in 2015 and available on-line at: http://www.dem.ri.gov/pubs/data.htm#quapps. A final data report, which includes an evaluation of data quality and final results is also available on-line at: http://www.dem.ri.gov/programs/water/quality/restoration-studies/reports.php.

The methodology utilized by RIDEM to derive chlorophyll-*a* and phosphorus targets for the nine reservoirs is described below and, as stated earlier, are patterned after the New York studies (Callinan 2009 and Callinan et al. 2013). RIDEM's study examined the relationships between 1) dissolved organic carbon (DOC) and the formation potential of total trihalomethanes (TTHMs), 2) chlorophyll-a and dissolved organic carbon, and 3) total phosphorus and chlorophyll-a. The waterbodies investigated in the NY study span a wider trophic state range (oligotrophic through eutrophic) while the trophic state of the nine Newport reservoirs ranges from eutrophic to hypereutrophic. Due to the highly eutrophic nature of the Newport reservoirs, as well as the similarities of the studies themselves, it was believed that expanding the dataset to include the waterbodies examined in the NY study was appropriate and would expand the predictive capability of the relationships between chlorophyll-*a* and DOC, and total phosphorus and chlorophyll-*a* in the Newport reservoirs. This is easily observed in Figures 4 and 5 and further justification is provided in Steps 2 and 3. Table 5.3 provides a comparison of key trophic variables from the New York and Rhode Island study waterbodies.

Table 5.3. Trophic Summaries of NY Study and RI Study waterbodies.

System	TP (ug/l)	Chl *a* (ug/l)	Secchi Disk (m)	DOC (mg/l)	Average TSI*
NEW YORK STATE STUDY WATERBODIES					
Skaneateles Lake	4.14	0.71	8	1.4	27
Alcove Reservoir	5.69	2.43	6.3	3	34
Keuka Lake	5.7	2.62	6	2.7	34
Canandaigua Lake	7.69	2.32	6.9	2.8	35
Chenango Lake	8.65	5.59	-	2.9	41
Seneca Lake	9.01	2.36	6.3	2.4	36
Hemlock Lake	10.22	5.16	4.3	2.6	41
Canadice Lake	11.37	2.53	3.9	2.5	40
Kiamesha Lake	12.71	3.84	2.5	4.1	44
Owaska Lake	13.04	4.55	4.5	2.5	42
Tomhannock	14.3	6.9	4.1	2.9	44
Cayuga Lake	15.82	4.07	3.9	2.5	43
Otisco Lake	16.21	6.34	3.5	2.2	45
Stoney Creek	18.6	9	3.3	4.6	47
Lake Louise Marie	19.51	8.5	2.4	4.1	49
Sleepy Hollow Lake	20.97	6.74	1.5	5.2	51
Honeoye Lake	26.9	11.36	3.7	3.7	49
Chadwick Lake	27.6	20.96	1.3	4.8	56
Conesus Lake	28.31	7.37	3	3.1	49
Basic Creek Reservoir	35.34	22.75	1.5	4.5	57
De Forest Reservoir	47.14	28.49	-	4.5	62
RHODE ISLAND STUDY WATERBODIES					
Nonquit Pond	41.3	16.2	1.0	11.3	59
Watson Reservoir	17.21	14.41	1.47	5.2	52
Lawton Valley	41.66	35.06	1.08	4.7	61
Sisson Pond	87.74	55.92	0.81	8.5	67
St. Marys Pond	71.10	38.17	1.16	5.6	63
North Easton Pond	57.20	44.73	0.77	5.1	65
South Easton Pond	37.13	30.96	0.78	5.4	61
Gardiner Pond	43.08	36.69	1.15	6.2	61
Paradise Pond	79.55	37.27	0.86	8.0	65

*Carlson (1977). All values represent seasonal mean epilimnetic values.

Step 1: Evaluate the relationship between mean epilimnetic total trihalomethane (TTHM) and mean dissolved organic carbon (DOC) in the Newport reservoir waterbodies. The relationship between mean epilimnetic DOC and mean TTHM for the nine reservoirs is presented in Figure 5.3. TTHM values reported in the New York study (APHA Standard Method 6232) were derived using a different methodology than those in the Rhode Island study (Summers et al. 1996), and were not comparable, and therefore were not included in the analysis. As expected, there is a fairly strong relationship between epilimnetic DOC and TTHM concentrations which show increasing levels of TTHM production with increasing levels of DOC. Nonquit Pond exhibited the highest levels of DOC of any of the nine ponds and much of this appears, as evidenced by elevated SUVA values, to be of external origin (i.e. watershed-derived natural humic and tannic acids). The trend in increasing TTHM with increasing DOC is best represented by an exponential function, which shows that approximately 74% of the variability in TTHM concentration is accounted for by differences in DOC concentration.

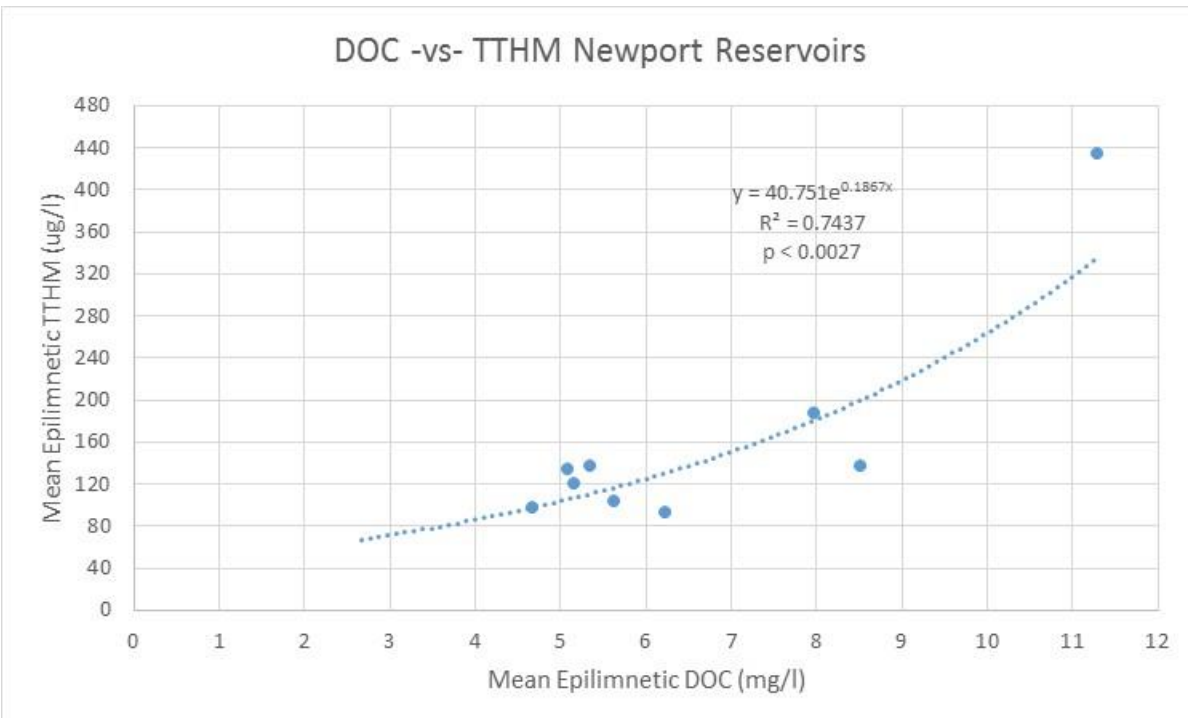


Figure 5.3. Mean epilimnetic DOC versus TTHM- Newport Reservoirs 2015.

Utilizing the equation derived solely from the RI study dataset and substituting the Safe Drinking Water Act (SDWA) current TTHM Maximum Contaminant Level (MCL) of 80 ug/l results in a mean epilimnetic DOC value of 3.6 mg/l. The Newport reservoirs raw water DOC target of 3.6 mg/l derived from the above equation is within the range of various other technically derived source water DOC thresholds for drinking water supplies. Callinan (2009) and Callinan et al. (2013) proposed a raw water DOC threshold of 3.0 mg/l and the Colorado Water Quality Control Division, utilizing a different methodology, proposed a raw water threshold of 4.0 mg/l (COWQCD 2011).

Solving for TOC from a TTHM value of 80 ug/l, which is the current SDWA MCL, is conservative in that it does not account for any reduction of TOC within the treatment process. There are two reasons why this was deemed reasonable and defensible within the context of both the SDWA and CWA. **First**, the properties of organic carbon affect the effectiveness with which it can be removed by either conventional treatment or by enhanced coagulation (WQCD 2011)[3]. EPA guidance (USEPA 1999) and multiple other authors (White et al. (1997), Archer and Singer (2006a & 2006b), and Cheng and Chi (2003) find that in general, the performance of enhanced coagulation is poor when organic carbon has a low SUVA value. Furthermore, for SUVA values less than 2 L/mg-m, DOC removal is generally less than 25% (summarized in Eikebrokk et al. 2007). As documented in Table 5.2 above, with the exception of Nonquit Pond, Newport's water supply reservoirs exhibit seasonal average SUVA values less than 2.5 L/mg-m with five reservoirs having seasonal averages of 2.0 L/mg-m or less.

Second, Public Drinking Water Rule 216 RICR-50-05-1.8.5B specifies conditions that §5.0 systems (Public Water Supply systems supplied by a surface water source, or a ground water source under the direct influence of surface water) must meet in order to qualify for reduced monitoring of TTHM and HAA5. One common requirement is that the source water annual average TOC value, before any treatment, be **≤ 4.0 mg/l**.

If this 4.0 mg/l TOC requirement is met, then systems may reduce TTHM and HAA5 monitoring if the annual average TTHM concentration is ≤ 0.040 mg/l and the annual average HAA5 concentration is ≤ 0.030 mg/l. These concentrations are half of the current Stage 2 MCL values of 0.080 mg/l for TTHM and 0.060 mg/l for HAA5, respectively. In conclusion, establishing a TOC target of 3.6 mg/l is consistent with and provides a margin of safety in achieving the TMDL's goal that the quality of the reservoirs is such that the Safe Drinking Water Act (SDWA) requirements (for trihalomethanes specifically) can be met with conventional treatment alone.

Step 2: This step involves examining the relationship between epilimnetic levels of chlorophyll-*a* and dissolved organic carbon. Figure 5.4 displays the relationship between chlorophyll-*a* and dissolved organic carbon in the combined NY and RI waterbodies dataset which indicates a trend of increasing DOC concentrations with increasing levels of chlorophyll. Nonquit Pond is clearly an outlier. Relative to the other 8 reservoirs, the Nonquit Pond watershed is much larger in size and drains a large cedar swamp. In addition, one of the two major tributaries-Quaker Brook drains the Tiverton Landfill- which, according to data collected by RIDEM, is a source of organic carbon. The calculated mean epilimnetic SUVA value for Nonquit Pond is 4.2 L/mg-M indicating a primary DOC source that is external to the waterbody.

With Nonquit Pond data removed, there is a strong and significant ($p<0.0001$) association between DOC and chlorophyll-*a*, suggesting that DOC levels are largely governed by phytoplankton abundance. The trend of increasing DOC with increasing chlorophyll is best represented by a linear function. It can be seen that the RI waterbodies make up the upper end of the relationship albeit with slightly more scatter then the NY waterbodies. To provide additional credibility for combining the NY and RI datasets, a comparison of slopes test was applied to the linear regression of each individual dataset. Application of the significance of the difference

[3] Enhanced coagulation refers to optimizing coagulation, flocculation, clarification and filtration to remove organic matter from water that may contribute to formation of disinfection byproducts.

between two slopes test (Sokal et al. 1981) (T value= 0.01678, Df= 25, and P= 0.9867) showed that the slopes of the two linear regressions are not statistically significantly different.

Approximately 73 percent of the variability in mean epilimnetic DOC concentrations is explained by variations in mean epilimnetic phytoplankton biomass (as measured by chlorophyll-*a*). Thus, inclusion of the NY dataset provides valuable insight as to what levels of DOC could be expected with reductions in chlorophyll levels in the Newport Reservoirs. Solving the regression curve for chlorophyll using a threshold DOC value of 3.6 mg/l results in a mean chlorophyll target of 10.8 ug/l (rounded to 11 ug/l).

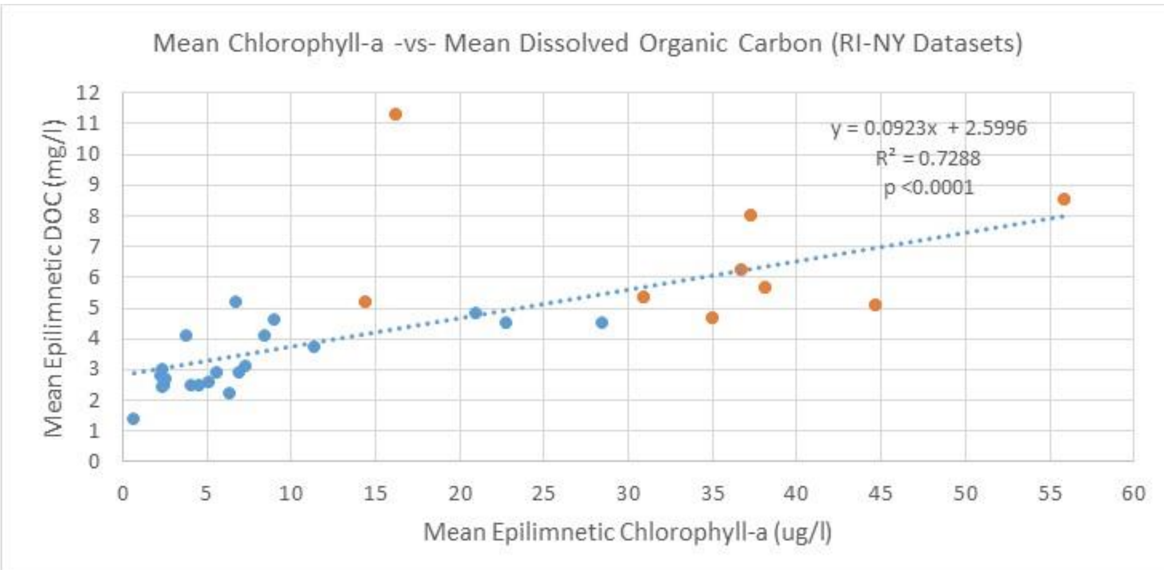


Figure 5.4 Mean epilimnetic chlorophyll-*a* versus DOC- NY and RI waterbodies.

Step 3: Step 3 involves evaluating the relationship between epilimnetic levels of total phosphorus and chlorophyll-*a* in the RI and NY waterbodies. The relationship between mean epilimnetic total phosphorus and mean chlorophyll-*a* from the NY and RI waterbodies is presented in Figure 5.5 and indicates that approximately 88 percent of the variability in phytoplankton biomass, as measured by chlorophyll-*a*, is accounted for by differences in total phosphorus concentrations ($p < 0.0001$). Again, inclusion of the NY dataset allows for evaluation of the phytoplankton response in the Newport Reservoirs as phosphorus levels are reduced to a more meso-oligotrophic state. As in Step 2, a comparison of slopes test was applied to the linear regression of each individual dataset. Application of the significance of the difference between two slopes test (Sokal et al. 1981) (T value= 0.0182, Df= 26, P= 0.985) showed that the slopes of the two linear regressions are not statistically significantly different. Substituting the chlorophyll-*a* target of 11 ug/l derived in Step 2 and solving for TP results in a mean epilimnetic total phosphorus target of 20 ug/l. A 10% Margin of Safety was added, resulting in a final total phosphorus target of 18 ug/l- to be expressed as an epilimnetic seasonal mean value.

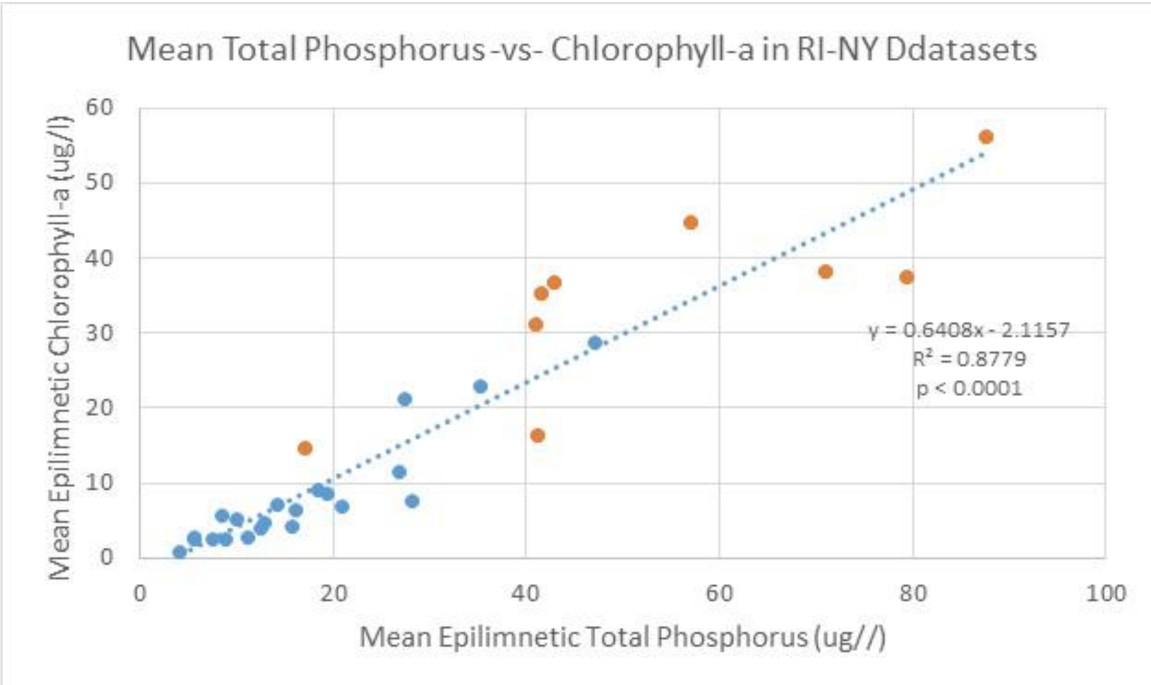


Figure 5.5 Mean epilimnetic total phosphorus versus chlorophyll- NY and RI waterbodies.

5.4.5 Summary of Findings

In summary, RIDEM is proposing a chlorophyll target of 11 ug/l and a total phosphorus target of 18 ug/l for Newport reservoirs. These targets should be assessed as a mean of epilimnetic or1 m below surface when not stratified values obtained during the growing season- May through October. The threshold values proposed for chlorophyll-*a* and total phosphorus derived for the Newport reservoirs are consistent with findings from previous investigations. The total phosphorus target of 18 ug/l will be used to develop allowable phosphorus loads to the reservoirs. Since the target is lower than the existing Rhode Island numeric criterion of total phosphorus of 25 ug/l it will also be protective of the reservoirs' less sensitive designated use of aquatic life.

The chlorophyll and phosphorus targets are the basis of the calculation of allowable loads and required load reductions and as such serve to complement Newport Water Division's advanced treatment capabilities to ensure acceptable drinking water quality. The TMDL targets established are not intended as a means of *guaranteeing* compliance with disinfection by-product (DBP) MCLs. The focus is on control of algal abundance via reductions in nutrients (as opposed to control with copper sulfate or other algaecides) and it affects only the contribution that phytoplankton make to the pool of DOC in the reservoirs. Other natural sources of DOC are considered background and not 'controllable'.

5.4.6 Corroborative Studies and Research

As stated earlier, the study conducted by RIDEM largely patterns the work done by the NYSDEC. NYSDEC proposed chlorophyll-*a* and total phosphorus criteria to restrict DBP formation potential by controlling algal abundance in water supply lakes and reservoirs (Callinan

2009 and Callinan et al. 2013). Findings from this study indicated that a mean chlorophyll-*a* threshold of 4-6 ug/l would be protective of potable water supply lakes and reservoirs. A mean total phosphorus threshold of 12 ug/l corresponded to these chlorophyll values. To date, these proposed thresholds have not become adopted in state regulation.

The state of Colorado conducted a study similar to the New York study and determined that a chlorophyll-*a* concentration of 5 ug/l would be protective of Colorado's direct-use public water supply source reservoirs (CDPHE 2011). This criterion is assessed as the average of values measured in the water supply from March through November and may be exceeded once every 5 years. The criterion was calculated from the chlorophyll-*a* level associated with an in-lake dissolved organic carbon threshold of 4 ug/l. Setting a limit on algal abundance by regulating chlorophyll-a in direct-use water supply reservoirs was meant as a preventative measure aimed at controlling or reducing algal-derived precursors of DBPs (Saunders et al. 2015).

The state of Oklahoma Water Resources Board developed a chlorophyll-*a* criterion, expressed as a long-term average, of 10 ug/l for selected public water supplies (OWRB 2005). The criterion is intended to limit the occurrence of carcinogenic disinfection byproducts and offensive taste and odor problems in drinking water that are caused by excessive algae and blue-green algae. This criterion was incorporated into the state's water quality standards in 2006 and were also approved by EPA Region 6 in November 2006.

In 2011, the Kansas Department of Health and the Environment-Bureau of Water published a white paper (KDHE 2011) outlining the rationale for protecting water quality in drinking water lakes and reservoirs by adopting a chlorophyll-*a* criterion for public water supply lakes. The white paper develops options for numeric chlorophyll-*a* standards that range between 8 and 10 ug/l. The 2010 Kansas 303(d) list used 10 μg/L of chlorophyll-*a* as the listing criterion for domestic water supply lakes. The 2008 Kansas 305(b) list used the following thresholds of chlorophyll-*a* for domestic water supply uses: < 10 μg/L fully supportive; 10-12 μg/L fully supportive but threatened; 12-20 μg/L partially supportive; and >20 μg/L non-supportive.

Downing et al (2001) evaluated prediction of the risk of waterbodies with phytoplankton populations dominated by cyanobacteria. Their study concluded that chlorophyll-*a* levels above 10 μg/l exponentially increased the likelihood of cyanobacteria dominance, causing more occurrences of taste and odor problems for drinking water supply reservoirs.

Rhode Island has also been in the process of evaluating its current numeric nutrient criterion for TP and other numeric indicators of nutrient enrichment. As part of this effort, RIDEM evaluated historical water quality data collected between 2000 and 2009 from 72 freshwater lakes, ponds, and reservoirs in Rhode Island. RIDEM used multiple lines of evidence and analyses including change point analysis and conditional probability to evaluate and select numeric criteria and thresholds. A change point analysis searches along a gradient of TP (low to high concentrations) to find the greatest change in chlorophyll-*a* response. The results of the chlorophyll-*a* change point analysis suggest that an ecological change is occurring in Rhode Island lakes at TP equal to 24μg/L and at 16μg/L.

A conditional probability analyzes the probability that a chlorophyll-*a* response will happen given a concentration of TP or greater has occurred. The conditional probability analysis confirmed the suggested TP change points discussed above. For a worst-case scenario, lakes at TP equal to or greater than 24μg/L have an 80% risk of a growing season mean chlorophyll-*a* greater than 10μg/L, and lakes at TP equal to or < 16μg/L have a 45% risk of a growing season mean chlorophyll-*a* greater than 10μg/L. As noted earlier the concentration of 10μg/L of chlorophyll-*a* can be linked to increased risk of cyanobacteria populations (Downing et al. 2001).

In 2011 and 2012, a separate RIDEM/OWR project focused on further understanding cyanobacteria blooms/occurrence in Rhode Island lakes sampled several of the lakes being used to develop numeric nutrient criteria. Lakes exceeding recreational health advisory levels for cyanobacteria also tended to exceed 10μg/L of chlorophyll-*a* in more than 50% of samples in a single growing season. This suggests exceeding 10μg/L of chlorophyll-*a* in more than 50% of five or more samples is indicative of cyanobacteria dominance in Rhode Island lakes.

While the analysis of Rhode Island's numeric nutrient criteria evaluation focused on non-drinking water lakes greater than 2m in maximum depth it can be informative to the analysis of the Newport Water System TMDL. The lower TP value of 16ug/l suggested by the evaluation of Rhode Island's numeric nutrient criteria is in line with the 18ug/l derived in the Newport TMDL analysis. The TP value suggested by the numeric nutrient criteria evaluation was derived using a chlorophyll-*a* target of 10ug/L, which is similar to that derived in the Newport analysis. The values from Rhode Island's numeric nutrient criteria evaluation confirm that the Newport analysis values are in line with the general conditions in Rhode Island lakes and should be protective of the designated uses.

5.5 Calculation of Existing Total Phosphorus Loads

Understanding the quantitative relationship between phosphorus loading and in-lake phosphorus concentrations is a key component in developing an effective strategy for achieving the TMDLs for the Newport reservoirs. Various empirical models have been developed to predict in-lake total phosphorus concentration from data on annual phosphorus loadings, hydraulic flushing rates, and lake morphometry (Vollenweider (1975), Dillon and Rigler (1974), Kirchner and Dillon (1975), Chapra (1975), Jones and Bachmann (1976), Reckhow (1977 and 1979), and Canfield and Bachmann (1981). These models are based on statistical relationships between mass loading of phosphorus and average algal biomass, as measured by chlorophyll-a. These models typically take into consideration the waterbody's hydraulic loading rate and some factor to account for settling and storage of phosphorus in the lake sediments.

RIDEM conducted a review of numerous commonly used empirical models and selected two to predict phosphorus loadings to the water supply reservoirs. In a review of five commonly used empirical mass balance models-<u>with particular focus on their applicability to reservoirs</u>, Mueller (1983) found that the empirical model developed by Dillon and Rigler (1974) provided the most accuracy (based on correlation coefficient and standard error). A second empirical model applied to the Newport reservoirs was developed by Canfield and Bachmann (1981) which was developed from a dataset of 704 natural and artificial lakes, including 626 lakes in the U.S. EPA National Eutrophication Survey.

For the Newport reservoir applications, the models were used to estimate existing phosphorus loads given existing in-reservoir total phosphorus concentrations. The mean of the two model results was used as a best estimate of existing total phosphorus loads to each reservoir. The models were also used to back-calculate the allowable total phosphorus load to each reservoir given the 18 ug/l total phosphorus target. Both empirical models and their applications to the Newport Reservoirs are described below.

5.5.1 Dillon and Rigler (1974) Model Application

The Dillon and Rigler empirical lake model was developed using a database of 18 lakes located in southern Ontario. The lakes were selected to provide the greatest variation in the parameters in the original application of the Vollenweider model (Vollenweider 1969) including phosphorus loading, flushing time, and mean depth. Surface areas ranged from 1 to 13 km^2 and mean depths ranged from 0.7 to 27 m. Dillon and Rigler showed that total phosphorus concentration in these oligo- and mesotrophic lakes could be reasonably predicted over a broad range of loading and flushing rates. They recommended that more studies were needed in regions with higher nutrient concentrations and in shallower and smaller lakes.

Mueller (1980) evaluated existing mass balance models, including the Dillon and Rigler model using data from the U.S. EPA National Eutrophication Survey. Several models from the literature were compared for accuracy in application to western state reservoir data. The dataset including 68 reservoirs, distributed in the western regions of the United States- five (5) reservoirs were classified as oligotrophic, 16 mesotrophic, and 47 were classified as eutrophic. Although the reservoirs used in Mueller's (1980) study are all located in the western states, the morphological, chemical, and physical parameters of the Newport reservoirs all fall well within those of the 68 reservoirs from the National Eutrophication Survey. As mentioned above, the Dillon and Rigler (1974) proved most accurate- as measured by root-mean-square error of logarithmically transformed estimations and the correlation between observed and estimated phosphorus concentrations.

The Dillon and Rigler empirical equation (as written by Maine DEP 2000) is as follows:

$$\mathbf{L = P\,(A \cdot z \cdot p) / (1-R)}$$

Where:
L = external total phosphorus load (kg/yr)
P = spring overturn total phosphorus concentration (ppb)
A = lake basin surface area (km^2)
z = mean depth of lake basin (m)
p = annual flushing rate (flushes/yr)
R = phosphorus retention coefficient, where:

R = 1/(1+ SQRT(p)) (Larsen and Mercier 1976)

Sources of information for the empirical model parameters are as follows:

p (reservoir flushing rate): Flushing rate is calculated as the inverse of detention time (DT). Except for Nonquit Pond, the detention time for each reservoir was calculated using the following formula:

2015 Mean reservoir volume (MG) / Total loss (outflow) recorded in 2015 (MG) = detention time (DT) (yrs)

Much of the information used to calculate residence times was provided by the City of Newport Water Department and included hypsographs and weekly measurements of reservoir pool elevation, depth, and pre-calculated corresponding reservoir volumes. This information was used to calculate mean reservoir capacity for 2015. Newport Water Department also provided RIDEM with bi-weekly water level information for 2015. This information was used to calculate total volume loss for each reservoir for each year. The loss in volume for each reservoir includes water that has been both transferred out of the reservoir by the Newport Water Division and/or lost via any natural tributary outflow or other mechanisms (seepage, evaporation, etc).

Nonquit Pond was not utilized as a water source in 2015. Nonquit Pond, having a larger watershed than the other eight reservoirs, receives tributary inflow from Borden Brook, Quaker Brook, and several other smaller tributaries. The Maidford River, Bailey Brook, and Paradise Brook become ephemeral in the summer-fall months. Aside from a brief period during the spring-summer when water elevation was lowered, elevations remained constant, and therefore volume in the reservoir remained constant for 2015, which would generally indicate that inflow is equal to outflow.

Since discharge data for Nonquit Pond are not available, it was estimated by regressing mean annual inflows, based on long-term records of gauged streams in Rhode Island, against drainage area. This resulted in a value of 2 cfs per square mile. The watershed area of Nonquit Pond is 6.9 mi^2, which, when multiplied by 2 cfs/mi^2 results in a watershed value of 13.8 cfs. One (1) cfs is equivalent to 0.538 million gallons per day (MGD) (http://www.kbergconsulting.com/wp-content/uploads/2014/10/water_conversion_factors_and_formula_sheet.pdf); therefore, 13.8 cfs is equivalent to 8.97 MGD or 3274 MGY (year). The mean reservoir volume of Nonquit Pond in 2015 was 559 MG. The residence time is therefore calculated as 559 MG/3274 MG = 0.17 yrs (approximately 62 days). The inverse of residence time, the flushing rate, is calculated as 1/0.17 yrs and equals 5.86 flushes per year.

P (total phosphorus concentration): Bi-weekly samples were collected in each reservoir by RIDEM at 2-3 discrete depths during the 2015 sampling season (n=12). Additional total phosphorus data were collected in St. Marys Pond and Watson Reservoir in 2015 as part of a study contracted by the Newport Water Department (https://www.cityofnewport.com/CityOfNewport/media/City-Hall/Departments/Utilities/Water/Presentations-Plans/NewportWaterShetFinalRepor.pdf).

These data were collected on a monthly basis beginning in April of 2015 and ending in Sept 2015 and were added to the St. Marys Pond and Watson Reservoir total phosphorus datasets. Mean total phosphorus concentration for each reservoir was calculated from epilimnetic values only with sample sizes (n) of 18 for Watson Reservoir and St. Marys Pond and 12 for the remaining 7 waterbodies.

z (mean depth): Mean reservoir depth was calculated by dividing the reservoir volume at full capacity by the reservoir surface area (at full capacity).

A (surface area): the surface area used was calculated as surface area at full capacity.

R (phosphorus retention coefficient) is the fraction of inflowing phosphorus that is retained in the sediments.

Several studies (Larsen and Mercier 1976; Canfield and Bachmann 1981) have shown that lake phosphorus retention is highly correlated with the areal hydraulic load. For the Dillon and Rigler application, the phosphorus retention coefficient developed by Larsen and Mercier (1976) was utilized. Use of the Larsen and Mercier (1976) total phosphorus retention term, based on localized data (northeast and north-central U.S.) from 20 lakes in the US-EPA National Eutrophication Survey (US-EPA-New England) provides an accurate model for northeastern regional lakes. Table 5.4 provides the input parameters and annual phosphorus loading results for the Newport reservoirs utilizing the Dillon and Rigler (1974) empirical model.

Table 5.4. Dillon and Rigler (1974) empirical model parameters and resulting annual loads.

Reservoir	p (flushes/yr)	z (meters)	R (P retention coefficient)	TP (ppb) Seasonal mean	A (km^2) Surface area of reservoir	TP Load in lbs/yr
Nonquit Pond	5.86	2.6	0.2923	41.3	0.809	**1613**
Watson Reservoir	0.25	4.4	0.6667	22.0	1.507	**242**
Lawton Valley Reservoir	1.65	4.9	0.4323	41.7	0.323	**431**
Sisson Pond	1.04	1.7	0.4949	87.7	0.253	**176**
St. Marys Pond	1.98	1.8	0.4142	78.5	0.431	**456**
North Easton Pond	1.28	2.7	0.4896	57.2	0.437	**359**
South Easton Pond	1.04	2.1	0.5000	41.0	0.605	**237**
Gardiner Pond	0.49	4.0	0.5882	43.1	0.404	**182**
Paradise Pond	1.71	3.0	0.4344	79.6	0.126	**201**

5.5.2 Canfield and Bachmann (1981) Model Application

The Canfield and Bachmann model was developed and tested using data from 704 natural and artificial lakes, including 626 lakes in the U.S. EPA National Eutrophication Survey. Of these 704 lakes, 433 were artificial lakes. The Canfield and Bachmann (1981) model is essentially an expression of the Vollenweider equation (1975) with a modified sedimentation coefficient for artificial lakes and is expressed as follows:

$$\mathbf{TP = (L/1000) / 0.305\ X\ \mathit{Z}\ (0.114\ (L/Z)^{0.589} + 1/\mathit{T}}$$

Where:

TP = mean total phosphorus concentration (volume-weighted) for each reservoir in mg/l
L = loading rate in mg/m^2
Z = mean depth of reservoir in feet
T = residence time of water in years
Sources of information for the empirical model parameters are the same as those previously described for use in the Dillon and Rigler (1974) model and are described below:

T (reservoir detention time): The retention time for each reservoir was calculated using the formula described earlier.

P (total phosphorus concentration): Bi-weekly samples were collected in each reservoir by RIDEM at 2-3 discrete depths during the 2015 sampling season (n=12). Additional total phosphorus data were collected in St. Marys Pond and Watson Reservoir in 2015 as part of a study contracted by the Newport Water Department (http://www.cityofnewport.com/departments/utilities/water/water-shed-protection). These data were collected on a monthly basis beginning in April of 2015 and ending in Sept 2015 and were added to the St. Marys Pond and Watson Reservoir total phosphorus datasets. Mean total phosphorus concentration for each reservoir was calculated from epilimnetic values only with sample sizes (n) of 18 for Watson Reservoir and St. Marys Pond and 12 for the remaining 7 waterbodies.

D_m (mean depth): Mean reservoir depth was calculated by dividing the reservoir volume at full capacity by the reservoir surface area (at full capacity).

SA (surface area): the surface area used was calculated as surface area at full capacity.
Table 5.5 provides the input parameters and annual phosphorus loading results for the Newport reservoirs utilizing the Canfield and Bachmann (1981) empirical model. Using available information, including mean reservoir phosphorus concentrations from 2015, the model was used to back-calculate phosphorus loading in $mg/m^2/yr$ and then converted to an annual load in kg.

Table 5.5. Canfield and Bachmann empirical model parameters and resulting annual loads.

Reservoir	T (yrs)	D*m* (feet)	TP (mg/l)	L (mg/m²/yr)	SA (m²) Surface area of reservoir	TP Load in lbs/yr
Nonquit Pond	0.17	8.7	0.041	818	808,940	**1459**
Watson Reservoir	4.04	14.5	0.022	33	1,506,595	**153**
Lawton Valley Reservoir	0.61	16.2	0.042	557	322,524	**373**
Sisson Pond	0.96	5.7	0.088	368	253,325	**201**
St. Marys Pond	0.50	5.9	0.079	450	430,976	**485**
North Easton Pond	0.78	8.8	0.057	434	436,656	**335**
South Easton Pond	0.96	6.9	0.041	144	605,005	**200**
Gardiner Pond	2.04	13.1	0.043	163	403,863	**154**
Paradise Pond	0.58	9.9	0.080	1156	125,853	**216**

As stated above, existing total phosphorus loads to each reservoir are calculated as the mean of the two empirical model results. These are reported below in Table 5.6.

Table 5.6 Estimated existing annual total phosphorus loads to the Newport reservoirs.

Reservoir	Existing Mean annual TP load (lbs/yr)
Nonquit Pond	**1536**
Watson Reservoir	**198**
Lawton Valley Reservoir	**402**
Sisson Pond	**189**
St. Marys Pond	**471**
North Easton Pond	**347**
South Easton Pond	**219**
Gardiner Pond	**168**
Paradise Pond	**209**

5.6 Calculation of Allowable Total Phosphorus Loads

In section 5.5, existing phosphorus loads were calculated from in-pond total phosphorus concentrations using the Dillon and Rigler (1974) and Canfield and Bachmann (1981) empirical models. Allowable loadings (TMDLs) were back-calculated using the same models and the 18 ug/l total phosphorus numeric water quality target derived from the analysis described in Section 5.4. Allowable total phosphorus loads to each reservoir are calculated as the mean of the empirical model results. These are reported below in Table 5.7.

Table 5.7 Estimated Allowable total phosphorus loads to the Newport reservoirs.

Reservoir	Dillon and Rigler calculated allowable TP load (lbs/yr)	Canfield and Bachman calculated allowable TP load (lbs/yr)	Average Allowable Load TP load (lbs/yr)
Nonquit Pond	703	582	**643**
Watson Reservoir	198	116	**157**
Lawton Valley Reservoir	186	135	**161**
Sisson Pond	36	25	**31**
St. Marys Pond	105	78	**92**
North Easton Pond	113	79	**96**
South Easton Pond	104	72	**88**
Gardiner Pond	76	48	**62**
Paradise Pond	46	34	**40**

5.7 Required Reductions and Load/Wasteload Allocations

5.7.1 The Watershed Treatment Model-Overview and Justification for Use

The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection (http://www.cwp.org/pollution-calculators/), is a spreadsheet-based model used to calculate annual pollutant loads (total phosphorus, total nitrogen, total suspended sediment, and fecal coliform) and runoff volumes as well as estimate benefits from a wide range of stormwater runoff and pollutant removal practices.

Recent watershed restoration projects undertaken by the Town of Middletown and City of Newport have included application of the WTM to the Maidford River, Paradise Brook, St. Marys Pond, and Watson Reservoir. To be consistent with these studies, RIDEM has selected to also use the WTM as its watershed modeling tool. It has been re-applied to St. Marys Pond, Watson Reservoir, the Maidford River, and Paradise Brook and newly applied to Nonquit Pond, Lawton Valley Reservoir, Sisson Pond, North and South Easton Ponds (the Bailey Brook watershed), and Gardiner and Paradise Ponds.

The primary purpose for applying the WTM to the water supply reservoirs was to evaluate sources/source categories of phosphorus generated from various land uses within each watershed and acquire information as to the relative importance (i.e. magnitude) of each source. The WTM results were solely used to apportion the allowable annual load (calculated for each reservoir using empirical models and summarized above in Table 5.7) to various source categories (i.e. urban, agricultural, etc.) within each reservoir's catchment. The TMDL sets allowable loads for phosphorus (calculated from empirical reservoir models as described above). Estimations of total nitrogen loading were for secondary evaluation only (and not applicable to this TMDL) and total suspended sediment (TSS) and fecal coliform loads to the water supply reservoirs were not modeled. WTM description, setup, results, and quality assurance are available at: http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/tdml-nonquit-wtm.pdf

Calculations of required phosphorus reductions were based on existing and allowable loads with consideration of natural background loads. The natural background load, derived with the WTM,

is calculated as the sum of estimated total phosphorus loads generated from forested lands and wetlands and atmospheric deposition to each impoundment. Since phosphorus loads from these sources are expected to remain relatively static with time, they were subtracted out from both the existing and allowable load to each reservoir, prior to calculating required reductions.
As expected, there are differences between annual phosphorus loads predicted by the empirical models (which are based on ambient water quality and physical data from the water supply reservoirs) and those predicted by the WTM (which are based on land cover and literature-based export coefficients and event mean pollutant concentrations-EMCs) (Table 5.8). The likely reasons for this are described in the WTM report and briefly summarized below.

- Unquantifiable loadings from outside of reservoir watersheds (due to intra-reservoir water transfers).

- Hypolimnetic withdrawal and concomitant removal of phosphorus from reservoirs. This would impact the calculated mean annual TP concentration for each reservoir.

- Inability of WTM to account for specific watershed phosphorus removal attributes.

- Lack of watershed-specific export coefficients and pollutant export coefficients.

RIDEM believes that because the empirical model results of annual total phosphorus loads are based on water quality data collected from the reservoirs' they better reflect the actual phosphorus loads to each individual reservoir. Although it is not possible to quantify the differences listed above, RIDEM believes that it does not diminish the applicability of the WTM results to be used to apportion phosphorus load and wasteload allocations to each reservoir.

5.7.2 WTM Land Use -Required Reductions and Load-Wasteload Allocations

The proportional allocation of phosphorus loads between stormwater wasteload allocations (WLAs) and load allocations (LAs) for the Newport reservoirs were completed using the results from the Watershed Treatment Model (WTM). There are no known point source discharges, other than municipal or RIDOT owned stormwater outfalls, in any of the water supply reservoir watersheds. WTM predicted phosphorus loads from existing land use (sub)categories in each watershed were placed into one of three primary land use categories: urban, agriculture, and natural background. This re-compartmentalization of land use categories and phosphorus loading results for purposes of evaluating WLA and LA in the TMDL is displayed below in Table 5.8. The WTM results were then used to apportion the annual phosphorus loads predicted by the empirical models. To do this, the WTM-derived percentages of the annual load attributable to each phosphorus source category were multiplied by the empirical model predicted loads. These steps are outlined, for each reservoir, in Tables 5.9 through 5.26.

There is some evidence of internal phosphorus cycling within Newport's Water Reservoirs, however, because of the confounding influence of intra-reservoir water transfers, tributary inflow and hypolimnetic water withdrawals, estimations of internal load are approximate in nature and likely vary from year to year. A more accurate estimation of internal loads would require flow measurements and phosphorus sampling of intra-reservoir water transfers, major tributaries, and water withdrawals into the North Easton and Lawton Valley Water Treatment facilities.

Internal loads are not accounted for or allocated in these TMDLs due to the large amount of uncertainty in load estimates. If future studies indicate that internal loading constitutes a significant source of phosphorus to the reservoirs it will have to be taken into consideration with respect to phosphorus control measures.

The focus of this TMDL's implementation section is the control of identified external sources of phosphorus discharged to these lakes. However, it must be understood that even if external loading is significantly reduced, improvement in water quality may be delayed possibly for decades, because of continued internal loading. Given that there is evidence of some internal cycling of phosphorus occurring in the water supply reservoirs, consideration and further study should be given to in-reservoir management techniques to control internal cycling. Methods to control internal cycling of phosphorus from sediments are discussed in the Implementation Section of this TMDL.

Table 5.8. Compartmentalized land use categories in the Newport reservoir watersheds.

Urban Land Use	(Point Source) Wasteload Allocation (WLA)
Low Density Residential	
Medium Density Residential	
High Density Residential	
Transportation (all roadways)	
Commercial	
Industrial	
Institutional	
Tiverton Landfill	
Onsite Wastewater Treatment Systems (OWTS)	Load Allocation (LA) (Non-Point Source)
Agricultural Land Use	(Non-Point Source) Load Allocation (LA)
Livestock	
Hay/Brushland	
Meadow	
Nursery	
Orchard	
Vineyard	
Tree Farm	
Pasture	
Quarry	
Row Crop	
Managed Grass	
Transitional	
	Load Allocation (Natural Background) (subtracted from existing P loads to each reservoir) Not expected to change.
Natural Background	
Forestland	
Wetland	
Atmospheric Deposition	

The total phosphorus loads predicted by the WTM only accounts for each reservoirs' respective watershed loadings. As mentioned earlier, the reservoirs are interconnected through a complex network of piping, tributaries, and pumping stations. These interconnections provide the means for the NWD to bring in the highest quality source water for treatment at Station 1 and Lawton Valley Water Treatment Plant. Oftentimes this necessitates the mixing or 'blending' of water from various reservoirs. Blending occurs as necessary and can occur in various combinations on time scales ranging from daily to monthly. Because the transfer of water from one reservoir also includes the transfer of its various chemical constituents, including nutrients, these transfers constitute a 'nutrient load' export from the source reservoir and import to the receiving waterbody. At present, data is not available to quantify phosphorus loadings to individual reservoirs from any of the other reservoirs and depending on environmental and operational factors likely vary significantly on both a seasonal and annual basis.

Despite this confounding issue, if the assumption is made that the goal of the TMDL is to achieve the allowable phosphorus loads to each reservoir, which are based on a target phosphorus concentration of 18 ug/l, then the transfer of water from one reservoir to another would result in the maintenance of the 18 ug/l total phosphorus target in all of the reservoirs.

Nonquit Pond- WTM results, Required Reductions, and Load-Wasteload Allocations

Results from the WTM application to Nonquit Pond are shown in Table 5.9. Over 40% of the phosphorus load is generated from urban land uses in the watershed, with the remaining phosphorus load split nearly evenly between agriculture and natural background sources. The mean total phosphorus load predicted by the empirical models is 1536 lbs. The adjusted total phosphorus loads to Nonquit Pond are displayed in the last column of Table 5.9.

Table 5.9. WTM results and adjusted empirical model estimated TP loads to Nonquit Pond.

Nonquit Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	816	41	1536	630
Agriculture	541	27		415
Natural Background	583	30		461
OWTS Failure to surface water	36	2		31

Table 5.10 presents the existing and allowable loads to Nonquit Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic derived total phosphorus load to Nonquit Pond is 1076 lbs and the allowable anthropogenic load is 183 lbs. The resulting 86% reduction in total phosphorus load to Nonquit Pond applies to both the urban and agricultural source categories.

Table 5.10. Existing and Allocated Annual Total Phosphorus Loads- Nonquit Pond.

Existing total phosphorus load to Nonquit Pond				1536 lbs
Natural Background (Forest + Atmospheric) Load				461 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				1075 lbs
Allowable Total Phosphorus Load				643 lbs
Allowable Total Phosphorus Load – Natural Background Load				182 lbs
Required Reduction from Anthropogenic Sources				893 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**86%**
An 85% reduction is required between all anthropogenic source categories				
Land Use Category	**Existing Annual TP Load (lbs)**	**Allowable Annual TP Load (lbs)**	**WLA**	**LA**
Urban	630	91	100%	
Agriculture	415	60		100%
OWTS failure to surface water	31	0		-
Forest/Wetland/Atmospheric	461	461		Natural Background

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

Wasteload Allocation for Tiverton Landfill

The field investigations and sampling RIDEM staff performed at various sites downstream of the Tiverton Landfill did not allow for accurate mass-based estimates of total phosphorus to either Quaker Creek or Borden Brook. NPDES regulations specify that mass-based WQBELs are required in permits except when pollutants cannot appropriately be expressed in terms of mass; the applicable standards are expressed in terms of other units; or limits expressed in terms of mass are infeasible because the mass of a pollutant cannot be related to a measure of operations and permit conditions ensure that dilution will not be used as a substitute for treatment. See 40 CFR 122.45(f)(1). The regulations also give permit writers the discretion to include other limits, such as concentration-based limits, to supplement mass-based WQBELs. 40 CFR 122.45(f)(2). The NPDES regulations further require that WQBELs be consistent with the assumptions and requirements of any available wasteload allocation in the TMDL. 40 CFR 122.44(d)(1)(vii)(B). Section §1.18 of the RIPDES Regulations addresses mass-based limits (https://rules.sos.ri.gov/regulations/part/250-150-10-1) and allows for the prohibition or limitation of specified pollutants by mass, concentration, or other appropriate measure.

RIDEM has determined that discharges from the Tiverton Landfill are point source discharges of pollutants and therefore has required the Town of Tiverton to obtain a Rhode Island Pollution Discharge Elimination System (RIPDES) Permit. It is anticipated that the draft permit (RI0023973) will include the following effluent limitations and monitoring requirements for seven (7) outfalls on the landfill site that discharge to Quaker Creek and/or wetlands connected to Quaker Creek and Borden Brook (Table 5.11). Outfall 003 and 007 are considered internal outfalls – each contributes to the outfall 005 drainage area, and therefore will not have monitoring requirements. Outfall 001, 002, 004 do not receive any flow from active portions of the landfill, and discharges are considered uncontaminated stormwater under 40 CFR §445.2(b). Therefore, outfall 001, 002, and 004 will have proposed monitoring requirements for TSS and flow, and effluent limitations for total phosphorous because of the listed impairment/TMDL. Outfall 006 will contain TBELs consistent with 40 CFR §445.21, because it discharges landfill wastewater, as well as total phosphorous effluent limits because of the listed impairment/TMDL.

Outfall 005 will contain WQBELs and TBELs because it has been determined that contaminated groundwater/landfill leachate is discharged through this outfall, including total phosphorous effluent limits. The total phosphorus limits for all outfalls will be calculated using the 18 ug/l target total phosphorus targets established in this TMDL (Section 5.0)

Table 5.11 Tiverton Landfill outfalls covered under Draft RIPDES permit # RI0023973.

Permit Outfall Number	Description (Attachment C in Permit)	Receiving Water
001	OF-1 north-northwest on site	Quaker Creek
002	OF-2, north-northeast on site	Borden Brook
004	OF-4, east-northeast on site	Borden Brook
005	OF-5, southwest corner on site	Quaker Creek
006	OF-6, west-southwest on site across the landfill access road from OF-5	Quaker Creek
003	OF-3	Flows to outfall 005
007	OF-7	Flows to outfall 005

Additional Permit Requirements

Because the Tiverton Landfill is in the process of submitting closure plans to cap portions of the landfill, with the goal of eventually capping the entire landfill, it is anticipated that the permit will allow the Tiverton Landfill to request a reduction in monitoring requirements after portions of the landfill have been capped. This condition will reduce the need for permit modifications as construction takes place to close the landfill. In order to determine that requested outfalls are no longer receiving landfill wastewater, a request for reduction in monitoring requires six (6) consecutive months of monitoring for which the pollutants listed in the permit are no longer detected. Additionally, capping of the landfill should ensure that no dry-weather flow is possible from the site. Therefore, requests for reduction in monitoring must also consist of six (6) months of dry-weather inspections that show dry-weather flow is not a component of landfill runoff.

The draft permit is anticipated to require that Tiverton Landfill conduct an annual Priority Pollutant Scan at outfall 005, due to the complex nature of landfill effluents and potential for variability in effluent composition. The Priority Pollutant Scan must be performed at outfall 005, and results must be included as part of the facility's Annual Report. For pollutants in the Priority Pollutant Scan that are above detection limits, the permittee must continue to monitor for those pollutants at the outfalls where they were detected on a quarterly basis. The results of ongoing quarterly sampling must also be included in the Annual Report. This data will be used to ensure that the discharges do not have adverse impacts to water quality.

It is anticipated that the draft permit will require inspections of the erosion control measures be conducted in a manner consistent with the permits Stormwater Management Plan (SWMP) and identifies some of the key inspections that must be conducted along with their minimum frequencies. The permit will also include a requirement that the Tiverton Landfill complete an Annual Report and submit it to the DEM by January 31st of each year, for the previous calendar year. This report must summarize the results of the site inspections required under the permit.

The draft permit will also require that the permittee comply with a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP includes, but is not limited to, a description of the sedimentation and erosion controls as well as maintenance activities necessary to properly control storm water runoff. The remaining general and specific conditions of the permit will be based on the RIPDES regulations as well as 40 CFR Parts 122 through 125 and consist primarily of requirements common to all storm water permits.

Watson Reservoir

Results from the WTM application to Watson Reservoir are shown in Table 5.12. A majority (52%) of the phosphorus load is generated from urban land uses in the watershed. Twenty-nine percent (29%) of the phosphorus load is generated by agricultural land uses with the remaining 18% of the total phosphorus load generated from natural background sources. The load from surface failure of OWTS is minimal. The mean total phosphorus load predicted by the empirical models is 198 lbs. The adjusted total phosphorus loads to Watson Reservoir are displayed in the last column of Table 5.12.

Table 5.12. WTM results and adjusted empirical model estimated TP loads to Watson Reservoir.

Watson Reservoir Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	718	52	198	103
Agriculture	408	29		57
Natural Background	249	18		36
OWTS failure to surface water	15	1		2

Table 5.13 presents the existing and allowable loads to Watson Reservoir, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic derived total phosphorus load to Watson Reservoir is 162 lbs and the allowable load is 121 lbs. The resulting 26% reduction in total phosphorus load to Watson Reservoir applies to both the urban and agricultural source categories.

Table 5.13. Existing and Allocated Annual Total Phosphorus Loads- Watson Reservoir.

Existing total phosphorus load to Watson Reservoir				198 lbs
Natural Background (Forest + Atmospheric) Load				36 lbs
Anthropogenic phosphorus load (Existing Load – Natural Background)				162 lbs
Allowable Total Phosphorus Load				157 lbs
Allowable Total Phosphorus Load – Natural Background Load				121 lbs
Required Reduction from Anthropogenic Sources				41 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**26%**
A 25 % reduction is required between all anthropogenic source categories				
Land Use Category	**Existing Annual TP Load (lbs)**	**Allowable Annual TP Load (lbs)**	**WLA**	**LA**
Urban	103	77	100%	
Agriculture	57	42		100%
OWTS failure to surface water	2	0		-
Forest/Wetland/Atmospheric	36	36		Natural Background

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

Lawton Valley Reservoir

Results from the WTM application to Lawton Valley Reservoir are shown in Table 5.14. A majority (70%) of the phosphorus load is generated from urban land uses in the watershed. Sixteen percent (16%) of the phosphorus load is generated by agricultural land uses. Six percent of the total phosphorus load is estimated to come from Green Valley Country Club, three (3) percent from OWTS failure to surface water, with the remaining 5% of the load coming from natural background sources. The mean total phosphorus load predicted by the empirical models is 402 lbs. The adjusted total phosphorus loads to Lawton Valley Reservoir are displayed in the last column of Table 5.14.

Table 5.14. WTM results and adjusted empirical model estimated TP loads to Lawton Valley Reservoir.

Lawton Valley Reservoir Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	582	70		281
Agriculture	131	16		64
Golf Course	50	6	402	24
OWTS failure to surface water	26	3		12
Natural Background	43	5		20

Table 5.15 presents the existing and allowable loads to Lawton Valley Reservoir, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic total phosphorus load is 382 lbs and the allowable anthropogenic phosphorus load is 141 lbs. A 65% reduction applies to all anthropogenic source categories.

Table 5.15. Existing and Allocated Annual Total Phosphorus Loads- Lawton Valley Reservoir.

<table>
<tr><td colspan="4">Existing total phosphorus load to Lawton Valley Reservoir</td><td>402 lbs</td></tr>
<tr><td colspan="4">Natural Background (Forest + Atmospheric) Load</td><td>20 lbs</td></tr>
<tr><td colspan="4">Anthropogenic phosphorus load (Existing Load - Natural Background)</td><td>382 lbs</td></tr>
<tr><td colspan="4">Allowable Total Phosphorus Load</td><td>161 lbs</td></tr>
<tr><td colspan="4">Allowable Total Phosphorus Load – Natural Background Load</td><td>141 lbs</td></tr>
<tr><td colspan="4">Required Reduction from Anthropogenic Sources</td><td>241 lbs</td></tr>
<tr><td colspan="4">Expressed as a Percent[1] = [(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100</td><td>65%</td></tr>
<tr><td colspan="5">A 65 % reduction is required between all anthropogenic source categories</td></tr>
<tr><th>Land Use Category</th><th>Existing Annual TP Load (lbs)</th><th>Allowable Annual TP Load (lbs)</th><th>WLA</th><th>LA</th></tr>
<tr><td>Urban</td><td>281</td><td>98</td><td>100%</td><td></td></tr>
<tr><td>Agriculture</td><td>64</td><td>22</td><td></td><td>100%</td></tr>
<tr><td>Golf Course</td><td>24</td><td>8</td><td></td><td>100%</td></tr>
<tr><td>OWTS failure to surface water</td><td>12</td><td>0</td><td></td><td>-</td></tr>
<tr><td>Forest/Wetland/Atmospheric</td><td>20</td><td>20</td><td></td><td>Natural Background</td></tr>
</table>

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

Sisson Pond

Results from the WTM application to Sisson Pond are shown in Table 5.16. Approximately 61% of the WTM predicted total phosphorus load is generated from agricultural land uses. Thirty-four percent (34%) of the phosphorus load is generated from urban land uses in the watershed with the remaining 5% of the phosphorus load attributed to natural background. The mean total phosphorus load predicted by the empirical models is 189 lbs. The adjusted total phosphorus loads to Sisson Pond are displayed in the last column of Table 5.16.

Table 5.16. WTM results and adjusted empirical model estimated TP loads to Sisson Pond.

<table>
<tr><th>Sisson Pond

Source Category</th><th>WTM Predicted Annual P load (lbs/yr)</th><th>% of Total P Load</th><th>Empirical Model Predicted TP load (lbs/yr)</th><th>Adjusted Total P Load (lbs/yr)</th></tr>
<tr><td>Urban</td><td>99</td><td>34</td><td rowspan="4">189</td><td>64</td></tr>
<tr><td>Agriculture</td><td>176</td><td>61</td><td>115</td></tr>
<tr><td>OWTS failure to surface water</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Natural Background</td><td>14</td><td>5</td><td>9</td></tr>
</table>

Table 5.17 presents the existing and allowable loads to Sisson Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 181 lbs and the allowable anthropogenic load is 22 lbs. An 88% reduction applies to both the urban and agricultural source categories.

Table 5.17. Existing and Allocated Annual Total Phosphorus Loads- Sisson Pond.

Existing total phosphorus load to Sisson Pond				189 lbs
Natural Background (Forest + Atmospheric) Load				9 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				181 lbs
Allowable Total Phosphorus Load				31 lbs
Allowable Total Phosphorus Load – Natural Background Load				22 lbs
Required Reduction from Anthropogenic Sources				159 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**88 %**
An 88 % reduction is required between all anthropogenic source categories				
Land Use Category	**Existing Annual TP Load (lbs)**	**Allowable Annual TP Load (lbs)**	**WLA**	**LA**
Urban	64	8	100%	
Agriculture	115	14		100%
Forest/Wetland/Atmospheric	9	9		Natural Background

St. Marys Pond

Results from the WTM application to St. Marys Pond are shown in Table 5.18. A majority (57%) of the WTM predicted total phosphorus load is generated from urban land uses in the St. Marys Pond watershed, while 32% is generated from agricultural land uses in the watershed. Six percent of the phosphorus load is attributed to natural background sources and five percent is attributed to surface failure from OWTS. The mean total phosphorus load predicted by the empirical models is 471 lbs. The adjusted total phosphorus loads to St. Marys Pond are displayed in the last column of Table 5.18.

Table 5.18. WTM results and adjusted empirical model estimated TP loads to St. Marys Pond.

St. Marys Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	311	57	471	268
Agriculture	176	32		151
OWTS failure to surface water	28	5		24
Natural Background	32	6		28

Table 5.19 presents the existing and allowable loads to St. Marys Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 443 lbs and the allowable anthropogenic load is 64 lbs. A 91% reduction in the total phosphorus load applies to both the urban and agricultural source categories.

Table 5.19. Existing and Allocated Annual Total Phosphorus Loads- St. Marys Pond.

Existing total phosphorus load to St. Marys Pond				471 lbs
Natural Background (Forest + Atmospheric) Load				28 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				443 lbs
Allowable Total Phosphorus Load				92 lbs
Allowable Total Phosphorus Load – Natural Background Load				64 lbs
Required Reduction from Anthropogenic Sources				379 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**91%**
An 91 % reduction is required between all anthropogenic source categories				
Land Use Category	**Existing Annual TP Load (lbs)**	**Allowable Annual TP Load (lbs)**	**WLA**	**LA**
Urban	268	26	100%	
Agriculture	151	14		100%
OWTS failure to surface water	24	0		-
Forest/Wetland/Atmospheric	28	28		Natural Background

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

North Easton Pond

North Easton Pond is situated at the terminus of the Bailey Brook watershed. South Easton Pond, located south of and adjacent to North Easton Pond, is entirely bermed and has a negligible amount of land surface draining to it. The only source of flow to South Easton Pond is North Easton Pond via a small (~18 inch) pipe. Flow via this pipe occurs only if the elevation of North Easton Pond needs to be reduced. Water from South Easton Pond flows by gravity into the south wet well at the Raw Water Building and then into the treatment plant.

The WTM was applied to the Bailey Brook watershed and model results were used to evaluate source categories in both North and South Easton Ponds. Results from the WTM application to North Easton Pond are shown in the first three columns of Table 5.20. A majority (88%) of the total phosphorus load in the Bailey Brook watershed is generated from urban land uses. Only 10% of the total phosphorus load is generated from agricultural sources. Natural background accounts for 2% of the total phosphorus loads, respectively. The empirical model predicts a total phosphorus load of 347 lbs to North Easton Pond. The WTM adjusted total phosphorus loads to North Easton Pond are displayed in the last column of Table 5.20.

Table 5.20. WTM results and adjusted empirical model estimated TP loads to North Easton Pond.

North Easton Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	3404	88	347	305
Agriculture	390	10		35
OWTS failure to surface water	25	0		0
Natural Background	61	2		7

Table 5.21 presents the existing and allowable loads to North Easton Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 340 lbs and the allowable anthropogenic load is 89 lbs. A 74% reduction applies to both the urban and agricultural source categories in the North Easton Pond (Bailey Brook) watershed.

Table 5.21. Existing and Allocated Annual Total Phosphorus Loads- North Easton Pond.

Existing total phosphorus load to North Easton Pond				347 lbs
Natural Background (Forest + Atmospheric) Load				7 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				340 lbs
Allowable Total Phosphorus Load				96 lbs
Allowable Total Phosphorus Load – Natural Background Load				89 lbs
Required Reduction from Anthropogenic Sources				251 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**74%**
A 74 % reduction is required between all anthropogenic source categories				
Land Use Category	Existing Annual TP Load (lbs)	Allowable Annual TP Load (lbs)	WLA	LA
Urban	305	80	100%	
Agriculture	35	9		100%
OWTS failure to surface water	0	0		-
Forest/Wetland/Atmospheric	7	7		Natural Background

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

South Easton Pond

As described earlier, South Easton Pond is entirely bermed and inflow consists solely of contributions from North Easton Pond (i.e. Bailey Brook). It was therefore conservatively assumed that the WTM model results for Bailey Brook apply to both North Easton and South Easton Ponds (i.e. they are the same). Results from the WTM application to South Easton Pond are shown in Table 5.22. A majority (88%) of the total phosphorus load in the Bailey Brook watershed is generated from urban land uses. Only 10% of the total phosphorus load is generated from agricultural sources. Natural background was minimal, accounting for 2% of the total phosphorus load to South Easton Pond. The empirical model predicts a mean annual total phosphorus load of 219 lbs to South Easton Pond. The adjusted total phosphorus loads to South Easton Pond are displayed in the last column of Table 5.22.

Table 5.22. WTM results and adjusted empirical model estimated TP loads to South Easton Pond.

South Easton Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	3404	88	219	193
Agriculture	390	10		22
OWTS failure to surface water	25	0		0
Natural Background	61	2		4

Table 5.23 presents the existing and allowable loads to South Easton Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 214 lbs and the allowable anthropogenic load is 84 lbs. South Easton Pond requires a 61% reduction in annual total phosphorus loads to meet the TMDL requirements. As stated above, North Easton Pond requires a 74% reduction in total phosphorus loads. Required reductions in total phosphorus loading to North Easton Pond exceed, and therefore meet, the required reductions for South Easton Pond.

Table 5.23. Existing and Allocated Annual Total Phosphorus Loads- South Easton Pond.

Existing total phosphorus load to South Easton Pond				219 lbs
Natural Background (Forest + Atmospheric) Load				4 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				215 lbs
Allowable Total Phosphorus Load				88 lbs
Allowable Total Phosphorus Load – Natural Background Load				84 lbs
Required Reduction from Anthropogenic Sources				131 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**61%**
A **61** % reduction is required between all anthropogenic source categories				
Land Use Category	Existing Annual TP Load (lbs)	Allowable Annual TP Load (lbs)	WLA	LA
Urban	193	75	100%	
Agriculture	22	9		100%
OWTS failure to surface water	0	0		-
Forest/Wetland/Atmospheric	4	4		Natural Background

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

Gardiner and Paradise Ponds

Both the inflow and outflow to Paradise and Gardiner Ponds are affected by several (non-static) variables, making it difficult to estimate the transfer of water into and between individual reservoirs. There is a piped connection between Paradise and Gardiner ponds that is controlled seasonally; it is closed in winter and open in summer. As a result, at times both ponds can be operated jointly as a single reservoir. The Maidford River can be diverted, via a spillway, directly into either Paradise or Gardiner Pond - depending on water elevations in the ponds. At higher flows (i.e. wet weather events), a certain and unknown, percentage of the flow is diverted from the Maidford River into either pond and the remainder flows over the spillway, by-passing both ponds, and flowing into the Sakonnet River.

Results from the WTM applications to Paradise Brook and Maidford River were used to partition the empirically predicted phosphorus loads to each pond. Results from the WTM application to Gardiner Pond are shown in Table 5.24. The empirical model predicted load to Gardiner Pond is 168 lbs. A majority (61%) of the total phosphorus load to both ponds is generated from urban land uses. Thirty-six percent (36%) of the total phosphorus load is generated from agricultural sources. Natural background accounts for approximately 5% of the total annual phosphorus load. The adjusted total phosphorus loads to Gardiner is displayed in the last column of Table 5.24.

Table 5.24. WTM results and adjusted empirical model estimated TP loads to Gardiner Pond.

Gardiner Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	1291	61	168	102
Agriculture	771	36		60
OWTS failure to surface water	15	0		0
Natural Background	56	3		5

Table 5.25 presents the existing and allowable loads to Gardiner Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 163 lbs and the allowable anthropogenic phosphorus load is 57 lbs. A 65% reduction applies to both the urban and agricultural source categories from the combined watersheds draining to Gardiner Pond. While this includes the Maidford River watershed- the larger 83% reduction required for Paradise Pond will apply in the Maidford River watershed.

Table 5.25. Existing and Allocated Annual Total Phosphorus Loads- Gardiner Pond.

Existing total phosphorus load to Gardiner Pond				168 lbs
Natural Background (Forest + Atmospheric) Load				5 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				163 lbs
Allowable Total Phosphorus Load				62 lbs
Allowable Total Phosphorus Load – Natural Background Load				57 lbs
Required Reduction from Anthropogenic Sources				106 lbs
Expressed as a Percent[1] = ***[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100***				**6**5 %
A **65** % reduction is required between all anthropogenic source categories				
Land Use Category	Existing Annual TP Load (lbs)	Allowable Annual TP Load (lbs)	WLA	LA
Urban	102	36	100%	
Agriculture	60	21		100%
OWTS failure to surface water	0	0		-
Forest/Wetland/Atmospheric	5	5	Natural Background	

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

Results from the WTM application to Paradise Pond are shown in Table 5.26. A majority (61%) of the total phosphorus load is generated from urban land uses within the Maidford River and Paradise Brook watersheds. Thirty-six percent (36%) of the total phosphorus load is generated from agricultural sources. OWTS failure to surface water is minimal (1%) and natural background accounts for approximately 3% of the total annual phosphorus load. The adjusted total phosphorus loads to Paradise Pond is displayed in the last column of Table 5.26.

Table 5.26. WTM results and adjusted empirical model estimated TP loads to Paradise Pond.

Paradise Pond Source Category	WTM Predicted Annual P load (lbs/yr)	% of Total P Load	Empirical Model Predicted TP load (lbs/yr)	Adjusted Total P Load (lbs/yr)
Urban	1291	61	209	127
Agriculture	771	36		75
OWTS failure to surface water	15	0		0
Natural Background	56	3		6

Table 5.27 presents the existing and allowable loads to Paradise Pond, as well as the required load reductions and final allocations of the allowable total phosphorus load to each source category. The existing anthropogenic phosphorus load is 203 lbs and the allowable anthropogenic phosphorus load is 34 lbs. An 83% reduction applies to both the urban and agricultural source categories from the combined watersheds draining to Paradise Pond. This includes the Maidford River and Paradise Brook watersheds.

Table 5.27. Existing and Allocated Annual Total Phosphorus Loads- Paradise Pond.

Existing total phosphorus load to Paradise Pond				209 lbs
Natural Background (Forest + Atmospheric) Load				6 lbs
Anthropogenic phosphorus load (Existing Load - Natural Background)				203 lbs
Allowable Total Phosphorus Load				40 lbs
Allowable Total Phosphorus Load – Natural Background Load				34 lbs
Required Reduction from Anthropogenic Sources				169 lbs
Expressed as a Percent[1] = *[(Required Reduction from Anthropogenic Sources/ (Anthropogenic Phosphorus Load- OWTS Surface Failure P Load))]*100*				**83** %
A**n 84** % reduction is required between all anthropogenic source categories				
Land Use Category	Existing Annual TP Load (lbs)	Allowable Annual TP Load (lbs)	WLA	LA
Urban	127	21	100%	
Agriculture	75	13		100%
OWTS failure to surface water	0	0		-
Forest/Wetland/Atmospheric	6	6	Natural Background	

[1]The allowable load for OWTS surface failure is zero (0). The percent reduction is inclusive of this.

The reduction required in Paradise Pond is 83% and the required reduction in Gardiner Pond is 65%. Because the two waterbodies receive inputs from both Maidford River and Paradise Brook, application of the larger of the two reductions (83%) is expected to meet TMDL requirements in both Paradise and Gardiner Ponds.

To summarize, current total phosphorus loadings (and in-reservoir phosphorus concentrations) in all nine waters supply reservoirs are greater than required to support the most sensitive designated use, which is drinking water supply. The total phosphorus load reductions required to meet designated uses in each reservoir is calculated by subtracting the target load from the existing load. The allocations for each TMDL are expressed as annual loads since annual loads better align with the design and implementation of watershed and lake management strategies. Allocations for each reservoir include a WLA, LA, and MOS. Natural Background loads from forest, wetland, and atmospheric are assumed to static and were subtracted out prior to setting the WLA and LA. The WLA for the Tiverton Landfill is described above. The Newport Water supply reservoir TMDLs are summarized below in Table 5.28.

Table 5.28 Newport Water Supply Reservoir TMDL Summaries.

Reservoir	TMDLs Allowable P Load[1] (lbs/yr)	WLA (lbs P/yr)	LA (lbs P/yr)	Natural Background Load (lbs P/yr)	MOS[2]
Nonquit[3] Pond	*612*	91	60	461	10% explicit
Watson Reservoir	*155*	77	42	36	10% explicit
Lawton Valley Reservoir	*149*	98	31	20	10% explicit
Sisson Pond	*31*	8	14	9	10% explicit
St. Marys Pond	*68*	26	14	28	10% explicit
North Easton Pond	*96*	80	9	7	10% explicit
South Easton Pond	*88*	75	9	4	10% explicit
Gardiner Pond	*62*	36	21	5	10% explicit
Paradise Pond	*40*	21	13	6	10% explicit

[1]There is no (zero) allowable load for OWTS surface failure since it is illegal. The existing load from this source has been removed from the allowable loads listed in the first column of this table and in Table 5.7.

[2] An explicit MOS of ten percent (10%) was included in the TMDL analysis when phosphorus concentration targets were developed. See Section 5.1.

[3] Additional Wasteload Allocation for Nonquit Pond applies to Tiverton Landfill permit and closure. See Section 5.7.2.

5.8. Internal Cycling of Phosphorus from Sediments

Based on information collected in 2014 and 2015, each of the nine reservoirs has exhibited some circumstantial evidence of internal loading (the release of phosphorus from lake sediments). The circumstantial evidence includes hypoxic bottom waters, elevated levels of phosphorus in the bottom waters, increases in chlorophyll-a concentrations after fall turnover, elevated lake sediment-phosphorus concentrations, and/or increases in reservoir phosphorus mass during the growing season.

Internal loading for Newport's nine reservoirs was estimated using two well-established methodologies: (1) assessing in-situ increases in reservoir phosphorus, and 2) estimating a sediment-phosphorus release rate based on sediment-phosphorus concentrations. As stated earlier, the internal loading analysis for the Newport reservoirs is available on RIDEMs website at: http://www.dem.ri.gov/programs/water/quality/restoration-studies/reports.php

The in-situ method appeared to be the better method for quantifying the internal load from the Newport reservoirs, since the in-situ method assumptions more closely match reservoir water quality conditions (i.e. the occurrence of harmful algal blooms). The data used to estimate internal loading for the reservoirs consisted of single sediment cores collected in each of the reservoirs in 2014, and water quality data (including phosphorus and DO data) collected biweekly from May through October 2015.

The analysis documents evidence of internal phosphorus cycling within Newport's Water Reservoirs, however, because of the confounding influence of intra-reservoir water transfers, tributary inflow and hypolimnetic water withdrawals, the estimations of internal load are approximate in nature and likely vary from year to year. A more accurate estimation of internal loads would require flow measurements and phosphorus sampling of intra-reservoir water transfers, major tributaries, and water withdrawals into the North Easton and Lawton Valley Water Treatment facilities.

Internal loads are not accounted for or allocated in these TMDLs. If future studies indicate that internal loading constitutes a significant source of phosphorus to the reservoirs it will have to be taken into consideration with respect to phosphorus control measures.

The focus of this TMDL's implementation section is the control of identified external sources of phosphorus discharged to these lakes. However, it must be understood that even if external loading is significantly reduced, improvement in water quality may be delayed possibly for decades, because of continued internal loading. Given that there is evidence of some internal cycling of phosphorus occurring in the water supply reservoirs, consideration and further study should be given to in-reservoir management techniques to control internal cycling. Methods to control internal cycling of phosphorus from sediments are discussed in Section 6 of this TMDL.

5.9 Reasonable Assurance

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) or state issued permit (i.e. RIPDES) provides the reasonable assurance that the wasteload allocation contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with 'the assumptions and requirements of any available wasteload allocation' in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA assumes that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions for a TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

The nine water supply reservoirs addressed in this TMDL are impaired by both point and non-point sources (Section 4.0). Reductions in phosphorus loadings to all reservoirs are required to meet the water quality targets set in the TMDL. Section 5.0 of this TMDL describes how WLAs from regulated point sources (generally MS4s and the Tiverton Landfill) and non-regulated LAs for nonpoint sources (generally agricultural-related sources) were determined. Given the difficulty in accurately separating these sources, it is possible that the WLA may include some loads from nonpoint sources. RIDEM acknowledges that it will take significant effort to reduce phosphorus loading to the maximum extent practicable from as many sources as possible to fully restore support designated uses in the water supply reservoirs. In some cases, phosphorus reductions from individual sources can and should be greater than the prescribed reductions in this TMDL, in order to make up for areas of the combined nine-reservoir watershed where greater reductions are not attainable.

This TMDL cites numerous elements of reasonable assurance. The successful reduction in nonpoint total phosphorus loadings depends on the willingness and motivation of stakeholders to get involved and the availability of federal, state, and local funds. Reasonable assurance that non-point loads will be reduced include enforcement of Rhode Island's existing water quality regulations (RIDEM 2018a) as well as the collaborative efforts of RIDEM, NRCS, ERICD, The Aquidneck Land Trust, municipalities, and many agricultural producers in the reservoir watersheds. The activities/actions described below contribute to the high likelihood of reductions in phosphorus loadings to the reservoirs. In addition, the commitments and strong partnerships developed between state agencies, municipalities, and other groups in the reservoir watersheds will assure continued implementation of best management practices to control nonpoint sources of pollution to the drinking water supply reservoirs.

5.9.1 Rhode Island Water Quality Regulations

Enforcement of the following regulatory controls, excerpted below, from Rhode Island's 2018 water quality regulations https://rules.sos.ri.gov/regulations/part/250-150-05-1
Section 1.11 (Effect of Activities on Water Quality Standards) offer reasonable assurance that non-point sources of pollution have been ad will continue to be reduced.

A. Activities Shall Not Violate Water Quality Standards - No person shall discharge pollutants into any waters of the State or perform any activities alone or in combination which the Director determines will likely result in the violation of any State water quality criterion or interfere with one or more of the existing or designated uses assigned to the receiving waters or to downstream waters in accordance with §§ 1.9, 1.10, and 1.20 of this Part. In addition, Best Management Practices, as determined by the Director, shall be used to control erosion, sedimentation and runoff in accordance with § 1.17 of this Part.

B. Activities Shall Not Further Degrade Low Quality Waters - No person shall discharge pollutants into any waters of the State, or perform any activities alone or in combination which the Director determines will likely result in the additional degradation of water quality of the receiving waters or downstream waters which are already below the water quality standard assigned to such waters.

C. Activities Shall Not Violate Antidegradation - No person shall discharge pollutants into any waters of the State, or perform any activities alone or in combination which the Director determines will likely result in a violation of the Antidegradation provisions of these regulations (§ 1.20 of this Part).

NWQI investigations in 2015 and 2018 (described in detail in Section 4.0) resulted in the Office of Water Resources (OWR) requesting the Office of Compliance and Inspection (OCI) to initiate formal enforcement action for violations of the regulations described above in Section 5.9.1.. <u>Activities which were found to result in the violation of water quality standards include the following:</u>

- the presence of a silage pile located in a wetland perimeter where OWR documented violations of water quality criteria for ammonia, turbidity, phosphorus, and enterococci in the headwaters of an Un-named Tributary to Borden Brook which flows to Nonquit Pond;

- various areas where livestock from a farm have direct access to wetlands and the stream channel of another stream, Un-named Tributary to Nonquit Pond where OWR documented violations of water quality criteria for total phosphorus and enterococci at a downstream sampling location at Barnswallow Street.

- failure to control erosion, sedimentation and runoff resulting in the discharge of untreated concentrated flow of runoff from the nursery fields at various locations in Middletown into storm drainage structures including (catch basin, culvert, and roadside swale) that convey runoff into the Maidford River. RIDEM sampling documented violations of water quality criteria for bacteria, turbidity, and total phosphorus as well as adverse effects to physical, chemical, and biological integrity of habitat.

It is noted that formal enforcement actions were not taken in the above examples, however the Office of Water Resources and Division of Agriculture worked with NRCS, ERICD, and the landowners to address these specific issues. Table 6.6 and Section 6.1 provides more detailed information on specific BMPs for these projects.

5.9.2 Additional Reasonable Assurances

During the development of this TMDL, RIDEM worked with other agencies including the National Resources Conservation Service (NRCS) and the Eastern Rhode Island Conservation District (ERICD) to identify and prioritize agricultural land uses with existing practices that are or had the potential to contribute to nutrient loadings to the reservoir tributaries. RIDEM and the ERICD expended significant resources to document these sources and engage with the landowners to remediate many of the existing problems. These efforts were part of the NWQI/TMDL investigations/sampling completed in the reservoir watersheds.

Table 6.6 in the Implementation Section of this TMDL provides extensive information on the completed, ongoing, and proposed best management practices at numerous agricultural sites within the reservoir watersheds. Approximately 25 properties/landowners were evaluated as part of the NWQI investigations in the Maidford River, Paradise Brook, Borden Brook, and Quaker Creek watersheds. These properties included an equestrian center, dairy/cow farms, hobby farms, nurseries, and orchards. Agricultural related practices on these properties that had the potential to or were documented as having impacts to watercourses or wetlands in the tributary watersheds included the following:

- Livestock/animals having access to a watercourse or wetland.
- Flooded livestock paddocks draining to wetland or watercourse
- Erosion from livestock paddocks draining to watercourse or wetland
- Uncovered manure piles draining to ditch to MS4 or watercourse
- Rill erosion from crop fields draining to watercourse
- Erosion from nursery fields

Table 6.6 provides clear evidence that the NWQI and associated TMDL investigations provide accountability for water quality improvements. Continued efforts by the Eastern RI Conservation District to implement BMPs at these locations speaks to the high likelihood water quality improvements will continue. The Implementation Section of this TMDL further describes the ongoing BMP construction activities at the Hoogendorn Nurseries, which was documented to have significant impacts on the Maidford River during wet weather events. Construction/completion of the largest BMPs were completed in summer/fall 2020.

5.10 Strengths and Weaknesses in TMDL Approach

Strengths:

- General approach to developing these TMDLs (lake total phosphorus) is similar to those utilized by other states and includes widely used and well accepted methodologies.

- Prior to TMDL data collection activities, RIDEM formed a 'technical advisory' committee consisting of technical staff/experts from the Newport Water Department, RIDEM, URI, EPA, and MADEP. The purpose of the advisory committee was to discuss and achieve consensus regarding RIDEM's technical approach for developing the TMDLs. More information about the committee and overall effectiveness of this is provided in the Public Participation Section of this TMDL.

- The TMDLs are based on actual data collected in the reservoirs.

- The empirical models applied to the water supply reservoirs have been documented in the scientific literature to be applicable/appropriate to artificial lakes (reservoirs).

- Extensive field visits and aerial photo analysis was used to further delineate and refine agricultural land uses in each reservoirs' watershed. This information was used in place of the 'general' agricultural land use categories in the original RIGIS database.

- The derivation of total phosphorus and chlorophyll a- targets for the water supply reservoirs was patterned after similar studies in New York and Colorado. The study completed by RIDEM was completed with extensive input from engineers and scientists involved with the NY and CO studies. The technical report was peer reviewed by experts/technical staff from EPA, URI, MADEP, NY State DEC, and consultants for the Newport Water Department.

- Significant resources were spent on field investigations to determine suspected sources of agricultural related nutrient pollution. A majority of this field work was conducted under the NWQI program.

Weaknesses:

- Inherent uncertainty of TP load estimates using the Watershed Treatment Model and associated variability and generality of TP export coefficients and event mean concentrations.

- WTM results may under-predict nutrient loads from various land uses (i.e. much greater than average nutrient loads can be generated from small parcels of land which the WTM was unable to detect due to the relatively coarse modeling scale).

- Inherent difficulty of evaluating nonpoint sources of nutrients to the reservoirs.

- RIDEM could not secure various operational information such as: dates and amounts of water transferred between reservoirs or more information regarding the operation of the Maidford River diversion structure. This information would have been valuable to the estimation of existing phosphorus loads to individual reservoirs.

- Inability to account and allocate internal loading may lead to delay in recovery if internal loading management strategies are not pursued.

6.0 TMDL IMPLEMENTATION

The Implementation Section of this TMDL describes water quality improvement activities in the Newport reservoir watersheds that have been or are being implemented by various agencies/entities. This section also outlines additional required and recommended best management practices (BMP's) that will need to be implemented to meet the water quality targets established in this TMDL. Existing water quality improvement activities/plans are described in further detail in Section 6.1 below and include:

- Source Water Phosphorus Reduction Feasibility Plan- City of Newport
- Maidford River Watershed Assessment and BMP Design- Town of Middletown
- Aquidneck Island Water Quality Initiative- Multiple partners
- Maidford River and Paradise Brook Watershed Conservation Plan- Aquidneck Land Trust
- North Easton Pond Stormwater Attenuation and Source Reduction Strategy
- Hoogendorn Nursery BMP Implementation- NRCS and RIDEM

6.1 Overview of Existing Water Quality Improvement Activities/Plans

Source Water Phosphorus Reduction Feasibility Plan-City of Newport

In 2014, the Newport Water Department received a grant from the Narragansett Bay Estuary Program (NBEP) funded through the United States Environmental Protection Agency (EPA), specifically EPA's Southern New England Program for Coastal Watershed Restoration, to conduct a study to assess potential phosphorus reduction in sources waters of the NWD water supply, focusing on St. Marys Pond and Watson Reservoir and their watersheds. The study was conducted by Fuss and O'Neill for the City of Newport. The plan, titled 'Source Water Phosphorus Reduction Feasibility Study' is available online at: http://www.cityofnewport.com/departments/utilities/water/water-shed-protection.

Representatives from the Aquidneck Land Trust, the Sakonnet Preservation Association, the R.I. Office of the Natural Resources Conservation Service, RIDEM, and the Town of Portsmouth participated in the stakeholder group that assisted to identify current watershed conditions and prioritize management practices. The study commenced in Spring of 2015 with the main goals of:

- Documenting the existing trophic conditions in St Marys Pond and Watson Reservoir.
- Application of the Watershed Treatment Model (WTM) to evaluate phosphorus and nitrogen loadings to each reservoir.
- Sub-watershed WTM application to identify and rank specific sub-watersheds according to phosphorus and nitrogen loadings
- Identification of management strategies to control phosphorus (and nitrogen) loading.
- Development of a plan to implement the recommended management strategies.

Documentation of existing conditions in the reservoirs and their watersheds included: 1) in-reservoir (water column and sediment) and tributary sampling and 2) application of the Watershed Treatment Model (WTM) to evaluate watershed derived sources of phosphorus. The management measures presented in the Implementation Plan of this report include both structural and non-structural BMPs. Non-structural BMP's include educating residents about lawn care, pet waste practices, and septic system maintenance. Other non-structural practices like street sweeping were considered in the plan but were found to be relatively minor in terms of reductions in nutrient loading due to the limited number of roads within the watersheds. RIDEM believes that street sweeping may provide more benefit in reservoir watersheds such as North Easton Pond (Bailey Brook) that have a higher road density.

Other non-structural BMPs proposed for Watson Reservoir and St. Marys Pond include re-establishment of vegetative buffers. While there is some variability in the scientific literature regarding the width of the buffer needed to protect water quality and habitat, there is consensus that, typically, the wider the buffer the more protective of the resource the buffer becomes (Rhode Island Legislative Task Force, 2014) http://www.planning.ri.gov/planning-areas/land-use/legislative-task-force.php.

Two buffer widths, 100-foot and 200-foot were used in the study to evaluate the potential for pollutant removal in the St. Marys Pond and Watson Reservoir watersheds. In the Watson Reservoir watershed, the forested riparian buffer surrounding the reservoir is largely intact both at the 100- foot and 200- foot widths. Approximately 65% of the 100-foot buffer and 68 percent of the 200-foot buffer are currently mapped as forested based on RIGIS land use/cover mapping. The re-establishment of the buffers in the areas shown in orange (100-foot) and yellow (200-foot) would reduce nutrient loading in both of these watersheds.

Watershed pollutant loading model (WTM) results estimated that if the forested riparian buffer is increased to 100 percent of the reservoir perimeter, excluding the dam area, there could be a 7 to11 percent reduction in annual watershed total phosphorus loading and a 5 to 8 percent reduction in annual total nitrogen loading. In St. Marys Pond, if the forested riparian buffer was increased to 100 percent, excluding the dam, there could be as much as a 7 percent reduction in annual total phosphorus loads and 5-8% reduction in annual total nitrogen loads. RIDEM recommends that the buffer expansion scenarios run for St. Marys Pond and Watson Reservoir be applied to the other seven reservoirs to examine the potential for both phosphorus and nitrogen reductions.

Specific agricultural BMPs were not evaluated in the St. Marys Pond or Watson Reservoir watersheds in Newport's Source Water Phosphorus Reduction Plan. Because of the potential variation in the effectiveness of nutrient management, two scenarios involving nutrient reductions from agricultural areas were considered, one with a nutrient (TP, TN) reduction of 25 percent and a second with a nutrient reduction of 75 percent. The plan assumed a 25 percent to 75 percent reduction in nutrient loading, resulting in total annual phosphorus loads reduced by 7 to 22 percent in the Watson Reservoir watershed and by 4 to 13 percent in the St. Marys Pond watershed compared to existing conditions if implemented at all agricultural areas.
The plan states that costs associated with nutrient management are site-specific and will vary based on the crops produced and management practices used. Bonham et al. (2006) provides one

of the few published estimates of cost-effectiveness of nutrient management and estimates $415 to $486 per pound of phosphorus reduction for a variety of farm types.

The plan illustrates locations identified for the potential placement of new structural best management practices or the retrofit of existing stormwater management structures. These locations were selected based on a combination of modeling estimates of loading and field reconnaissance. Recommended BMP types (i.e., bioretenton, etc) are a function of existing infrastructure, soils and soil infiltration capacity, target pollutant (nutrients) and available space. With the exception of land controlled by the Aquidneck Land Trust or the City of Newport in the St. Marys Pond watershed, structural BMPs have only been recommended in existing roadway rights-of way.

The plan provides a summary of the potential BMPs by watershed. Each BMP is then described in greater detail on an individual sheet. Potential nutrient reductions associated with the BMPs were estimated using the Watershed Treatment Model (WTM). Information presented for each BMP assumes that 100% of the water quality volume (WQv) is being treated by the BMP. Technical Appendix H of the plan http://www.cityofnewport.com/departments/utilities/water/water-shed-protection contains more detail on the methods of estimating BMP cost-effectiveness.

The structural BMP's described in the plan include bioretention, linear bioretention, tree filters and/or filtration retrofits, and wet vegetated treatment systems. RIDEM believes that this plan provides a sound framework for nutrient abatement measures in the Watson Reservoir and St. Marys Pond watersheds. All proposed BMP sites in the plan should be addressed with priority given to those sites where the largest nutrient removal potential exists.

The implementation section of the plan synthesizes information from field investigations, prior studies, pollutant load modeling, and local stakeholder input to identify a roadmap for feasible and cost-effective prioritization of efforts to reduce phosphorus loads to Watson Reservoir and St. Marys Pond over the next several years. Implementation of specific structural BMPs will require additional site-specific information to support design and construction, however the study demonstrated the feasibility and potential benefit of structural BMPs in both watersheds. Although external (i.e., watershed) sources currently dominate phosphorus loading in each waterbody, it is important to continue to assess in-lake conditions and internal loading from bottom sediments.

The prioritization process in the plan identified structural BMP locations that are within existing municipal or state roadway rights-of-way or on land owned by the City of Newport or project stakeholder, the Aquidneck Land Trust, in order to both identify an initial project champion and also an entity that could assume or assist with ongoing maintenance. In addition, emphasis was placed on identifying management practices that would be eligible for state or federal funding programs (e.g., NRCS EQIP, Section 319), for at least initial construction/implementation. RIDEM believes that the management measures presented in the implantation section of this plan are widely applicable to other watersheds within the other seven reservoir watersheds and should be considered by other municipalities in the reservoir watersheds.

Maidford River Watershed Assessment and BMP Design-Town of Middletown

The goal of this project was to evaluate the Maidford River and Paradise Brook watersheds to determine the primary causes of the water quality and flooding impacts and recommend feasible and effective solutions to those problems. Funding for this project was provided by the Hurricane Sandy Coastal Resiliency Grant Program through the U.S. Department of Interior and administered by the National Fish and Wildlife Foundation (NFWF). The plan was prepared by Fuss and O'Neill for the Town of Middletown.

The Maidford River Watershed Assessment and BMP Design report provided an overview of the water quality and flooding concerns in the watersheds, primarily utilizing information obtained by RIDEM staff as part of the NWQI investigations, described in Section 4.0 of this TMDL. In addition, the Watershed Treatment Model (WTM) was applied to both watersheds to evaluate nutrient loadings and identify the land uses contributing to these loadings.

The Fuss and O' Neill WTM results indicated that the actions associated with the underlying land uses in the watersheds, rather than specific activities that occur in the watersheds, are responsible for the majority of loading for all the pollutants considered (91% TN, 77% TP, 93% FC, and 41% TSS for the Paradise and Maidford sub-watersheds combined). WTM results indicated that agriculture and medium density residential areas generated the most nutrients (TN and TP), as well as TSS, a result which is also consistent with RIDEM's NWQI-related observations of higher instream turbidity concentrations near agricultural areas within the watersheds.

Section 5 of the Maidford River Watershed Assessment and BMP Design Plan summarizes potential best management practices that could significantly improve water quality (and flooding) problems in the Maidford River and Paradise Brook (Figure 5-1 of the design plan). Stormwater best management practices include: retrofitting existing detention basins, retrofitting existing roadside swales, and new stormwater BMPs (including use of bioretention systems). The BMP design plan also lists examples of conservation practices that could be utilized in agricultural areas in the Maidford River and Paradise Brook watersheds. These include: establishment of riparian buffers, planting of cover crops, residue and tillage management, nutrient management, water and sediment control basins, and constructed wetlands. Other best management options proposed in the plan include: repair of stream bank erosion, homeowner lawn care education, OWTS maintenance, enforcement of pet waste programs, and hobby farm fertilizer use and manure management education.

The plan identifies specific locations where BMPs would be sited as well as a matrix that 'scores' each of the potential BMP's based on four criteria: (1) construction costs, (2) maintenance needs, (3) pollutant load reduction, and (4) flood reduction. Table 5-2 of the plan provides more detail for each BMP as well as expected benefits. As of March 2018, three BMPs have been completed by the Town of Middletown. These include (as identified in the plan):

- A2: Retrofit of Hoogendorn Nurseries detention basins along Berkeley Avenue- connected 2 existing basins into one large system with a baffle down the middle to lengthen flow path and maximize sediment removal.

- C3: Bioretention on public land adjacent to the Maidford River along Green End Avenue- divert stormwater collected from upstream areas into bioretention areas (one along the northeast corner of the intersection and one along the southwest corner of the intersection)

- C5/C6: Divert Prospect Avenue storm drainage into bioretention at corner of Paradise Valley Park prior to discharge to Maidford River.

RIDEM recommends that the Town of Middletown continue to prioritize, fund, and construct additional BMPs proposed within this plan.

Aquidneck Island Water Quality Initiative
The Aquidneck Island Water Quality Initiative (AIWQI) "Island Waters Project" is a program developed by the Aquidneck Island Planning Commission (APC) in partnership with the City of Newport, and the Towns of Middletown and Portsmouth, along with the non-profit partners Clean Ocean Access and the Aquidneck Land Trust. In September 2016, the US EPA Region 1 selected the AIWQI "Island Waters" for funding under its Southeast New England Program (SNEP). SNEP is a geographically-based program serving as a collaborative framework for advancing ecosystem resiliency, protecting and restoring water quality, habitat, and ecosystem function, and developing and applying innovative policy, science, and technology to environmental management in southeast coastal New England.

As part of the funding, the Island Waters Project will prioritize and install BMPs and other structural and non-structural measures to reduce pollution to impaired waters on Aquidneck Island. The focus is on nutrient reduction in impaired drinking and coastal waters and includes agricultural BMPs such as nutrient reduction strategies through partnership with USDA Natural Resources Conservation Service (NRCS) and Southern RI Conservation District.

This project is part of a two-year program funded through EPA Southeast New England Program. The initial focus of the project is restoration of impaired waters and pollution prevention through nutrient management and other aspects of ongoing regulatory projects aimed at water quality. Ultimately, it will serve as a foundation for increasingly integrated water resources and habitat planning, policy, and implementation, including the development of sustainable funding mechanisms for water quality management.

Island Waters Project's goals are to:

- Develop a sustainable inter-municipal partnership for restoring water quality;
- Provide the communities with approximately $700,000 in new direct funding for actions to reduce stormwater impacts;
- Engage and inform thousands of Island residents in watershed stewardship;
- Evaluate the results of the program, including benefit/cost analysis for the municipalities;
- Develop a financing plan for future stormwater needs; and
- Share results with communities elsewhere in New England and the U.S

BMP related activities include:

- Development of BMP prioritization model that maximizes results and cost-effectiveness;

- Generating a list of prioritized BMPs including cost and load reduction estimates;

- Design permit and installation of 5-20 high-priority BMPs in some or all of the following drinking watersheds: Maidford River, Bailey Brook/Easton Ponds, Lawton Reservoir, and St. Marys Pond.

  Develop, demonstrate, and assess innovative approaches to illicit discharge detection and elimination (IDDE), initially to address impaired waters and shellfish bed closures in the Island Park (Portsmouth) area; ultimately for use throughout Aquidneck Island and SNE region;

- Training for departments of public works (DPW) staff (at least one training for each municipality. This includes assessing existing practices and developing a training program that includes general practices as well as specific practices that address water supply impairments.

Water quality restoration measures will prioritize and install BMP's and other measures, focusing on nutrient pollution. Sites will be chosen through a prioritization model, resulting in 10-20 installed BMP's, illicit connection detection, and training for Department of Public Works staff. A large communication campaign will be developed to reach the Island's residents and document economic and environmental benefits of water quality restoration through a public report. The program will also include a cost-benefit analysis of the completed work and develop a finance and implementation plan for a 5 and 10-year horizon with identification of high-priority projects, estimated load reductions, and other quantitative measures.

In November 2017, AIPC was awarded an additional $300,000 toward the Island Waters Project to restore water quality on Aquidneck Island. Specifically, the funding will be used to expand the scope of planned green infrastructure improvements in the drinking water source watersheds. The origin of the funding is the State's 2016 Green Economy Bond Aquidneck Island Planning Commission: $300,000 for the construction of stormwater pollution abatement best management practices incorporating green infrastructure in the St. Marys Pond (Portsmouth), Bailey's Brook (Middletown) and Maidford River (Middletown) watersheds. The project will reduce pollutant loadings into surface waters that are part of the Newport public drinking water system and aligns with the Island Waters partnership on Aquidneck Island.

Maidford River and Paradise Brook Conservation Plan

The Maidford River and Paradise Brook Conservation Plan was developed in 2017 by the Aquidneck Land Trust (ALT) and is meant to guide the ALT's preservation and restoration efforts in the two watersheds for the next five years. The Plan draws from results of the 'Maidford River Watershed Assessment and BMP Design' described in Section 6.1.2 of the plan. The Plan focuses on privately owned parcels, including those with easements, owned directly by the ALT. Other privately-owned lands are prioritized for a variety of 'conservation actions' including outreach and education that are focused on BMPs for land management, water quality, and land conservation.

In terms of a broad strategy, the Plan uses existing water quality and flooding data, along with assessments performed as part of the project to identify parcels for conservation that will provide the most benefit for the protection of water quality, habitat improvement, and flood reduction. Agricultural land uses are a major focus of implementation activities in the plan because:

1. Most ALT easements in the watersheds are held on parcels with active agriculture.
2. Property ownership in the upper portions of both watersheds is dominated by agricultural parcels.
3. Previous studies have shown that agriculture is a major contributor to nutrient loads in both the Maidford River and Paradise Brook watersheds.
4. The principal conservation strategies undertaken by the ALT, including purchase of development rights, conservation easements, and fee simple acquisition, are most effectively targeted to larger landowners.
5. The Maidford River and Paradise Brook watersheds were selected for funding under the National Water Quality Initiatives (NWQI) which focuses water quality sampling in watersheds affected by agricultural land uses.

The Maidford River and Paradise Brook Conservation Plan defines parcels within the watershed that will provide the greatest level of benefit for protection and restoration efforts. The plan also includes advocacy and outreach efforts required to implement the plan and to promote other conservation measures to private property owners. All existing parcels in the watershed were subdivided into four categories based on land use and ownership, and the presence of easements. Categories are defined below.

- Category 1: Five sites identified as top priorities for structural BMPs.

- Category 2: Conserved parcels identified as top priorities for specific outreach and education focused on BMPs for agriculture and identified pollutant sources.

- Category 3: Private lands consisting of a mix of larger agricultural or commercial lots and residential lots greater than 2 acres, with open space, identified for outreach and education focused on agriculture or other measures appropriate for large residential holdings.

- Category 4: All other private land with 2 acres or less, with primarily residential or commercial uses identified for general outreach and education focusing on stormwater.

In the Maidford River and Paradise Brook Conservation Plan, concept designs for each of the five BMP sites which include:

1. Floodplain restoration along the Maidford River (2 Phases)

2. Headwaters of the Maidford River: parcels with row crops

3. Maidford River: Vineyard and golf course

4. Headwaters of Paradise Brook: parcels with active agriculture

5. Paradise Brook Nursery

Cost estimates were prepared for each of the BMP recommendations using available literature. Cost estimates for flood plain restoration projects were derived from NRCS floodplain restoration project profiles previously funded in Rhode Island under the American Reinvestment and Recovery Act of 2009. The concept designs are presented in the Maidford River and Paradise Brook Conservation Plan.

North Easton Pond Stormwater Attenuation and Source Reduction Strategy
The North Easton Pond Stormwater Attenuation and Source Reduction Strategy was developed in 2013 and was supported by a non-point source management grant from RIDEM. The grant was provided for the purpose of attenuating phosphorus and bacteria from storm sewer outfalls owned by the Town of Middletown in the North Easton Pond watershed. Phosphorus reduction was the primary goal of the study and was meant to address the North Easton Pond TMDL, completed by RIDEM initially in 2007. The report includes a review of potential structural improvements (i.e. bioretention, sand filters, and wet vegetated treatment systems) as well as non-structural practices (i.e. enhanced operation and maintenance and pollution prevention).

The specific objectives of the study were to determine which BMPs will be most cost-effective in reducing peak volume, phosphorus, and bacteria to Baileys Brook and North Easton Pond and to determine where they should be located. Catchment mapping was completed for 17 catchments with Town-owned outfalls and drainage networks in the study area. The 17 catchments are described in detail in the plan and a pollutant loading analysis using the Simple Method (from Appendix H of the Rhode Island Stormwater Design and Installation Standards Manual 2015 (http://www.dem.ri.gov/pubs/regs/regs/water/swmanual15.pdf) was completed for significant outfalls in each catchment.

Conceptual Designs of structural alternatives for each outfall are presented in the plan and include bioretention systems, bioswales, linear bioretention, subsurface infiltration, disconnected catch basins, sand filters, and gravel wet vegetated treatment systems. An order of magnitude cost-benefit analysis for proposed treatments in each catchment are presented in the plan. In addition, phosphorus source reductions strategies were identified and recommended, as a supplement to BMP installation(s) for each catchment.
The last section (Section 7.0) of the North Easton Pond Stormwater Attenuation and Source Reduction Strategy provides an Implementation Strategy with steps for identifying required resources (including funding), determining permitting requirements for construction, and completing BMP design. An overview of this strategy includes:

- Implementation of the recommended phosphorus source reduction recommendations in Section 6.3 of the report
- Determination of available resources (funding, labor, equipment, etc)
- Identification of available resources
    - Field review with grant program managers

    - Open a dialogue with RI Clean Water Finance Agency (RICWFA)
    - Identify landowners and their potential contribution
    - Determine available Town resources
    - Identify other partners (i.e. RIDOT) resources
- Design, Permitting, Construction
- Cost-Benefit in Catchments and Type of BMP

As of 2020, the Town of Middletown has constructed BMPs in the 'New South' catchment, which is a 70-acre catchment containing mostly commercial property with an approximate 46% impervious area. The outfall discharges to North Easton Pond at Valley Road. BMPs in this catchment include two bioretention basins.

Hoogendorn Nursery BMP Implementation- NRCS and RIDEM
Agricultural operations at Hoogendorn Nursery result in significant exposed soils that erode during storm events. Currently the drainage systems at this site consist of unstabilized ditches that further contribute to erosion and sediment loads. Past observations by DEM staff have revealed sediment-laden runoff from at least four ditches contributed to road flooding and discoloration of the Maidford River at the Berkeley Avenue culvert. Past NWQI sampling by RIDEM has determined that this site is a significant source of sediments and nutrients to the Maidford River and contributes to the eutrophication of both Paradise and Gardiner Ponds. The site owner has received funding from NRCS, the Aquidneck Island planning Commission (AIPC), and RIDEM to construct agricultural BMP's on the site. NRCS, in collaboration with RIDEM, completed BMP designs and NRCS staff will inspect, certify and sign off on BMP construction. The Eastern Rhode Island Conservation District (ERICD) will serve as project manager, will coordinate the project team, and will provide oversight as well as fiscal management.

Three new sedimentation basins will be constructed onsite, in addition to the existing basin that was retrofitted on land leased to the nursery by the Town. Lined waterways, grassed waterways, diversions, and culverts will be installed to provide a stable conveyance system to collect runoff from the site and covey it to the proposed or existing sedimentation basins. Three fields will be stabilized with planting in conservation cover. New access roads to the fields as well as reconstructed existing roads will be constructed to further stabilize the site. This project was completed in December 2020.

6.2 Additional Required and Recommended Implementation Activities
This TMDL will require additional implementation activities to reduce both point and nonpoint sources of nutrient loadings to the water supply reservoirs. These implementation activities include: 1) urban stormwater management, 2) control of runoff from agricultural land uses and implementation of additional agricultural best management practices including fencing animals and livestock out of riparian areas and wetlands, management of manure and silage piles, and establishment or expansion of riparian areas within agricultural lands, 3) implementation of a goose reduction/control strategy-with a primary focus on the water supply watersheds, 4) protection of and re-establishment or expansion of riparian buffers within all nine water supply reservoir watersheds, 5) Tiverton Landfill Closure, 6.) implementation of the Newport Airport

Stormwater Pollutant Prevention Plan (SWPPP) and 7.) further evaluation of internal cycling of nutrients in specific reservoirs. These are discussed further in the sections below.

6.2.1 Stormwater Management

In 2007, Rhode Island adopted the Smart Development for a Cleaner Bay Act (General Laws Chapter 45-61.2), requiring RIDEM and the Coastal Resources Management Council (CRMC) to update the Rhode Island Stormwater Design and Installations Manual. The revised manual, adopted January 2011 and amended in 2015, provides twelve minimum standards addressing LID site planning and design strategies, groundwater recharge, water quality, redevelopment projects, pollution prevention, illicit discharges, and stormwater management system operation and maintenance, among other concerns. The manual as adopted into regulation in 2018 (RIDEM 2018b), provides appropriate guidance for stormwater management on new development and redevelopment projects and, most importantly, incorporates LID as the "industry standard" for all sites, representing a fundamental shift in how development projects are planned and designed. The revised stormwater manual regulation (RIDEM 2018b) is available online at: https://rules.sos.ri.gov/regulations/part/250-150-10-8

A companion manual on LID site planning and design has also been prepared by RIDEM to provide Rhode Island-specific guidance regarding the site planning, design, and development strategies that communities should adopt to encourage low impact development. This manual is also available on-line at: http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/lidplan.pdf. Rhode Island joins a growing number of states and localities including the Puget Sound area (http://www.psat.wa.gov/Programs/LID.htm) that rely heavily on LID techniques to protect and restore their waters.

RIDEM recommends that a combination of structural and non-structural BMP's be used to manage stormwater runoff in the Newport water supply watersheds. Structural Best Management Practices (BMPs) are engineered constructed systems that can be designed to provide water quality and/or water quantity control benefits. Structural BMPs are used to address both existing watershed impairments and the impacts of new development.

Common structural BMPs include the following:

Infiltration systems: designed to capture stormwater runoff, retain it, and encourage infiltration into the ground;

Detention systems: designed to temporarily store runoff and release it at a gradual and controlled rate (considered acceptable for flood control only);

Retention systems: designed to capture a volume of runoff and retain that volume until it is displaced in part or whole by the next runoff event (considered acceptable for flood control only);

Wet vegetated treatment systems: designed to provide both water quality and water quantity control; and

Filtration systems: designed to remove particulate pollutants found in stormwater runoff through the use of media such as sand, gravel or peat.

Non-structural BMPs are a broad group of practices designed to prevent pollution through maintenance and management measures. They are typically related to the improvement of operational techniques or the performance of necessary stewardship tasks that are of an ongoing nature. These include institutional and pollution-prevention practices designed to control pollutants at their source and to prevent pollutants from entering stormwater runoff. Non-structural measures can be very effective at controlling pollution generation at the source, thereby reducing the need for costly "end-of-pipe" treatment by structural BMPs. Examples of non-structural BMPs include maintenance practices to help reduce pollutant contributions from various land uses and human operations, such as street sweeping, road and ditch maintenance, or specifications regarding how and when to apply fertilizers and pesticides.

Structural and non-structural BMPs are often used together. Effective pollution management is best achieved from a management systems approach, as opposed to an approach that focuses on individual practices. Some individual practices may not be very effective alone, but in combination with others, may be more successful in preventing water pollution.

RIPDES Phase II Stormwater Management Programs **SWMPPs**

Stormwater runoff is most often carried to waterways by publicly owned drainage networks. Historically, these networks were designed to carry stormwater away from developed land as quickly as possible to prevent flooding with little to no treatment of pollutants. In 1999, the USEPA finalized its Stormwater Phase II rule, which required the operators of small municipal separate storm sewer systems (MS4s) to obtain permits and to implement a stormwater management program as a means to control polluted discharges. In Rhode Island, the RIDEM RIPDES Program administers the Phase II program using a General Permit that was established in 2003 (RIDEM, 2003). Rhode Island municipalities, the Rhode Island Department of Transportation (RIDOT), and Federal, State, and Quasi-State agencies serving more 1000 people per day are regulated under the Phase II program. The regulated municipalities include the towns of Middletown and Portsmouth.

The Phase II Program requires MS4 operators to develop a stormwater management program that is based on six minimum measures. Operators develop Stormwater Management Program Plans (SWMPPs) that detail how their stormwater management programs comply with the Phase II regulations. SWMPPs describe BMPs for the six minimum measures, including measurable goals and schedules. The implementation schedules include interim milestones, frequency of activities, and result reporting. Plans also include any additional requirements that are mandated for stormwater that discharges to impaired waters.

The six minimum measures are listed below.

• A public education and outreach program to inform the public about the impacts of stormwater on surface water bodies;

• A public involvement/participation program;

• An illicit discharge detection and elimination program;

• A construction site stormwater runoff control program for sites disturbing 1 or more acres;

• A post construction stormwater runoff control program for new development and redevelopment sites disturbing 1 or more acres; and

• A municipal pollution prevention/good housekeeping operation and maintenance program.

In general, municipalities and RIDOT were automatically designated as part of the Phase II program if they were located either completely or partially within census-designated urbanized or densely populated areas. Densely populated areas have a population density greater than 1000 people per square mile and a total population greater than 10,000 people. In the Newport reservoir watersheds, Newport, Middletown, and Portsmouth are designated as Phase II municipalities, and require Phase II permits. In addition to RIDOT, non-municipal MS4 operators include federal, state, and quasi-state facilities serving an average daily population equal to or greater than 1,000 people. Accordingly, the cities of Newport, Middletown, Portsmouth, and RIDOT have submitted the required Stormwater Management Program Plans (SWMPPs).

Required SWMPP Amendments to TMDL Provisions

In Rhode Island, Part IV.D of the Phase II General Permit requires MS4 operators to address TMDL provisions in their SWMPP if the approved TMDL identifies stormwater discharges that directly or indirectly contain the pollutant(s) of concern (Part II.C3). Operators must comply with Phase II TMDL requirements if they contribute stormwater to priority outfalls via system interconnections, even if they do not own the outfall. Operators are legally responsible for pollutants transported via their drainage systems including, for example, bacteria sources from wildlife that enter MS4 drainage systems. Operators must identify amendments needed to their current SWMPP to comply with TMDL requirements. Operators must also address any previously non-regulated areas that are brought into the Phase II program as part of a TMDL and are encouraged to apply their requirements town-wide. To avoid confusion and to better track progress, the SWMPP amendments should be addressed in a separate TMDL Implementation Plan (TMDL IP). Upon approval of a TMDL, the towns of Portsmouth, Middletown, and RIDOT should make revisions in their TMDL IP. The 2003 RIPDES General Permit requires that the revisions (i.e. TMDL IP) be submitted within one hundred and eighty (180) days of the date of written notice from RIDEM that the TMDL has been approved, as described in more detail below (RIDEM, 2003).

It is common for state-owned and municipal-owned storm drains to interconnect. RIDEM encourages cooperation between MS4 operators when developing and implementing the six minimum measures and in conducting feasibility analyses and determining suitable locations for the construction of BMPs. Communities affected by the Phase II program are encouraged to cooperate on any portion of, or an entire minimum measure when developing and implementing their stormwater programs. An important first step in implementing this TMDL will be to confirm the ownership of the priority outfalls identified in this TMDL, and to determine interconnections within these drainage systems to the priority outfalls.

TMDL Implementation Plan (IP) Requirements

The TMDL Implementation Plan (TMDL IP) must address all parts of the watershed that discharge to the impaired water and all impacts identified in the TMDL, including those areas that are brought into the Phase II program as part of a TMDL. The TMDL IP must describe the six minimum measures and other additional controls that are or will be implemented to address the TMDL pollutants of concern. MS4 operators must provide measurable goals for the development and/or implementation of the amendments to the six minimum measures and as relevant, for additional structural and non-structural BMPs that will be necessary to address the stormwater impacts identified in this TMDL.

TMDL IP requirements must include an implementation schedule, which must contain all major milestone deadlines, including start and finish calendar dates, estimated costs, proposed or actual funding sources, and anticipated improvement(s) to water quality. These requirements apply to any operators of MS4s contributing stormwater to specifically identified outfalls, regardless of outfall ownership.

The TMDL IP must specifically address the following requirements that are described in Part IV.D of the RIPDES Stormwater General Permit (RIDEM, 2003).

1. Determine the land areas contributing to the discharges identified in the TMDL using sub-watershed boundaries, as determined from USGS topographic maps, stormwater sewer maps, or other appropriate means;

2. Address all contributing areas and the impacts identified by the Department;

3. Assess the six-minimum control measure BMPs and additional controls currently being implemented or that will be implemented to address the TMDL provisions and pollutants of concern and describe the rationale for the selection of controls including the location of the discharge(s), receiving waters, water quality classification, shellfish growing waters, and other relevant information;

4. Identify and provide tabular description of the discharges identified in the TMDL including:
    - Location of discharge (latitude/longitude and street or other landmark);
    - Size and type of conveyance (e.g. 15” diameter concrete pipe);
    - Existing discharge data (flow data and water quality monitoring data);
    - Impairment of concern and any suspected sources(s);
    - Interconnections with other MS4s within the system;

- TMDL provisions specific to the discharge;
- Any additional outfall/drainage specific BMP(s) that have or will be implemented to address TMDL provisions; and
- Schedule for construction of structural BMPs including those for which a Scope of Work is to be prepared, as described below.

This TMDL has determined that the six minimum measures alone are insufficient to restore water quality and that structural BMPs are necessary. The TMDL IP must describe the tasks necessary to design and construct BMPs that reduce the pollutants of concern and stormwater volumes to the maximum extent feasible. The TMDL IP must describe the process and the rationale that will be used to prioritize outfalls/drainage systems, select structural BMPs (or low impact development (LID) retrofits) and measurable goals to ensure that the TMDL provisions will be met. In a phased approach, operators must identify any additional outfalls not identified in the TMDL that contribute the greatest pollutant load and prioritize these for BMP construction. Referred to as a Scope of Work in the current permit, this structural BMP component of the TMDL IP must also include a schedule and cost estimates for the completion of the following tasks:

- Prioritization of outfalls/drainage systems where BMPs are necessary. If not specified in TMDL, priority can be assessed using relative contribution of the pollutant(s) of concern, percent effective impervious area, or estimated pollutant loads based upon drainage area, pipe size, land use, etc. A targeted approach to construct stormwater retrofit BMPs at state and locally owned stormwater outfalls is recommended;

- Delineation of the drainage or catchment area;

- Determination of interconnections within the system and the approximate percentage of contributing area served by each operator's drainage system, as well as a description of efforts to cooperate with owners of the interconnected system;

- Completion of catchment area feasibility analyses to determine drainage flow patterns (surface runoff and pipe connectivity), groundwater recharge potentials(s), upland and end-of pipe locations suitable for siting BMPs throughout the catchment area, appropriate structural BMPs that address the pollutant of concern, any environmental (severe slopes, soils, infiltration rates, depth to groundwater, wetlands or other sensitive resources, bedrock) and other siting (e.g. utilities, water supply wells, etc.) constraints, permitting requirements or restrictions, potential costs, preliminary and final engineering requirements;

- Design and construction of structural BMPs; and

- Identification and assessment of all remaining discharges, not identified in the TMDL, owned by the operator, contributing to the impaired waters addressed by the TMDL, taking into consideration the factors addressed above.

In summary, the SWMPPs must be revised to describe the six minimum measures and other additional controls that are or will be implemented to address the TMDL pollutants of concern. The operators must provide measurable goals for the development and/or implementation of the six minimum measures and additional structural and non-structural BMPs that will be necessary to address provisions for the control of stormwater identified in this TMDL including an implementation schedule, which includes all major milestone deadlines including the start and finish calendar dates, the estimated costs and proposed or actual funding sources, and the anticipated improvement(s) to water quality. If no structural BMPs are recommended, the operator must evaluate whether the six minimum measures alone (including any revisions to ordinances) are sufficient to meet the TMDL's specified pollutant reduction targets.

Modifications to Six Minimum Measures

As described previously, the towns of Portsmouth and Middletown, and RIDOT must assess the six minimum control measure BMPs for compliance with the TMDL provisions and provide measurable goals for any needed amendments. The TMDL IP must include a description of selection of controls including the location of the discharge(s), receiving waters, water quality classification, and other relevant information (General Permit Part IV.D.3.c). The following sections outline activities that should or must be implemented and/or considered when modifying six minimum measures.

Public Education/Public Involvement

The public education program must focus on both water quality and water quantity concerns associated with stormwater discharges within the applicable reservoir watersheds. Public education material should target the particular audience being addressed, while public involvement programs should actively involve the community in addressing stormwater concerns.

The targeted educational campaign should include activities that residents can take to minimize water quality and water quantity impacts. For instance, measures that can reduce nutrient contamination include eliminating any wastewater or other illicit connections to the storm drain network, proper disposal of pet and yard waste, eliminating waterfowl feeding, and eliminating or modifying habitat that attracts nuisance populations of waterfowl-particularly Canada Geese. Proper methods of fertilizer and pesticide application should also be included.

Reducing runoff volume can be accomplished by grading the site to minimize runoff and to promote stormwater attenuation and infiltration, creating rain gardens, and reducing paved areas such as driveways. Driveways can be made of porous materials such as crushed shells, stone, or porous pavement. Buffer strips and swales that add filtering capacity through vegetation can also slow runoff. Waterfront properties as well as those adjacent to hydrologically connected streams and wetland areas should establish and maintain natural buffers, planted with native plants, shrubs and/or trees to minimize impacts of development and restore valuable habitat. Other audiences include commercial, industrial, and institutional property owners, land developers, and landscapers. In addition to the activities discussed above for residential land use, educational programs for these audiences could discuss BMPs that should be used when redeveloping or re-paving a site to minimize runoff and promote infiltration. Measures such as minimizing road widths, installing porous pavement, infiltrating catch basins, breaking up large tracts/areas of impervious surfaces, sloping surfaces towards vegetated areas, and incorporating buffer strips and swales should be used where possible.

As noted, the RI Stormwater Design and Installation Standards Manual was revised and adopted into regulation in 2018 (RIDEM 2018). This revised manual as adopted into regulation provides appropriate guidance for stormwater management on new development and redevelopment projects and, most important, incorporates LID as the "industry standard" for all sites, representing a fundamental shift in how development projects are planned and designed. The revised stormwater manual is available online at: https://rules.sos.ri.gov/regulations/part/250-150-10-8.

A companion manual on LID site planning and design has also been prepared by RIDEM to provide Rhode Island-specific guidance regarding the site planning, design, and development strategies that communities should adopt to encourage low impact development. This manual is available at:
http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/lidplan.pdf

The University of Rhode Island Cooperative Extension's Stormwater Phase II Public Outreach and Education Project provides participating municipalities with education and outreach programs that can be used to address TMDL public education recommendations. This project is funded by RIDOT and has many partners, including RIDEM. More information may be found on the URI website (http://www.ristormwatersolutions.org/).

Illicit Discharge Detection and Elimination

Illicit discharges are any discharge to a separate storm drainage system that is not composed entirely of stormwater with some exceptions. On-site Wastewater Treatment Systems (OWTS) or sewer line connections to a storm drain result in the discharge of untreated sewage to a waterbody and are considered illicit discharges. Routine illicit discharge detection and elimination (IDDE) work conducted by the municipalities, including sampling storm drains in dry weather can reveal illicit discharges.

It is not unexpected that illicit sewer connections may be found in storm drainage systems serving the older developed portions of the Bailey Brook watershed. Any outfall with elevated bacteria or phosphorus values and exhibiting a steady flow should be prioritized for further investigation to eliminate any illicit discharges.

The New England Interstate Water Pollution Control Commission developed a publication entitled Illicit Discharge Detection and Elimination Manual, A Handbook for Municipalities available at: http://neiwpcc.org/neiwpcc_docs/iddmanual.pdf

Construction/Post Construction

MS4 operators are required to establish post construction stormwater runoff control programs for new land development and redevelopment at sites disturbing one or more acres. Land development and re-development projects must utilize best management practices within the water supply reservoir watersheds. Local ordinances meant to comply with the post construction minimum measures (General Permit Part IV.B.5.a.2.) must require that applicable development and re-development projects use LID techniques as the primary method of stormwater control to the maximum extent practicable and maintain groundwater recharge to pre-development levels.

As mentioned previously, examples of acceptable reduction measures include reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, using porous pavement, and installing infiltration catch basins where feasible. Other reduction measures to consider are the establishment of buffer zones, vegetated drainage ways, cluster zoning or low impact development, transfer of development rights, and overlay districts for sensitive areas. The revised RI Stormwater Design and Installation Standards Manual (RIDEM 2018b) contains detailed information on use of low impact development (LID) techniques. To ensure consistency with the goals and recommendations of the TMDL, the TMDL IP must also address any revisions to local ordinances that are needed to ensure that:

- New land development projects employ stormwater controls to prevent any net increase in total phosphorus loadings to applicable waterbodies.

- Redevelopment projects employ stormwater controls to reduce total phosphorus loadings to the water supply reservoirs (as detailed above) to the maximum extent feasible.

In addition, Portsmouth, Middletown, Tiverton, and Little Compton should also consider expanding ordinances to include projects that disturb less than one acre. At a minimum, the TMDL IP must assess the impacts of imposing these requirements on lower threshold developments. The TMDL IP should also assess and evaluate various enforceable mechanisms that ensure long-term maintenance of BMPs.

Good Housekeeping/Pollution Prevention

The RIDEM Storm Water General Permit (see Part IV.B.6.a.2 and Part IV.B.6.b.1) extends storm water volume reduction requirements to operator-owned facilities and infrastructure. In addition, any new municipal construction project or retrofit should incorporate BMPs that reduce storm water and promote infiltration.

The TMDL Implementation Plan should provide a list of municipally owned properties and any BMPs located within the applicable reservoir watersheds that may have been implemented to date, and/or where opportunities exist for future implementation. As part of their Good Housekeeping/Pollution Prevention requirements, MS4 operators must identify the potential sources of pollution, including specifically the TMDL pollutants of concern, which may reasonably be expected to affect the quality of stormwater discharges from their facilities; and describe and ensure implementation of practices, which the permittee will use to reduce pollutants in stormwater discharges from the facility.

The SWPPP must address all areas of the facility and describe existing and/or proposed BMPs that will be used and at minimum must include the following:

- Frequent sweeping of roads, parking lots and other impervious areas;
- Effective management (storage and disposal) of solid waste and trash;
- Regular inspection and cleaning of catch basins and other stormwater BMPs; and
- Other pollution prevention and stormwater BMPs as appropriate.

Structural BMP Requirements in Rhode Island

As described previously, this TMDL finds that the six minimum measures alone are insufficient. to restore water quality and that structural BMPs are needed. MS4 owners must identify priority outfalls as discussed above. An Implementation Plan must be completed that details the tasks necessary to design and construct BMPs that reduce the pollutants of concern and stormwater volumes to the maximum extent feasible. As noted previously, TMDL provisions apply to any MS4 operators contributing stormwater to identified outfalls regardless of outfall ownership. The BMP study should include all the components of Part IV.D.4 (RIDEM, 2003b) that were previously described in the TMDL IP section. It must evaluate the feasibility of distributing infiltration or equivalent BMPs throughout the drainage area of the priority outfalls as an alternative to end of pipe technologies since the amount of land available for BMP construction is limited.

Specific RIDOT and Municipal Storm Water Measures
To realize water quality improvements in the Newport Water reservoirs, both pollutant concentrations in storm water and the volume of storm water discharged to the reservoirs must be reduced. The impervious area within the watershed contributes substantial increases in the amount of runoff and pollutants entering the reservoirs during and immediately after rain events. As the amount of impervious area in a watershed increases, the peak runoff rates and runoff volumes generated by a storm increases because developed lands have lost much or all of their natural capacity to delay, store, and infiltrate water. As a result, pollutants from streets, lawns, wildlife, and domestic pets quickly wash off during storm events and discharge into the nearby waterbodies. In some cases increased runoff rates also result in the transport of eroded phosphorus-rich sediment and organic matter such as leaf litter.

Town of Middletown
The Town of Middletown is authorized to discharge stormwater under the RIPDES Phase II Stormwater General Permit (Permit RIR040024) to Bailey’s Brook and its tributaries (RI0007035R-01), a tributary to North Easton Pond (RI0007035R-05), the upper Maidford River (RI0007035R-02A), and Paradise Brook (RI0007035R-03). Upon notification by RIDEM of the US Environmental Protection Agency’s approval of this TMDL, Middletown will have 180 days to amend their SWMPP consistent with Part IV.D of the General Permit and these specific TMDL requirements.

There are eleven (11) identified outfalls which discharge to Bailey’s Brook ranging in size from 12-36”, two (2) identified outfalls that drain to a tributary to North Easton Pond ranging in size from 12-24”, twenty two (22) identified outfalls which discharge to the Maidford River ranging in size from 12-36”, as well eight (8) identified outfalls which discharge to Paradise Brook ranging in size from 12-30”. In addition to the modifications to the six minimum measures described above, the Town must also assess and prioritize drainage systems for the design and construction of BMPs that reduce both the pollutants of concern and stormwater volumes to the *maximum extent feasible*. Priority should be given to those outfalls greater than 24-inches in diameter and identified below in Table 6.1.

Table 6.1. Town of Middletown Priority Outfalls.

Outfall ID	Direct Discharge to	LAT	LONG	Pipe Diameter (inches)	Receiving Waterbody
MI-BB01	River	41.5391998	-71.2899017	24	Bailey's Brook
MI-WIL01	BMP	41.5299988	-71.2919998	18	
MI-BB02	River	41.5297012	-71.2917023	24	Bailey's Brook
MI-BB02A	River	41.5297012	-71.2917023	24	Bailey's Brook
MI-BB03	River	41.5241013	-71.2954025	12	Bailey's Brook
MI-BB04	River	41.5239983	-71.2955017	12	Bailey's Brook
MI-BB05	River	41.5203018	-71.2965012	12	Bailey's Brook
MI-BB07A	River	41.5178986	-71.2959976	36	Bailey's Brook
MI-BB07B	River	41.5180016	-71.2960968	24	Bailey's Brook
MI-GR01	BMP	41.5098991	-71.2893982	48	
MI-BBT401	Tributary 4	41.5098	-71.2901001		Bailey's Brook
MI-BB08	Swale	41.508158	-71.293493	24	Bailey's Brook
MI-BB08A	Swale	41.505915	-71.291544	24	Bailey's Brook
MI-NEPT01	Tributary	41.4964981	-71.2838974	12	N. Easton Pond
MI-NEPT02	Tributary	41.498666	-71.280115	24	N. Easton Pond
MI-MR01	Wetland	41.529636	-71.270802	12	Maidford River
MI-WS-01	Swale	41.5209999	-71.2630997	12	Maidford River
MI-WS-02	Swale	41.5210991	-71.2636032	12	Maidford River
MI-WS-03	Swale	41.5214996	-71.2652969	12	Maidford River
MI-MYSO1	Swale	41.5217018	-71.2667007	12	Maidford River
MI-WS-04	Swale	41.5222015	-71.2690964	15	Maidford River
MI-MR05	River	41.5157013	-71.2686996	18	Maidford River
MI-BS01	Swale	41.5140991	-71.2683029	12	Maidford River
MI-BS02	Swale	41.5130005	-71.2683029	36	Maidford River
MI-MR06	Swale	41.5113983	-71.2686005	24	Maidford River
MI-MR07	Swale	41.5110016	-71.2686996	15	Maidford River
MI-MR08	Swale	41.5098991	-71.2690964	12	Maidford River
MI-MR09	River	41.5097008	-71.2693024	18	Maidford River
MI-MR09A	River	41.5097008	-71.2693024	12	Maidford River
MI-MR10	River	41.5093994	-71.2695007	30	Maidford River
MI-MR11	River	41.5091019	-71.2692032	18	Maidford River
MI-PS01	Swale	41.5054016	-71.2685013	24	Maidford River
MI-MR13	River	41.5023994	-71.2680969	18	Maidford River
MI-MR14	River	41.5019989	-71.2680969	15	Maidford River
MI-MR15	River	41.5018997	-71.2680969	24	Maidford River
MI-MR16	River	41.5009003	-71.2677994	30	Maidford River
MI-MR17	River	41.5009995	-71.2678986	30	Maidford River
MI-PB02	River	41.5144997	-71.2574997	12	Paradise Brook
MI-PB03A	River	41.5144997	-71.2574997	18	Paradise Brook
MI-PB03B	River	41.5144997	-71.2574997	12	Paradise Brook
MI-PB04	River	41.5074005	-71.2545013	12	Paradise Brook
MI-PB04A	River	41.506494	-71.254306	30	Paradise Brook
MI-PB05	River	41.506624	-71.254445	24	Paradise Brook
MI-PB05A	River	41.506573	-71.254352	12	Paradise Brook
MI-PB05B	River	41.506511	-71.254308	12	Paradise Brook

A reasonable first step is for the Town of Middletown to coordinate with RIDOT to confirm outfall ownership and system interconnections. As discussed previously, the catchment area associated with the priority outfalls must be identified and delineated. The Town must also assess and prioritize the drainage systems identified above, as well identify any previously unidentified drainage systems wholly or partially owned by the town that drain to the Maidford River or Paradise Brook. The Town must design and construct BMPs, within priority catchments that reduce the pollutants of concern and stormwater volumes to the *maximum extent feasible.*

The Town of Middletown should begin this assessment process by reviewing available information for outfalls, as well as any other monitoring data collected by the city or others. Attention must be given to whether the data was collected under dry or wet weather conditions and thus whether priority ought to be given to illicit discharge detection and elimination, or construction of BMPs to reduce wet weather pollutant loads. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

RI Department of Transportation

RIDOT is authorized to discharge stormwater under the RIPDES Phase II Stormwater General Permit (RIPDES Permit RIR040036) to Bailey's Brook and its tributaries (RI0007035R-01), to an unnamed tributary to North Easton Pond (RI0007035R-05), to North Easton Pond (RI0007035L-03), to Lawton Valley Reservoir via Sisson Brook (RI0007035R-06), to Watson Reservoir (RI0007035L-07) via an unnamed tributary, to Quaker Creek (RI0010031R-04), to Borden Brook (RI0010031R-01), and to an unnamed tributary to Nonquit Pond (RI0010031R-20). Upon notification by RIDEM of the US Environmental Protection Agency's approval of this TMDL, RIDOT will have 180 days to amend their SWMPP consistent with Part IV.D of the General Permit.

RIDOT owns five (5) identified outfalls that discharge to Bailey's Brook and its tributaries, ranging in size from 18-36", seven outfalls that discharge to an unnamed tributary to North Easton Pond, ranging in size from 12-36", six (6) outfalls that discharge to North Easton Pond, ranging in size from 18-24", two 24" outfalls that discharge to Lawton Valley Reservoir via Sisson Pond Brook, one (1) outfall that discharges to Quaker Creek, two (2) outfalls that discharge to Borden Brook (RI0010031R-01), and two 24" outfalls that discharge to an unnamed tributary to Nonquit Pond. Priority should be given to those outfalls greater than 24-inches in diameter and identified below in Table 6.2.

Table 6.2. RIDOT Priority Outfalls.

Outfall ID	Direct Discharge to	LAT	LONG	Pipe Diameter (inches)	Receiving Waterbody
DOT-NARR159	BMP	41.537925	-71.291944	36	
DOT-NARR167	River	41.523203	-71.296013	36	Bailey's Brook
DOT-NARR425	River	41.517970	-71.296030	24	Bailey's Brook
DOT-NARR426	River	41.517933	-71.295972	36	Bailey's Brook
DOT-NARR181	Unnamed Tributary	41.516175	-71.283107	18	Bailey's Brook
DOT-NARR492	Unnamed Tributary	41.515424	-71.283491	18	Bailey's Brook
DOT-NARR182	Short Swale> Sewer	41.499965	-71.279266	36	Trib. to N.E. Pond
DOT-NARR182A	Stream	41.498614	-71.280186	36	Trib. to N.E. Pond
DOT-NARR184	Stream	41.498000	-71.280946	18	Trib. to N.E. Pond
DOT-NARR184A	Stream	41.497230	-71.282151	12	Trib. to N.E. Pond
DOT-NARR184B	Stream	41.497008	-71.282367	24	Trib. to N.E. Pond
DOT-NARR184C	Stream	41.496600	-71.282939	18	Trib. to N.E. Pond
DOT-NARR185	Stream	41.495729	-71.283947	18	Trib. to N.E. Pond
DOT-NARR185A	Pond	41.495115	-71.285059		North Easton Pond
DOT-NARR185B	Pond	41.496030	-71.286075		North Easton Pond
DOT-NARR168	Pond	41.496596	-71.286465	18	North Easton Pond
DOT-NARR169	Pond	41.500615	-71.288114	24	North Easton Pond
DOT-NARR170	Pond	41.502474	-71.288885	24	North Easton Pond
DOT-NARR170A	Pond	41.503339	-71.289103	24	North Easton Pond
DOT-NARR161	Sisson Pond Brook	41.559122	-71.280465	24	Lawton Valley Reservoir
DOT-NARR162	Sisson Pond Brook	41.559091	-71.280576		Lawton Valley Reservoir
DOT-SKNT1000	Wetland to Stream	41.533129	-71.197878	24	Watson Reservoir
DOT-SKNT1001	Wetland to Stream	41.533129	-71.197878	24	Watson Reservoir
DOT-NARR273	Quaker Creek	41.574396	-71.188144		Nonquit Pond
DOT-NARR249	Borden Brook	41.569240	-71.187230	24	Nonquit Pond
DOT-NARR249A	Borden Brook	41.569240	-71.187230		Nonquit Pond
DOT-NARR249B	Stream	41.562174	-71.187246	24	Nonquit Pond
DOT-NARR249C	Stream	41.562174	-71.187246	24	Nonquit Pond

In addition to the modifications to the six minimum measures described, RIDOT must also assess and prioritize drainage systems for the design and construction of BMPs that reduce both the pollutants of concern and stormwater volumes to the *maximum extent feasible*.

A reasonable first step is for RIDOT to coordinate with the Towns of Middletown, Portsmouth, Tiverton, and Little Compton to confirm outfall ownership and system interconnections. As discussed previously, the catchment area associated with the priority outfalls must be identified and delineated. RIDOT must also assess and prioritize the drainage systems listed above, as well identify any previously unidentified drainage systems wholly or partially owned by RIDOT that drain to the drinking water reservoirs. RIDOT must design and construct BMPs, within priority catchments that reduce the pollutants of concern and stormwater volumes to the *maximum extent feasible*. RIDOT should begin this assessment process by reviewing available information for outfalls, as well as any other monitoring data collected by the city or others. Attention must be given to whether the data was collected under dry or wet weather conditions and thus whether priority ought to be given to illicit discharge detection and elimination, or construction of BMPs to reduce wet weather pollutant loads. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

Town of Portsmouth

The Town of Portsmouth is authorized to discharge stormwater under the RIPDES Phase II Stormwater General Permit (Permit RIR040023) to an unnamed tributary (RI0007035R-07) to Lawton Valley Reservoir and an unnamed tributary to St. Marys Reservoir (RI0007035L-05). Upon notification by RIDEM of the US Environmental Protection Agency's approval of this TMDL, Portsmouth will have 180 days to amend their SWMPP consistent with Part IV.D of the General Permit and these specific TMDL requirements. There is one identified 24" outfall that discharges to an unnamed tributary that discharges to St. Marys Reservoir and one identified 24" outfall that discharges to an unnamed tributary discharging to Lawton Valley Reservoir (Table 6.3).

Table 6.3. Town of Portsmouth Priority Outfalls.

Outfall ID	Direct Discharge to	LAT	LONG	Pipe Diameter (inches)	Receiving Waterbody
PO-1000	Wetland	41.555124	-71.263752	24	St. Marys Reservoir
PO-1001	Wetland	41.570349	-71.265931	24	Lawton Valley Reservoir

In addition to the modifications to the six minimum measures described above in Section 6.2.1.4, the Town must also assess and prioritize drainage systems for the design and construction of BMPs that reduce both the pollutants of concern and stormwater volumes to the *maximum extent feasible*.

A reasonable first step is for the Town of Portsmouth to coordinate with RIDOT to confirm outfall ownership and system interconnections. As discussed previously, the catchment area associated with the priority outfalls must be identified and delineated. The Town must also assess and prioritize the drainage systems identified above, as well identify any previously unidentified drainage systems wholly or partially owned by the town that drain to the tributaries to the three Newport Water Reservoirs, located within the Town. The Town must design and construct BMPs, within priority catchments that reduce the pollutants of concern and stormwater volumes to the *maximum extent feasible.*

The Town of Portsmouth should begin this assessment process by reviewing available information for outfalls, as well as any other monitoring data collected by the city or others. Attention must be given to whether the data was collected under dry or wet weather conditions and thus whether priority ought to be given to illicit discharge detection and elimination, or construction of BMPs to reduce wet weather pollutant loads. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

Town of Tiverton

The watershed of Nonquit Pond is almost entirely located outside of the Phase II Stormwater Area of Tiverton, with a small portion in the Phase II area in the northern part of town near the intersection of Bulgarmarsh and Brayton roads. Stormwater has been determined to be a significant source of pollutants of concern to Nonquit Pond, however, it is unclear if the Town has any MS4 discharges directly to the Pond. Upon approval of this TMDL and once the DEM notifies the Town of the TMDL's requirements, the Town must identify any MS4 discharges to the Pond, including contributing drainage areas; provide a description of BMPs that have been or will be implemented to address the requirements of the TMDL and the provisions of its MS4 permit; and prepare a Scope of Work (SOW) describing the process and rationale that will be used to select BMPs and measurable goals to ensure that the TMDL provisions will be met. Priority should be given to those outfalls greater than 24-inches in diameter and identified below in Table 6.4. RIDEM has identified an outfall that discharges to headwaters of Borden Brook (RI0010031R-01), and one identified outfall that discharges to an unnamed tributary (RI0010031R-20) to Nonquit Pond.

As part of the outfall identification mentioned above, the Town of Tiverton shall coordinate with RIDOT to confirm outfall ownership and system interconnections. As discussed previously, the catchment area associated with the priority outfalls must be identified and delineated. The Town must also assess and prioritize the drainage systems identified above, as well as identifying any previously unidentified drainage systems wholly or partially owned by the town that drain to the tributaries to Nonquit Pond. The Town must design and construct BMPs, within priority catchments that reduce the pollutants of concern and stormwater volumes to the *maximum extent feasible.*

The Town of Tiverton should begin this assessment process by reviewing available information for outfalls, as well as any other monitoring data collected by the Town or others. Attention should be given to whether the data was collected under dry or wet weather conditions and thus whether priority ought to be given to illicit discharge detection and elimination, or construction of BMPs to reduce wet weather pollutant loads. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

Table 6.4. Town of Tiverton TMDL Priority Outfalls.

Outfall ID	Direct Discharge to	LAT	LONG	Pipe Diameter (inches)	Receiving Waterbody
TI-1000	Stream	41.563853	-71.190337	unknown	Nonquit Pond
TI-1001	unknown	41.623911	-71.172766	unknown	Nonquit Pond
TI-1001	Swale	41.623856	-71.169484	18	Nonquit Pond

RIDEM's 2018-2020 303(d) List includes the following waterbodies located within the Town of Tiverton: Borden Brook and tributaries, Quaker Creek, and 'tributary to Nonquit Pond'. The 2018-2020 303(d) List was approved by EPA on February 17th, 2021. Upon EPA approval of this TMDL and DEM providing notification to the Town of the TMDL's approval, The Town of

Tiverton will need to comply with Section II.C (Discharges to Water Quality Impaired Waters) of the RIPDES General Permit (RIR040000) covering stormwater discharge from small MS4's and Industrial Activity at eligible facilities operated by regulated small MS4s (http://www.dem.ri.gov/pubs/regs/regs/water/ms4final.pdf). Section II.C of the permit will require the town of Tiverton to:

1. To the extent the information is available at the time of application, the operator must determine whether any portion of the MS4 or any facility owned or operated by the MS4 operator, discharges storm water either directly or indirectly into a water body on the current 303(d) list.

2. The operator must determine whether storm water discharges from any part of the MS4 or a facility owned or operated by the MS4 operator discharges the pollutant(s) identified as causing the impairment or contributes the pollutant of concern, either directly or indirectly, to the impairment of a 303(d) listed water body and whether the TMDL has been completed.

3. If a TMDL has been approved for any water body into which storm water discharges from the MS4 or facility contribute directly or indirectly the pollutant(s) of concern, the operator's SWMPP must address the TMDL provisions or other provisions for storm water discharges from the MS4 or the facility, in accordance with Part IV.D of this permit.

4. If a TMDL has not been approved, the SWMPP must include a description of the BMPs that will be used to control the pollutant(s) of concern, to the maximum extent practicable. BMPs that will collectively control the discharge of the pollutants of concern from existing and new sources must be specifically identified.

5. In order to remain eligible for this permit, the operator must incorporate into the SWMPP any limitations, conditions and requirements applicable to discharges authorized by this permit, necessary to implement the recommendations in an approved TMDL. This may include monitoring and reporting. Dischargers not eligible for this permit, must apply for an individual or alternative RIPDES general permit.

6. Upon completion of outfall mapping required in Part IV.B.3 of this permit, the operator must reevaluate compliance with Parts 1-3 of this section and submit the information to the Department with the subsequent Annual Report and a request to modify the SWMPP as necessary.

7. Within ninety (90) days from the effective date of a revised/updated 303(d) list, the operator must determine whether any portion of the MS4 discharges storm water either directly or indirectly into a water body on the current 303(d) list and if so, comply with part 3 of this section, and submit the information to the Department with the subsequent Annual Report and a request to change the SWMPP as necessary.

Town of Little Compton

The Watson Reservoir watershed, located entirely within the Town of Little Compton, is not located in either the Urbanized Areas (UAs) or Densely Populated Areas (DPAs) that are regulated under RIDEM's Phase II program. However, stormwater may be a source of pollutants of concern to Watson Reservoir. Upon approval of this TMDL and once RIDEM notifies the Town of the TMDL's requirements, the Town must identify any MS4 discharges to the Reservoir and the contributing drainage area. In addition to Watson Reservoir itself being impaired for total phosphorus, four tributaries to Watson Reservoir are on RIDEM's 2018-2020 303(d) List as impaired for total phosphorus.

Based on the above information, RIDEM will determine if the Town needs MS4 permit coverage. Priority should be given to those outfalls greater than 24-inches in diameter and identified below in Table 6.4. RIDEM has identified several outfalls that discharge to ditches and swales that ultimately flow to Watson Reservoir.

Table 6.5. Town of Little Compton TMDL Priority Outfalls.

Outfall ID	Direct Discharge to	LAT	LONG	Pipe Diameter (inches)	Receiving Waterbody
LC-1000	Swale>Stream	41.532206	-71.167166	18	Watson Reservoir
LC-1001	Swale>Stream	41.532099	-71.167103	12	Watson Reservoir
LC-1002	Wetland>Stream	41.547770	-71.171633	12	Watson Reservoir
LC-1003	Wetland>Stream	41.549163	-71.172057	na	Watson Reservoir
LC-1004	Wetland>Stream	41.551572	-71.172785	18	Watson Reservoir

A reasonable first step is for the Town of Little Compton to coordinate with RIDOT to confirm outfall ownership and system interconnections. As discussed previously, the catchment area associated with the priority outfalls should be identified and delineated. The Town should also assess and prioritize the drainage systems identified above, as well identify any previously unidentified drainage systems wholly or partially owned by the town that drain to the tributaries to Watson Reservoir. The Town of Little Compton should begin this assessment process by reviewing available information for outfalls, as well as any other monitoring data collected by the Town or others. Attention should be given to whether the data was collected under dry or wet weather conditions

6.2.2 Agricultural Best Management Strategies

Well managed farms can operate with minimal adverse impacts on water resources. However, agricultural operations have the potential to adversely impact the state's water resources (surface water, groundwater and wetlands) and aquatic environment. The potential water quality contaminants associated with agricultural operations include nutrients (from fertilizers and animal wastes), pathogens and organic materials (primarily from animal wastes), sediment (from field erosion), pesticides, and petroleum products. In addition, the need for irrigation water can place high demands on local groundwater or surface water supplies which, in turn, can cause a low flow condition in streams potentially resulting in dramatic negative impacts on stream ecology.

Farmers should not create or maintain any discharge that adversely impacts surface waters, groundwaters or freshwater wetlands of the state without approval of the Department.

Agricultural best management practices will minimize adverse effects on the state's water resources and aquatic environment. Each farming operation is different due to the products produced, how the products are produced, the scale and the location. Therefore, the Department recognizes that water quality can be met by several different management practices.

Stormwater from barnyards, animal holding or feedlot areas, and manure storage areas should be managed to prevent direct discharge to surface waters or freshwater wetlands. Livestock should be prohibited from accessing freshwater wetlands, excluding farm ponds. Livestock should be prohibited from grazing within freshwater wetlands and within areas subject to frequent flooding. Manure piles should be covered to prevent exposure to precipitation and stormwater by either placing the manure within a structure or securely covering it with a durable, fabric cover. Stormwater from manure storage areas should be prevented from entering surface waters or freshwater wetlands without treatment. Manure piles should not be placed within the 100-year flood zone or within 200 feet of freshwater wetlands. Stormwater from farm roads, buildings, parking lots and other impervious surfaces should be managed to minimize the impact on surface water, groundwater and freshwater wetlands.

Cropland should be cultivated, and drainage patterns managed in a manner that retains soil in the field. Deposition of sediment into freshwater wetlands should be minimized and should in no case result in adverse impacts to aquatic habitat. Farmers should utilize the BMPs consistent with the RI Soil Erosion and Sediment Control Handbook and the US Department of Agriculture NRCS Conservation Practice Standards (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/) to the maximum extent practicable. Tilling of soil within freshwater wetlands should be avoided. A vegetated filter strip at the edge of field, and immediately upslope of any freshwater wetlands, should be maintained in permanent cover. The filter strip may be left to revegetate naturally or planted with trees, shrubs or grasses.

Application of sources of nutrients should be managed in a manner to prevent off-site transport of nitrogen and phosphorus by means of surface water runoff or groundwater infiltration to the maximum extent practicable. Ideally, a farm would comply with a Nutrient Management Plan that would require soil testing, analysis of all sources of nutrients, evaluation of types of fertilizers, expected crop uptake, etc. Application of sources of nutrients in watersheds of nutrient impaired waters and in areas where the concentration of nitrate in groundwater exceeds 5 ppm (i.e., should be limited to crop removal rates for the nutrient of concern. Manure, fertilizers or pesticides should not be applied on frozen ground, within freshwater wetlands, or on areas subject to frequent flooding. Manure, fertilizers or pesticides should not be applied when field conditions are conducive to flooding, runoff, ponding, or other off-site movement, or can be reasonably anticipated to result in flooding, runoff, ponding, or other off-site movement.

All fertilizers and pesticides should be stored within an enclosed, covered, weather resistant structure. Fertilizers and pesticides should not be mixed, loaded or stored within structures with floor drains. Fertilizer and pesticide mixing, loading and container washing in the field should be done as far as practicable from freshwater wetlands. A backflow preventer device should be utilized when filling tanks with liquid fertilizers and pesticide formulations and when applying fertilizers and pesticides through irrigation systems to prevent contamination of the water source. Farmers should maintain an emergency spill response kit onsite. Pesticide application should adhere to any labeling requirements and further restrictions placed into a permit issued by the RIDEM Division of Agriculture.

Agricultural composting activities should not take place within the 100-year flood zone. Stormwater from composting areas should be prevented from entering surface waters or freshwater wetlands without treatment. Compost piles should be covered to prevent exposure to precipitation and stormwater by either placing the manure within a structure or securely covering it with a durable, fabric cover. Agricultural composting activities should maintain a 200-foot separation from freshwater wetlands.

Crop irrigation should be applied in the most efficient manner practicable to minimize water use. Irrigation should occur at the appropriate times and rates to most efficiently meet crop needs and to minimize loss of nutrients and pesticides to waters of the state. Irrigation should not contribute to soil erosion and loss of sediment to freshwater wetlands. Farm ponds that intersect the seasonal high groundwater table should be lined.

Table 6.6 summarizes the agricultural-related sources of nutrients to the major tributaries to the Newport Water reservoir system, including the Maidford River, Paradise Brook, Quaker Brook, Borden Brook, and two other unnamed tributaries to Nonquit Pond. As documented in the table, agricultural runoff and erosion have been documented at many sites within the sampled watersheds. The impact of these observed pollution sources on water quality are confirmed by the results of sampling conducted up- and down- stream of these sites, presented previously in Tables 4.10-4.20. It should be noted that the information contained in Table 6.6 reflects improvements and proposed improvements as of 2019. Additional improvements may have been made in 2020.

As previously discussed, beginning in 2014, RIDEM OWR partnered with the Rhode Island Natural Resources Conservation Service (NRCS) to focus NWQI water quality investigations in several tributaries within the Newport reservoir watersheds. These included: 1) the Maidford River (tributary to Paradise Pond and Gardiner Pond), 2) Paradise Brook (tributary to Paradise Pond), and 3) Quaker and Borden Brook and two other unnamed tributaries (all tributaries to Nonquit Pond).

The streams were sampled for turbidity, total suspended solids, nutrients, and pathogens under both dry and wet weather conditions. Six surveys were conducted-three wet weather and three dry weather surveys. Sampling stations were located upstream and downstream of agricultural areas, to help identify agricultural sources of pollution. In addition, DEM staff field inspected the entire length of all of the tributaries, to visually identify potential sources of pollution. The main pollutant sources identified were excessive erosion from farm fields and livestock access to streams, adjacent wetland areas, or areas subject to flooding. Agricultural sources of pollution, field observations, and existing and proposed best management practices, for all reaches of the Maidford River, Paradise Brook, Quaker Creek, Borden Brook, and unnamed tributaries to Nonquit Pond, are shown in Table 6.6.

Table 6.6. Agricultural -Related Sources of Nutrients and Proposed and Existing BMP's.

	River Reach	Downstream Station *	Exceedances of Criteria/Guidance (Most Upstream Station) and Significant (>20%) Pollutant Increases (Downstream Stations)		Potential Agricultural Sources	Field Observations	Existing or Proposed BMPs	Comments
			Dry Weather	Wet Weather				
Quaker Creek	Q2 to Q3	**Station Q3 Downstream of Dairy Farm**	Enterococci	Dissolved Organic Carbon Turbidity Total Phosphorus Enterococci	Equestrian Center	Livestock have access to Stream	Owner has indicated he will establish 50-foot vegetated buffers along the resource areas on his property. As part of establishing the buffer he intends to remove a chicken coop which is located within the proposed buffer area. Horses are currently kept out of these areas. Intends on erecting fencing along buffer.	Owner working with NRCS
						Flooded Paddocks on both sides of stream		Owner working with NRCS
						Erosion from paddocks sand parking area/drive, and bus depot		Owner working with NRCS
					Equestrian Center	Uncovered Manure Pile		Need a site visit by RIECD and Division of Ag.
					Dairy Farm	Livestock have access to Stream	The livestock are watered via a well fed watering tough further upslope. Proposing a 50-75 ft. vegetated buffer along the stream including fencing. Working on grazing plan with NRCS.	Working with NRCS.
	Q3 to Q4	**Station Q4 East Road**	Organic Nitrogen	Total Phosphorus	Dairy Farm,	Cows have access to Western Farm Pond	The Pond on the property is no longer accessed by livestock. The field surrounding the pond is proposed to be fenced off from the cows. The livestock are watered via a well fed watering tough. Working on grazing plan with NRCS.	Working with NRCS.
Tributary to Borden Brook	Headwaters to Bt	**Bt Terminus of Tributary**	Total Nitrogen Organic Nitrogen	Total Nitrogen Organic Nitrogen	Cow Farm	Large Silage Pile adjacent to headwaters	Silage pile cannot be moved without ruining the silage through oxidation. Silage pile will be reduced by feeding cows onsite and looking for buyers in the local area. Intends to invest in bagging system for silage. NRCS to suggest covering existing silage pile.	Has met with Ken Ayars and is working with NRCS.
						Cow Access at Headwaters	NRCS to finish the fencing to restrain cow access by 10/18/18.	OK. Fencing will be completed by 10/18/18.
					Livestock Pen	Fenced pens at least 70 ft. from stream, however livestock have access to stream) as evidenced by manure on stream banks. Site inspection revealed the presence of goats, chickens, and a pig	All of these animals were fenced in their respective areas with no access to stream during subsequent field inspection.	Need a manure management plan.
	Headwaters to Bth	**Bth Headwaters of tributary** Wet-Weather Targeted Sample Taken Immediately Downstream of Silage Pile Adjacent to Stream		Turbidity Total Phosphorus Ammonia Organic Nitrogen Enterococci	Cow Farm	Dense Growth of Filamentous Algae with White Scum Downstream of Silage	Silage pile cannot be moved without ruining the silage through oxidation. Silage pile will be reduced by feeding cows onsite and looking for buyers in the local area. Intends to invest in bagging system for silage. NRCS to suggest covering existing silage pile.	Has met with Ken Ayars and is working with NRCS.

*Stream reaches are depicted in Figures 4.1 through 4.3.

Table 6.6. Agricultural-Related Sources of Nutrients and Proposed and Existing BMP's (cont.).

	River Reach	Downstream Station *	Exceedances of Criteria/Guidance (Most Upstream Station) and Significant (>20%) Pollutant Increases (Downstream Stations)		Potential Agricultural Sources	Field Observations	Existing or Proposed BMPs	Comments
			Dry Weather	Wet Weather				
Borden Brook	B1 TO B2	**B2 East Road**	No Significant Pollutant Increases	No Significant Pollutant Increases	Silage Pile	Silage Pile adjacent to East Road	The majority of this material has been removed. Bobby Carr advised us in the field the remainder of the material will be removed shortly.	Ok. No further action needed.
					Chicken Pen	Chicken Coop adjacent to East Road Ditch	This coop has been removed from the area of concern.	Ok. No further action needed.
					Dairy Farm	Livestock Access to Stream		Owner is going to meet with NRCS to discuss fencing the cows out of the stream.
	B2 to B3	**B3 Main Road**	Total Phosphorus Total Nitrogen Organic Nitrogen	Total Nitrogen Organic Nitrogen	Small Livestock Farm	Livestock access to stream		Have spoken with owner to set up meeting. Needs followup.
						Manure Pile 30 ft. from Stream		Have spoken with owner to set up meeting. Needs followup.
						Erosion		Have spoken with owner to set up meeting. Needs followup.
Unnamed Tributary to Nonquit Pond	Headwaters to N1	**N1 Northeastern Fork at Barnswallow Street**	Total Phosphorus Total Nitrogen Organic Nitrogen	Total Phosphorus Total Nitrogen Organic Nitrogen	Dairy Farm	Cows Have Access to Flooded Areas Adjacent to Stream and Stream Itself		OK. Fencing will be completed by 10/18/18.
	N1 to N2	**N2 Peaceful Way**	Nitrate	Turbidity Total Nitrogen Organic Nitrogen Enterococci	Crop Field	Western Fork: Bisects Crop Field with Inadequate Buffer (15 ft.)	The field has been seeded in hay. Provided the field is stable with grasses and not subject to plowing/disturbance and regular fertilizing the site is not expected to significantly contribute to after quality concerns. If the site is returned to regular field production I would recommend a vegetated buffer be established.	OK. No further action needed.
						Eastern Fork: Flows along Border of Hay Field and Crop Field	The field has been seeded in hay. Provided the field is stable with grasses and not subject to plowing/disturbance and regular fertilizing the site is not expected to significantly contribute to after quality concerns. If the site is returned to regular field production I would recommend a vegetated buffer be established.	OK. No further action needed.
						Erosion especially at northern end of cropfield	The field has been seeded in hay. Provided the field is stable with grasses and not subject to plowing/disturbance and regular fertilizing the site is not expected to significantly contribute to after quality concerns. If the site is returned to regular field production I would recommend a vegetated buffer be established.	OK. No further action needed.

*Stream reaches are depicted in Figures 4.1 through 4.3.

Table 6.6. Agricultural-Related Sources of Nutrients and Proposed and Existing BMP's (cont.).

	River Reach	Downstream Station *	Exceedances of Criteria/Guidance (Most Upstream Station) and Significant (>20%) Pollutant Increases (Downstream Stations)		Potential Agricultural Sources	Field Observations	Existing or Proposed BMPs	Comments
			Dry Weather	Wet Weather				
Maidford River	MDF-SW-1 to MDF-SW-2	**Wyatt Road**	No Significant Increases	Total Phosphorus Enterococci	Cattle Farm	Cattle have access to Stream	The fields recently acquired by Newport Vineyards are currently stable and vegetated with low grade hay. No animals are present on the property and all surface areas are vegetated with no erosion visible. The activities occurring at this location are unlikely to adversely impact water quality at this time.	ALT easement; sold to Newport Vineyard; this buffer piece is restricted from any ag use under ALT easement. Livestock are gone. OK. No further action needed.
					Nursery	Observed Erosion from Nursery into Storm Drain system; uncertain discharge point		Working with NRCS. CTA contract. To date, conversation has been focused on Wapping Rd operation.
	MDF-SW-2-MDF-3A	**Berkeley Av. Spur**	Organic Nitrogen Nitrate Total Nitrogen	Turbidity Total Suspended Solids Total Phosphorus Organic Nitrogen Nitrate Total Nitrogen Fecal Coliform	Nursery	Documented uncontrolled runoff and major erosion	Town retrofitted an existing stormwater basin on Town-owned easement and diverted flow into basin which previously bypassed basin.	Regarding need for additional BMPs, Working with NRCS EQIP program and AIPC funding to build out additional BMPs.
					Crop Field	Documented Turbid Runoff Manure Spreading?	Site was stable and heavily vegetated at the time of inspection. Erosion controls associated with future construction activities have been installed.	Site is slated to to be developed by Newport National Golf Club. OK. No further action needed.
					Nursery/Orchard/Crop Fields	Observed erosion into ditch that parallels slope at top of vineyard bordering farm. Erosion upslope of 90 degree bend in ditch where it turns directly downslope to the Maidford River.	The ownert has implemented many NRCS designed water quality measures in other areas of the farm, removed from this problem area. BMPs include berms, ditches, and vegetated strips. No manure has been spread onsite for a few years nor does the owner plan on spreading any in the future.	Need a site revisit by RIECD and the Division of Ag.
					Hay fields	Lack of vegetated buffer. Manure Spreading?		Site was not vistited. Need a site visit by RIECD and Division of Ag.
	MDF-SW-3A to MDF-SF-1	**Reservoir Ave**	No Significant Increases	Enterococci	Cattle Farm	Cattle have Access to Tributary to Stream	The area surrounding the stream, much of which is be biological wetland is currently heavily vegetated and stable. We were told the subject area is used for grazing by a couple of cows they have. As the area is biological wetland and a significant portion slopes toward the watercourse.	Recommend contacting NRCS to get their opinion on what would be the appropriate use of the area. If biological wetland exists on property, a buffer protecting this area seems appropriate.
					Hay fields	Lack of buffer.		RIECD has met with owners of the 2 hay fields. The chair of a condo association has stated that she will discuss possible stream/floodplain restoration. The owner of the other hay field stated that no chemicals are applied. No further action needed.

*Stream reaches are depicted in Figures 4.1 through 4.3.

Table 6.6. Agricultural-Related Sources of Nutrients and Proposed and Existing BMP's (cont.).

	River Reach	Downstream Station *	Exceedances of Criteria/Guidance (Most Upstream Station) and Significant (>20%) Pollutant Increases (Downstream Stations)		Potential Agricultural Sources	Field Observations	Existing or Proposed BMPs	Comments
			Dry Weather	Wet Weather				
Paradise Brook	PDS-SW-3A to PDS-SW-1	Mitchell's Ln	Total Phosphorus Organic Nitrogen	Turbidity Total Suspended Solids Total Phosphorus Fecal Coliform	Cattle Farm	Although cattle are fenced out of stream, cattle have access to wet area next to stream.	Landowner has worked to implement intentional rotational grazing plan. The cattle have been fenced out of the stream and they are rotated through the fields. Cattle will be kept out of seasonally-flooded field during wet season.	The division of Agriculture will defer to NRCS's judgment and has no concerns with this property at this time.
					Mixed Livestock Farm	Livestock Have Access to Stream and hydrologically connected farm pond. Stream has fencing on one side only with animal access to other side of stream via ungated bridge. Documented Turbid Runoff.	The pile of manure which was noted as a potential impact to water quality has been removed. Mr. Ventura stated he will truck material offsite and not stockpile any without first consulting the Eastern District or DEM.	RIECD and Division of Ag. will revisit regarding access to eastern side of stream via ungated bridge and access to hyrologically connected farm pond.
					Hay Field	Inadequte buffer		RIECD and Division of Ag. will contact owner
	PDS-SW-1 to PDS-SW-2	Green End Av.	Nitrate Total Nitrogen	No Significant Increases	Nursery	Documented Turbid Runoff (via Culvert)		NRCS developing plan.
					Nursery/Orchard/Crop Fields	Documented Turbid Runoff from drive (southern access road to farm building) and lower crop field.		RIECD and Division of Ag. will revisit
	PDS-OCI5 to PDS-OCI-6A	Downstream of Newport Equestrian	No Significant Increases	No Significant Increases	Equestrian Center	Horses in Frequently Flooded Paddock Adjacent to Stream.	TBD.	Working with Division of Agriculture
						Horses with Direct Access to Stream from lower paddock east of stream.	Horses fenced out of wetland.	OK. No further action needed.
Sisson Pond Watershed					Cattle Farm	No buffer along tributary.		Site visit required
						Fencing appox. 35 ft. from and parallel to stream, but no fencing parallel to cartpath crossing stream. Cows have direct access to stream via cartpath as evidenced in 2018 aerial photos.		Site visit required

*Stream reaches are depicted in Figures 4.1 through 4.3.

6.2.3 Goose Abatement Strategies

In urban and suburban areas throughout Rhode Island, expanses of short grass, abundant lakes and ponds, lack of natural predators, limited hunting, and supplemental feeding have created an explosion in resident Canada Goose numbers in some areas. While most people find a few geese acceptable, problems develop as local flocks grow and the droppings become excessive.

RIDEM's Division of Fish & Wildlife conducts an annual goose survey of many of the State's waterbodies, during early January, via helicopter. Surveys were conducted on the water supply reservoirs, between 2009 and 2017, although none of the reservoirs were surveyed each consecutive year. Nonquit Pond and Watson Reservoir both had mean Canada Goose populations of over 400 birds (Table 6.7). As previously discussed, vast quantities of goose droppings were observed by RIDEM Fish and Wildlife staff along the majority of reservoir shorelines, especially along the well-manicured earthen berms, that surround much of the reservoirs. Geese produce approximately 3 lbs. of fecal matter daily (https://www.des.nh.gov/organization/commissioner/pip/factsheets/bb/documents/bb-53.pdf) Geese produce about 0.40-0.79 lbs. of phosphorus per year (Manny et al., 1994 and Ayers et al., 2010). The annual phosphorus load, contributed by geese, may comprise a significant percentage of the total watershed load, in many of the reservoirs, particularly in Lawton Valley Reservoir, St. Marys Pond, and Watson Reservoir (Table 6.7). It is important to note that these estimates are likely highly variable. They are meant to highlight the issue of waterfowl as a source of nutrients to the water supply reservoirs and were not quantitatively incorporated into the TMDL.

Table 6.7. Estimates of percentage of total phosphorus load contributed by Canada Geese.

Waterbody	Estimated mean annual goose population	Estimated TP load (lbs/yr)[1]	% of WT- Predicted Total TP Load contributed by Canada Geese[2]
St. Marys Pond	205	81-162	13-23
Lawton Valley Reservoir	159	63-125	7-13
Sisson Pond	62	24-49	8-14
North and South Easton Ponds	303	119-239	3-6
Gardiner Pond	95	38-75	2-4
Paradise Pond	6	2-5	0.1-0.2
Nonquit Pond	488	193-386	9-16
Watson Reservoir	412	163-325	10-19

[1]Based on range estimates from Manny et al. 1994 and Ayers et al. 2010.

[2]Estimates of P load from geese were added to WTM loads prior to calculating percentages.

There is a lack of a vegetative buffer at most, if not all reservoirs of the Newport water system. The lack of vegetated buffer is most prevalent along the earthen berms around the impounded reservoirs. Geese often utilize the well-manicured berms, as evidenced by vast quantities of goose droppings. The lack of vegetated buffer significantly adds to the attractiveness of the sites during the spring and summer period. During this period, geese are molting and cannot fly, and thus must walk from water to land to forage. Geese do not like going through areas of dense vegetation to get to a manicured area of grass to feed.

The earthen berms are mowed periodically for dam safety, to keep woody vegetation from growing and having the roots penetrate the dam, and to facilitate the inspection of the dam's integrity. However, if vegetated buffers are created, by allowing grass on the side slopes of the earthen berms to grow to a mature height, it will decrease the attractiveness of these sites and the birds will eventually move elsewhere. Reflective streamers or other shiny moving objects can also serve as a deterrent. Predator decoys are another option, but there is some anecdotal information regarding habituation to predator decoys that do not move or change position. An annual mowing in the fall, long after resident birds have molted and are again flying, should not be an issue. Of course, any mowing regimen must be consistent with dam safety, maintenance, and inspection.

During the fall and winter, goose populations in Rhode Island increase due to the influx of migratory birds coming from points north. These migrant birds use the freshwater ponds, lakes and reservoirs until they freeze, and then move further south, or to the coast. A few of the reservoirs of the Newport Water system (Lawton Valley Reservoir, and St. Marys and North Easton Ponds) have had bubblers installed in them to improve water quality. However, the bubblers also keep the water from freezing, during the winter months. This creates open water habitat and invites the geese to stay on the freshwater throughout the winter when they would normally be forced to move on elsewhere. Bubblers are generally most effective in improving water quality during the summer and early fall, when they de-stratify and oxygenate the water column, and help mitigate algal blooms. During the winter months, ponds are generally not stratified, are well oxygenated, and do not experience algal blooms. Therefore, Newport Water should consider turning off the bubblers during the winter months especially if there is no documented benefit of the bubblers to water quality during winter months.

As previously discussed, reservoir levels fluctuate fairly rapidly, particularly in the summer and fall months when demand is higher and inter-reservoir water transfers are more common. The drawdown of water from reservoirs, during the peak demand season, creates extensive mud flats along the edges of many of the reservoirs. RIDEM staff regularly observed goose fecal material on mud flats that was completely submerged on the next visit. Because of the fluctuating water regime, the establishment of vegetative buffer in these areas is not possible. Other methods, detailed below, should be used to control geese in these areas.

During the molt, geese congregate at ponds and lakes. However, when not molting, geese are more likely to be found away from water. Any area lacking a vegetative cover and/or providing a food source may provide habitat for non-migratory Canada Geese. These include athletic fields, residential and commercial areas with extensive lawns, golf courses, and agricultural fields.

Once geese settle in a location, they will be more tolerant of disturbances and more difficult to disperse. No single technique of goose control is universally effective and feasible in a suburban or urban setting. Persistent application of a combination of methods is usually necessary and yields the best results. Some methods for controlling goose populations include the following: discontinuing feeding, modifying habitat, installing fencing, using visual scaring devices, applying repellents, and controlling goose nesting and capturing and removing geese (RIDEM Division of Fish & Wildlife and U.S. Department of Agriculture, written communication), some of these methods may require permitting from the appropriate authority. Although the preceding methods pertain to the control of goose populations, many of the methods may also work for other waterfowl and gulls.

Although many people enjoy feeding waterfowl, feeding waterfowl is illegal in the State of Rhode Island and may cause large numbers of geese to congregate in unnatural concentrations. Well-fed domestic waterfowl, often act as decoys, attracting wild birds to the site. Geese that depend on supplemental feeding are also less likely to migrate when winter arrives. Feeding usually occurs in the most accessible areas such as lawns, streets, walkways, and parking areas. Some success in reducing goose feeding may be achieved through simple public education such as "Do not feed the geese" signs (the Division of Fish & Wildlife will provide examples on request). Further reduction of feeding may require the adoption and enforcement of local ordinances such as fines or community service (cleaning up droppings for example) for violations.

Geese are grazing birds that prefer short, green grass or other herbaceous vegetation for feeding. Well-manicured lawns adjacent to the shoreline provide excellent habitat for these grazing birds. Wherever possible, grass should be allowed to grow to its full height (10-14 in.) around waterbodies. Also, the use of lawn fertilizers should be minimized to reduce the nutritional value of grass to the birds. Lawn areas immediately adjacent to the shoreline of ponds may be allowed to revegetate naturally to discourage the congregation of waterfowl. In addition to discontinuing mowing next to ponds, the installation of a buffer of native vegetation is recommended to further discourage waterfowl and to limit the establishment of invasive plant species.

Fencing or other physical barriers installed along the shoreline can be effective where geese tend to land on water and walk up to adjacent lawns to feed. Fencing works best when geese are in their summer molt and unable to fly. Fences must completely enclose a site to be effective. Fencing around large open areas, such as athletic fields, have little effect for free flying birds. Goose fences should be at least 30 inches tall. Wire garden fencing will last for years. Less expensive plastic or nylon fencing could be used but will have to be replaced more often. Snow fencing or erosion fabric may be used as a temporary barrier to molting geese. The installation of any fencing adjacent to a pond would require a permit from the Wetlands Permitting office of RIDEM.

Various materials may be used to create a visual image that geese will avoid, especially if they are not already established on a site. Geese are normally reluctant to linger beneath an object hovering overhead. However, visual scaring device are not likely to be effective on suburban lawns where trees or other overhead objects exist and where geese have been feeding for years. One very effective visual deterrent for geese is Mylar tape that reflects sunlight to produce a flashing effect. Also, when wind catches the tape, it pulsates to produce a humming sound that also repels birds. Some slack should be left in the tape and it should be twisted as it is strung from stake to stake. Another visual scaring technique is the placement of flagging or balloons on poles. Helium-filled bird-scaring balloons with eye spots are sold at some garden supply and party stores. Owl decoys may also be effective. If geese become acclimated to any of these devices, frequent relocation may be necessary. The use of remote-control boats can also be used to repel geese and may be practical if local hobbyists are willing to participate.

The U.S. Environmental Protection Agency has approved the product, ReJeXiT ®, as a goose repellent for lawns. The active ingredient in ReJeXiT ® is methyl anthranilate (MA), which is a human-safe food flavoring derived from grapes. Geese will avoid feeding on treated lawns because they dislike the taste. However, geese may still walk across treated areas. The material is available at some garden supply shops and costs about $125 per acre per application. Several applications per year are usually necessary.

Dogs trained to chase but not harm geese have been used effectively to disperse geese from parks, golf courses, and athletic fields. Border Collies or other breeds with herding instincts work best. The dogs must be closely supervised during this activity. Initially, chasing must be done several times a day for several weeks, after which less frequent but regular patrols will be needed. Dogs generally should not be used when geese are nesting or unable to fly, such as during the summer molt or when goslings are present. This activity should be conducted in accordance with all applicable laws regulating the harassment of birds.

The control of goose nesting and the capture and removal of geese are two other methods that could be used to reduce excessive goose populations on lakes and ponds. Both activities require federal permits. The Division of Fish & Wildlife of RIDEM should be contacted if this method is being considered.

Without efforts to reduce nuisance waterfowl populations, these non-lethal methods of control may just shift the populations and their associated negative water quality impacts to other waterbodies. In areas where waterfowl populations are particularly problematic, the involvement of cities and towns working with property owners, and the Division of Fish & Wildlife and USDA Wildlife Services is necessary to develop a more comprehensive and publicly acceptable strategy. Methods to be considered may include where applicable, the extension of the hunting season and/or increased limits for specific waterbodies where waterfowl have been identified as a significant source of pollution in a TMDL.

Some methods of geese control are not recommended because they are ineffective, labor-intensive, or illegal. These include: the use of swans, bird distress calls, scarecrows, dead goose decoys, use of trained birds of prey, sterilization, fountains or aerators, introduction of predators, introduction of disease, and the use of poisons.

6.2.4 Protection and Reintroduction/Expansion of Riparian Buffers

Protection/Regulation

The 1971 Rhode Island Freshwater Wetlands Act authorized the Department of Environmental Management to preserve and regulate the freshwater wetlands of the state for the public benefits that they provide. "Freshwater wetlands in the vicinity of the coast" are regulated by the Coastal Resources Management Council (CRMC). RIDEM's Freshwater Wetland Permitting Program implements avoidance and minimization requirements thereby keeping direct wetland losses to a minimum. The existing rules and regulations governing the administration and enforcement of the Fresh Water Wetlands Act are available at:
https://rules.sos.ri.gov/regulations/part/250-150-15-1

Current regulations (RIDEM 2018) designate the regulated area as:

1) 200 feet around rivers 10 feet or greater in width (referred to as large rivers) and 100 feet around narrower rivers and streams and

2) 50 feet around lakes and ponds greater than ¼ acre.

The functions and values of wetland buffers are numerous and include water quality protection (erosion control and sediment, nutrient, biological and toxics removal), hydrologic event modification, groundwater interaction, aquatic and wildlife habitat protection. Rhode Island's current regulations were amended to strengthen the protection of freshwater wetland resources while streamlining the regulatory framework applicable to proposed projects and activities taking place near wetlands. The amended regulations acknowledge the important functions and values of freshwater wetlands and their buffers, the need to strengthen wetland protection and the need to protect and regulate the area adjacent to wetlands.

RIDEM is currently reviewing feedback on Preliminary Draft Revisions to the Freshwater Wetlands Rules are available at: http://www.dem.ri.gov/programs/water/permits/pn-wetland.php

Water quality benefits associated with reintroduction and expansion of riparian buffers
A vegetated buffer is a protective area between water bodies and human activity, such as development or agriculture. Vegetated buffers protect water resources from nonpoint source pollution. Vegetation layers create a barrier to surface water movement by absorbing the impact of rainfall. The forest floor acts as a sponge, and trunks and stems slow runoff velocity. Vegetated buffers capture and remove sediment and nutrients in runoff over ground, thereby lowering the loads that get to surface waters. For maximum effectiveness, buffers must extend along all streams, including intermittent and ephemeral segments. Buffer zones increase infiltration and capture nutrients underground as water travels through the soil, by way of soil adsorption, plant root uptake and use by microorganisms.

Maintaining buffers around stream headwaters will likely be most effective at maintaining overall watershed water quality while restoring degraded riparian zones, and stream channels may improve nutrient removal capacity (Mayer et al., 2005). Buffer zones also protect aquatic species by shading and cooling waters, provide habitat and travel corridors for wildlife, maintain recreational values and aesthetic diversity, and can provide flood storage and can slow the velocity of flood waters, thereby protecting structures and property from damage.

In general, the wider the buffer and the more complex the vegetation within it, the more effective it is in removing sediment and nutrients. Slope, soil type, vegetative density, surface roughness, litter characteristics, and grass height also affect the effectiveness of buffers for this purpose. Healthy native forest riparian vegetation usually consists of a canopy of large trees accompanied by a thick undergrowth of shrubs and grasses.
A study (Beeson and Doyle 1995) of 748 stream bends found that 67% of bends without vegetation suffered erosion during a storm, while only 14% of bends with vegetation were eroded. Nonvegetated bends were more than 30 times as likely to suffer exceptionally severe

erosion as fully vegetated bends. Areas where streambank erosion has been documented should be planted in native vegetation to stabilize the streambanks and prevent further erosion.

Most studies found that larger particle sizes in sediment are deposited in the first 10 to 30 feet of the buffer while smaller sized particles may be transported and deposited or infiltrated farther overland into the buffer (Chaubey et al. 1994, 1995; Robinson et al. 1996; Barfield et al. 1998; Mendez et al. 1999). To prevent most erosion, vegetated buffers of 30 feet to 100 feet have been shown to be effective (Hawkes and Smith, 2005; Wenger, 1999). However, areas with steeper slopes and areas where land uses yield excessive erosion may require wider buffers. Sediment can build up at the field-buffer interface and create a dam or berm. Overland flow is then diverted around the berm, creating channelized flow through the buffer (Wenger 1999).

In many cases phosphorus is attached to sediment or organic matter, so buffers sufficiently wide to control sediment should also provide adequate short-term phosphorus control. However, because phosphorus is stored in buffers and is not transformed, it is susceptible to being remobilized, therefore, where high flows may overwhelm filters, (Daniels and Gilliam 1996). Adsorption sites on soil particles may become saturated causing an excess concentration of dissolved phosphorus in runoff. Dissolved phosphorus is initiated by desorption from soil or plant particles. In addition, under reducing conditions, including anoxic and acidic settings, phosphorus can become dissolved and can be transported in groundwater. Up to 45% of the phosphorus component entering riparian areas in runoff is in dissolved form (Uusi-Kamppa et al. 1997; Fleming and Cox 2001).

Buffers are short-term sinks for phosphorus, but over the long term their effectiveness may be limited. Long-term management of phosphorus requires effective on-site management of its sources. This can be accomplished through effective erosion control methods; judicious application of fertilizers; and restrictions on the land application of waste from animal feeding operations. If phosphorus is managed responsibly on-site, buffers can store significant amounts of the excess; but if phosphorus is uncontrolled, buffers can quickly become saturated and overwhelmed (Wenger, 1999, Daniel and Moore 1997).

Many of the tributaries to the nine reservoirs of the Newport Water system have inadequate vegetative buffers, as described in Section 4.4. These tributaries include Bailey’s Brook, the Maidford River, Paradise Brook, Quaker Creek, and Borden Brook, as well as numerous lesser tributaries. More quantitative estimates of existing riparian buffer widths, for all tributaries to the Newport reservoirs as well as the reservoirs themselves were made by RIDEM staff using the departments environmental resource mapping tools. These riparian buffer-width estimates are graphically shown in Figures 6.1 through 6.8 of the TMDL.

RIDEM recommends that Figures 6.1 through 6.8 should be utilized to plan and prioritize where buffer re-establishment or buffer augmentation should occur through voluntary or conservation efforts. As previously discussed, a 100-foot buffer is sufficient in most cases to control both sediment and phosphorus, although long term management of phosphorus may require effective on-site management of its sources.

Cleared areas on Aquidneck island often revert to dense monostands of multiflora rose (an invasive species). Shading from rose thickets typically prevents the growth of herbaceous plants in the understory. The bare soil underneath the stands of multiflora rose is susceptible to soil erosion, especially in the winter months, after leaf fall. Where an opportunity presents itself, an effort should be made to eradicate monostands of multiflora rose and replant with native trees, shrubs and grasses.

Figure 6.1 Bailey's Brook-Estimated Vegetated Buffer Zone Widths.

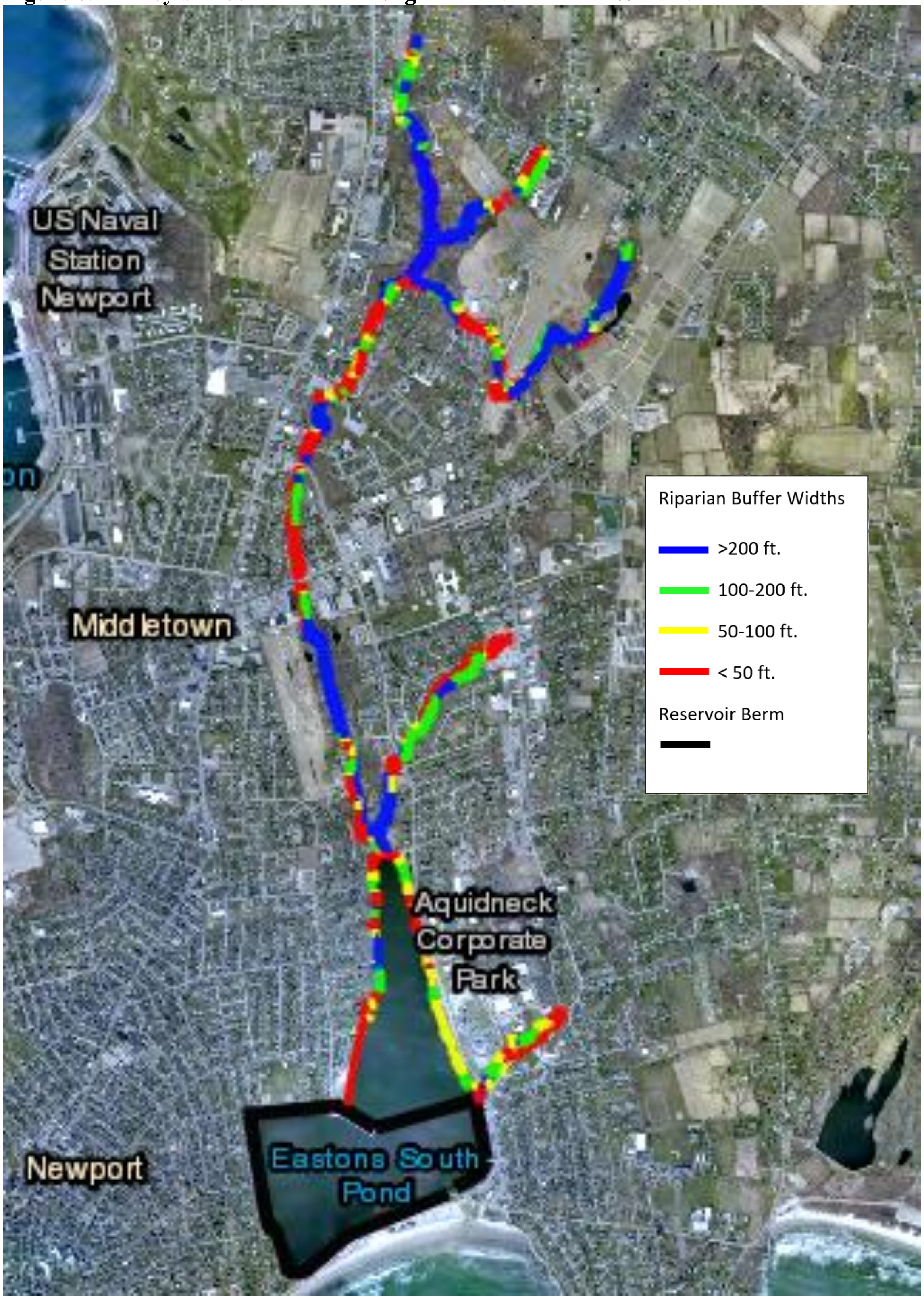


Figure 6.2. Northern Bailey's Brook Estimated Vegetated Buffer Zone Widths.

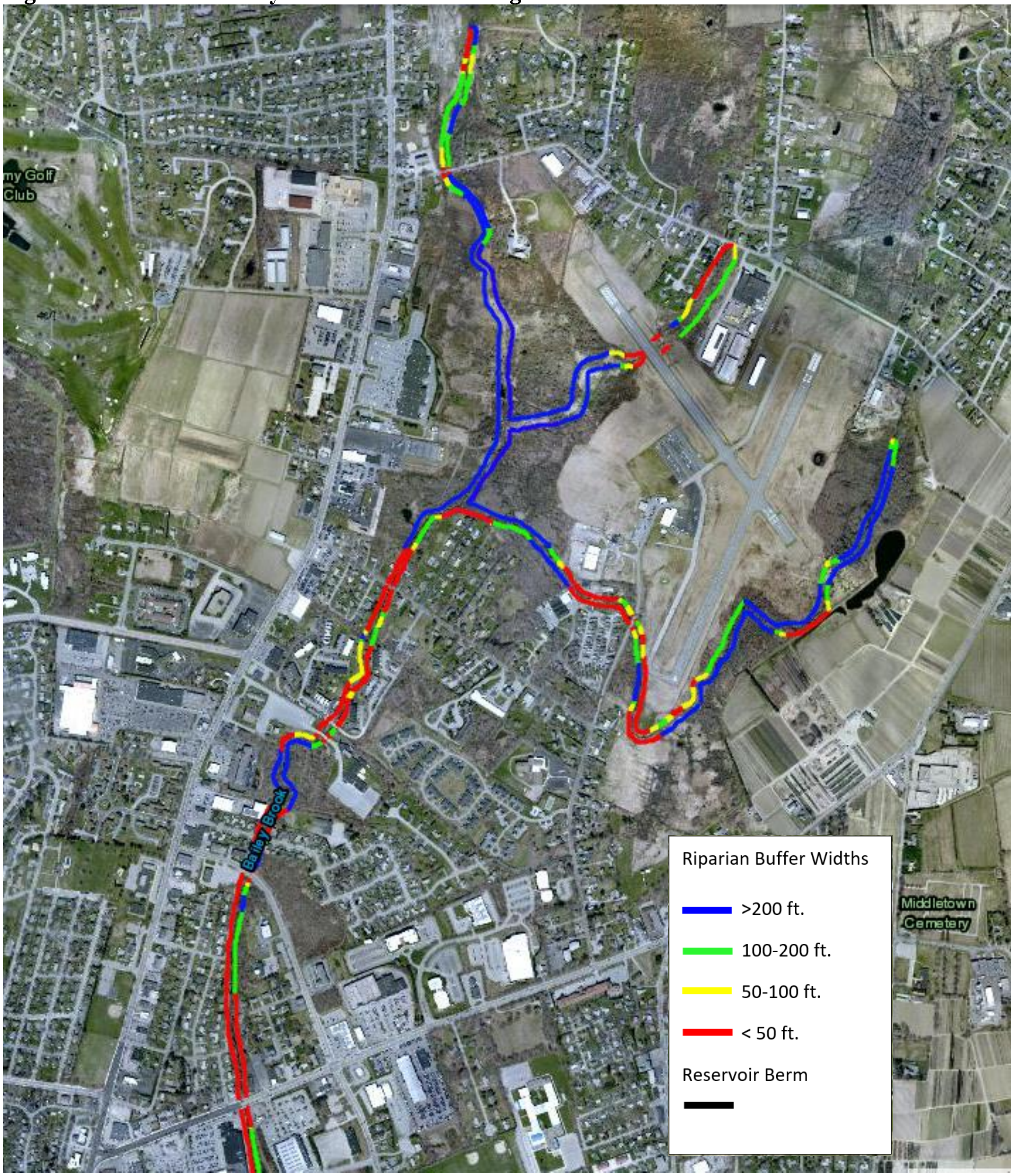


Figure 6.3. Southern Bailey's Brook Estimated Vegetated Buffer Zone Widths.

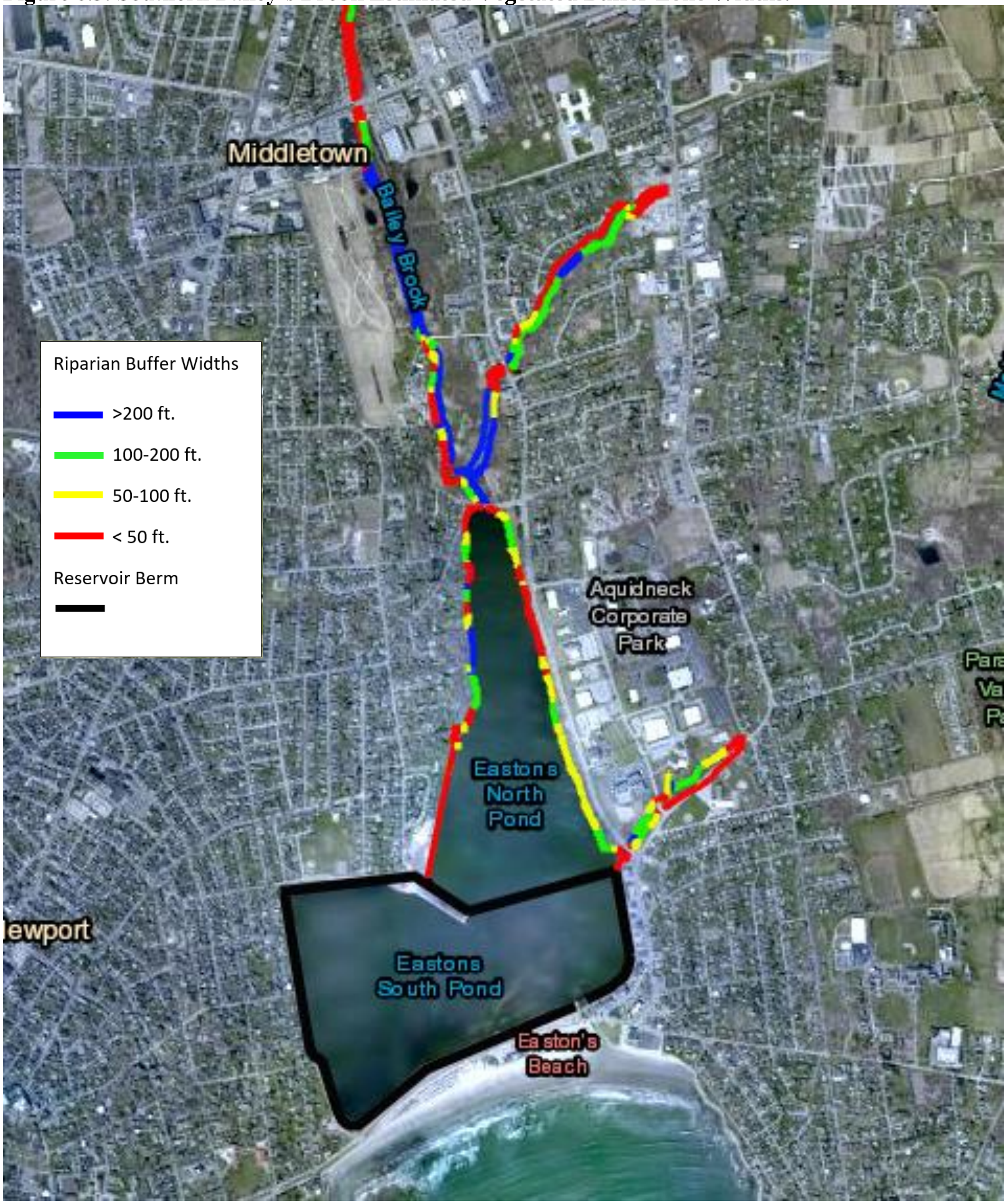


Figure 6.4. Maidford River and Paradise Brook Estimated Vegetated Buffer Zone Widths.

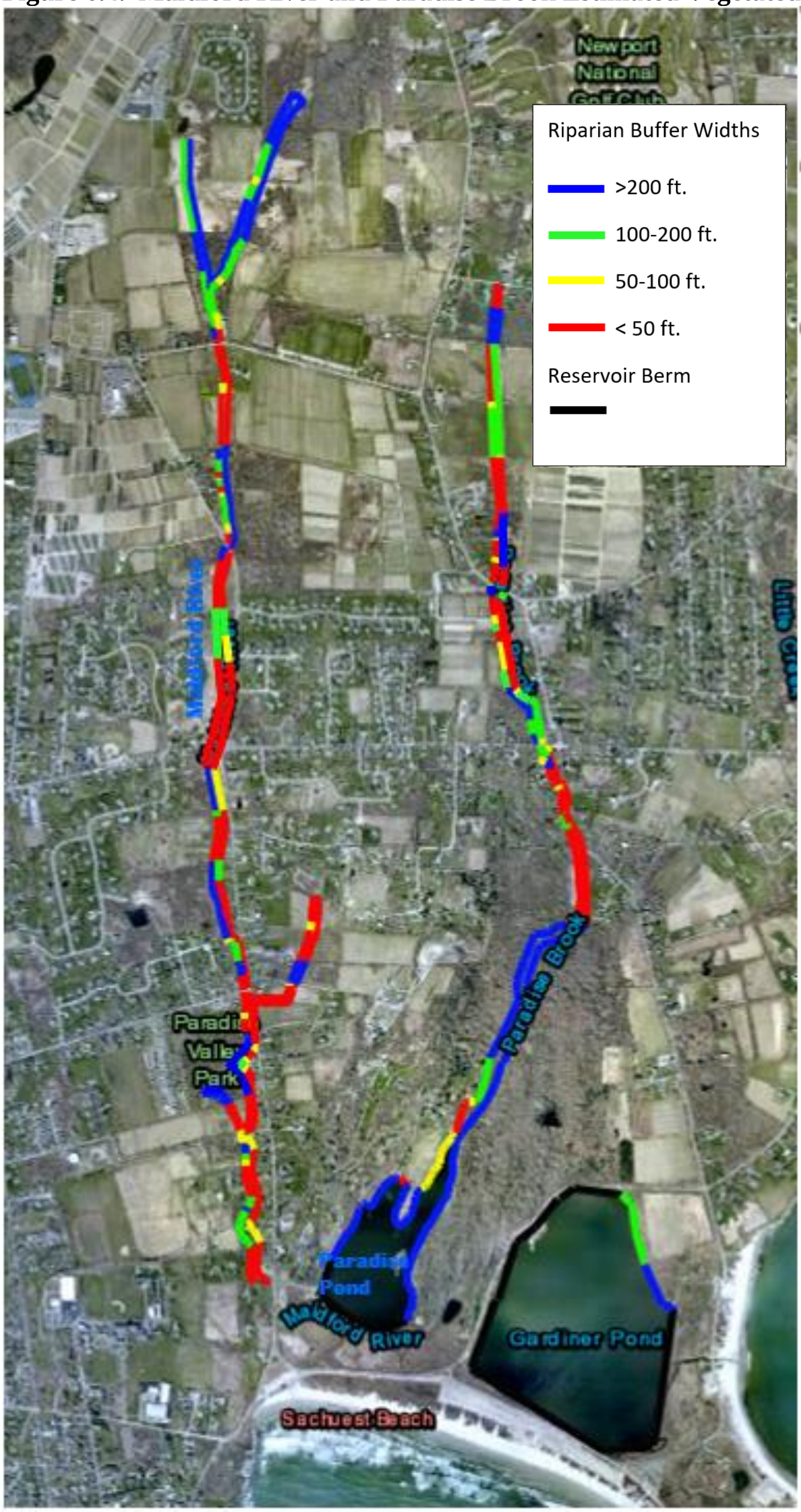


Figure 6.5. Northern Aquidneck Island Reservoirs Estimated Vegetated Buffer Zone Widths.

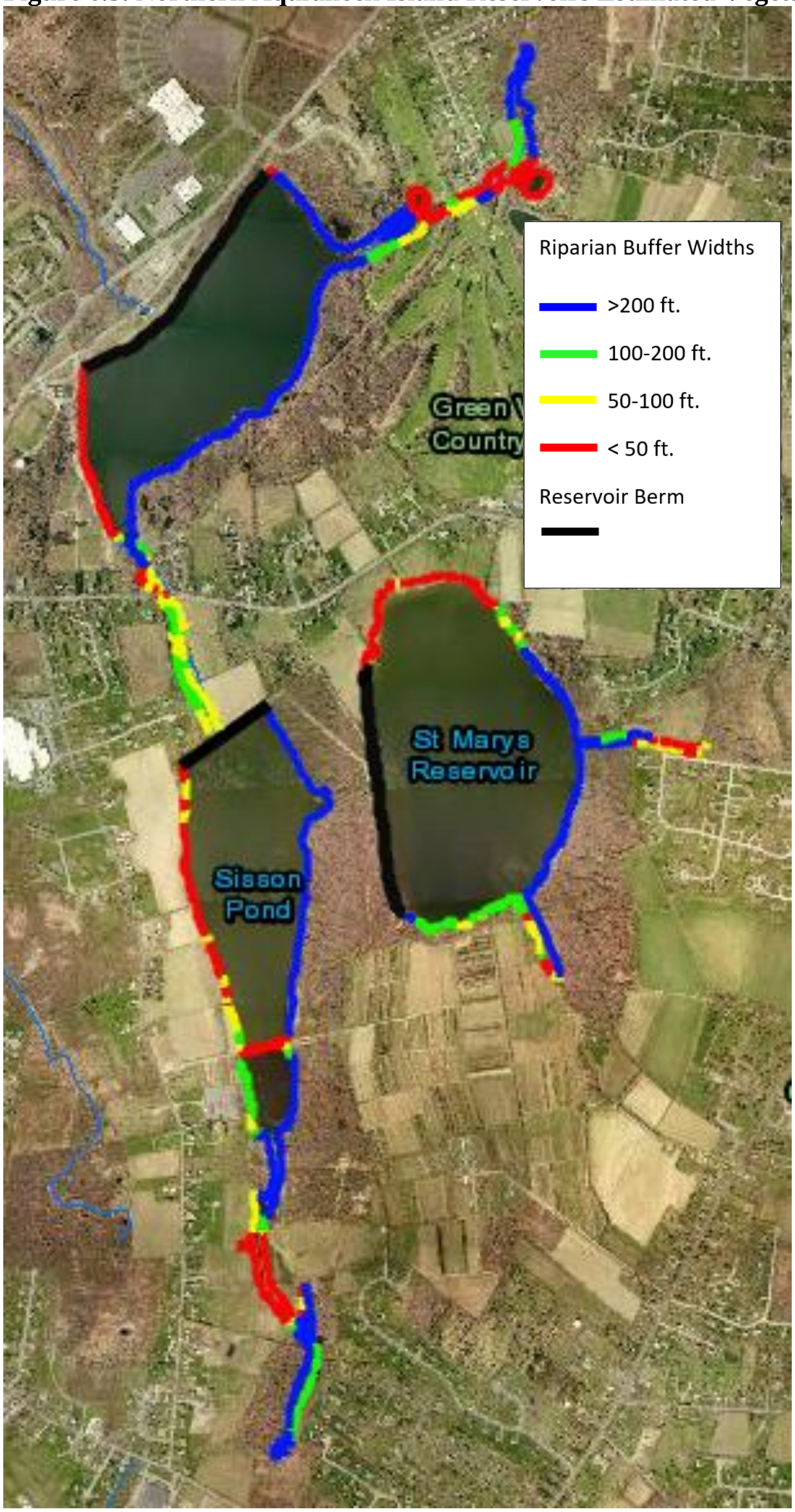


Figure 6.6. Nonquit Pond Tributaries Estimated Vegetated Buffer Zone Widths.

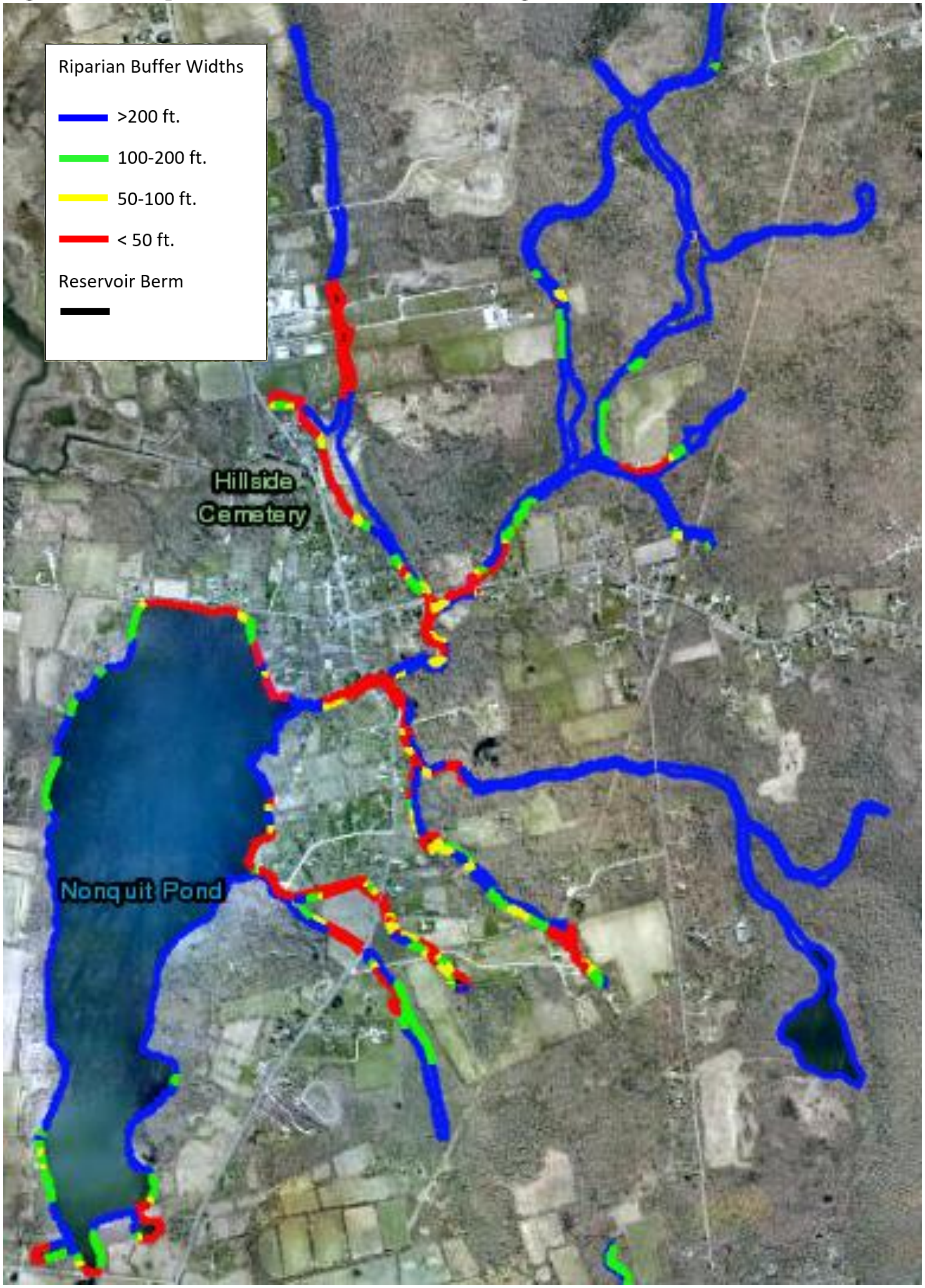


Figure 6.7. Upper Borden Brook Estimated Vegetated Buffer Zone Widths.

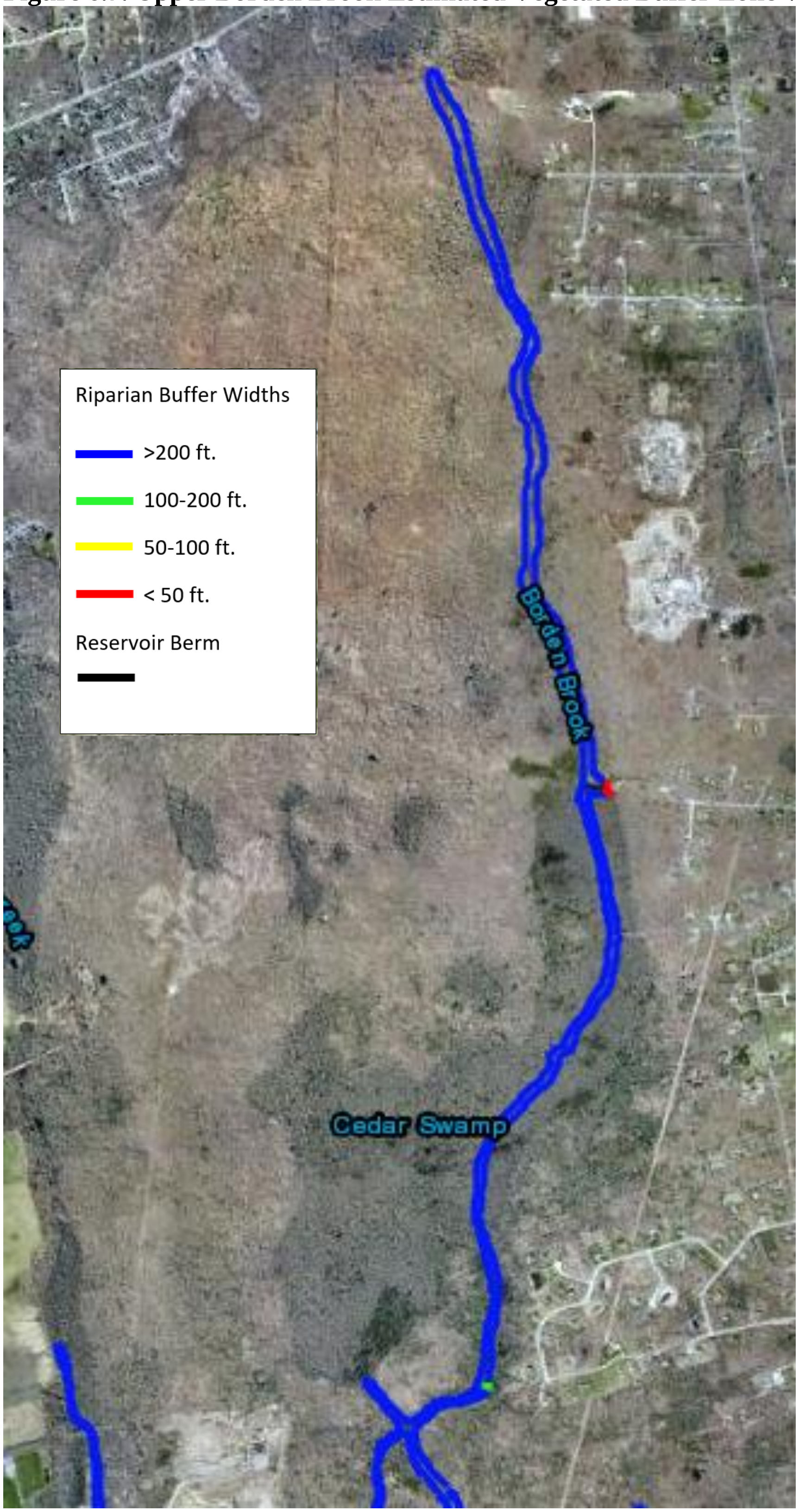
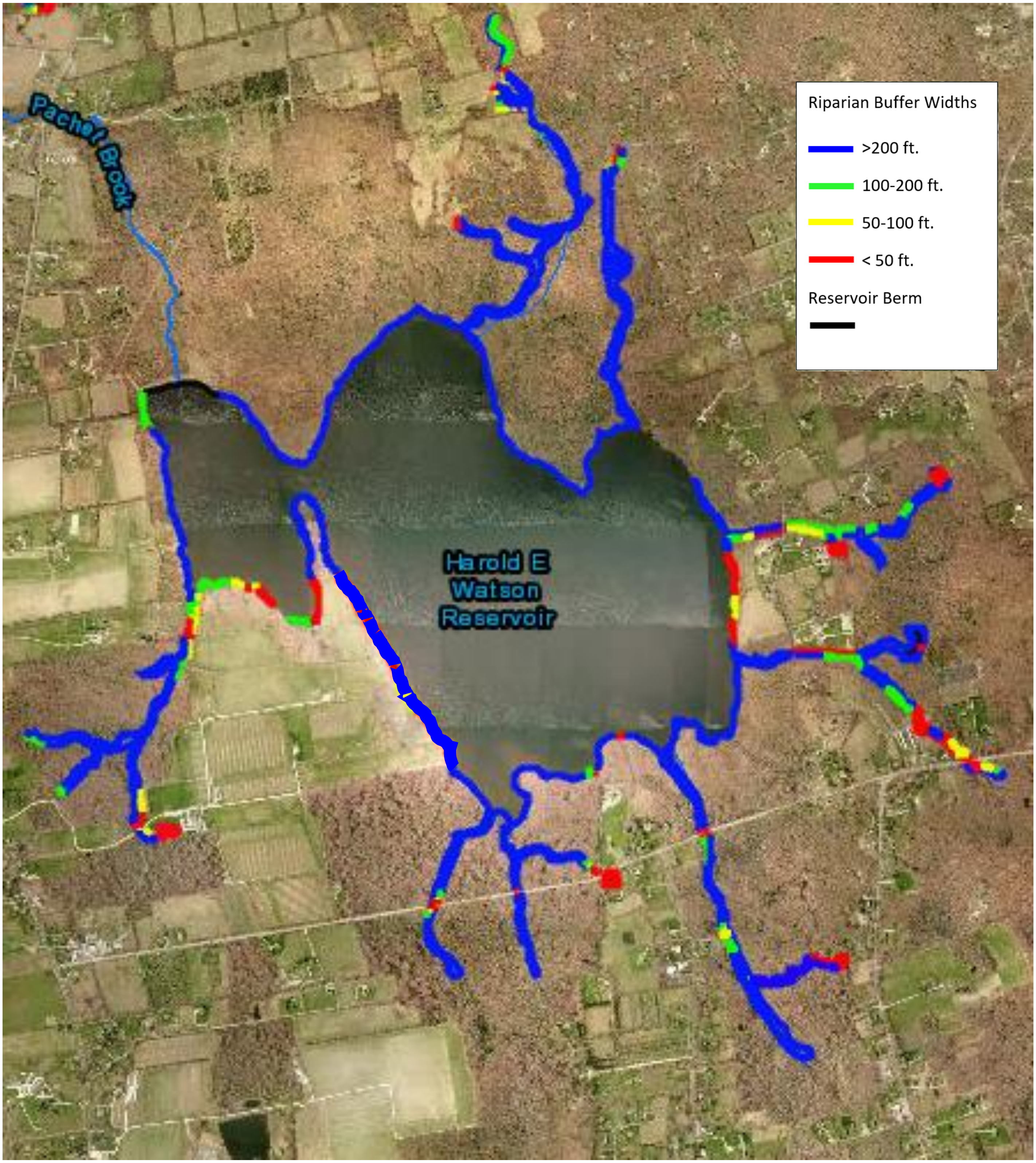


Figure 6.8. Watson Reservoir Tributaries Estimated Vegetated Buffer Zone Widths.



6.2.5 Tiverton Landfill Closure and RIPDES Permit

As previously discussed, RIDEM has documented various water quality impacts to Quaker Creek from the Tiverton Landfill under both dry and wet weather conditions. The landfill swale conveys leachate containing TSS, ammonia, and dissolved organic carbon (DOC) during dry weather. Stormwater runoff from the upper portions of the landfill during wet weather is elevated in TSS, total phosphorus, total nitrogen (primarily as ammonia), DOC, and Enterococci. Data collected by RIDEM and confirm these impacts. RIDEM OWR staff also observed uncontrolled runoff from various portions of the landfill containing sediment, litter and petroleum hydrocarbons flowing into the main landfill drainage swale.

Approximately 33 acres of the site is permitted for solid waste landfilling activities. The landfill area is currently owned and maintained by the Town of Tiverton. The Town is preparing for the closure of the site in accordance with RIDEM's *Rules and Regulations for Solid Waste Management Facilities and Organic Waste Management Facilities (250-RICR-140-05-1)* https://rules.sos.ri.gov/regulations/part/250-140-05-1 to eliminate and/or control threats to human health and the environment in a timely manner. Work will include the installation of a geomembrane cap, a passive gas ventilation system, stormwater management facilities, and miscellaneous site improvements. The proposed stormwater management and collection system has been designed in accordance with the Rhode Island Construction General Permit (http://www.dem.ri.gov/programs/water/permits/ripdes/stormwater/construction.php).

The current closure proposal, submitted to RIDEM for review, includes four (4) detention basins, three (3) bioretention basins, three (3) sediment forebays, four (4) dry swales, diversion berms and stone drainage ditches. Diversion berms, dry swales, and stone drainage ditches are designed to slow runoff and divert stormwater to detention basins and bioretention areas. The current proposal is subject to change, during the regulatory review process. The landfill closure will include an impermeable geomembrane (Closure Turf®) liner, established over all areas of the former landfill, with a minimum thickness of six (6) inches of subgrade soil cap. The impermeable geomembrane liner includes no natural soil, reducing soil erosion, thereby reducing the possibility of migration of contaminants to nearby wetlands and Quaker Creek. In addition, the impermeable geomembrane limits subsurface infiltration and through the waste layer. Upon completion of the landfill closure, the Town will be responsible for the maintenance of stormwater controls and the geomembrane.

The Town is also required to obtain a Rhode Island Pollutant Discharge System (RIPDES) permit (Section 5.0). The Town will be responsible for sampling discharge from all outfalls discharging stormwater from the closed landfill. The water samples will be analyzed for numerous pollutants associated with landfills, including the pollutants identified in the TMDL as being present in elevated concentrations. The RIPDES permit will stipulate the list of pollutants to be analyzed, and the Town will be required to meet pollutant concentration limits set by the RIPDES permit. The Town has will also continue to sample wells around the landfill and have the samples analyzed for pollutants stipulated by the RIDEM's Office of Waste Management. The Office of Waste Management may require the Town to drill and sample additional wells around the perimeter of the closed landfill.

6.2.6. Newport Airport Stormwater Pollutant Prevention Plan (SWPPP)

Newport Airport occupies approximately 250 acres in the Town of Middletown and is managed by the Rhode Island Airport Corporation. (RIAC). Stormwater generated from Newport Airport discharges via a storm drain system and via overland flow and infiltration. A Stormwater Pollutant Prevention Plan (SWPPP) was developed for Newport Airport in accordance with the Rhode Island Pollutant Elimination System (RIPDES) stormwater program. This plan has been developed for RIAC to identify potential sources of pollution at the airport and to eliminate or minimize the potential for pollutants in the stormwater discharges from the site. The SWPPP describes facility inspections, spill prevention, material inventories, drainage plans, measures and controls to reduce pollutants in stormwater, and site evaluations.

Potential sources of pollution associated with the airport include, stormwater contamination, facilities (runways, taxi ways, aprons, and airport operation buildings), exposed and stored materials, leaks and spills, vehicle and aircraft washing facilities, fueling activities, deicing practices and waste materials.

Preventative maintenance at the site related to stormwater discharge includes routine maintenance and inspection of material storage, transfer areas, and equipment. In addition, the stormwater drainage system must be maintained, including cleaning of catch basins, upkeep and inspection of stormwater outfalls for signs of pollution, and maintenance of grassed swales. Other practices related to reducing stormwater pollution include the visual inspection of the airport's buildings and facilities, including piping, motors, pumps, and valves and hoses associated with fuel storage and transfer facilities, and the inspection of oil storage tanks

Good housekeeping practices employed at the airport include proper storage of engine fluids, maintenance products, and waste, and prompt removal and remediation of incidental spills, maintenance of clean dry floors, minimization of the quantity of materials stored with exposure to stormwater, coverage of materials stored outside, and prevention of the discharge of wash waters to surface waters via floor drains and storm drains. Employee training and record keeping procedures related to stormwater is also critical in reducing stormwater contamination.

6.2.7 Control of Internal Loading of Phosphorus

There are four primary techniques to reduce internal loading of phosphorus in waterbodies: dredging, aeration/oxygenation of the hypolimnion, complete circulation/destratification of the entire lake, and the application of alum (or other phosphorus-binding agents). Dredging is the most effective method but is extremely costly (~50 times alum) and may encounter regulatory prohibitions (Welch, 2005). Hypolimnetic aeration/oxygenation treats anoxic phosphorus release only and depends on iron availability to bind phosphorus and iron may not be inactivated itself in highly polluted sediments. Complete circulation/destratification has the same effect on sediment phosphorus as hypolimnetic aeration, but with a greater risk of increasing phosphorus availability in the epilimnion by removing the thermocline barrier.

Also, shallow lakes are generally already aerated. Aeration techniques also have no lasting effect and once the source of air is shut off the internal loading will return. Alum treatment has proven to be effective in both stratified anoxic and unstratified oxic lakes. While first year costs for alum and aeration/oxygenation are similar (~$1,000-$3000/hectare), alum cost is only one-tenth as much when spread over ten years. As with application of any chemical, the use of alum must be carefully evaluated and controlled to minimize the risk of potential negative chemical and biological impacts.

For those ponds identified as having a significant internal cycling of phosphorus, RIDEM recommends that a professional consultant with experience in the control of phosphorus release from pond sediments be hired to specifically address this source. The consultant should confirm the significance of internal cycling as a source of phosphorus to the pond, and secondly, evaluate the most effective and feasible BMPs to control phosphorus release from the sediment. Lastly, many BMPs used to control the release of internal phosphorus may have undesirable effects on the waterbody if not properly conducted and therefore the consultant should also be retained to oversee implementation of the selected BMPs.

7.0 Public Participation

During the planning stages of TMDL development for the Newport water supply reservoirs, RIDEM formed a technical advisory committee (TAC), consisting of technical staff/experts from the Newport Water Department, RIDEM, University of Rhode Island (URI), EPA's Atlantic Coastal Environmental Science Division (ACESD), and the Massachusetts Department of Environmental Protection (MADEP). The purpose of the TAC was to discuss approaches for developing TMDLs for the water supply reservoirs, and if possible, achieve consensus regarding RIDEMs proposed approaches. RIDEM convened three meetings of the advisory committee, all held in Newport City Hall, on August 5th, 2014, Oct 6th, 2014, and Dec 9th, 2014. All three meetings were well attended by TAC members.

Members of the TAC reviewed RIDEM's draft approach for developing TMDLs and provided valuable feedback regarding aspects of the various proposed methods. With the exception of the Newport Water Department, there was general agreement on the validity of the overall approach. Major components of the approach included description of methodologies for 1) developing total phosphorus and chlorophyll a targets for the reservoirs and 2) developing the TMDLs based on the total phosphorus targets. RIDEM developed a Quality Assurance Project Plan (QAPP). The QAPP was approved by EPA in early May 2015 and commenced sampling the water supply reservoirs in mid-May.

In 2017, RIDEM circulated a draft report to the TAC which detailed the methodologies used to derive total phosphorus targets for the reservoirs. The analysis in the report utilized the data collected by RIDEM in 2015. The total phosphorus target was used as the basis for deriving the TMDLs for the water supply reservoirs. Members of the TAC submitted extensive review of the document, which resulted in only minor changes to the original. In addition, RIDEM received extensive feedback from staff at the NY State Department of Environmental Conservation (NYSDEC). With the exception of the Newport Water Department, there was general agreement on the validity of the approach.

RIDEM has prioritized informing the public about efforts to improve water quality in the water supply reservoirs. In general, and through efforts by other groups/organizations including the Aquidneck Island Planning Commission, Aquidneck Land Trust, Clean Ocean Access, the Eastern RI Conservation District (ERICD), Natural Resource Conservation Service (NRCS), and municipalities, public awareness of water quality issues on Aquidneck Island is high. Between 2015 and the present, RIDEM has held numerous public meetings to inform municipalities and members of the public and other stakeholders of RIDEMs efforts to develop TMDLs in the water supply reservoirs. RIDEM has also presented this information at various venues held by other stakeholders. These meetings/presentations are briefly described below.

On March 25 and March 31st, 2015 RIDEM held separate meetings for both municipal officials and the general public, respectively, to discuss the Source Water Protection Initiative for the water supply reservoirs. Numerous municipal officials were present at the public meeting on March 31st. Both meetings were held at the Newport Public Library. Both presentations included an overview of the following topics: 1) background of the Source Water Protection Initiative, including brief overview of applicable portions of the federal Clean Water Act, 2) water quality conditions in the reservoirs, 3) proposed approach for developing TMDLs, 4) overview of proposed monitoring, 5) next steps in TMDL development, 6) ongoing watershed protection and water quality monitoring activities by Aquidneck Island communities, 7) question and answer session. The meetings were generally well attended with significant feedback from many attendees. RIDEM considers these meetings to be the 'public kickoff' meetings for the TMDL project.

On June 11, 2015, RIDEM participated in a Natural Resource Conservation Service (NRCS) 'Soil Health' workshop at Sweet Berry Farm in Middletown, RI. RIDEM covered the same topics as during the March 25th and 31st meetings with the addition of discussing preliminary results from the NWQI monitoring conducted in the Maidford River and Paradise Brook. This meeting was attended by members of the public as well as nursery and landscape professionals. Staff from NRCS and the Eastern RI Conservation District (ERICD) also made presentations.

On November 5th, 2015, NRCS and the Rhode Island Association of Conservation Districts held an informal workshop "Healthy Soil, Clean Water: Techniques to Improve Your Farm's Soil Health and Water Resources" at Greenvale Vineyard, located in Portsmouth, RI. The workshop included presentations by NRCS staff, the Rhode Island Association of Conservation Districts, and RIDEM staff. RIDEM discussed water quality challenges on Aquidneck Island, including the Source Water Protection Initiative with an overview of TMDL development in the reservoirs and results of NWQI monitoring. The workshop was well attended, and significant engagement/dialogue followed RIDEM's presentation.

On November 19th, 2015, RIDEM staff presented at a joint meeting of the New England and Rhode Island Water Works Associations (NEWWA/RIWWA). Both associations are membership organizations for those working in the drinking water profession. The NEWWA is accredited by the International Association for Continuing Education and Training and holds two major conferences and several specialty symposia each year. RIDEM presented information on existing water quality in the water supply reservoirs, TMDL development efforts, and other ongoing water quality restoration activities in the water supply reservoir watersheds.

On September 16, 2016, RIDEM presented at a New England Interstate Water Pollution Control Commission (NEIWPCC) Commissioner's meeting. The presentation was similar in scope to the previous presentations and focused both on TMDL development as well as NWQI results in the Maidford River and Paradise Brook.

On October 13, 2016, RIDEM held a public meeting in the Council Chambers at the Middletown Town Hall to provide an update on TMDL progress. RIDEM reviewed the proposed technical approach and provided an overview of preliminary results from the 2015 monitoring effort. RIDEM also provided a review of the final NWQI monitoring results in Paradise Brook and Maidford River, including photo-documentation of significant agricultural-related source of nutrients. RIDEM also noted the proposed 2016 303(d) listings for the Maidford River, Bailey Brook, and Paradise Brook. Next steps in TMDL development were also discussed. The meeting was well attended.

On December 8th, 2016 the Aquidneck Island Planning Commission held "The Future of Clean Water: The Island Waters Public Forum" at the Community College of Rhode Island Newport Campus. The public forum on clean water, hosted by the Island Waters Project partnership of local organizations and island municipalities, provided an overview of Aquidneck Island's waters and watersheds; describe new and ongoing efforts to reduce water pollution; and present information to help all Aquidneck Islanders ensure the future of clean water. Approximately 150 people attended this forum and the former EPA Region 1 director, Curt Spaulding, gave the keynote address. Presentations were made by: RIDEM, Newport Water, Town of Middletown, Town of Portsmouth, the Aquidneck Land Trust, Clean Ocean Access, and the Eastern RI Conservation District. RIDEM presented information relative to the Source Water Protection Initiative.

On January 25th, 2017, RIDEM was invited to present at the Rhode Island Nursery and Landscape Association's (RINLA) annual meeting held at Newport Vineyards in Middletown. RINLA is a 501(C)(6) professional trade association that serves the green industry and promotes environmental stewardship. RINLA members include nurseries, landscape contractors, arborists, green engineers, masons, garden centers, landscape architects, landscape designers, fruit/vegetable growers, compost/mulch manufacturers, suppliers and allied businesses.

RIDEM presented an update of the Source Water Protection Initiative that included the following topics: 1) Impairments on the 2014 303(d) List, 2) TMDL Study Objectives, 3) Technical approach overview, 4) Results from 2015 sampling of water supply reservoirs, 5) NWQI overview and summary of water quality condition in Maidford River and Bailey Brook, and 6) next steps-timeframe for TMDL completion. This meeting was well attended and there were numerous questions and lengthy discussions after RIDEM's presentation.

On June 25th, 2018, Staff from RIDEM's Office of Water Resources and Division of Agriculture met with staff from NRCS to go over findings from the NWQI surveillance and monitoring in the Maidford River, Paradise Brook, and tributaries to Nonquit Pond. The presentation included a summary of priority pollution sources related to agricultural land uses.

The draft TMDL was presented at a virtual public meeting held on June 23rd, 2021 from 3pm to 5pm. The draft TMDL was posted on RIDEMs website on June 23rd and was accompanied by a press release on DEM's website. An email providing the meeting notification, a link to the TMDL document, and a Fact Sheet was sent out to approximately 100 individuals. The June 23rd meeting marked the beginning of a 45-day public comment period. Approximately 45 individuals attended the meeting, many of whom were present at previous public meetings. Attending organizations included: Conservation Law Foundation (CLF), City of Newport Water Division, RIDEM, Natural Resources Conservation Service (NRCS), Eastern Rhode Island Conservation District (ERICD), Save the Bay, USEPA, and RI Dept. of Health Center for Drinking Water Quality. Comments and RIDEM responses to those comments received during the public comment period are located in Section 10.0.

8.0 Follow Up Monitoring

RIDEM recommends that an ambient monitoring program be developed and implemented to assess progress in achieving the TMDL targets. A targeted monitoring effort in all nine water supply reservoirs is necessary to determine the effectiveness of the implementation measures described in this TMDL. Implementation of phosphorus reduction measures will require long term commitments from all municipalities, RIDOT, and other stakeholders. RIDEM recommends that the Newport Water Department develop a sampling plan that evaluates the nutrient and algal conditions of the reservoirs. Ideally, the Newport Water Department would oversee the program with sampling/cost shared among various municipalities. Monitoring should continue into the foreseeable future so trends in nutrient and chlorophyll concentrations in the reservoirs can be evaluated through time. Monitoring should also include frequent evaluation of the phytoplankton communities in the reservoirs. RIDEM recommends additional long-term monitoring at the outlet of major reservoir tributaries including but not limited to: Maidford River, Bailey Brook, Paradise Brook, and Quaker Creek

The monitoring program is also an opportunity to build awareness of reservoir health and good housekeeping practices with property owners and businesses. RIDEM believes that this could serve as a way of increasing engagement and building support within the community for ongoing watershed protection efforts. RIDEM recommends that the Newport Water Department actively engage the municipalities of Portsmouth, Middletown, Little Compton, and Tiverton, as well as other groups including the Aquidneck Island Land Trust, Clean Ocean Access, and the Aquidneck Island Planning Commission to develop and implement a long-term monitoring plan. Monitoring results and any trends in water quality in the reservoirs and reservoir tributaries could be distributed to consumers with their annual consumer confidence report.

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10.0 Response to Comments

July 9th 2021 Save the Bay Comments (Jed Thorpe)

1. ***We've long been concerned about runoff from residential fertilizers, and know that it's challenging to know how much things like fertilizer are contributing to the overall nutrient problem. Our understanding is that the modelling is tricky, and that the unique attributes of any watershed make it difficult to apply models across watersheds. Can you tell us more about the modelling used in making assumptions about fertilizers as a percentage of the urban/residential runoff total, and how applicable those models are here?***

The Watershed Treatment Model (WTM) report is available on DEM's website:

http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/tdml-nonquit-wtm.pdf

This report summarizes results from the application of the WTM to the nine reservoirs and the Maidford River to estimate external watershed loadings of total phosphorus and total nitrogen to each waterbody. Appendix B (page 38 of the report) describes in detail the assumptions used when evaluating fertilizer contributions in the reservoir watersheds.

2. ***Do you know the relative P contribution from direct runoff vs MS4s?***

The Watershed Treatment Model (WTM) uses the Simple Method (Schueler 1987) to calculate loads from urban stormwater. "Urban stormwater" was considered to come from the following land uses: low density residential, medium density residential, high density residential, all roadways (transportation), commercial, industrial, and institutional) and is considered to be conveyed via MS4s (i.e. Urban Land corresponds to impervious surface and stormwater runoff from permitted municipal separate stormwater discharges (MS4s)).

Direct runoff is assumed to come from rural (agricultural) land uses and loads in the WTM are estimated as the product of area and a loading rate. Loads are calculated from both baseflow and storm flow.

The relative contributions of total phosphorus loads to each reservoir (and the Maidford River) from MS4 -vs- direct runoff are presented in Tables 4.1 and 4.9 in the draft TMDL.

3. Does DEM intend to modify permits to achieve the necessary load reductions from MS4s and is there willingness on the part of the interim director to enforce SW permits?

Upon notification of TMDL completion, MS4 permittees are required to update their Stormwater Protection Plans as described in Section IV of the MS4 general permit. The MS4 general permit is currently undergoing comprehensive review. Discussion is ongoing to include further detail regarding compliance with TMDLs. A final decision has not been made whether this TMDL implementation will be included under the previous MS4 GP or to delay until the new permit is issued. At this point, we are not prepared to share the details.

4. In the recent public workshop, you mentioned using enforcement for documented water quality violations. Has DEM taken action on documented water quality violations?

NWQI investigations in 2015 and 2018 (described in detail in Section 4.0 of the TMDL) resulted in the Office of Water Resources (OWR) requesting the Office of Compliance and Inspection (OCI) to initiate formal enforcement action for violations of the regulations described in Section 5.9.1 of the TMDL <u>Activities which were found to result in the violation of water quality standards include the following:</u>

- *the presence of a silage pile located in a wetland perimeter where OWR documented violations of water quality criteria for ammonia, turbidity, phosphorus, and enterococci in the headwaters of an Un-named Tributary to Borden Brook which flows to Nonquit Pond;*

- *various areas where livestock from a farm have direct access to wetlands and the stream channel of another stream, Un-named Tributary to Nonquit Pond where OWR documented violations of water quality criteria for total phosphorus and enterococci at a downstream sampling location at Barnswallow Street.*

- *failure to control erosion, sedimentation and runoff resulting in the discharge of untreated concentrated flow of runoff from the nursery fields at various locations in Middletown into storm drainage structures including (catch basin, culvert, and roadside swale) that convey runoff into the Maidford River. RIDEM sampling documented violations of water quality criteria for bacteria, turbidity, and total phosphorus as well as adverse effects to physical, chemical, and biological integrity of habitat.*

It is noted that formal enforcement actions were not taken in the above examples, however the Office of Water Resources and Division of Agriculture worked with NRCS, ERICD, and the landowners to address these specific issues. Table 6.6 and Section 6.1 (in the TMDL) provide more detailed information on specific BMPs for these projects.

5. Can you tell us any more about what changes you're planning/willing to make to MS4 permits to give them more "teeth?" (Structural changes, not just BMPs.) Not sure if you have already done that or are planning to do so. Related, how about any changes to the MS4 reporting?

DEM will continue to use formal and informal options to enforce MS4. As noted, the MS4 general permit is currently undergoing comprehensive review which discussion is ongoing to *include further detail regarding compliance with TMDLs. The discussions regarding the new MS4 permit have also included consideration of reporting.*

6. What tools does either DEM or municipalities have to make buffer restoration (which can be very challenging) a reality? Is DEM prepared to give MS4 "credit" for buffer restoration, and what formula/standards would you use to calculate that credit?

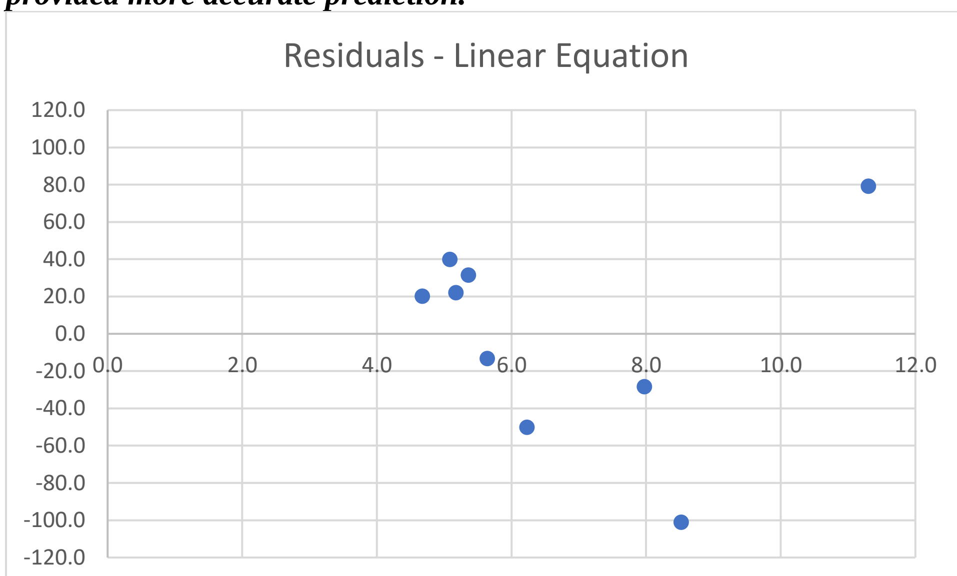
Although RIDEM has not yet evaluated the credit that would be given for buffer restoration, we may give credit for Impervious Cover (IC) disconnection. At present, to the extent the buffer restoration turns a compacted/poorly vegetated area into a functioning pervious area, there's already a mechanism for assigning credit under consent decrees such as RIDOT's.

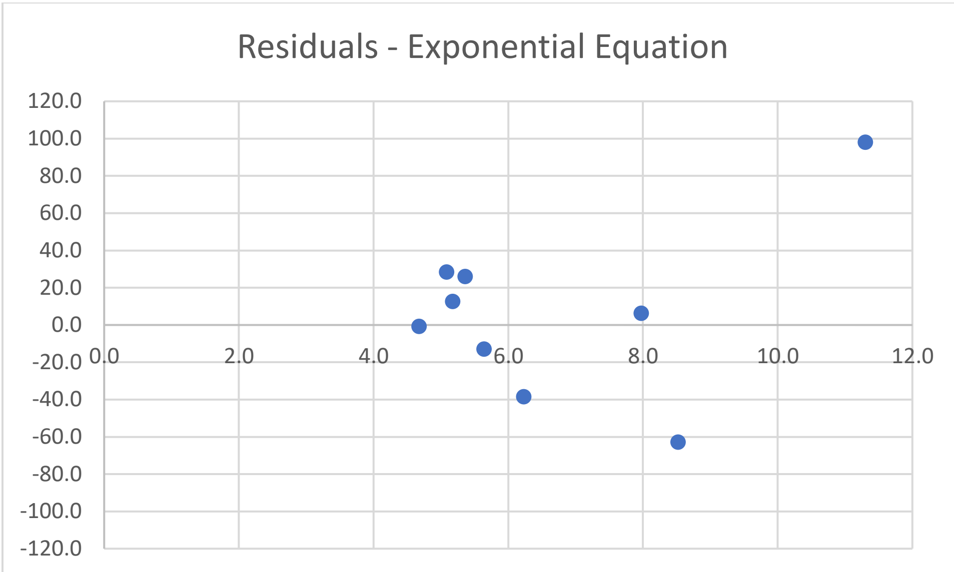
CDM Smith on Behalf of City of Newport Comments- August 3, 2021

Review of the statistical analyses for the numeric target phosphorus development suggest that the underlying analyses used in the sequential regression analysis are fraught with too much variability and lack both meaningful statistical and causal relationships to be a reasonable foundation for the development of a target phosphorus concentration for Newport's reservoirs

1. The DOC-TTHM regression analysis is a flawed bases for the foundation of the chlorophyll a and total phosphorus numeric targets
   a. The TTHM and DOC data may not be sufficient to set a DOC target concentration and an exponential regression may not be the best fit to the data.

   RIDEM Response: RIDEM recognizes that the R^2 values are comparable between the linear and exponential equations. While not presented in the document, an examination was carried out to evaluate the residuals of the equations to further evaluate the best fit of the trendline. Presented below are the residual plots where it was determined that the exponential function was a better fit of the data and provided more accurate prediction.





Additionally, this comment discusses an EPA comment on a draft approach document regarding accounting for DOC with a simple regression does not consider all the potential variability. RIDEM concurs that further variability is likely to influence TTHM formation, specifically factors such as humic acid concentration, temperature, pH, and bromide ion concentration. By sampling across various conditions May through October and including Nonquit Pond in this portion of the analysis, RIDEM's goal was to capture as much of the seasonal variability as possible to include in the analysis. No changes to the TMDL document have been made to address this comment.

b. Including Nonquit Reservoir in the DOC-TTHM relationship is inconsistent with the remainder of the analysis in the TMDL

RIDEM Response: As noted above, RIDEM included Nonquit to account for various conditions of DOC present within the Newport water supply reservoir system. It is well recognized in water quality studies, and noted within the TMDL, that waters with high humic content have different production pathways and was therefore excluding from further steps. No changes to the TMDL document have been made to address this comment.

c. Using seasonal average to develop a relationship between DOC and TTHM formation potential and the alternative of using individual data points for DOC and TTHM formation potential has a weak statistical relationship

RIDEM Response: It is inappropriate to plot the data in this way, as coincident pairs. This is called 'pseudoreplication', which is a common (and risky) problem in statistics. You increase your chances of statistical error and not capturing the variability of the system appropriately. In statistical terms, pseudoreplication occurs when individual observations are heavily dependent on each other, to avoid this, RIDEM averaged the dependent data points/pairs for each reservoir. No changes to the TMDL document have been made to address this comment.

d. Without a valid statistical basis for the DOC-TTHM the remainder of RIDEM's analysis has no foundation

RIDEM Response: This section summarizes the above comments to invalidate the next steps in the process. RIDEM references the above comments regarding the already submitted comments in this section. No changes to the TMDL document have been made to address this comment.

2. The TTHM test method used for this assessment is overly conservative and is not representative of the TTHM formation potential in Newport's water supply system.

   RIDEM Response: The test method used is based on EPA approved methods and Standard Methods, which are both accepted test methods for analysis of TTHM. Additionally, as noted by Chowdhury et al. (2009)[4], estimation of disinfection byproduct formation is difficult to estimate in field-scale studies, especially the reaction time within the distribution system, and does not account for residual natural organic matter (NOM) in the distribution system. A more conservative method represents a worst-case scenario and is therefore inherently more protective. No changes to the TMDL document have been made to address this comment.

3. The regression analysis used to establish the DOC threshold exceeds the precision of the DOC measurements

   RIDEM Response: The statement applies the reported EPA Method 415.3 precision quality control benchmark of 20% to the DOC relationship and subsequently through the chlorophyll a target. The precision of a laboratory method is data quality indicator and measurement of variability of the laboratory method introduced within the laboratory. It is inappropriate to apply the data quality indicators to the relationship of DOC to chlorophyll a. The commenter also discusses the accuracy of the DOC analytical method, which is another data quality indicator of the laboratory method as impacting the relationship between DOC and chlorophyll a. We reference the earlier comment that it is inappropriate to apply data quality indicators to the relationship of DOC to chlorophyll, whether precision or accuracy. We note that no laboratory data was qualified and met all data quality indicators. No changes to the TMDL document have been made to address this comment.

4. RIDEM has not demonstrated that a clear relationship exists between DOC and chlorophyll a.

   RIDEM Response: The commenter again uses individual datapoints to derive a graph depicting Newport Reservoir DOC and chlorophyll a. The use of individual datapoints inherently introduced pseudoreplication, artificially inflating the number of samples, which is not statistically valid method of determining whether a relationship exists (see

[4] Chowdhury, S., P Champagne, P.J. McLellan. 2009. Models for predicting disinfection byproduct (DBP) formation in drinking waters: A chronological review. Sci. Total Environ. 407: 4189-4206.

RIDEM response above). Additionally, lakes generally respond to nutrient loading on a seasonal time scale, rather than a daily time scale.
The commenters also discuss the combination of the New York and Newport datasets, which were previously submitted for the data analysis plan, and comments that the New York dataset is driving the selection of targets. The below Figure has been generated by CDM Smith and has been presented to RIDEM in past comments (italics).

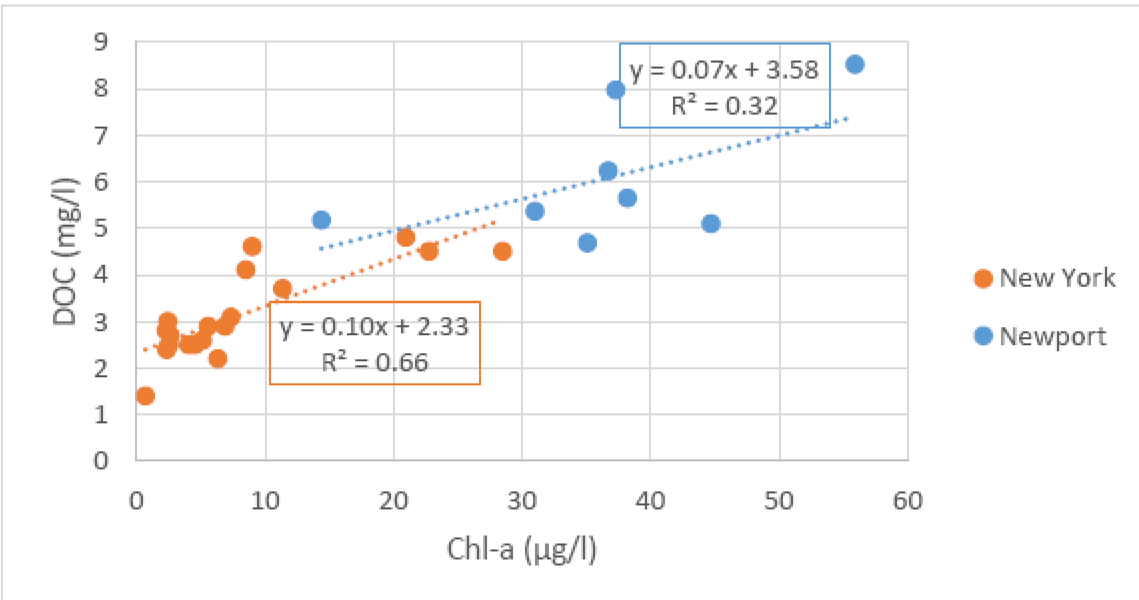


Figure 3: Comparison of Chlorophyll-a and DOC Regressions for the New York State and Newport Datasets

Figure 3 shows the correlation between chlorophyll-a and DOC is significantly stronger for the New York State dataset than it is for the Newport dataset. This suggests that the strength of the correlations presented in the RIDEM Technical Approach document are largely driven by the New York State data and may not adequately describe the relationships between chlorophyll-a and DOC in Newport's system. In other words, the chlorophyll-a and total phosphorus targets are established primarily based on the relationships between chlorophyll-a and DOC observed in New York State.

RIDEM Response: The slopes of the linear regression lines fitted to the individual NY and RI datasets in CDM Smith Figure 3 were evaluated using a significance of the difference between two slopes test (Sokal and Rohlf 1995)[5] and were found to be not significantly different (t = 0.01678, df = 25, p = 0.9867) indicating a similar relationship between chlorophyll-a and dissolved organic carbon is present in both the NY and RI

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[5] Sokal, R.R., and Rohlf, F.J. 1995. Biometry: The principals and practice of statistics in biological research. 3rd edition. San Francisco: New York. W.H. Freeman.

systems. This indicates that grouping the NY and RI data into one regression is valid and allows for insight as to what the expected levels of DOC in the Newport reservoirs may be given reductions in seasonal phytoplankton biomass.

5. The lack of statistical rigor in RIDEM's analysis and the variability in the predicted target concentrations suggests that an appropriate interim target concentration is the existing 25 µg/L numeric nutrient criterion.

   RIDEM has authority to utilize a value different than the existing total phosphorus criterion, meant to protect aquatic life use, of 25 µg/L. The study conducted and subsequent analysis demonstrated that to protect drinking water use a lower total phosphorus target is appropriate.

Additional Comments

1. Updates to Table 2.2 to reflect Newport Water Department operations

   Updates as requested has been made to the document.

2. Grass maintenance for goose control

   We note that the document contains the statement that mowing regiment must be consistent with dam safety, maintenance, and inspection.

3. Aeration system during winter months

   RIDEM agrees with the reasons CDM Smith suggested that it may not be reasonable for the aeration system to be turned off during the winter months. We note that the statement regarding turning off the aeration in the winter months is stated as "should consider turning off the bubblers during the winter months especially if there is no documented benefit [of the bubblers] to water quality during this time". The document presents this as a potential implementation strategy for reduction of winter-time goose habitat. No requirement to do so it presented in the document. The portion in brackets above has been added to the document for clarity.