Baseline Monitoring Data Report

August 2023

Maidford River Restoration Pilot Project

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The Southeast New England Program Network

The Southeast New England Program (SNEP) Network brings together local environmental organizations, academic institutions, regional planners, and consultants who collaborate to provide municipalities, tribes and organizations in Rhode Island and Southeast Massachusetts access to free training and technical assistance to advance stormwater management, ecological restoration, and sustainable financing goals across the region. The SNEP Network is administered through EPA's partnership with the New England Environmental Finance Center, a non-profit technical assistance provider for EPA Region 1.

The Maidford River Restoration Project baseline monitoring initiative was developed by SNEP Network Partners (Elizabeth Scott Consulting and Save the Bay) in partnership with the Town of Middletown, Aquidneck Land Trust and RI Department of Environmental Management and financial support from NEEFC. The project team selected TRC Environmental Corporation from the SNEP Network's pre-approved consultant pool to collect streamflow and water quality data, to document presence/absence of state-listed species of concern within the Maidford River Project area and to prepare the Maidford River Restoration Project Baseline Monitoring Report and Maidford River Watershed Condition Report. Consultants in the pre-approved consultant pool were evaluated on their qualifications, track record, and performance of their selected service areas.

The SNEP Network has supported the Maidford River Restoration Project including this baseline monitoring initiative as a key resource to demonstrate best practices for improving Southeast New England's water resources. Find out more about the SNEP Network at www.snepnetwork.org.

Disclaimer

The SNEP Network is administered by: New England Environmental Finance Center at the University of Southern Maine, UMaine System.

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1.0 Introduction

The Maidford River Restoration Project is a pilot project undertaken by the Southeast New England Program Network (SNEP) in Middletown, Rhode Island. The Maidford River is a highly-altered, small low-gradient coastal stream located on Aquidneck Island in lower Narragansett Bay. Its approximately 1,821-acre watershed drains the southeastern corner of Middletown, providing inflows to the City of Newport's water supply reservoir system via a diversion. The remainder of the flow that is not diverted, discharges at Middletown's Third Beach. The watershed is predominantly composed of agricultural (40%) and residential (27%) land uses and has experienced issues with degraded water quality and flooding. SNEP Network partners are assisting the Town of Middletown and Aquidneck Land Trust to advance use of nature-based solutions to mitigate flooding along the Maidford River and restore water quality and habitat. The project entails an initiative to restore the river's riparian buffer along its length, as well as a river and floodplain restoration component in one reach of the river.

To advance the project, the SNEP Network provided consultant services in support of the design and engineering of the river and floodplain restoration project, and partner services to support project management, funding/financing assistance, communications, and community engagement (including direct outreach to riparian property owners) from Summer 2020 through Winter 2022. The project's goals are to mitigate flooding of local roads (Berkeley Avenue and Berkeley Avenue Extension) and farm fields, and to improve water quality and both riparian and aquatic habitat. The Maidford River Restoration Project boundary extends from the river's headwaters to the Newport Water Supply Diversion west of Nelson Pond, although the river and floodplain restoration project area (Pilot Project Area) is bounded upstream by the Berkeley Avenue culvert and downstream by the intersection with Green End Avenue.

Prior to implementation of the Maidford River Restoration Project, the SNEP Network and project partners are documenting baseline conditions in the Maidford River and its watershed. As part of these efforts, TRC collected streamflow and water quality over the course of approximately 18 months, which were used to derive baseline annualized phosphorus, nitrogen, and sediment loads. Streamflow and water quality data were collected at three locations on the Maidford River, including the Berkeley Avenue, Green End Avenue, and Prospect Avenue road crossings (Figure 1).

Additionally, TRC documented presence/absence of state-listed species of concern (specifically, the northern leopard frog [*Lithobates pipiens*]) within the Maidford River Restoration Project area over a 14-week study period in spring 2022.

The approach and results of these baseline condition monitoring efforts are documented in the following sections of this report.

Figure 1. Water Quality and Discharge Monitoring Locations

2.0 Methods

2.1 Streamflow Measurements

Dataloggers

On June 25, 2021, TRC deployed two Solinst Levelogger non-vented dataloggers to measure water level and temperature at the Berkeley Avenue and Green End Avenue Maidford River baseline monitoring locations. Additionally, a Solinst Barologger was installed near the Prospect Avenue monitoring location to provide barometric correction for the water level dataloggers. A third Solinst Levelogger was deployed at the Prospect Avenue monitoring location on July 14, 2021.

Dataloggers were programmed to collect readings at 15-minute intervals. However, an initial verification download on August 19, 2021 revealed that the Green End Avenue stream datalogger had mistakenly been set to collect readings at 15-hour intervals. The problem was diagnosed and the stream datalogger was reset to collect data at the appropriate interval that same day.

The Prospect Avenue water level datalogger (white PVC tube at center-left) was positioned in a pool to minimize the risk of exposure during low flows.

A second Solinst Levelogger was installed at the Berkeley Avenue monitoring location on August 19, 2021 because the original stream datalogger could not be found, due to dense growth of vegetation in the channel. However, the original water level datalogger was later located and both units were left in place for the duration of the monitoring program.

Stream dataloggers and the barologger were deployed and operated in a manner consistent with SOPs established under the project-specific QAPP. This included the use of a PVC tube to provide protection over the course deployment. PVC tubes included screw caps on either end to allow for access to the datalogger inside for maintenance and data download. The tubes and caps were pre-drilled with 1/4” holes at multiple locations to allow air and water to pass through and prevent trapping of air bubbles or water. The stream datalogger PVC tubes were firmly attached to driven rebar using two hose clamps. Installation was targeted for pool features or other low spots in the streambed to avoid stranding of stream dataloggers above the water. Stream dataloggers were also installed with the sensor side at the bottom of the PVC tube in order to capture as much of the water column as possible.

During field visits, raw water level datalogger and barologger files were transferred from each logger to a laptop computer. The raw water level logger files were corrected for barometric pressure using proprietary software provided by the manufacturer (Solinst Levelogger Software v. 4.6).

Discharge

Discharge measurements were collected at each of the three Maidford River baseline monitoring stations. Prior to collection of the first measurements, cross sections were established perpendicular to the mean direction of flow at each streamflow monitoring location. Iron rebar or wooden stakes were driven and flagged at the top of each bank to mark the left and right ends of the cross section.

When streamflow was perceptible, TRC measured velocity and depth at multiple width intervals across the channel. Measurements were collected in accordance with SOPs established under the project-specific QAPP. A Spoffer 2100 series propeller-style current meter mounted on a calibrated wading rod, was used to measure velocity. The number of readings for each cross section varied by width of the wetted stream channel on each date but was not less than four when water was sufficiently deep and flowing.

Measuring discharge during the March 24, 2022 wet weather event.

In addition to streamflow, TRC also manually measured the depth of each stream datalogger. This served as a means of confirming that the dataloggers had not been displaced by flowing debris or tampered. Where a staff gauge was present, TRC also recorded the water level associated with the gauge during each streamflow monitoring visit.

TRC made a total of eight streamflow measurement visits over the course of the Baseline Monitoring Program. Five of the visits were conducted during dry weather conditions and three were conducted during wet weather. The dates and extent of streamflow measurements collected are presented in Table 1.

Table 1. Streamflow Measurement Dates and Number of Measurements Collected

Date	Event Type	Berkeley	Green End	Prospect
7/14/2021	Dry Weather	0*	0*	1
8/19/2021	Dry Weather	0*	0*	1
11/16/2021	Dry Weather	1	1	1
3/24/2022	Wet Weather	3	3	3
5/24/2022	Dry Weather	1	1	1
9/22/2022	Wet Weather	2*	2*	3
12/16/2022	Wet Weather	3	3	3
Total		10	10	13

*Lack of measurable flow during one or more rounds

Streamflow measurements were used to develop stage-discharge rating curves for each location. These rating curves were applied to the stage series to convert water level to discharge.

2.2 Water Quality Sampling

TRC collected water quality samples during five sampling events, including two dry weather events and three wet weather events. One round of water quality was collected at each of the three monitoring locations during dry weather. The number of samples collected at each location varied during wet weather events. The dates and extent of water quality sampling completed are presented in Table 2.

Table 2. Water Quality Sampling Dates and Rounds of Samples Collected

Date	Event Type	Berkeley	Green End	Prospect
11/16/2021	Dry Weather	1*	1*	1*
3/24/2022	Wet Weather	0	0	3
5/24/2022	Dry Weather	1	1	1
9/22/2022	Wet Weather	0	0	3
12/16/2022	Wet Weather	3	3	3
Total		5	5	11

*Ammonia not collected

For each wet weather event, three sounds of sampling were targeted at the Prospect Avenue location: one to capture conditions during the rising limb of the hydrograph, one to capture peak flow, and one to capture the receding limb. Wet weather water quality was only targeted for collection at Berkeley Avenue and Green End Avenue during the December 16, 2022 event.

Field-measured parameters included the following:

- Water temperature
- Dissolved oxygen (% saturation and concentration)
- Turbidity
- pH
- Specific conductance

Laboratory-analyzed water quality included the following:

- Total phosphorus
- Dissolved phosphorus
- Total suspended solids (TSS)
- Total nitrogen (total Kjeldahl nitrogen [TKN] and nitrate/nitrite-nitrogen)
- Ammonia

- Enterococci

Sample volume was insufficient to analyze for ammonia as part of the November 16, 2021 dry weather sampling event. This was remedied in all subsequent sampling rounds by increasing the volume of sample collected.

Water quality measurements and samples were collected in accordance with SOPs established under the project-specific QAPP. Sample collection personnel wore new nitrile gloves when collecting and handling samples. Bacteria samples were collected using aseptic techniques to avoid contamination of the sample matrix or containers. All samples transferred to laboratory custody were accompanied by a completed chain-of-custody (COC) form specific to the laboratory performing the analyses.

2.3 Loading Estimates

The total phosphorus, TSS, and total nitrogen water quality results were applied to the discharge record for each location to calculate loads of each over the course of the Maidford River Baseline Monitoring Program. Loads were derived following methods used by RIDEM for the Newport Water Supply TMDL (RIDEM 2021).

This involved dividing study period days into dry or wet weather days. Dry weather days were defined as those with less than 0.20 inches of precipitation (as measured at Newport State Airport, which is less than a mile from the Maidford River Baseline Monitoring Program area). Wet weather days were defined as those with 0.20 inches or more of precipitation, as well as the following day.

Dry weather loads were derived by taking the mean instantaneous concentration measured during both dry weather sampling events and applying this to all calculated discharges occurring on dry weather days. This provided daily dry weather load totals, which were then added together over the period of the Maidford River Baseline Monitoring Program to develop a program-total dry weather load.

Wet weather loads were derived by developing an Event Mean Concentration (EMC) for each wet weather event. The individual EMCs were then averaged together to develop a single mean EMC for the entirety of the Maidford River Baseline Monitoring Program. This EMC was then applied to all calculated discharges occurring on wet weather days. This provided daily wet weather load totals, which were then added together over the period of the Maidford River Baseline Monitoring Program to develop a program-total wet weather load.

Finally, the total dry and wet weather loads were added together to calculate a total load over the course of the Maidford River Baseline Monitoring Program. This total load was divided by the number of days in the Baseline Monitoring Program and multiplied by 365 to obtain the total annualized load for each pollutant.

2.4 Anuran Call Count Surveys

Anuran (frog) call count surveys were conducted to monitor for the presence of state-listed northern leopard frogs (*Lithobates pipiens*) in and near the Maidford River Restoration Pilot Project area.

Surveys were conducted on a biweekly basis (i.e., every other week) from April 1, 2022 to June 23, 2022, for a total of seven surveys. Survey dates were as follows:

- April 1
- April 14
- April 28
- May 12
- May 26
- June 6
- June 23

Each survey began approximately 30 minutes after sunset and was completed before midnight.

To avoid detecting individuals at multiple stations, monitoring stations were spaced at least 173 meters (570 feet) apart within the monitoring area and were located to provide the greatest reasonably obtainable coverage of the project area while avoiding overlap (Figure 2). This resulted in the selection of five stations (AN-01, AN-02, AN-03, AN-04, and AN-05). The order in which stations were visited was alternated between weeks.

Each station was visited for five minutes during each survey, with survey periods broken into one-minute intervals. Calls were recorded by species and assigned a call index value ranging from 0 to 3, as follows:

0 – No calls heard
1 – Few individuals
2 – Several individuals
3 – Full chorus (i.e., individual calls cannot be distinguished, chorus is constant and overlapping)

Figure 2. Anuran Call Count Monitoring Locations

Although the target of the survey was the northern leopard frog, all anuran species were recorded. Opportunistic observations of other wildlife species were also noted.

Additionally, the following supporting environmental variables were recorded for each survey:

- Air temperature
- Wind speed
- Cloud cover
- Days since last rainfall
- Ambient noise level
- Number of cars passing during active survey

3.0 Results

3.1 Streamflow Measurement

The streamflow measurement results for the Maidford River Restoration Pilot Project Baseline Monitoring Program are summarized in Table 3.

Table 3. Streamflow Measurement Results

Date	Event Type	Event Magnitude (in)	Discharge (cfs)		
			Berkeley	Green End	Prospect
6/25/2021	Dry Weather	N/A	0	0	0
7/14/2021	Dry Weather	N/A	0	0	0.447
8/19/2021	Dry Weather	N/A	0	0	0.403
11/16/2021	Dry Weather	N/A	0.548	0.256	0.887
3/24/2022	Wet Weather Rising	1.18	9.342	13.570	19.954
	Wet Weather Peak		6.751	11.248	14.769
	Wet Weather Receding		3.750	8.693	7.257
5/24/2022	Dry Weather	N/A	0.179	0.062	0.356
9/22/2022	Wet Weather Rising	0.73	0.029	0	0.076
9/22/2022	Wet Weather Peak		0.007	0.011	0.362
9/22/2022	Wet Weather Receding		0	0.125	3.183
12/16/2022	Wet Weather Rising	1.55	3.391	4.990	6.474
	Wet Weather Peak		5.734	6.823	9.492
	Wet Weather Receding		5.849	6.624	8.028

Given the flashiness of the Maidford River system and the typical logistical constraints of wet weather event sampling, it was difficult to collect measurements that fully captured the targeted portions of a storm hydrograph (rising limb, peak, and receding limb) at all three of baseline monitoring locations. For example, the March 24, 2022 visit was initiated too late in the storm event to effectively capture the rising limb of the stream hydrograph. The September 22, 2022 visit was initiated at better point in the storm event but the low antecedent flow conditions and the late start combined with the short duration of the event resulted in missing the rising limb at Berkeley Avenue and the falling limb at Prospect Avenue. Of the three wet weather visits, the December 16, 2022 event appeared to best represent the targeted portions of the storm hydrograph.

The rating curves developed for each streamflow measurement station are provided in Figure 3. Note that events with no measurable flow were omitted from the curves because they provide no additional information and cannot be used in the development of a power curve. Additionally events conducted without a valid water level reading from the associated datalogger were excluded from the rating curves. Therefore, the number of measurements used to calibrate each rating curve vary by location.

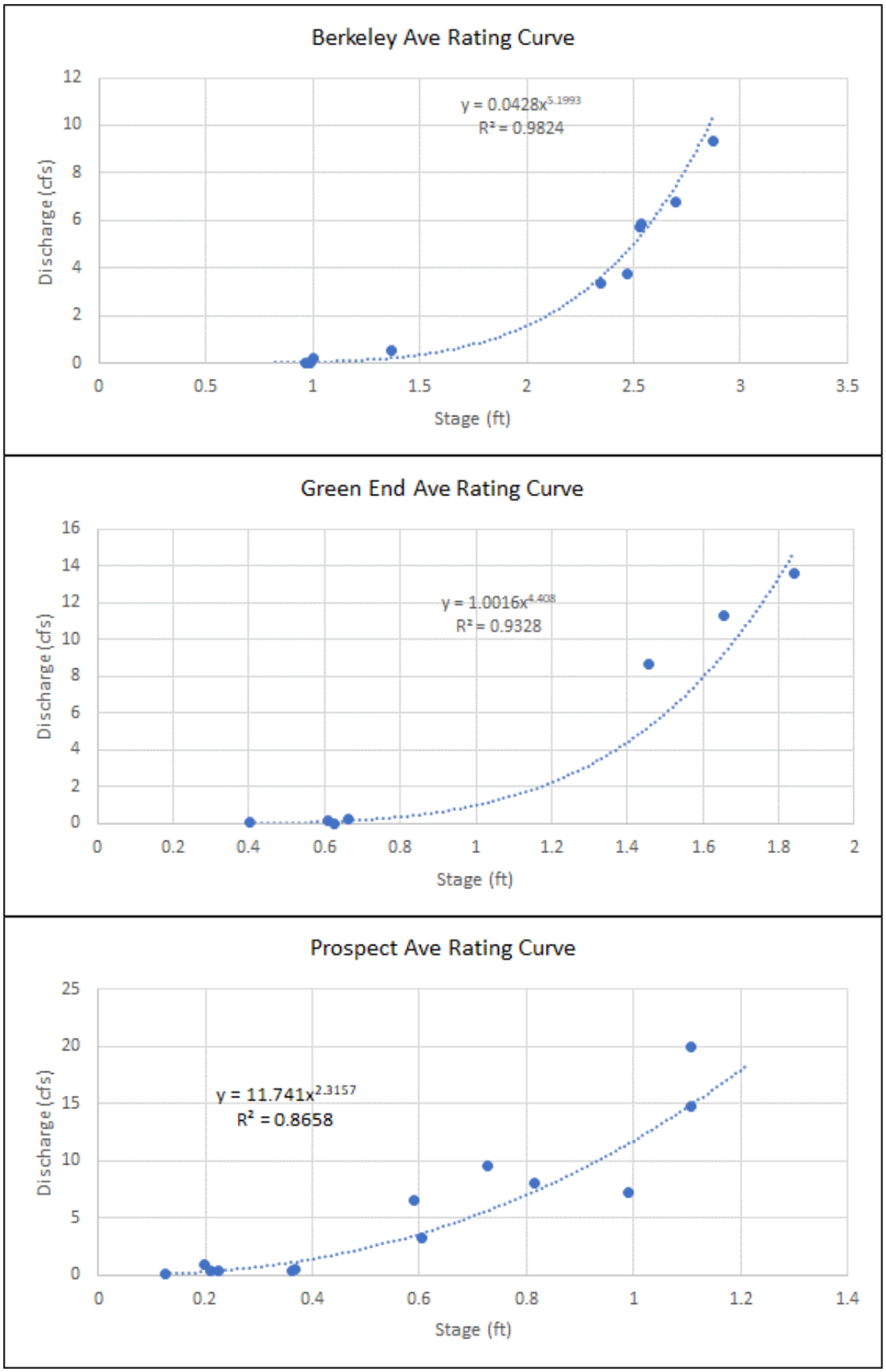

Figure 3. Maidford River Stage-Discharge Rating Curves

3.2 Water Quality Sampling

Full water quality sampling results are presented in Table 4 for field-measured parameters and Table 5 for laboratory-analyzed parameters. Brief descriptions of the results are also provided in the sections below.

Dissolved Oxygen

As in terrestrial ecosystems, oxygen is required to support respiration in most life associated with aquatic ecosystems, including plants, algae, fish, invertebrates, and many other life forms. Oxygen dissolves in water at a rate inversely related to temperature; solubility increases with decreasing water temperature. The Maidford River is a warmwater system, meaning that water temperatures rise too high during the summer to adequately support trout, sculpin, and other coldwater fishes.

In Rhode Island, the state instantaneous dissolved oxygen standard for support of aquatic organisms is 5.0 mg/L and a daily average not less than 60 percent saturation for systems classified as warmwater fish resources.

All measurements collected from the Maidford River met the state instantaneous standard for dissolved oxygen (Table 4).

Water Temperature

Water temperature is a critical factor in a variety of stream physicochemical processes and can be impacted by a variety of direct and indirect factors. Outside of thermal discharges from industrial facilities, most stream temperature impacts are related to reduction of riparian canopy cover or increased watershed imperviousness.

Water temperature standards are typically written in relation to temperatures as they naturally occur. None of the water temperature field measurements were unusual (Table 4), although the lack of natural riparian cover and development of the watershed likely have some impact on temperatures in the Maidford River.

Specific Conductance

Specific conductance is a measure of dissolved ions (salts) in the water standardized to 25°C. Although there are no state numerical standards for conductivity, measurements above 100 µS/cm appear to be associated with human impact in Rhode Island, except near the immediate coast or limestone outcrops. Pavement deicing is one of the most obvious sources of human-derived conductivity, although landscape practices (such as liming and fertilization), septic systems, and treated wastewater discharges, among other contributions may also serve as sources.

All measurements collected from the Maidford River were elevated but none were extreme (Table 4). The highest values were observed under low flow conditions in late spring and early autumn.

Table 4. Water Quality Sampling Results: Field-Measured Parameters

Site / Weather	Date	Time	DO (mg/L)	DO (%)	Temp (C)	Spec. Cond. (µs/cm)	Turbidity (NTU)	pH (SU)
Berkeley								
Dry	11/16/2021	1115	*	*	8.2	299.3	3.1	7.17
Dry	5/24/2022	1115	7.78	76.5	14.3	236.7	0.73	6.74
Wet	12/16/2022	930	9.51	75.6	5.1	217.2	7.88	6.76
Wet	12/16/2022	1100	11.41	91.3	5.3	192.9	10.29	6.58
Wet	12/16/2022	1230	11.54	92.6	5.6	185.7	8.09	6.55
Green End								
Dry	11/16/2021	1030	*	*	8	143.9	2.08	7.15
Dry	5/24/2022	1040	8.13	82.7	16.1	309.1	0.22	7.20
Wet	12/16/2022	900	11.36	90.0	5.1	208.3	10.06	6.88
Wet	12/16/2022	1040	11.18	89.4	5.3	193.5	12.36	6.73
Wet	12/16/2022	1200	10.98	88.6	5.6	184.5	12.01	6.71
Prospect								
Dry	11/16/2021	915	*	*	8.3	147.5	1.19	6.96
Wet	3/24/2022	900	13.15	103.6	5.3	141.6	21.98	7.40
Wet	3/24/2022	1145	12.02	96.0	5.8	122.3	15.94	7.41
Wet	3/24/2022	1330	12.26	102.1	6.2	165.0	11.94	7.40
Dry	5/24/2022	1000	8.93	86.2	13.9	346.8	0.65	6.88
Wet	9/22/2022	1330	8.01	85.7	18.4	368.0	1.87	6.66
Wet	9/22/2022	1445	8.82	94.1	18.4	348.1	1.75	6.35
Wet	9/22/2022	1530	8.83	94.0	18.3	238.1	7.2	6.52
Wet	12/16/2022	830	11.83	94.7	5.5	230.2	8.23	6.87
Wet	12/16/2022	1000	11.48	92.1	5.6	193.8	11.85	6.77
Wet	12/16/2022	1130	11.52	92.9	5.7	196.1	7.53	6.62

*Not measured due to sensor malfunction

Turbidity

Turbidity is a measure of light scattering by matter in the water column and tends to increase with the input or disturbance of sediments or organic matter.

Some waterbodies are naturally turbid. Therefore, turbidity standards seek to prevent the elevation of turbidity above naturally occurring background levels. In Rhode Island, the water quality numerical criterion for turbidity is not to exceed 5 NTU over background in Class AA waters.

In the Maidford River, turbidity tended to be highest during wet weather conditions, often rising to levels an order of magnitude higher than dry weather (Table 4)

pH

The pH of water indicates whether it is acidic (< 7 SU), circumneutral (~7 SU), or basic (> 7 SU). As with dissolved oxygen, pH may vary substantially over distances and over time (even in a single day). Therefore, a single snapshot of pH (as collected in this study) should be interpreted with caution.

In Rhode Island, the pH criteria are 6.5 to 9.0 standard units or as naturally occurs.

Maidford River pH levels ranged from somewhat acidic (6.35 SU) to somewhat basic (7.41 SU)(Table 4). The lower end of these readings, observed at Prospect Avenue on September 22, 2022 was below the state minimum numerical criterion. However, no observations were made that would indicate this pH value to be caused by a specific anthropogenic source.

No consistent seasonal, weather, or longitudinal trends in pH were observed at the Maidford River during the course of this study (Table 4).

Phosphorus

Phosphorus is an essential nutrient for aquatic life but high levels of phosphorus can result in rapid growth of algae and lead to eutrophication. Excessive phosphorus may also encourage cyanobacteria blooms, particularly in still waters, which can lead to production of cyanotoxins or taste and odor issues. This may impact aquatic life, recreation, and aesthetics, as well as drinking water in water supply reservoirs, such as those in the Newport Water Department's reservoir system.

The Rhode Island phosphorus numeric criterion is 0.025 mg/L for any lake, pond, kettlehole, or reservoir, as based on average total phosphorus. Phosphorus in tributaries, such as the Maidford River, cannot cause an exceedance of this criterion in in receiving waters. The 2021 Total Maximum Daily Load for the City of Newport's drinking water reservoirs, which receiving diverted water from the Maidford River, set a total phosphorus target of 0.018 mg/L.

Dissolved phosphorus does not carry the same numeric criteria as total phosphorus. However, because dissolved phosphorus is likely to be more biologically available than particulate phosphorus, substantially lower concentrations are typically desirable.

Both total and dissolved phosphorus concentrations analyzed as part of this study were highest during wet weather (Table 5). However, dissolved phosphorus made up a larger fraction of total phosphorus during dry weather conditions. All total phosphorus results were well above 0.025 mg/L.

Nitrogen

As with phosphorus, nitrogen is an essential nutrient for aquatic life. Likewise, high levels of nitrogen can result in eutrophication. Although elevated nitrogen levels are less directly associated with the development of cyanobacteria blooms in freshwaters, they are still considered undesirable and can lead to excessive algal growth. Additionally, nitrogen tends to have a more substantial impact on brackish and saltwater receiving waters.

The nitrogen cycle is somewhat more complex than that of phosphorus. As with phosphorus, nitrogen compounds can be added via atmospheric deposition, inputs of plant matter from shoreline vegetation, and transport of nitrogen into a water body through runoff, other surface flows, or groundwater movement. However, unlike phosphorus, atmospheric nitrogen can also be converted into more available forms of nitrogen and added to the aquatic systems when it is "fixed" by cyanobacteria. Likewise, nitrogen can be removed from aquatic systems through the process of denitrification, in which microbes convert nitrate back to inert gaseous nitrogen.

There are no state numerical standards for nitrogen in Rhode Island. However, total nitrogen values above 1.0 mg/L are typically indicative of human influence, particularly when nitrate, nitrite, or ammonia are documented at or above this concentration.

The nitrogen results obtained as part of this study were well above 1.0 mg/L at every location during each sampling round (Table 5). Nitrate-nitrogen was particularly elevated during dry weather and tended to increase in the downstream direction. TKN, which includes both organic nitrogen and ammonia-nitrogen, was also frequently elevated, although it tended to be highest during wet weather conditions. Ammonia concentrations were generally low or not detectable, indicating that most of the TKN was organic nitrogen. Finally, nitrite-nitrogen was the least commonly detected nitrogen fraction and only found at low levels in four samples.

TSS

Total suspended solids (TSS) is a measure of the amount of particulate and colloidal material suspended in the water column (and therefore readily transported). This measure may be used to assess water clarity as well as a correlate for pollutants that are commonly found in particulate organic matter (e.g., TKN) or bound to or growing on particulate mineral substrates (e.g., phosphorus and bacteria). Although TSS is naturally occurring at some level, excessive TSS may produce undesirable effects in receiving waters.

There are no state numerical standards for TSS in Rhode Island.

TSS was low at all locations during dry weather conditions (Table 5). However, TSS concentrations became elevated during wet weather, more so at Green End Avenue and Prospect Avenue than Berkeley Avenue.

Bacteria (Enterococci)

Enterococci, occur in the digestive tracts of humans and other animals. Although these bacteria may not always directly cause illness, they serve as indicators of fecal contamination and possible pathogens. Enterococci are salt-tolerant organisms, as compared to *E. coli*, and are therefore usually preferred for monitoring bacteria levels in brackish or salt water (Byappanahalli et al. 2012).

The Rhode Island enterococci numeric criteria are applicable for primary contact recreation and swimming. Although the Maidford River is not used for primary recreation, high levels of bacterial indicators are still undesirable, especially since some flow is diverted to the City of Newport's water supply reservoir system and the rest is discharged at Third Beach, a saltwater swimming

beach. The single sample maximum is 61 colonies/100 mL for freshwater and 104 colonies/100mL for saltwater.

Enterococci results from this study indicated increasing levels downstream during all weather conditions (Table 5). Some dry weather and all wet weather samples exceeded the state numerical criteria. Six of the nine wet weather samples collected at Prospect Avenue were too high to quantify (>2,400 MPN).

Table 5. Water Quality Sampling Results: Laboratory-Analyzed Parameters

Site / Weather	Date	Time	Total P (mg/L)	Dissolved P (mg/L)	Nitrate-N (mg/L)	Nitrite-N (mg/L)	TKN (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Enterococci (MPN)
Berkeley										
Dry	11/16/2021	1115	0.053	0.045	1.21	<0.010	0.57	*	<3.3	41
Dry	5/24/2022	1115	0.073	0.019	0.9	<0.010	0.69	<0.05	3.3	26
Wet	12/16/2022	930	0.188	0.086	0.81	<0.010	1.05	<0.10	29	250
Wet	12/16/2022	1100	0.216	0.116	0.74	<0.010	1.12	<0.10	26	866
Wet	12/16/2022	1230	0.181	0.102	0.7	<0.010	1.08	0.15	14	1200
Green End										
Dry	11/16/2021	1030	0.045	0.042	1.9	<0.010	0.53	*	<3.3	59
Dry	5/24/2022	1040	0.059	0.035	1.45	0.01	0.82	<0.05	<3.3	340
Wet	12/16/2022	900	0.233	0.092	0.9	<0.010	1.15	<0.10	41	1300
Wet	12/16/2022	1040	0.268	0.121	0.86	<0.010	0.86	<0.10	44	1410
Wet	12/16/2022	1200	0.247	0.139	0.88	<0.010	1.25	0.1	32	1300
Prospect										
Dry	11/16/2021	915	0.049	0.028	2.37	<0.010	0.82	*	<3.3	82
Wet	3/24/2022	900	0.294	0.07	0.57	<0.010	1.88	0.22	58	>2400
Wet	3/24/2022	1145	0.222	0.10	0.62	<0.010	1.45	0.19	40	>2400
Wet	3/24/2022	1330	0.171	0.072	0.62	<0.010	1.48	0.29	22	>2400
Dry	5/24/2022	1000	0.07	0.053	2.82	<0.01	0.93	<0.05	6	130
Wet	9/22/2022	1330	0.048	0.038	2.43	0.01	0.63	<0.05	<3.3	>2400
Wet	9/22/2022	1445	0.089	0.058	2.3	0.012	0.79	0.08	8.7	>2400
Wet	9/22/2022	1530	0.202	0.12	1.67	0.02	1.3	0.24	17	>2400
Wet	12/16/2022	830	0.184	0.101	1.07	<0.010	1.3	<0.10	37	1730
Wet	12/16/2022	1000	0.234	0.077	0.85	<0.010	1.22	<0.10	41	1990
Wet	12/16/2022	1130	0.251	0.117	0.89	<0.010	0.89	<0.10	38	1410

*Not analyzed during this round due to insufficient sample volume.

3.3 Loading Estimates

The calculated discharge series for each location is presented in Figures 4 through 6. The discharge series demonstrate the flashiness of the Maidford River system, with runoff-driven peak flows towering over the minimal base flows observed. Figures are depicted in order from upstream (Berkeley Avenue) to downstream (Prospect Avenue).

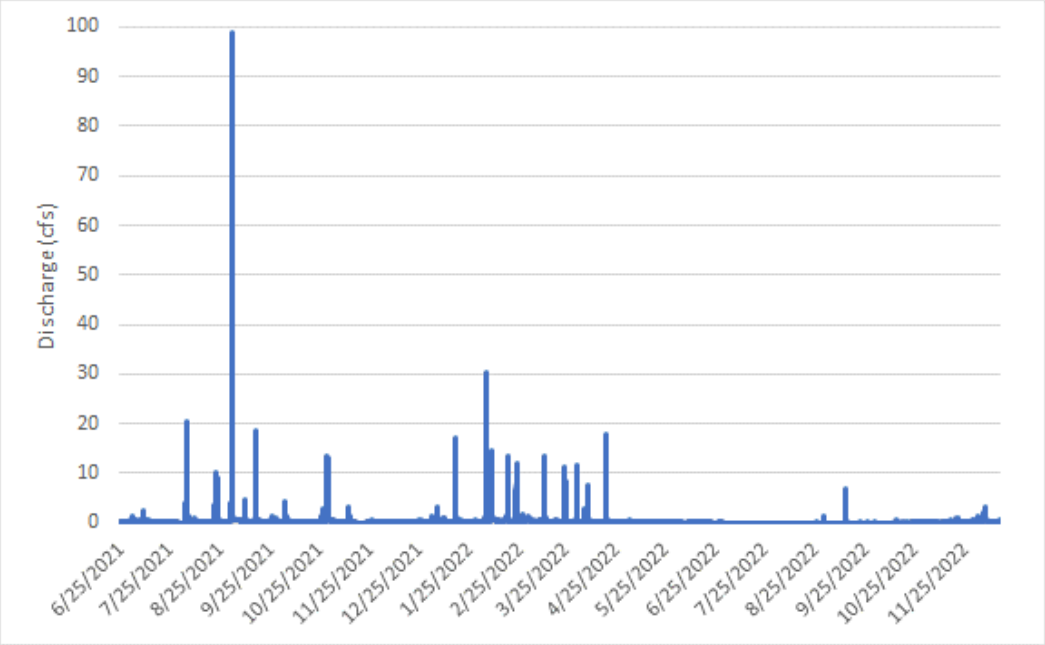

Figure 4. Berkeley Avenue Discharge Series

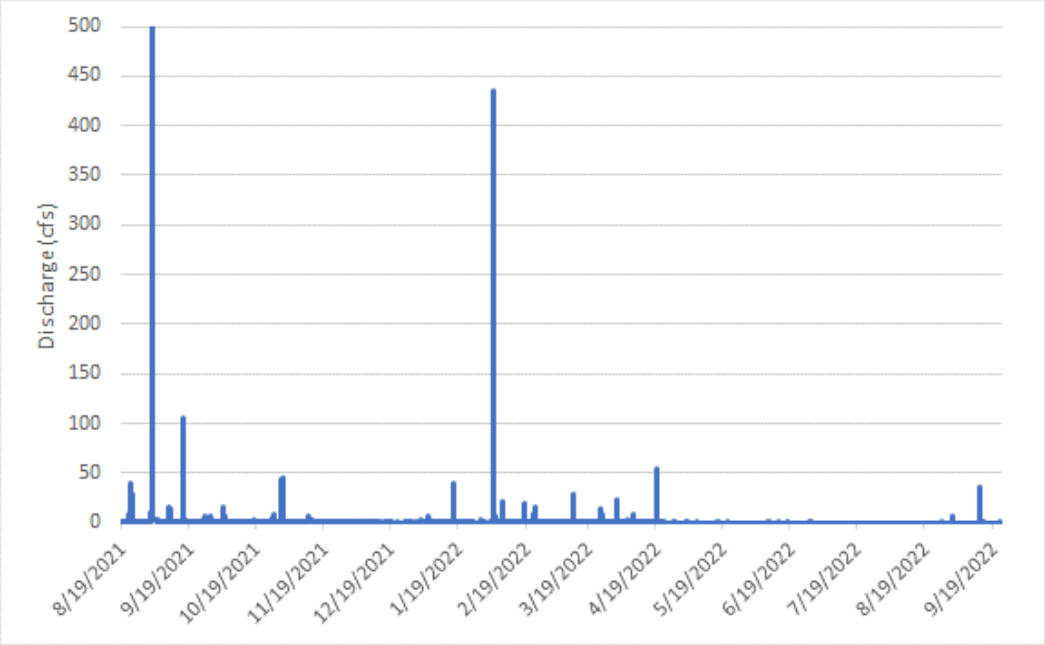

Figure 5. Green End Avenue Discharge Series

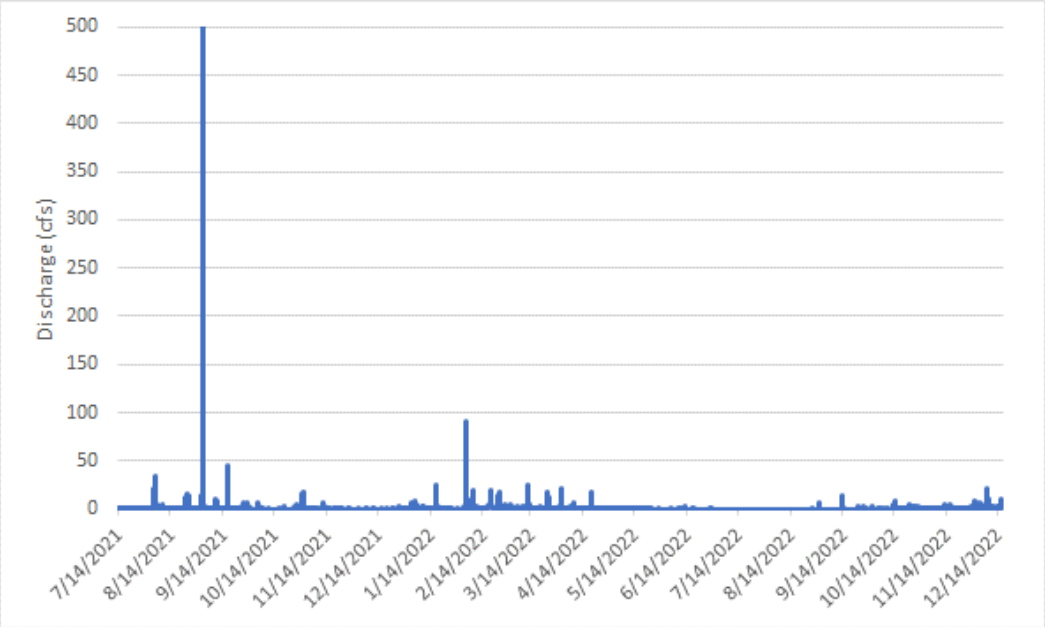

Figure 6. Prospect Avenue Discharge Series

Flow statistics for each location, including mean, median, low, and peak flows are presented in Table 6. Each statistic is also broken out by dry and wet weather conditions. As expected, most flow statistics increased from upstream to downstream, although of note, all three flow monitoring locations experienced cessation of flow at some point over the course of the study (Table 6).

The Berkeley Avenue monitoring location sustained the longest period without flow (Figure 4). This is also reflected in the temperature record for the Berkeley Avenue location, which indicates large diel swings in temperature (a sign of datalogger exposure) from mid-July to early September 2022 (Figure 7). The Green End Avenue and Prospect Avenue temperature records also suggests some exposure of the datalogger, although for shorter periods in August (Figures 8 and 9).

Table 6. Key Flow Statistics

Statistic	Berkeley			Green End			Prospect		
	All	Dry	Wet	All	Dry	Wet	All	Dry	Wet
Number of Days	400	296	104	400*	296	104*	400	296	104
Mean Flow (cfs)	0.441	0.174	1.200	2.508*	0.233	9.035*	1.138	0.467	3.048
Mean Flow (cfs) Excluding 9/2/21 and 2/4/22 events	N/A	N/A	N/A	0.599	0.233	1.671	N/A	N/A	N/A
Median Flow (cfs)	0.193	0.174	0.275	0.138	0.113	0.277	0.366	0.269	0.871
Low Flow (cfs)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Peak Flow (cfs)	98.9	1.661	98.9	4,528*	2.660	4,528*	594	5.372	594
Peak Flow (cfs) Excluding 9/2/21 and 2/4/22 events	N/A	N/A	N/A	105	2.660	105	N/A	N/A	N/A

*Results include extreme outlier events on September 2, 2021 (6.23 inch rainfall event) and February 4, 2022 (1.81 inch rainfall event with snowmelt).

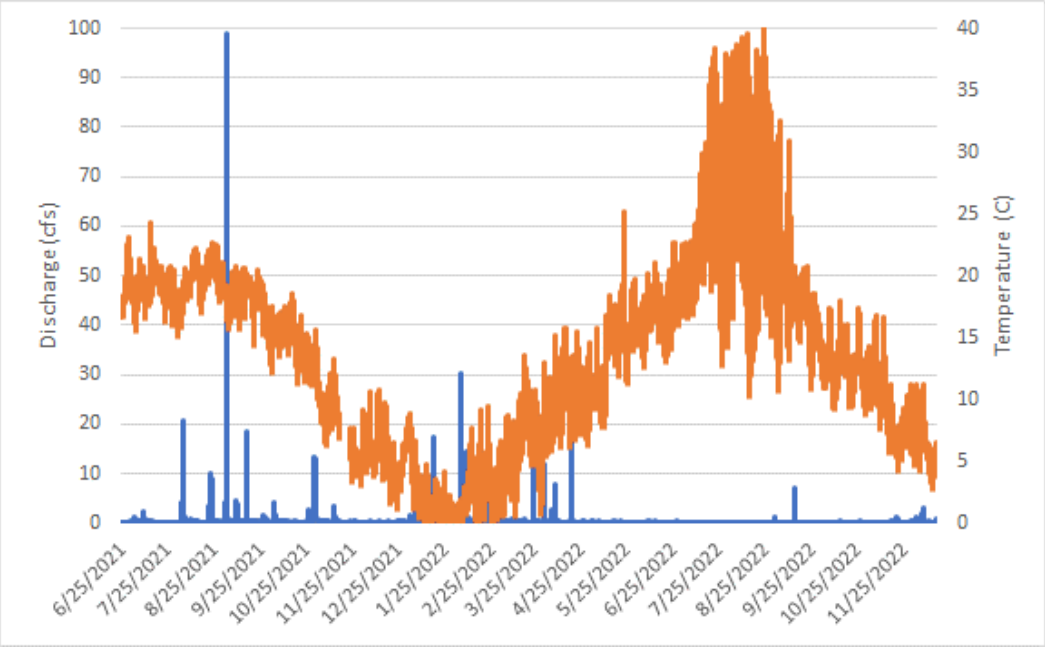

Figure 7. Berkeley Avenue Temperature Series

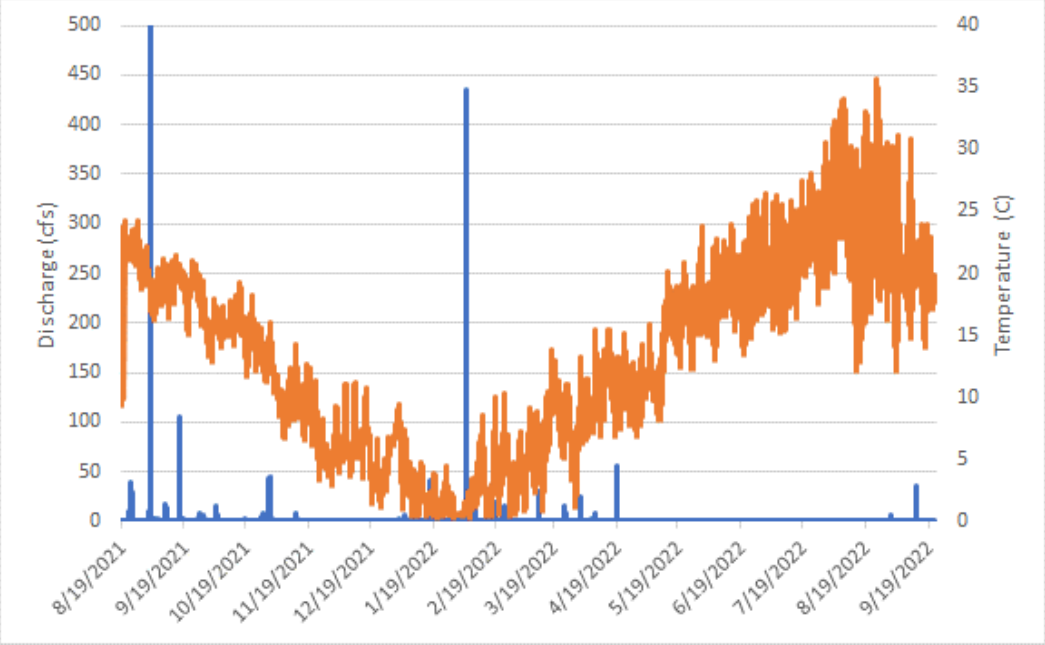

Figure 8. Green End Avenue Temperature Series

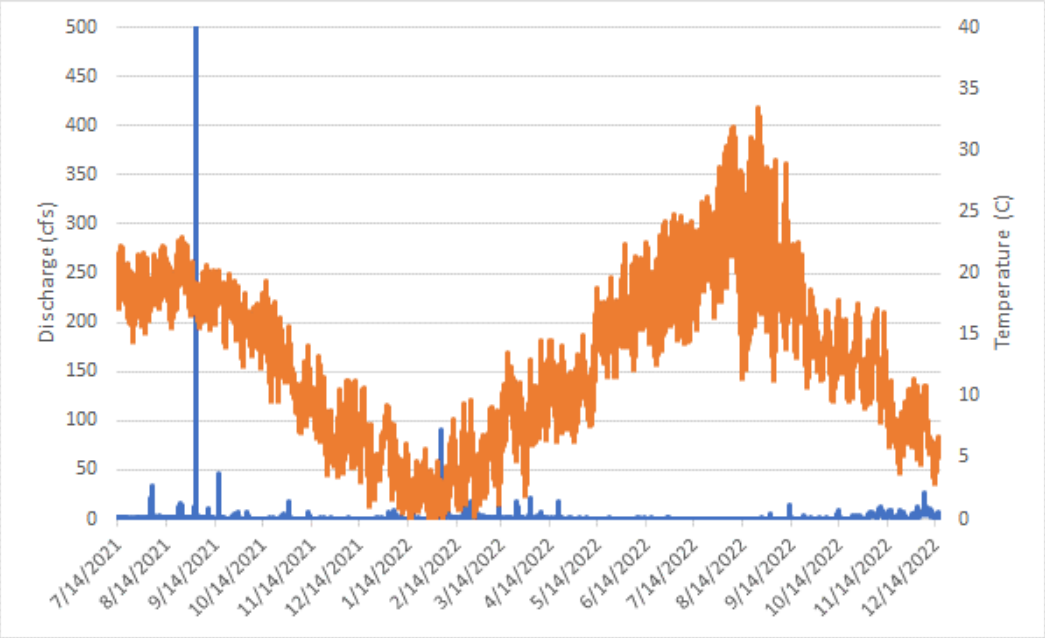

Figure 9. Prospect Avenue Temperature Series

The average concentrations of total phosphorus, total nitrogen, and TSS measured during dry and wet weather conditions are provided in Table 7. These values were used in combination with the mean flows to calculate loading estimates for each analyte over the course of this study, as well as on an annualized basis. As can be seen, the concentrations of total phosphorus and TSS greatly increased during wet weather conditions. Total nitrogen concentration increased somewhat during wet weather at Berkeley Avenue but decreased at Green End Avenue and Prospect Avenue.

Table 7. Dry and Wet Weather Concentrations

Weather	Berkeley			Green End			Prospect		
	Total P (mg/L)	Total N (mgl/L)	TSS (mg/L)	Total P (mg/L)	Total N (mgl/L)	TSS (mg/L)	Total P (mg/L)	Total N (mgl/L)	TSS (mg/L)
Dry	0.063	1.685	3.3	0.052	2.36	3.3	0.060	3.48	4.7
Wet	0.195	1.833	23	0.249	1.98	39	0.188	2.45	29.4

The total and annualized loading estimates for total phosphorus, total nitrogen, and TSS are provided in Table 8. Given the increasing discharge with distance downstream (Table 6) and the observed patterns in concentrations (Table 7), loading of all three analytes broadly increases in the downstream direction. Additionally, wet weather conditions drive the bulk of total phosphorus and TSS loading. Wet weather also produces the majority of total nitrogen loading, although the difference between dry and wet weather loading totals is less substantial than it is for total phosphorus and TSS.

Table 8. Loading Estimates for Phosphorus, Nitrogen and Suspended Sediments over Period of Study

Period	Weather	Berkeley			Green End			Prospect		
		Total P (kg)	Total N (kg)	TSS (kg)	Total P (kg)	Total N (kg)	TSS (kg)	Total P (kg)	Total N (kg)	TSS (kg)
Study Duration (400 Days)	Dry	6	161	313	7	300	419	15	886	1,184
	Wet	45	424	5,288	80	633	12,483	110	1431	17,190
	Total*	51	585	5,600	86	933	12,902	125	2,317	18,373
Annualized	Dry	6	147	286	6	274	383	14	808	1,080
	Wet	41	387	4,825	73	577	11,391	100	1,306	15,685
	Total*	46	533	5,110	79	851	11,773	114	2,114	16,766

*Total may not equal the sum of dry and wet weather loading, due to rounding error.

3.4 Anuran Call Count Surveys

The primary target species of the anuran surveys – northern leopard frog (*Lithobates pipiens*) – was not observed at any point over the course of the survey period. However, four other species of frogs were identified calling during the survey period: spring peeper (*Pseudacris crucifer*), American toad (*Anaxyrus americanus*), green frog (*Lithobates clamitans*), and gray treefrog (*Dryophytes versicolor*). Additionally, pickerel frog (*Lithobates palustris*) was visually observed to be present in the survey area during daytime stream discharge monitoring, even though it was not documented during the anuran call count surveys. The results of anuran calling for each survey were tabulated by survey station for each species (Table 9).

Table 9. Anuran Calls Heard by Survey Station and Calling Index, April 1 to June 23, 2022

Survey Station	Call Index	Number of 1-Minute Intervals Each Species was Heard Calling per Calling Index*			
	0-3	Spring peeper	American toad	Green frog	Gray treefrog
AN-01	0	0	0	3	4
	1	5	6	6	1
	2	15	4	1	0
	3	5	0	0	0
AN-02	0	3	10	9	0
	1	17	0	1	5
	2	0	0	0	0
	3	5	0	0	0
AN-03	0	5	5	10	0
	1	14	5	0	5
	2	6	0	0	0
	3	0	0	0	0
AN-04	0	9	8	4	0
	1	11	2	6	5
	2	5	0	0	0
	3	0	0	0	0
AN-05	0	4	7	9	5
	1	6	3	1	0
	2	1	0	0	0
	3	14	0	0	0
All Station Totals	0	21	30	35	9
	1	53	16	14	16
	2	27	4	1	0
	3	24	0	0	0
Audible Calling Index Totals**	**1-3**	**104**	**20**	**15**	**16**

* Pickerel frog was visually observed in the survey area but not heard during the anuran call count survey period.
** Audible Calling Index Totals is the total number of intervals that calls were heard for each species at intervals 1, 2, or 3, which excludes the Index 0 intervals when no calls were heard.

Spring peepers had the highest observed frequency of calling, as the species was heard at an index of 1, 2, or 3 during 104 of the total 175 one-minute survey intervals (Table 9). American toads had the second largest calling frequency as they were heard during 20 one-minute survey intervals. Green frogs were heard during 15 one-minute intervals during the last two surveys, and the gray treefrog was heard during 16 1-minute intervals during Survey 7.

Most calls heard throughout the survey were made by spring peepers, though no spring peepers were heard calling in Week 6 or Week 7 (Figure 10). Very few calls were heard by any species in Weeks 5, 6, and 7 compared to Weeks 1-4.

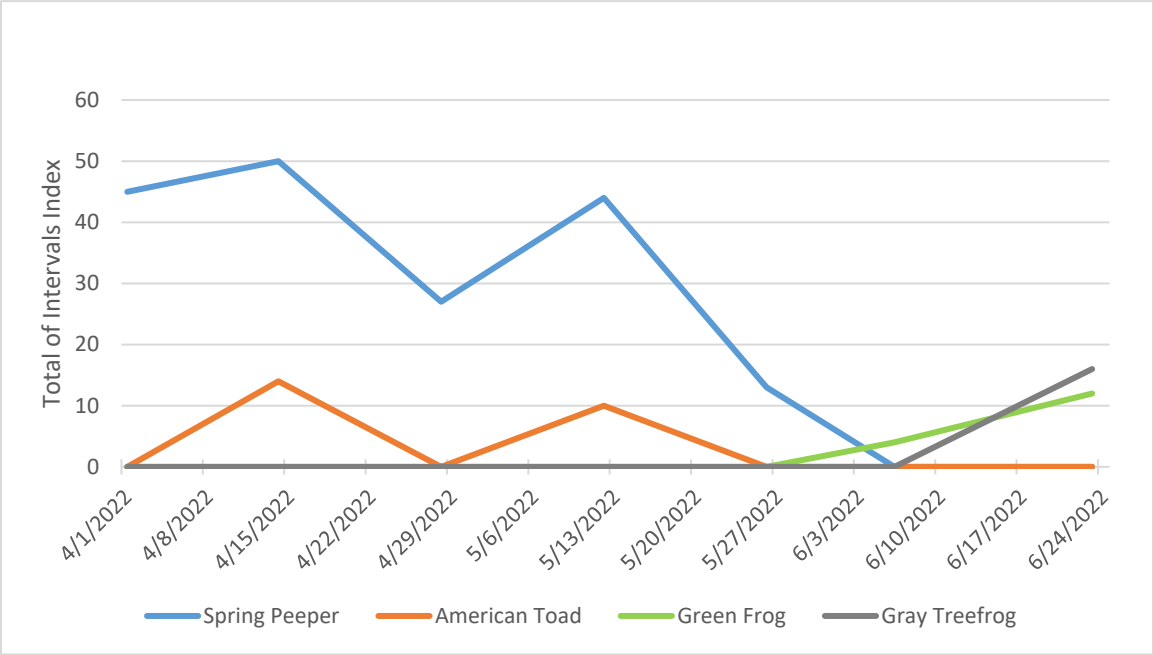

Figure 10. Biweekly Anuran Call Survey Totals by Species

A large wetland complex is found to the east of the Maidford River between survey stations AN-01 and AN-02 (Figure 2). A portion of this wetland is to the west of the river and east of Berkeley Avenue where the river nears its crossing with Berkeley Avenue as it flows to the south. Standing water was observed within the survey plot for AN-01 throughout the first three surveys, and an abundance of spring peepers were heard calling from this pooled area. Green frogs and gray treefrogs were also heard calling at AN-01, east of Berkeley Avenue, while American toads were heard calling at AN-01, west of Berkeley Avenue.

A wetland area exists to the west of Berkeley Ave near AN-02, and spring peepers were heard calling from this complex as well. A full chorus of spring peeper calls were heard here in early April but were infrequent through May, until they were no longer heard starting in June. Green frogs and gray treefrogs were heard from the AN-02 station during Survey 7, with both species vocalizing from the east of Berkeley Avenue.

AN-03 is adjacent to a densely vegetated scrub-shrub area with the Maidford River passes through in a southern direction. Spring peepers were heard calling in the roadside ditch, west of Berkeley Ave at AN-03, as well as to the east where roadside ditching occurs, and water collects. During Survey 2 American toads were heard calling at this station. Gray treefrogs were also heard from AN-03, with calls originating from the east side of Berkeley Avenue.

AN-04 is located on the western side of Berkeley Avenue where the road cuts to the southwest towards the Maidford River, which emerges from the forested/shrub area to run along the western side of the road. Spring peepers were heard from AN-04 primarily the eastern side of Berkeley Avenue, both where water pools in the roadside ditching and in the small wetland complex to the east of Berkeley Ave between AN-04 and AN-05. A single American toad was heard calling from AN-04 during Survey 4, and green frogs were heard calling during Surveys 6 and 7 from within

the river channel on the west side of Berkeley Ave. A gray treefrog was also heard calling from this station during Survey 7.

AN-05 is directly west of where the Maidford River emerges to the south of Green End Avenue after passing under. Spring peepers were heard in the wetland area to the south of the AN-05 station, with a full chorus heard during Surveys 1, 2 and 4. During Week 4, American toads were heard from AN-05, to the north of Green End Ave. A single green frog was heard calling at AN-05 during Survey 6, with another heard calling under the Green End Ave overpass between AN-04 and AN-05. Frequent traffic was experienced during survey stops at AN-05 as the station is located directly next to the intersection of Green End Ave and Berkeley Ave. This created significant noise interference while listening for calls.

4.0 Quality Assurance/Quality Control

Overall, data collected as part of this project met the Data Quality Objectives (DQOs) identified in the QAPP. However, where exceptions occurred, data were either qualified or removed from analysis, as appropriate. The primary exceptions are described below:

1. The first two months of water level data recorded at Green End Avenue (i.e., June and July 2021) were incomplete, the Prospect Avenue water level datalogger was not activated until July 14, 2022, and the Green End Avenue datalogger was lost after the September 22, 2022 field visit. Therefore, TRC truncated the dataset used to calculate annualized loading so that only continuous discharge data from the August 19, 2021 to September 22, 2022 period were used to support this calculation. That allowed the annualized loading calculations to be based on the same period for all three locations.
2. The Green End Avenue rating curve is based on the fewest measurements of the three monitoring locations and also lacks any measurements for the 0.7 feet to 1.4 feet stage interval. Stage was also more variable at this location than elsewhere in the study area, ranging from 0.0 feet to 6.7 feet. As a result, discharge calculations for this monitoring location were subject to more error, particularly when water levels far exceed the range for which field measurements were collected, as they did on September 2, 2021 and February 4, 2022. Therefore, data for these two largest storm event dates were removed from the loading calculations at Green End Avenue to reduce bias.

No other substantive QA/QC exceptions were noted over the course of the Baseline Conditions Monitoring Program.

5.0 References

Byappanahalli, M. N., M. B. Nevers, A. Korajkic, Z. R., Staley, and V. J. Harwood. 2012. Enterococci in the environment. *Microbiology and Molecular Biology Reviews,* 76(4): 685-706.

Rhode Island Department of Environmental Management [RIDEM]. 2017. Maidford River and Paradise Brook Water Quality Study and Pollutant Source Information. Prepared by Office of Water Resources, Rhode Island Department of Environmental Management.

Rhode Island Department of Environmental Management [RIDEM]. 2021. Total Maximum Daily Loads for Phosphorus for the City of Newport Drinking Water Reservoirs. Prepared by Office of Water Resources, Rhode Island Department of Environmental Management.

Appendix A: Continuous Data Records
(Digital Files)