Water Quality Report: 2018
Quabbin Reservoir Watershed
Ware River Watershed

Quabbin Reservoir at Sunset (Bernadeta Susianti, 2019)

August 2019

Massachusetts Department of Conservation and Recreation
Office of Watershed Management
Division of Water Supply Protection
Quabbin/Ware Region

Abstract

This report is a summary of water quality monitoring methods and results from 24 surface water sites located throughout the Quabbin Reservoir and Ware River watersheds, as well as other special assessment samples and periodic storm event sampling. The Department of Conservation and Recreation (DCR), Division of Water Supply Protection (DWSP), is the state agency charged with the responsibility of managing Quabbin Reservoir and its surrounding natural resources in order to protect, preserve, and enhance the environment of the Commonwealth and to assure the availability of safe drinking water to future generations. The Environmental Quality Section manages a comprehensive water quality monitoring program to ensure that Quabbin Reservoir water meets state drinking water quality standards. As part of this task, the Environmental Quality Section performs field work, interprets water quality data, and prepares reports of findings. This annual summary is intended to meet the needs of watershed managers, the interested public, and others whose decisions must reflect water quality considerations.

In 2018, Quabbin Reservoir water quality satisfied the requirements of the Filtration Avoidance Criteria established under the Environmental Protection Agency Surface Water Treatment Rule. Monitoring of tributaries is a proactive measure aimed at identifying trends and potential problem areas that may require additional investigation or corrective action. Compliance with state surface water quality standards among the tributaries varied, with minor exceedances attributed to higher solute loads measured during storm events, wildlife impacts on water quality, and/or natural attributes of the landscape.

The appendices to this report include field investigation reports, summary information on mean daily flows of gauged tributaries, water quality data summary tables, and plots of reservoir and tributary water quality results and flow statistics. Some of the ancillary data presented in this report has been compiled with the help of outside agencies (e.g., U.S. Geological Survey) and other workgroups within DWSP whose efforts are acknowledged below.

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Abbreviations

The following **abbreviations** are used in this report:

AIS	Aquatic invasive species
ARM	Acid Rain Monitoring Project at the University of Massachusetts
BWTF	Brutsch Water Treatment Facility
CVA	Chicopee Valley Aqueduct
DCR	Massachusetts Department of Conservation and Recreation
DWSP	Department of Conservation and Recreation, Division of Water Supply Protection
EPA	Environmental Protection Agency
EQA	Environmental Quality Assessment
E. coli	*Escherichia coli*
MassDEP	Massachusetts Department of Environmental Protection
MWRA	Massachusetts Water Resources Authority
PDA	Personal digital assistant
SWTR	Surface Water Treatment Rule
TKN	Total Kjeldahl nitrogen
TP	Total Phosphorus
UV_{254}	Ultraviolet absorbance at 254 nanometers
USGS	U.S. Geological Survey
WDI	Winsor Dam Intake

Units of Measurement

Chemical concentrations of constituents in solution or suspension are reported in milligrams per liter (mg/L) or micrograms per liter (µg/L). These units express the concentration of chemical constituents in solution as mass (mg or µg) of solute per unit of volume of water (L). One mg/L is equivalent to 1,000 µg/L. Fecal coliform results are reported as the number of presumptive colony forming units per 100 milliliters of water (CFU/100 mL). Total coliform and *E. coli* are reported as the most probable number (MPN/100 mL). Mean UV_{254} results are reported as the amount of ultraviolet light at a 254 nm wavelength that is able to transmit through a water sample in absorbance units per centimeter of path length (ABU/cm).

The following **units of measurement** are used in this report:

ABU/cm	Absorbance units per centimeter of path length
cfs	Cubic feet per second
CFU	Colony-forming unit
°C	Degrees Celsius
ft	feet
in	inch
µS/cm	Microsiemens per centimeter
MGD	Million gallons per day
µg/L	microgram/liter
mg/L	milligram/liter
m	meters
MPN	Most probable number
NTU	Nephelometric turbidity units
S.U.	Standard Units (pH)

1 Introduction

The Quabbin Reservoir, Ware River, and Wachusett Reservoir watershed system supplies drinking water to 51 communities in Massachusetts, serving approximately 3 million Massachusetts residents (DWSP, 2018a). These include 45 communities in the greater Boston and MetroWest region, three in western Massachusetts, and three as emergency supplies. The Department of Conservation and Recreation, Division of Water Supply Protection (DWSP), monitors and manages the watersheds to protect the drinking water source, while the Massachusetts Water Resources Authority (MWRA) manages the infrastructure and provides treatment. Both DWSP and MWRA monitor the water quality and quantity to deliver safe and sufficient drinking water to the communities served. The watershed system and the MWRA service area are shown in **Figure 1**. This report summarizes the water quality monitoring performed by DWSP in the Quabbin Reservoir and Ware River watersheds during 2018.

1.1 Description of Watersheds

The Quabbin Aqueduct serves to connect the three drinking water sources: the Quabbin Reservoir, Ware River, and Wachusett Reservoir. The Quabbin Reservoir is the largest of these sources, with a capacity of 412 billion gallons (the Wachusett Reservoir holds 65 billion gallons when filled to capacity). Construction of the Quabbin Reservoir was completed in 1939. In plan view, the reservoir shape is best described as two interconnected fingers (basins), trending North-South. The larger, eastern finger is 18 miles long with a maximum width of approximately four miles. The smaller, western, finger is 11 miles long and one mile in width at its widest point. The total surface area of the reservoir is 39 square miles (24,469 acres), with 118 miles of shoreline. General facts and figures about Quabbin Reservoir are summarized in **Table 1a**.

The Quabbin Reservoir watershed encompasses 187.5 square miles (119,935 acres) and includes nearly all of the towns of New Salem and Petersham, considerable portions of Pelham, Shutesbury, and Wendell, and smaller portions of Orange, Hardwick, Phillipston, Belchertown, Ware and Athol, MA (**Figure 2**). Nearly 90% of the watershed lands are forested, and DWSP owns and controls 53,278 acres (56%) of watershed area for water supply protection purposes. Including the reservoir, DWSP owns and controls 65% of the entire watershed area (**Table 1b**). Non-DWSP owned watershed lands are characterized as rural-residential with few agricultural areas (2%), which helps maintain the high quality of water in the Quabbin Reservoir.

The Ware River Watershed is located in the Central Uplands of north central Massachusetts, east of Quabbin Reservoir watershed. The Ware River begins as two branches (the East Branch and West Branch Ware River) that converge to form the Ware River in Hubbardston, MA. DWSP monitors a total area of 96.5 square miles (61,737 acres), upstream of the Quabbin Aqueduct at Shaft 8 in Barre, MA. The Ware River Watershed area monitored by DWSP intersects portions of the municipalities of Barre, Phillipston, Hubbardston, Oakham, Rutland, Princeton, Templeton, and Westminster, MA (**Figure 3**). Land use in the Ware River watershed is predominantly forested (75.6%), with approximately 41% of the watershed area controlled by DWSP (**Table 1c**). Agriculture comprises 3% of total watershed area for the Ware River watershed (DWSP, 2018a). The Ware River Watershed essentially functions as a tributary to Quabbin Reservoir via the Quabbin Aqueduct and a diversion structure along the Ware River in Barre. (**Figure 3**). Additional information regarding land use and ownership in the Quabbin Reservoir and Ware River watersheds is presented in the *Watershed Protection Plan FY19-23* (DWSP, 2018a) and the *2017 Land Management Plan* (DWSP, 2018d). Diversion of Ware River water to the Quabbin Reservoir is discussed in **Section 1.3** of this report.

Table 1. a) General information on the Quabbin Reservoir, b) Quabbin Reservoir Watershed, and c) Ware River Watershed (DWSP, 2018a).

a) Quabbin Reservoir General Information		
Description	**Units**	**Quantity**
Capacity	Billion gallons	412
Surface Area (at full capacity)	Acres	24,469
Length of Shoreline	Miles	118
Maximum Depth	Feet	141
Mean Depth	Feet	45
Surface Elevation, at Full Capacity	Feet, relative to Boston City Base	530
Reservoir gain (average) from 1” of precipitation	Billion gallons	1.6

b) Quabbin Reservoir Watershed General Information		
Description	**Units**	**Quantity**
Watershed Area	Acres	119,935
Land Area	Acres	95,466
	(% Total watershed area)	80
Forest Area	Acres	84,210
	(% Total land area)	88
Forested + Non-forested Wetland	Acres	5,317
	(% Total land area)	5.6
DWSP Controlled Area	Acres	53,278
	(% Total watershed area)	64.5

c) Ware River Watershed General Information		
Description	**Units**	**Quantity**
Watershed Area	Acres	61,737
Forest Area	Acres	46,673
	(% Total watershed area)	75.6
Forested + Non-forested Wetland	Acres	7,038
	(% Total watershed area)	11.4
DWSP Controlled Area	Acres	25,486
	(% Total watershed area)	41.3

Figure 1. Quabbin Reservoir, Ware River, and Wachusett Reservoir Watershed System. Interstate highways are represented by red lines. Inset map in lower left depicts location of the watershed system relative to MA.

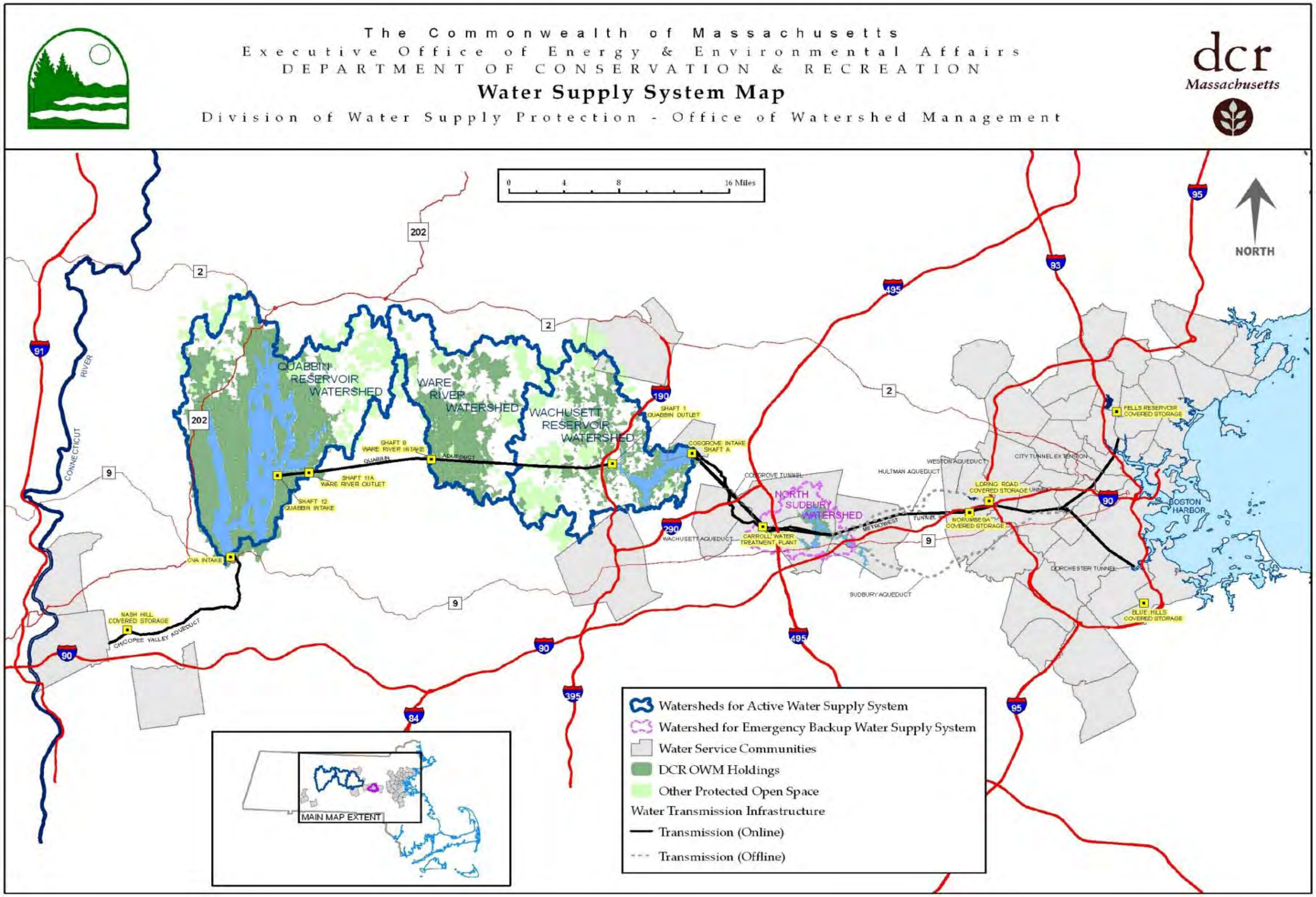


Figure 2. Hydrology, sanitary districts, and water quality monitoring sites for calendar year 2018 in the Quabbin Reservoir watershed.

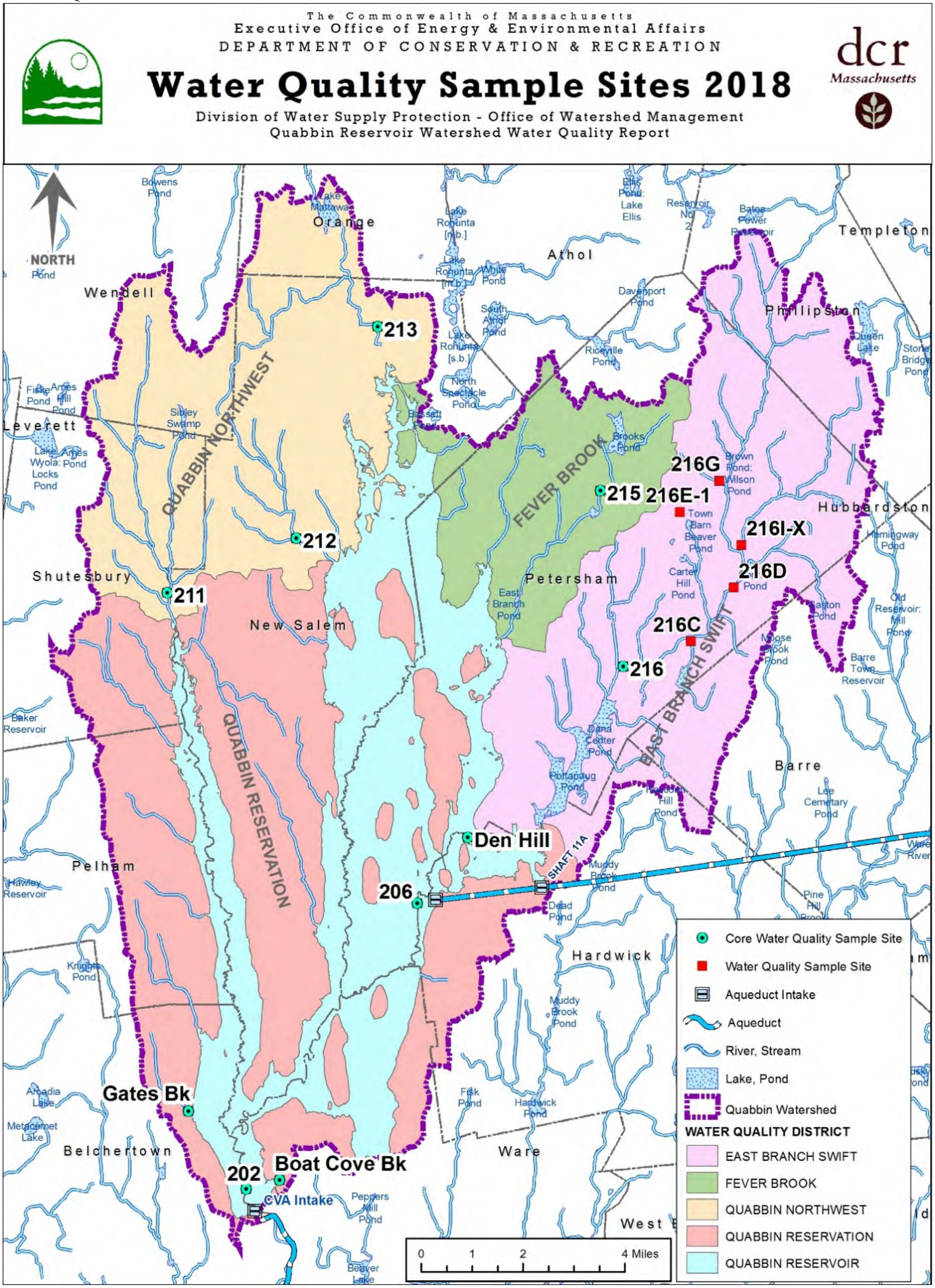
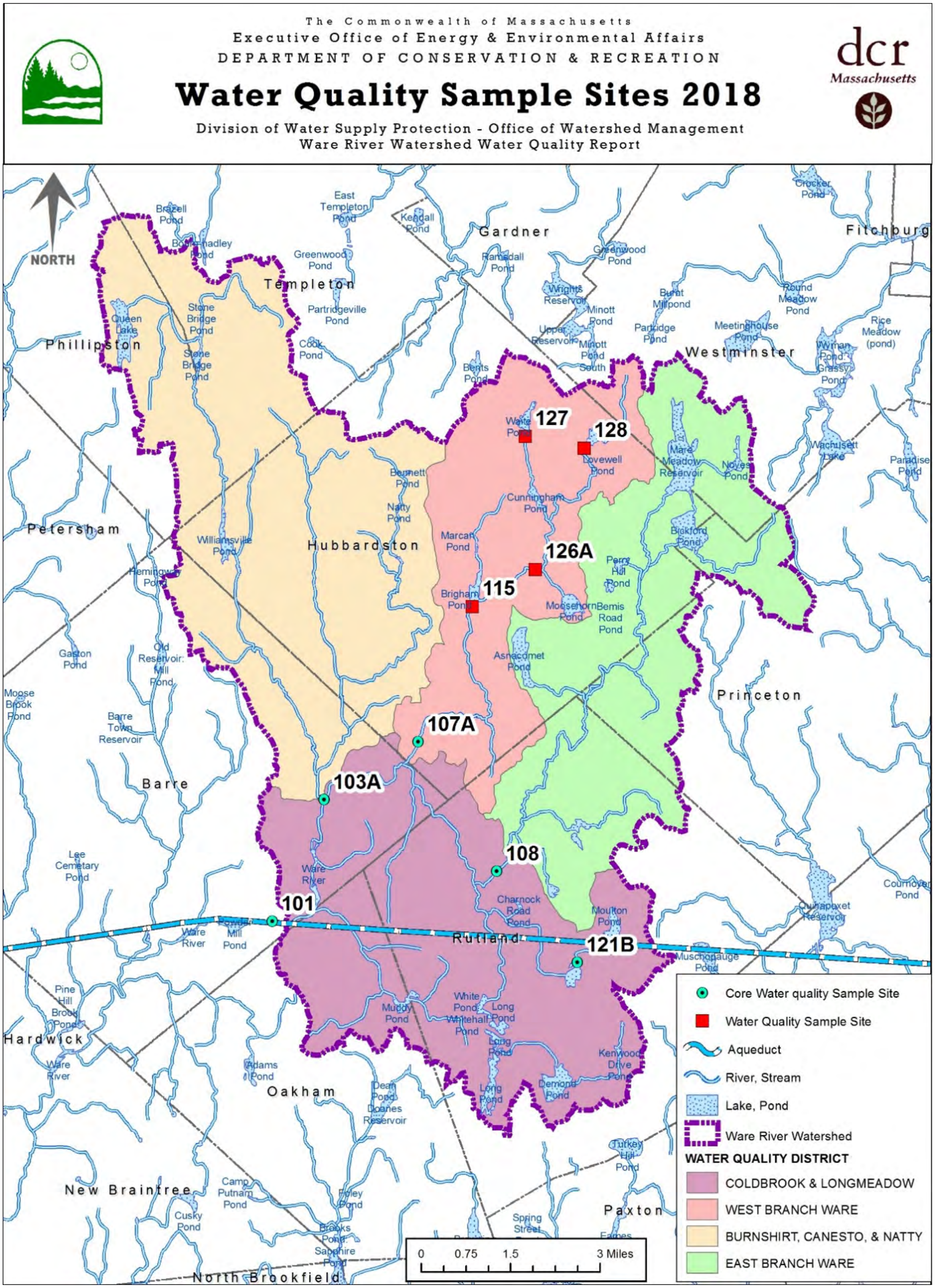


Figure 3. Hydrology, sanitary districts, and water quality monitoring sites for calendar year 2018 in the Ware River watershed.



1.2 Major Tributaries

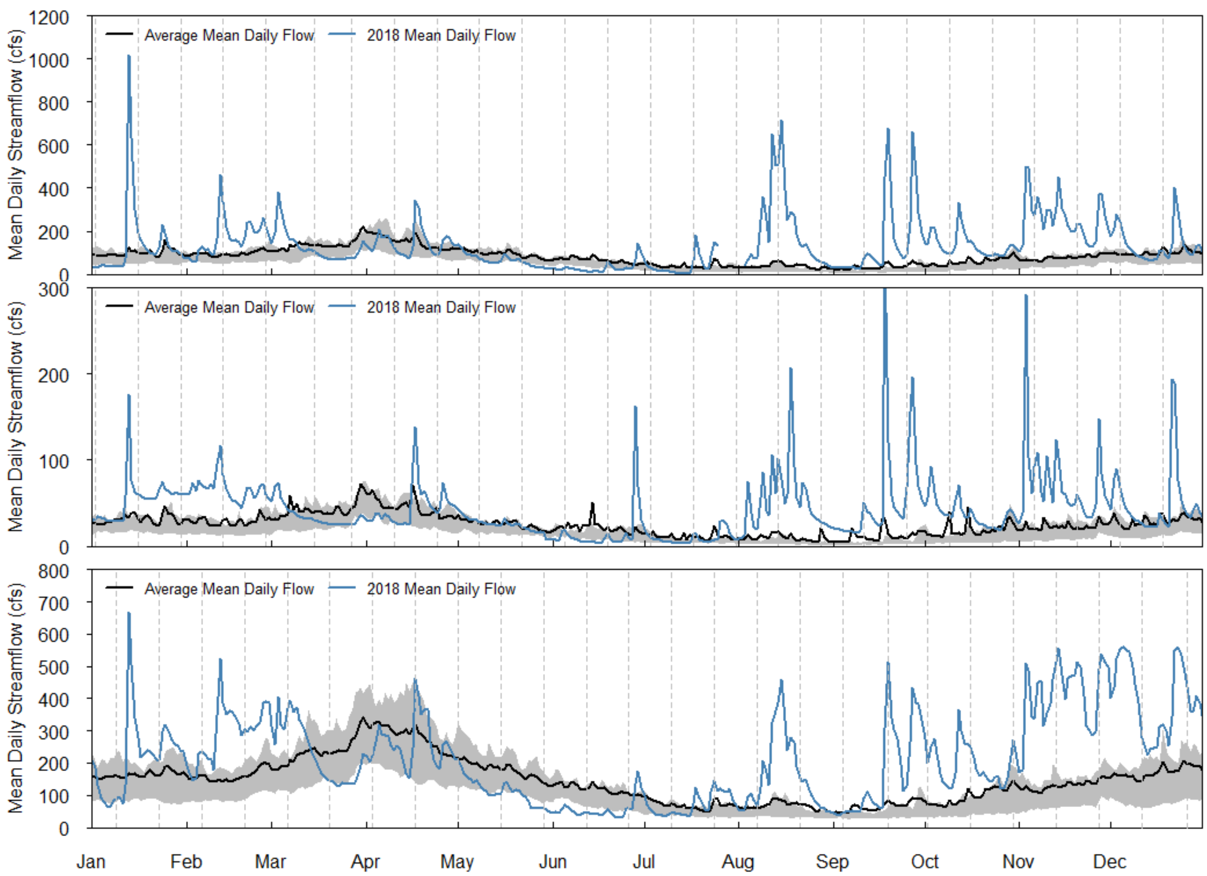
The main tributaries to the Quabbin Reservoir are the East Branch of the Swift River and the West Branch of the Swift River. The U.S. Geological Survey (USGS), Water Resources Division, maintains stream gauges on the East Branch Swift River in Hardwick (USGS Gauge No. 01174500), the West Branch Swift River in Shutesbury (No. 01174656), and the Ware River at the Intake Works in Barre (No. 01173000). The hydrographs for each are shown in **Figure 4**.

The East Branch Swift River drains into the eastern portion of the Quabbin Reservoir (**Figure 2**). The East Branch Swift River watershed is the largest stream tributary to Quabbin Reservoir, at 43.6 square miles in area. The western part of the watershed is primarily sourced by the West Branch Swift River. This 14.1-square-mile catchment area runs north-to-south between two well-defined, steeply sloped ranges. Steeply sloping ground, shallow soils, and a narrow drainage area combine to generate runoff that is extremely quick, and stream flows are typically characterized as flashy in the West Branch Swift River.

Mean daily flows for the East Branch Swift River ranged from 2.46-659.24 MGD (3.80-1,020 cfs) with an average of 87.87 MGD (135.95 cfs) in 2018 (**Figure 4a**). Streamflow in the East Branch Swift River was generally within the normal to above normal range for the duration of 2018, apart from an extended period of below normal streamflow during late May through June 2018. Above-normal peaks in January through March coincided with episodic snowmelt and/or precipitation events. The maximum streamflow occurred on January 13, 2018 in response to a rain-on-snow event coupled with unseasonably warm air temperatures (max. temperature of 59°F on January 13). Normal to above-normal stream flow was observed from mid-August through the end of December, with above-normal flows following precipitation events. Above average annual precipitation totals likely contributed to the observed deviation from normal flow ranges.

Mean daily flows for the West Branch Swift River ranged from 2.17-223.63 MGD (3.35-346 cfs) with an average of 28.16 MGD (43.56 cfs) in 2018 (**Figure 4b**). Mean daily flows in 2018 were generally above normal to the higher extent of the normal range, with above normal flows related to snowmelt and/or precipitation events. The maximum streamflow in the West Branch Swift River occurred on September 18 following a precipitation event in excess of 3 in.

Figure 4. Hydrographs of mean daily streamflow for (a; top) East Branch Swift River in Hardwick (USGS Gauge No. 01174500), (b; middle) West Branch Swift River in Shutesbury (01174656), and (c; bottom) the Ware River at the Intake Works in Barre (No. 01173000). Vertical lines mark sample collection dates for each watershed. The average of mean daily flows for the period of record (1987-2018 and 1995-2018 for East and West Branches of Swift River, respectively) are represented by the solid black line. The gray band denotes the normal (25th to 75th percentile) flow range for the period of record.



1.3 Water Transfers

Water from the Quabbin Reservoir is transferred to the Wachusett Reservoir via the Quabbin Aqueduct Intake at Shaft 12 (**Figure 2**). Transfers at Shaft 12 typically account for more than half of the of MWRA's system supply. During 2018, 35,572 million gallons (MG) of water were transferred to the Wachusett Reservoir from the Quabbin Reservoir, with an average transfer rate of 217 MGD, over 164 days. A lesser amount of water is transferred directly to three western Massachusetts communities daily via the Chicopee Valley Aqueduct (CVA) from the Winsor Dam Intake (WDI). In 2018, the CVA delivered on average 7.07 MGD of flow to the CVA communities (**Figure 1**). The net storage gain of the reservoir was 179,400 MG, and the maximum difference in reservoir levels was 8.53 feet.

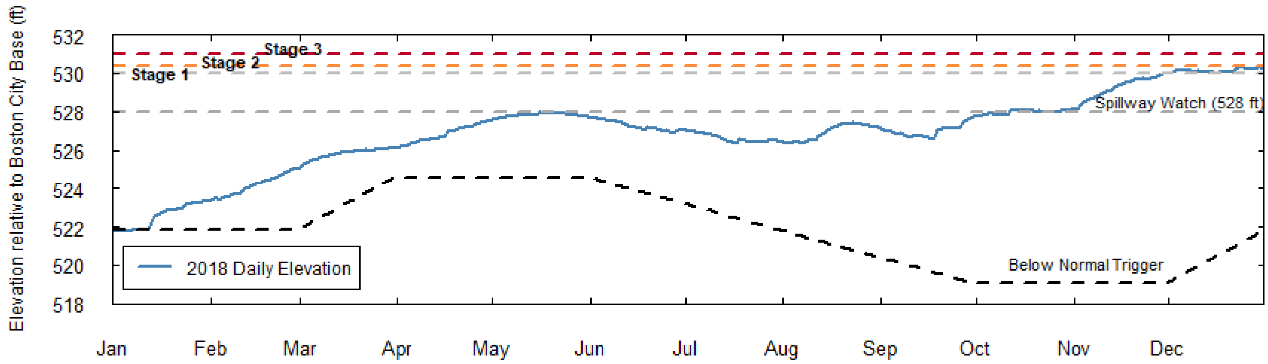
Water from Ware River may be used to supplement Quabbin Reservoir supplies. Ware River water is diverted into the Quabbin Aqueduct at Shaft 8 in Barre, MA and directed west towards Quabbin Reservoir via gravity flow. DWSP and MWRA closely coordinate on diversion decisions. Under the authority granted by Chapter 375 of the Massachusetts Acts of 1926, the diversion of water from the Ware River is limited to the period from October 15 to June 15, and at no time is diversion allowed when the flow of the river at the diversion works is less than 85 MGD (131.5 cfs). Water from the Ware River enters the reservoir at Shaft 11A, located east of the baffle dams in Hardwick, MA. A total of 316.8 MG was transferred from the Ware River to the Quabbin Reservoir on two days in January 2018. The average mean daily flow during 2018 at the USGS stream gauge near the Shaft 8 intake works was 171 MGD (265 cfs). The 2018 average mean daily flow was 112.8 MGD (174.5 cfs), greater than the average for the period of record (1987-2018). The hydrograph of 2018 flow in the Ware River is depicted in **Figure 4c**.

Daily fluctuations in reservoir water level for 2018 are shown in **Figure 5**. Reservoir elevation rose steadily through 2018 in response to precipitation, exceeding the spillway watch trigger of 528 ft on October 12, 2018 and continuing to rise to a maximum elevation of 530.29 ft on December 25 and 30, exceeding the Stage 1 Flood Watch trigger established by the DWSP Civil Engineering Section. Partial ice coverage on the reservoir commenced on January 8, 2018, with sustained coverage as of February 8. Ice began to unlock from the shore on February 21, with partial ice coverage continuing until the reservoir was free of ice by the end of March.

Table 2. Annual reservoir yield information for the Quabbin Reservoir and related transfers.

Diversion/Transfer	Measure	2018	2017	2016	2015
To Wachusett Reservoir (via Shaft 12)	Total Volume (million gallons)	35,572	32,274	53,843	53,192
	Number of Days	164	198	252	273
	Rate (MGD)	216.9	163	213.66	194.8
To Swift River	Annual (million gallons)	22,603	10,495	13,129	15,673
	Number of Days	365	365	365	365
	Daily (MGD)	61.93	28.75	35.87	42.9
To Chicopee Valley Aqueduct (CVA)	Total Volume (million gallons)	2,580	2,563	2,806	2,773
	Number of Days	365	365	366	365
	Rate (MGD)	7.07	7.02	7.67	7.6
From Ware River (via Shaft 11A)	Total Volume (million gallons)	316.8	6,120	412	90.6
	Number of Days	2	28	4	1
	Rate (MGD)	158.4	219	103	90.6
Spillway	Total Volume (million gallons)	10,823	0	0	168.7
	Number of Days	79	0	0	33
	Rate (MGD)	137	0	0	5.11

Figure 5. Daily elevation of the Quabbin Reservoir from January 1 through December 31, 2018 relative to Spillway Watch Triggers established by DWSP Civil Engineering Section.



1.4 Climatic Conditions

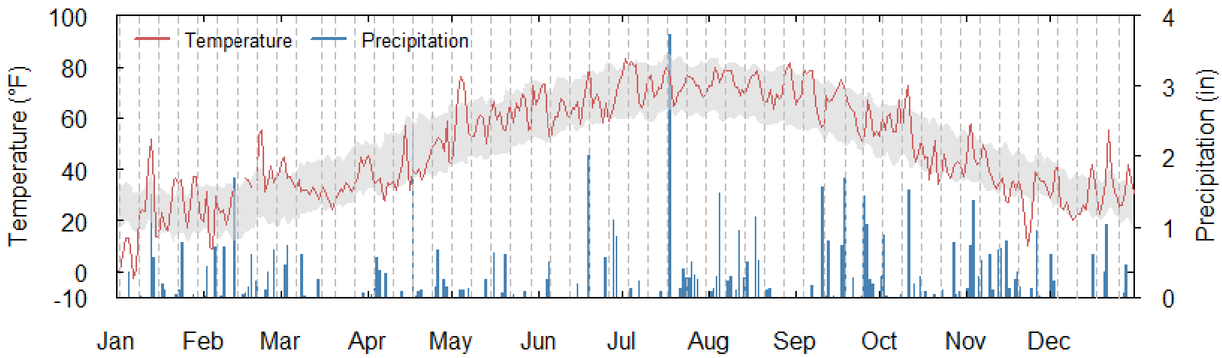
Climate in Belchertown, MA exhibits a distinct seasonality and is characterized as humid and temperate, with warm to hot and moist summers and cold, snowy winters (Flanagan et al., 1999).

Daily precipitation has been recorded at the Belchertown monitoring station since 1939. In 2018, the total precipitation was 61.30 in, exceeding the long-term average (46.13 in) and ranking as the fourth highest annual precipitation total on record. Monthly to seasonal precipitation totals were generally greater than the long-term averages (0.30-4.67 in), with the exclusion of March and May 2018 when monthly precipitation totals were below average. Total snowfall for the year (45.80 in) was less than the long-term average (51.97 in) and occurred during the months of January, February, April, and November. As precipitation totals were generally greater than the long-term average totals for these months, the reduced snowfall totals observed likely resulted from elevated winter temperatures during these months. No droughts or abnormally dry conditions were observed near the Quabbin Reservoir in 2018.

Daily median temperatures in Belchertown, MA during 2018 were generally within the average daily temperature range, in comparison to a 29-year record (DWSP, Civil Engineering). Exceptions occurred as unseasonably warm days during winter months (max. temperature of 59°F on January 13). The average daily median temperature observed during 2018 was 48.6°F, a 0.5°F increase from the long-term annual average. Temperatures ranged from -13 to 96°F, with annual minimum and maximum daily temperatures occurring in January and July. Temperature extremes in January and February were sporadic, ranging from -13 to 59°F and -5 to 73°F, respectively. Average daily temperatures during spring months (March, April, May) ranged from -5.4 degrees below average in April to 4.4 degrees above average in May and were likely impacted by seasonal extremes (e.g., 89°F on May 26). Summer (June-August) temperatures were closer to average (-1.0 to 3.4 °F deviation from average). Temperatures in the fall trended toward the lower extent of the average range (**Figure 4**).

The 2018 North Atlantic hurricane season was above average (for 1981-2010 period of record), with a total of 15 named storms (those that reached at least tropical storm strength), 8 hurricanes, and two major hurricanes (NOAA, 2019; NRCC, 2019). The average number of hurricanes during the North Atlantic hurricane season is 12.1 named storms, 6.4 hurricanes, and 2.7 major hurricanes. The 2018 hurricane season was tied for the tenth most documented hurricanes on record. The lack of El Niño conditions in the equatorial Pacific, with La Niña conditions developing near the end of the season, likely helped lead to the high frequency (NRCC, 2019).

Figure 6. Climatograph of daily median temperatures and precipitation totals for Belchertown, MA from January 1 through December, 31, 2018 (DWSP, 2018b). Vertical lines denote sample collection dates. Shaded band represents average daily temperature ranges for the period of record (1995-2018).



1.5 Public Water Supply System Regulations

The U.S. EPA introduced the Surface Water Treatment Rule (SWTR) in 1989 to ensure that public water supply systems using surface waters were providing safeguards against the contamination of water by viruses and bacteria. The regulations require filtration by every surface water supplier unless strict source water quality criteria and watershed protection goals can be met. The DWSP and MWRA have maintained a waiver from the filtration requirement since 1989.

Source water quality criteria rely on an indicator organism, fecal coliform bacteria, and a surrogate parameter, turbidity, to provide a measure of the sanitary quality of the water. The SWTR requires that fecal coliform concentrations at the intake of an unfiltered surface water supply shall not exceed 20 colony-forming units (CFU) per 100-ml in ninety percent of the samples in any six-month period. There are two standards for turbidity levels at source water intakes. The SWTR requires that turbidity levels at the intake be below five NTU at all times. MassDEP regulations specify that turbidity levels may exceed one NTU only if it does not interfere with effective disinfection.

2 Methodology

This report presents water quality results from regular monitoring performed throughout the Quabbin Reservoir and Ware River watersheds. The goals of the water quality monitoring program include:

1. To maintain long-term water quality statistics in terms of public health protection.
2. To satisfy watershed control criteria applicable to the filtration avoidance requirements stipulated under the EPA's SWTR.
3. To identify streams and water bodies that do not meet water quality standards and where specific control measures may be initiated to eliminate or mitigate pollution sources.
4. To conduct proactive surveillance of water quality trends to identify emerging issues and support ongoing assessments of threats to water quality.

2.1 Sample Site Locations

Water quality was monitored at 21 surface water sites in the Quabbin Reservoir and Ware River watersheds, as well as at three sites within the Quabbin Reservoir during 2018. Sampling locations included major tributaries to Quabbin Reservoir, other tributaries flowing to the Quabbin Reservoir or Ware River, and selected locations within the Quabbin Reservoir. The locations of surface water monitoring sites are shown on **Figures 2** and **3**, and drainage area characteristics for tributary monitoring sites are summarized in **Table 3**. Of the 21 monitoring sites, 12 were located within the Quabbin Reservoir watershed and nine were in the Ware River watershed. The remaining three sampling sites were in the Quabbin Reservoir.

The tributary monitoring locations within each watershed include Core sites and Environmental Quality Assessment (EQA) sites (see DWSP, 2006). Core sites represent long-term monitoring sites throughout the watershed that are included in the monitoring plan every year. Core sites are critical for DWSP assessments, as they provide a long-term record of water quality data from primary tributaries within each watershed. Each watershed is divided into sub-watersheds, referred to as sanitary districts, the locations of which are shown on **Figures 2** and **3**. EQA sites rotate to a different sanitary district annually. Data from EQA sites are used to support annual assessments of potential threats to water quality within each sanitary district. EQA data provide a more focused, year-long assessment of water quality within a specific portion of each watershed.

EQA sampling in 2018 was focused in the East Branch Swift River Sanitary District (Quabbin Reservoir Watershed) and the West Branch Ware River Sanitary District (Ware River Watershed). The Quabbin EQA sites were previously monitored in 2014-2015, while the Ware River EQA sites were previously monitored in 2014.

Table 3. Sub-catchment characteristics and DWSP site numbers for Core and EQA sites monitored in (top) Quabbin Reservoir Watershed and (bottom) Ware River Watershed in 2018.

Site Description		Sub-catchment Characteristics			
		DWSP Site No.	**Drainage Area (mi^2)**	**Wetland (% Area)**	**DWSP Owned Land (% Area)**
Core Sites	West Branch Swift River, at Route 202	211	12.42	3.4	45.0
	Hop Brook, inside Gate 22	212	4.62	2.5	32.2
	Middle Branch Swift River, at Gate 30	213	9.00	8.2	25.2
	East Branch of Fever Brook, at West Street	215	3.93	11.9	12.6
	East Branch Swift River at Route 32A	216	30.30	9.5	2.1
	Gates Brook, at mouth	GB	0.93	3.0	100
	Boat Cove Brook, at mouth	BC	0.15	<1.0	100
EQA Sites	Roaring Brook, Petersham Center	216G	1.00	6.77	0
	Moccasin Brook, above Quaker Road	216I-X	7.00	16.52	1.30
	Northern Tributary of 216E, at South St	216E-1	0.07	9.65	0
	Connor Pond outlet, at dam (near Pat Connor Rd)	216D	21.55	10.48	0.83
	Carter Pond, below outlet (at Glen Valley Rd)	216C	2.44	6.63	0

Site Description		Sub-catchment Characteristics			
		DWSP Site No.	**Drainage Area (mi^2)**	**Wetland (% Area)**	**DWSP Owned Land (% Area)**
Core Sites	Ware River, at Shaft 8 (intake)	101	96.50	13.9	37.8
	Burnshirt River, at Riverside Cemetery	103A	31.10	10.5	28.3
	West Branch Ware River, at Brigham Road	107A	16.60	15.6	45.8
	East Branch Ware River, at Intervale Road	108	22.30	16.8	12.6
	Thayer Pond, at inlet 2	121B	2.00	16.5	3.1
EQA Sites	Brigham Pond Outlet	115	11.36	15.93	38.47
	Moosehorn Pond Outlet	126A	6.59	18.93	39.56
	Waite Pond Outlet	127	0.93	10.00	0
	Lovewell Pond Outlet	128	1.84	21.86	0.12

2.2 Sample Collection and Analysis

At each tributary and reservoir sampling location, field parameters were measured *in situ* using a Eureka Manta Multiprobe. Measured parameters included temperature, dissolved oxygen, pH, and specific conductance. Data were stored digitally using a PDA and later transferred to a database maintained by the DWSP Environmental Quality Section.

2.2.1 Reservoir Sampling

Reservoir samples for bacteria and physicochemical parameters were collected from the three monitoring sites (202, 206, and Den Hill) monthly from April through December 2018, weather and reservoir conditions permitting. The sampling sites were located within three distinct sub-basins of the reservoir. Weather conditions, reservoir conditions, and water transparency were recorded during each survey.

Samples were collected from a boat, using a Kemmerer bottle to collect water from discrete depths. Bacteria samples are collected from the surface (0.5 m), mid-depth (6 m), and either the respective water supply intake depth (18 m for Site 202, 24 m for Site 206) or a deep sample (13 m at Den Hill). Physicochemical samples are taken at the surface (0.5 m), mid-depth, and within 2 meters of bottom when the reservoir is not thermally stratified. When the reservoir is stratified, physicochemical samples are collected from the surface (0.5 m), mid-metalimnion (generally 9 to 14 m), and deep (within 2 m of bottom).

Water column profiles of temperature, pH, dissolved oxygen, and specific conductance in the Quabbin Reservoir are measured *in situ* using a Eureka Manta Multiprobe. Readings are taken every meter at each of the three sites during times of thermal stratification and mixing, and every three meters during periods of isothermy – periods when the temperature of the reservoir does not change with depth.

Quarterly sampling for nutrients was performed at the onset of thermal stratification (May), in the middle of the stratification period (late July), near the end of the stratification period (October), and during a winter period of isothermy (December). Calcium monitoring began in 2010 to assess the risk of colonization by aquatic invasive organisms (e.g., zebra mussels). Calcium concentrations below 12 mg/L, in combination with a pH of less than 7.4, result in a low risk of zebra mussel colonization (DCR and MA Division of Fish and Game, 2009). Calcium monitoring began on a monthly basis at three depths but was reduced to quarterly at one depth since 2012 due to relatively low concentrations and low variability.

In addition to chemistry and bacteria sampling at all sites, phytoplankton sampling has been performed since 2007. This monitoring program was implemented in response to odor complaints about CVA water, an increase in chlorine demand at the William A. Brutsch Water Treatment Facility (BWTF) and increasing numbers of smelt on the intake screens. Samples were collected, weather and reservoir conditions permitting, twice per month from May through

September and once per month in other months. The samples were collected from Sites 202 and 206, typically at two depths. Samples were collected near the middle and bottom of the epilimnion (upper layer of water) during stratified conditions, and at 3-meter and approximately 8 to 10-meter depths during non-stratified conditions.

2.2.2 Tributary Sampling

Samples were collected at tributary sites in each watershed on a biweekly basis, such that samples were collected from the Quabbin Reservoir watershed and the Ware River watershed on alternating weeks. *In situ* measurements of temperature, dissolved oxygen, pH, and specific conductance were also conducted at the time of sample collection. Samples were collected early in the week (typically on Tuesdays) regardless of weather conditions. The goal of this relatively high sampling frequency was to provide a comprehensive assessment of tributary water quality that captures seasonal flow variations under a wide range of weather conditions.

2.2.3 Laboratory Analysis

All samples were submitted to MWRA Laboratory for analysis. Reservoir samples were analyzed for alkalinity, turbidity, fecal coliform, and *E. coli*, on a monthly basis. In addition, reservoir samples were analyzed for nutrients, UV_{254}, and calcium (at mid-depth only) on a quarterly basis. Tributary samples were analyzed for turbidity, *E. coli*, and calcium on a biweekly basis. Core samples were also analyzed for alkalinity, nutrients, and UV_{254} on a quarterly basis, except for Ware River watershed core samples, which were analyzed for UV_{254} on a biweekly basis. EQA samples were analyzed for alkalinity, nutrients, and UV_{254} on a biweekly basis. Laboratory methods are summarized in **Table 4**.

Table 4. MWRA Laboratory methods, adapted from Analytical and Field Methods for analysis of water samples from Standard Methods for the Examination of Water and Wastewater, 20th Edition (1998).

Parameter	Standard Method (SM)
Turbidity	SM 2130 B
pH	Eureka Manta Multiprobe, SM 4500 H+ using Orion 920A+ pH meter
Alkalinity	SM 2320 B (low level)
Conductivity	Eureka Manta Multiprobe
Temperature	Eureka Manta Multiprobe
Dissolved Oxygen	Eureka Manta Multiprobe
Total Coliform	SM 9223 (Enzyme Substrate Procedure)
Fecal Coliform	SM 9222D
Escherichia coli (*E. coli*)	SM 9223 (Enzyme Substrate Procedure)

Environmental Quality staff collected 662 source water (tributary and reservoir) samples for a variety of analyses in 2018. Nearly 4,000 analyses were performed on these samples, of which 54% (2,138) were nutrient analyses (including calcium, ammonia, nitrogen, silica, total Kjeldahl nitrogen, total phosphorus, and UV_{254}) performed at the MWRA Central Laboratory at Deer Island. The remaining analyses were comprised of 28% (1,115) physiochemical parameters (alkalinity, chloride, sodium, turbidity) and 28% bacterial analyses performed at the MWRA Quabbin and Deer Island Laboratories. MWRA staff at the Quabbin Laboratory also processed and analyzed 365 microbiological samples collected at the BWTF. In addition, over 2,600 physiochemical measurements (excluding reservoir profiles) were collected by DWSP staff using a water quality multimeter. Records of these laboratory and field results were maintained in bound books and in a database maintained by the DWSP Environmental Quality Section.

2.3 Additional Monitoring

Additional ongoing monitoring of the Quabbin Reservoir and associated watersheds includes daily pathogens (turbidity, *E. coli*, Giardia, and Cryptosporidium), aquatic invasive species (AIS), and long-term impacts of forestry activities on water quality. These programs are described in **Sections 3.1**, **3.4**, and **3.5**, respectively.

3 Results

3.1 Results: Winsor Dam Intake

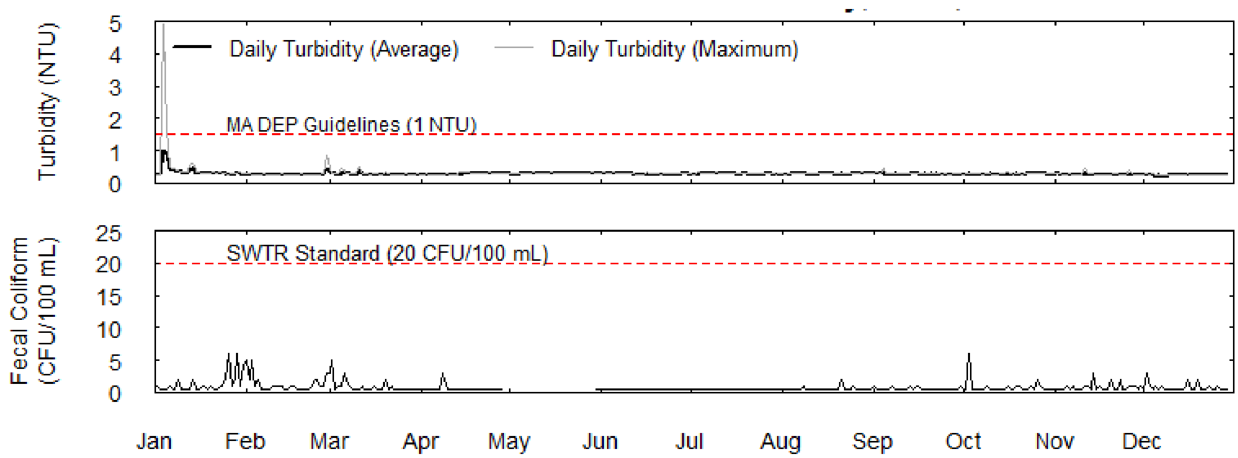
The MWRA monitors bacteria levels and turbidity of Quabbin Reservoir water daily prior to any disinfection in the BWTF to ensure compliance with the SWTR.

Turbidity levels were monitored by MWRA using an on-line turbidity meter located inside the BWTF. Daily average and maximum turbidity levels for 2018 are shown on **Figure 7a**. Maximum daily turbidity levels exceeded the one NTU MassDEP standard on two dates (1.65 and on January 4 and 4.89 NTU on January 5, 2018), but remained below five NTU – the SWTR requirement – for the entirety of 2018. These occurrences of elevated turbidity were attributed to strong winds, and turbid conditions may have been exacerbated by the lack of ice cover. Water quality was not adversely impacted in any instances of elevated turbidity levels during 2018. No violations of drinking water standards occurred during this time. Chlorine residuals were maintained, contact times were well above required levels, and bacteria results were satisfactory.

Daily fecal coliform bacterial counts were determined by MWRA from samples collected at the BWTF. Daily fecal coliform results from the BWTF for January through December 2018 are shown in **Figure 7b**. Fecal coliform bacteria were not detected above 20 CFU/100 ml during 2018. No fecal coliform bacteria were detected in 68% of samples collected in Quabbin Reservoir during 2018. The average and median daily fecal coliform bacteria counts in Quabbin Reservoir source water were less than 1.00 CFU/100 mL (0.81 and 0.50 CFU/100 ml).

A total of 26 samples were collected and analyzed for *Giardia* and *Cryptosporidium* monitoring in 2018. Neither *Giardia* nor *Cryptosporidium* were detected in 2018. Monitoring for these two pathogens will continue to be conducted on a biweekly basis at the BWTF in 2019.

Figure 7. (top) Quabbin Reservoir Source Water Turbidity (at the BWTF). The red dashed line denotes the threshold of less than one NTU specified by the MassDEP, while the uppermost extent of the vertical axis represents the SWTR requirement of five NTU. (bottom) Daily concentrations of Fecal Coliform bacteria, prior to disinfection, Quabbin Reservoir source water. The red dashed line represents the SWTR standard of 20 CFU/100-mL.



3.2 Results: Reservoir Monitoring

Quabbin Reservoir water quality data documented in 2018 demonstrated consistently reliable source water quality that met the stringent source water quality criteria stipulated under the SWTR. Characteristics of the three sampling sites that were sampled in 2018 are summarized in **Table 5**. Sample site locations are shown on **Figure 2**. General water quality at the three sites monitored in 2018 is summarized in **Table 6**. The profiles of water quality parameters with depth (as measured in the field) are included in **Appendix A**, and analytical data from each site are included in **Appendix B**. Reservoir monitoring results are discussed in the following sections, along with a brief summary of the relevance of each parameter to drinking water quality.

Table 5. 2018 Quabbin Reservoir Water Quality Monitoring Sites

Site Name	Site ID	Location	Approximate Depth (m)
Winsor Dam	202	Quabbin Reservoir west arm, offshore of Winsor Dam along former Swift River riverbed	42
Shaft 12	206	Quabbin Reservoir at site of former Quabbin Lake, offshore of Shaft 12	28
Den Hill	Den Hill	Quabbin Reservoir eastern basin, north of Den Hill	19

Table 6. Descriptive statistics (mean, minimum, and maximum) for select water quality parameters of Quabbin Reservoir Sites for 2018 (Environmental Quality Database, 2018).

Parameter	Statistic	Site 202	Site 206	Site Den Hill
Temperature (°C)	Average	8.78	10.17	11.43
	Min	3.02	3.69	4.41
	Max	23.96	24.00	25.88
Dissolved Oxygen (% Saturation)	Average	109.44	109.05	105.14
	Min	99.7	103.2	85.6
	Max	121.2	117.7	112.6
Turbidity (NTU)	Average	0.28	0.33	0.47
	Min	0.20	0.24	0.33
	Max	0.40	0.46	0.72
pH	Average	5.98	5.90	5.82
	Min	5.29	5.15	5.21
	Max	6.95	6.56	6.49
Specific Conductance (µS/cm)	Average	49.23	49.44	53.7
	Min	48.6	48.8	51.6
	Max	50.4	50.8	55.7
Secchi Disk Transparency (m)	Average	10.72	9.59	6.24
	Min	8.3	8.3	4.7
	Max	12.3	13.1	10.5
Fecal Coliform (CFU/100 mL)	Average	0.65	0.52	1.06
	Min	<1	<1	<1
	Max	2	1	6

3.2.1 Temperature

Thermal zones develop within a reservoir during the warmer months of spring and summer. These zones are referred to as the epilimnion, metalimnion and hypolimnion (listed in order from uppermost to lowermost), and have distinct temperature, water circulation, and water quality characteristics. The thermal stratification of a body of water has a profound impact on water quality as well as biological processes across the reservoir profile. Waters of the epilimnion (uppermost zone) are warmed by solar radiation and well-mixed by wind-driven currents. The epilimnion may become vulnerable to algal growth due to the availability of sunlight and entrapped nutrients introduced to the partitioned layer of surface water. The metalimnion (middle zone) represents a transitional layer that occurs between the warmer surface waters and colder, deep waters. This transition from well-mixed surface waters of the epilimnion to the lowermost hypolimnic waters is reflected in depth profiles of physical and chemical water quality parameters (e.g., temperature, dissolved oxygen, chloride). The deep waters of the hypolimnic zone are not impacted as readily by surface processes (e.g., wind) as the more uppermost zones. Thus, waters in the hypolimnic zone may become stagnant relative to shallower zones, and ultimately serve as a sink for decaying organic matter and sediments that settle out from the warmer waters of the epilimnion and metalimnion. Water in the Quabbin Reservoir is mixed annually by the settling of cooler surface waters in the fall and following springtime ice-out when an isothermal water column is easily mixed by winds.

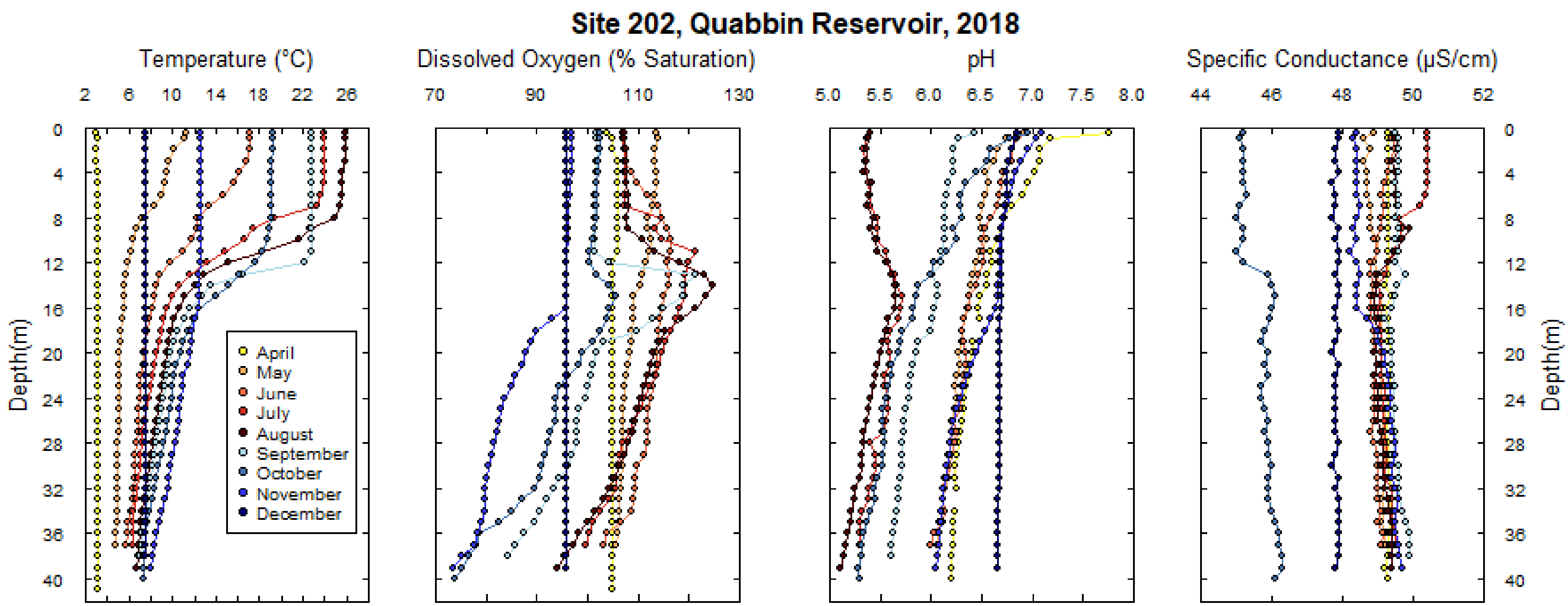
The thermal mixing and transition that occurs between isothermal (fully mixed) to stratified conditions is illustrated by reservoir temperature profile data collected at Site 202 (Winsor Dam) in **Figure 8a**. The temperature profiles from Site 202 and Site 206 (**Appendix A**) suggest that a shift from isothermal to stratified conditions occurred between the April 9 and May 17, 2018 sample dates. Fall turnover likely began between October 10 and November 1, 2018, and was fully accomplished by December 5, 2018, as suggested by the shift in reservoir temperature profiles from stratified to fully isothermal from October to December 2018. The timing of reservoir mixing during 2018 was consistent with data from previous years.

3.2.2 Dissolved Oxygen

Oxygen is essential to the survival of aquatic life (e.g., trout require a minimum of 5.0 mg/L of dissolved oxygen for survival, equivalent to 44 percent saturation at 10°C). Dissolved oxygen represents the measure of the amount of oxygen dissolved in water that is available to living organisms. Thus, dissolved oxygen is used as one index to characterize the trophic state of a lake. Aeration inputs such as wind-driven turbulence, reservoir currents, and atmospheric diffusion diminish with depth, leading to declining dissolved oxygen concentrations with depth. The sinking of decaying organic debris into the hypolimnion consumes oxygen (respiration by microbial populations responsible for the decomposition of organic wastes requires oxygen) from surrounding waters, and thus can be a major source of oxygen depletion in highly productive lakes. Hypolimnic oxygen reserves established in the spring are typically not replenished until the late fall, when cooling surface waters settle and re-mix the reservoir.

Dissolved oxygen in the hypolimnion ranged from a minimum of 3.83 mg/L at 16.0-m depth at the Den Hill location on October 17, 2018 to a maximum of 14.11 mg/L at 14.02-m depth at Site 202 on May 24, 2018. Depletion levels are generally most pronounced during the late stages of stratification (typically August through October). The minimum dissolved oxygen levels observed at each reservoir location during 2018 were 3.83 mg/L at Den Hill (on October 17, 2018 at 16.0-m), 8.99 mg/L at Site 202 (at 12.04-m on September 12th, 2018), 8.61 mg/L at Site 206 (on November 1, 2018 at 39 and 10.03-m), respectively. The seasonal development and breakdown of reservoir oxygen stratification for Site 202 are illustrated in **Figure 8**.

Figure 8. Monthly depth profiles (from left to right) of temperature, dissolved oxygen, pH, and specific conductance at Quabbin Reservoir Site 202 during 2018.



3.2.3 Alkalinity and pH

The alkalinity and pH of a water body are critical controls on water quality. Alkalinity is the buffering capacity of a solution and may also be described as the resistance to changes in pH. Alkalinity may be reported as mg/L as $CaCO_3$, and thus, is directly related to the inorganic carbon cycle dynamics of a reservoir. Monitoring of alkalinity in a water body may help to determine the ability of a water body to neutralize pollution from acid rain and/or potential wastewater inputs and serve as a general indicator of any possible changes in water quality.

pH is the negative logarithm of the number of hydrogen ions [H+], reported on a scale of 0 to 14 and used to express the acidity or basicity (alkalinity) of a solution. A pH of 7.0 represents neutral water, with levels below 7.0 considered acidic, and those above 7.0 more basic (alkaline). A decrease of one pH unit will correspond to a 10-fold increase in acidity due to the logarithmic nature of the measurement. Thus, only minor changes in the pH of a water body may have significant impacts on water quality. The pH of a water body may affect organisms living in the water. Changes in the pH of a water body may be indicative of natural weather processes such as rainfall or snowmelt, biological productivity (photosynthesis and respiration), or of contamination of water resources.

Alkalinity and pH dynamics in reservoirs are generally controlled by three principal processes. Direct acid inputs (e.g., rainfall, dry deposition, snowfall) may drive pH down in regions impacted by acid rain. Weathering of carbonate rocks in watershed may result in a higher pH of affected waters. Changes in biological respiration rates of organisms in the reservoir can increase alkalinity levels as oxygen is consumed and carbon dioxide is released, increasing the amount of carbon in the water. An upsurge in photosynthetic activity (predominantly by algae) in the epilimnion and metalimnion may lead to increased alkalinity and pH as free carbon dioxide and bicarbonate are consumed during photosynthesis.

Monitoring the pH of the Quabbin Reservoir is essential to ensuring that the Reservoir remains a sustainable and secure water supply for future generations. The solubility of nutrients (such as phosphorus, nitrogen, and carbon) and heavy metals (including lead, copper, and mercury) may, in part, be controlled by changes in pH. At pH levels less than 6.00, the solubility of mercury increases significantly, allowing the metal to more easily enter a water body, and thus increasing the likelihood for mercury accumulation in the tissue of living organisms (such as fish which are then consumed by humans). Many lakes in the northeastern USA, including the Quabbin Reservoir, have posted fish consumption advisories that suggest limiting the quantity of fish consumed because of the presence of higher mercury levels in the fish. Consumption of fish containing high levels of methylmercury is the main source of human exposure to methylmercury.

Quabbin Reservoir water was slightly acidic with a pH level that averaged 5.90 across the three sites monitored in 2018 (**Table 6**). DWSP does not currently monitor mercury levels in fish of the Quabbin Reservoir. Both pH and alkalinity have a long-term record of stability in the Quabbin

Reservoir, but levels fluctuate due to reservoir dynamics. Reservoir alkalinity was relatively low and averaged 4.01 mg/L as $CaCO_3$ across the three reservoir sites. Alkalinity levels across the three sites monitored in 2018 ranged from 3.57 to 5.51 mg/L as $CaCO_3$.

3.2.4 Specific Conductance and Dissolved Salts

Specific conductance, the measure of the ability of water to conduct an electrical current, is dependent on the concentration and availability of mineral ions. Generally, more conductive waters may have increased salinity. A spike in specific conductance of a water body may be indicative of an influx of ions from natural and/or anthropogenic processes. Processes related to human activities such as contamination via runoff from septic system effluent, stormwater discharges, road salt runoff, and/or agricultural practices may contribute to sudden spikes in specific conductance, or long-term increases in specific conductance of affected waters.

The ion chloride comprises the negatively charged component of many common salts. When dissolved in water, chloride concentrations correlate well with specific conductance. Thus, measures of specific conductance may serve as a general indicator of the dissolved salts in a water source. Similar to specific conductance, chloride may enter a watershed via natural processes such as via rainfall or rock weathering, or as a result of human activities such as the application of de-icing salts to paved surfaces, fertilization of agricultural lands, or through contamination of waters from septic and landfill leachates (Shanley, 1994; Lent *et al.*, 1998). Elevated concentrations of chloride are harmful to sensitive biota, threaten ecosystems, and may increase the corrosivity of affected waters. Chloride may persist in watersheds for years after initial introduction (Kelly *et al.*, 2008), thus increasing trends in chloride concentrations of a water body may warrant further investigation.

Specific conductance values measured in the reservoir have historically been quite low, compared to other water bodies in the northeastern United States, which may often exceed 1,000 µS/cm in highly urbanized watersheds. Specific conductance measurements were within the historical ranges during 2018, ranging from 48.60 µS/cm at Site 202 to 55.70 µS/cm at Den Hill (**Table 6**). Concentrations of sodium and chloride were not measured in Quabbin Reservoir water in 2018.

3.2.5 Turbidity

Turbidity levels measured in the Quabbin Reservoir were low and relatively stable throughout the year, reflective of the low productivity of the reservoir. Turbidity levels in reservoir samples ranged from 0.20 to 0.72 NTU during 2018. Generally, turbidity levels in the reservoir decreased with depth, and trended towards more elevated levels during wetter months (April through June). Storm activity (e.g., high streamflow), algal blooms, and shoreline erosion are common conditions that may result in increased turbidity measured in Reservoir waters.

The greatest turbidity level was measured at eight-meters depth on September 12, 2018 at Den Hill. This date corresponds to a period of relatively high streamflow preceded by an extended period of dry conditions in the East Branch Swift River, which may have resulted in an episodic (temporary) influx of suspended particles into the Reservoir from the East Branch Swift River. The Den Hill site is located nearest to the outlet of the East Branch Swift River and the Quabbin Reservoir (**Figure 2**).

3.2.6 Secchi Disk Transparency

Secchi disk transparency is determined by measuring the depth below the surface at which a 20-cm, black-and-white disk becomes indistinguishable to the naked eye. While sensitive to weather and reservoir conditions at the time of sampling, transparency can largely be influenced by the amount of phytoplankton activity, and thus is a critical parameter for interpreting the water quality of a body of water.

Water in the Quabbin Reservoir has historically demonstrated exceptional clarity, with Secchi disk readings exceeding 13 meters. Quabbin Reservoir transparency measurements were generally consistent with the pattern of phytoplankton dynamics (Worden, 2000). The maximum transparency in 2018 was measured at 13.1-meters depth at Site 206 on July 13, 2018. Transparency at the Den Hill site is characteristically much lower than Sites 202 and 206, reflecting the nearby contribution of large river inputs of the East Branch Swift River and the Ware River (when diverting). The East Branch Swift River, estimated to contribute as much as 9 to 16 percent of the annual flow to the reservoir, is a significant source of color that reduces transparency and may lead to elevated turbidity levels within the Reservoir, and in particular, at the Den Hill Site. In 2018, minimum transparency was measured at 4.7 meters at Den Hill on December 5, 2018. Monthly transparency measurements and corresponding weather observations are summarized in **Tables 6** and **7**.

Table 7. Monthly transparency and weather and water surface observations at Quabbin Reservoir sites in 2018.

Site	Date	Transparency (m)	Color of Water	Weather and Water Surface Observations		
				Weather	Wind	Water Surface Conditions
202	4/9/2018	8.3	Green	Light Clouds	10 mph N	Choppy 1 ft waves
	5/10/2018	11	Blue-Green	Cloudy	SW	Light Ripple
	6/13/2018	11.6	Dark Blue-Green	Partly Cloudy	-	Slight Ripple
	7/13/2018	12.3	Blue-Green	Sunny, Calm	Light	Calm
	8/16/2018	11.7	Blue-Green	Partly Sunny	4 mph W	Slight Ripple
	9/12/2018	9.4	Blue-Green	Rain	-	Slight Chop
	10/10/2018	11.2	Blue-Green	Sun and Clouds	0	Slight Ripple
	11/1/2018	10.1	Green	Cloudy, Sprinkles	0	Calm
	12/5/2018	10.9	Green	Sunny	-	Calm to Slight Ripple
206	4/9/2018	8.6	Green	Clouds	7 mph N	Choppy 1 ft waves
	5/10/2018	10.2	Blue-Green	Sun	SW	Light Ripple
	6/13/2018	9.7	Dark Blue-Green	Mostly Cloudy	-	14" Waves
	7/13/2018	13.1	Blue-Green	Sunny	Light	Small Ripple 3"
	8/16/2018	9.7	Blue-Green	Partly Sunny	6 mph SW	7" Wave
	9/12/2018	8.3	Blue-Green	Rain	-	Slight Chop
	10/17/2018	8.9	Blue-Green	Sunny + Cool	SW	Choppy Waves
	11/1/2018	8.6	Dark Green	Cloudy, Sprinkles	Slight SW	Slight Ripple
	12/5/2018	9.2	Blue-Green	Partly Cloudy		Slight Ripple
Den Hill	4/9/2018	5.1	Brown	Clouds	7 mph N	Slightly choppy 8 " waves
	5/10/2018	5.7	Brown	Some Clouds	10 SW	8" waves
	6/13/2018	7.7	Really Green	Mostly Cloudy	-	6" Waves
	7/13/2018	10.5	Olive Green	Sunny	Light	Calm
	8/16/2018	5.2	Brown-Green	Partly Sunny	4 mph SW	7" Wave
	9/12/2018	-	-	Rain	-	Slight Chop
	10/17/2018	5.5	Brown	-	-	Choppy Waves
	11/1/2018	5.5	Army Brown	Cloudy, Sprinkles	0	Calm
	12/5/2018	4.7	Brown	Partly Cloudy	-	Calm

3.2.7 Total coliform, Fecal Coliform, and *E. coli* Bacteria

The term “coliform” describes a group of bacteria based on biochemical functions, rather than taxonomy. The presence of total coliform bacteria may indicate contamination from fecal matter, although this group of bacteria also includes many species that are natural inhabitants of the aquatic system that can grow at a wide range of temperatures (Wolfram, 1996; Dutka and Kwan, 1980). The “fecal” coliform group represents a subset of the total coliform group that grows at more narrow range of temperatures, including those comparable to the intestinal tracts of warm-blooded animals (Toranzos and McFeters, 1997). Because fecal coliform bacteria grow at elevated temperatures, these bacteria may be considered a better indicator of recent fecal pollution. However, this group also includes some bacteria that originate from environmental sources other than fecal contamination (Toranzos and McFeters, 1997; Leclerc *et al.*, 2001). *E. coli* bacteria, inhabitants of the intestinal tracts of humans and other warm-blooded animals, are a better indicator of recent fecal pollution in temperate climates. Due to the ubiquitous nature of total coliform bacteria, fecal coliform and *E. coli* are the preferred indicators of recent fecal pollution and are thus monitored by DWSP. The SWTR specifies that when both total and fecal coliform bacteria are analyzed, fecal coliform findings have precedent.

A seasonal gull population that roosts on the reservoir overnight has previously been identified as the primary contributor of fecal coliform and *E. coli* bacteria contamination to the Quabbin Reservoir. Other sources may include other waterfowl, semi-aquatic wildlife and tributary inputs. As a result of the long residence time of the reservoir (reportedly on the magnitude of several years), fecal coliform and *E. coli* bacteria levels are historically quite low, reflecting microbial die-off and predation that occurs naturally.

In 2018, fecal coliform bacteria were detected in several reservoir samples, with most of these detections occurring at the Den Hill location. Of the detections at Den Hill, fecal coliform bacterial counts ranged from 1.0 to 6.0 CFU/100 mL. Fecal coliform was not detected in samples from Site 206 collected in 2018. Fecal coliform was detected in two samples from Site 202 in 2018 at 2 CFU/100mL. At Site 202, fecal coliform bacteria were detected in the shallow (0.5-meter) sample in November and well as the deep sample in December 2018.

E. coli bacteria were detected a total of five instances in 2018 – four at the detection limit of 10 MPN/100 mL. *E. coli* bacteria were detected at 20 MPN/100 mL in one sample, collected from the deepest sample point at Den Hill in December 2018. The maximum *E. coli* detection at the Den Hill location in 2018 corresponded to a fecal coliform bacterial detection of 4 CFU/100 mL.

3.2.8 Reservoir Nutrient Dynamics and Phytoplankton

The nutrient database for Quabbin Reservoir was established in 1998-99, beginning with a year of monthly sampling; quarterly sampling has been conducted since. Results from 2018 are summarized in **Table 8** and compared to historical data in **Appendix B**. Patterns of Quabbin Reservoir nutrient distribution in 2018 quarterly samples were consistent with those documented previously by Worden (2000). Specifically, prominent seasonal and vertical variations exist, likely due to demand by phytoplankton in the trophogenic zone (low concentrations in the epilimnion and metalimnion) and decomposition of organic matter in the tropholytic zone (higher concentrations accumulating in the hypolimnion). A lateral gradient in silica concentrations correlated to hydraulic residence time and mediated by diatom population dynamics has developed. Lastly, variably higher concentrations and intensities at the Den Hill monitoring site prevail throughout the monitoring period due to the loading effects of the East Branch Swift River that have been described previously.

Results of quarterly nutrient sampling in 2018 were generally consistent with historical data ranges (**Table 8**). Ammonia concentrations were near or below the detection limit of 5 µg/L in samples from the three depths at Site 202 and 206, as well as in most of the samples from Den Hill during 2018 and spanning the historic dataset. Total phosphorus concentrations were generally below or just above the detection limit of 5 µg/L, with a maximum of 12 µg/L detected at Den Hill on October 17, 2018. The depletion of ammonia and phosphorus in Reservoir water may be factors limiting the growth of phytoplankton during 2018. Phosphorus is typically the limiting nutrient in Quabbin Reservoir and other lakes in temperate climates (Worden, 2000). Concentrations of calcium in the Quabbin Reservoir ranged from 1.93 mg/L to 2.17 mg/L at the three reservoir sites. These results were consistent with historical ranges for the reservoir, indicating a continued low risk of zebra mussel colonization in the reservoir.

The results of phytoplankton monitoring in 2018 are described in **Appendix C** (2018 Phytoplankton Monitoring at Quabbin Reservoir). The most prevalent phytoplankton in 2018 included the diatoms *Asterionella*, *Cyclotella,* and *Rhizosolenia*; the chlorophytes (green alga) *Gloeocystis* and *Sphaerocystis*; and the cyanophytes (blue-green alga) *Microcystis, Rhabdoderma,* and *Aphanocapsa*. These phytoplankton species are typical of many oligotrophic systems located in the temperate zone. Phytoplankton densities were generally lower than in previous years. The average densities in 2018 at Sites 202 and 206 were 221 and 421 ASUs/mL. In comparison, the average densities at these sites in 2017 were 255 and 466 ASUs/mL, respectively. The highest diatom densities were observed in April 2018, earlier than the typical period of peak diatom densities for Quabbin Reservoir monitoring sites.

Table 8. Descriptive statistics (minimum, median, and maximum) for concentrations of nutrients (ammonia, nitrate, TKN, TP, UV_{254}, calcium, and silica) measured at Quabbin Reservoir Core sites in 2018. Quarterly sampling of Quabbin Reservoir nutrients was conducted in May, July, October, and December 2018. Water column locations are as follows: Deep = hypolimnion/bottom, Mid = metalimnion/middle, and Surface = epilimnion/surface. See **Appendix B** for comparison of ranges from 1998-2017 EQ database (after Worden, 2013).

Parameter	Statistic	Reservoir Monitoring Site								
		202			206			Den Hill		
		Deep	Mid	Surface	Deep	Mid	Surface	Deep	Mid	Surface
Ammonia (µg/L as N)	Minimum	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Median	<5	<5	<5	<5	<5	<5	<5	<5	5.4
	Maximum	12.8	6.4	<5	9.6	<5	<5	19.7	20.6	18.6
Nitrate (µg/L as N)	Minimum	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Median	8.27	5.58	5.28	15.3	11.4	7.13	29.4	26.6	16.5
	Maximum	12.5	12.9	13.2	18.2	15.1	15.3	38.8	38.7	36.8
Total Kjeldahl Nitrogen (µg/L)	Minimum	<100	<100	<100	<100	<100	<100	101	<100	<100
	Median	<100	106	<100	119	123	117	155	168	158
	Maximum	130	162	126	183	128	146	205	449	202
Total Phosphorus (µg/L)	Minimum	<5	<5	<5	<5	<5	<5	6.29	<5	<5
	Median	<5	<5	<5	<5	<5	<5	7.10	5.41	5.86
	Maximum	5.9	5.48	<5	5.55	6.86	<5	7.68	6.49	12
Mean UV_{254} (ABU/cm)	Minimum	0.022	0.023	0.022	0.024	0.024	0.023	0.048	0.037	0.036
	Median	0.023	0.026	0.025	0.025	0.026	0.026	0.091	0.091	0.094
	Maximum	0.027	0.029	0.028	0.030	0.030	0.030	0.128	0.125	0.120
Calcium (mg/L)	Minimum	-	1.93	-	-	1.93	-	-	2.08	-
	Median	-	2.05	-	-	2.08	-	-	2.11	-
	Maximum	-	2.17	-	-	2.16	-	-	2.14	-
Silica (mg/L)	Minimum	1.63	1.62	1.66	1.53	1.53	1.51	2.51	1.62	1.48
	Median	1.80	1.65	1.81	1.60	1.58	1.58	3.01	3.01	2.75
	Maximum	1.98	1.98	1.94	1.89	1.91	1.91	3.97	3.84	3.75

3.3 Results: Tributary Monitoring

Monitoring of tributary water quality is not required by the SWTR or other regulations. DWSP performs routine monitoring of the tributaries in order to establish a baseline of water quality data, from which trends may be used to identify sub-watersheds where localized activities may be adversely impacting water quality.

3.3.1 Temperature

Temperature is a critical parameter in controlling the amount of dissolved oxygen that is available in aquatic environments. As temperatures increase, the amount of oxygen that can be dissolved in water decreases. Moreover, higher stream temperatures increase the solubility of nutrients and may correlate well with an increase in the growth of filamentous green algae and may threaten sensitive aquatic habitats.

Temperature in Quabbin Reservoir watershed tributaries ranged from -0.20 to 25.67 ˚C in 2018. In Ware River tributaries, water temperatures spanned a comparable range of -0.10 to 26.65 ˚C. Stream temperatures in the two watersheds exhibited strong seasonality with maximum temperatures occurring during summer months, and minimum temperatures corresponding to winter sampling dates for both watersheds. Average seasonal temperatures during 2018 were generally within 0.5 ˚C of the historic seasonal means for each watershed.

3.3.2 Dissolved Oxygen

Dissolved oxygen dynamics in stream environments may be linked to fluctuations in temperature, rates of streamflow, channel depth, other physical characteristics of the stream channel (e.g., channel slope, morphology, tortuosity), and local hydrology. Depletion of dissolved oxygen in aquatic environments can result from the oxygen requirements of aquatic life, the decomposition of organic matter, and the introduction of oxygen-demanding substances (such as chemical reducing agents). The Massachusetts Class A standard is a minimum of 6.0 mg/L. Dissolved oxygen levels in Quabbin Reservoir and Ware River tributaries were relatively high during 2018. Fewer than 5% (n=23) of samples for all tributaries of the Quabbin Reservoir and Ware River watersheds were below the 6.0 mg/L standard during 2018.

3.3.3 Alkalinity and pH

The pH of a stream is largely a function of the groundwater hydrogeology of the basins and the effectiveness of the stream water in buffering the effects of acid precipitation. Median pH values of tributaries were below the Class A water quality threshold of 6.5 units at all tributary monitoring sites (Quabbin and Ware River watersheds) during 2018. pH values in tributary monitoring sites ranged from a minimum of 4.06 to a maximum of 7.01. pH measured in Ware River tributaries was generally slightly more acidic (<0.2 pH units) than that of tributaries in the Quabbin Reservoir watershed.

Alkalinity data from the EQA sites were compared to acid rain assessment criteria established under the Acid Rain Monitoring (ARM) Project at the University of Massachusetts. The ARM assessment criteria are used to evaluate the sensitivity of water bodies to acid deposition in MA. The ARM criteria are based on average results for the month of April (Godfrey *et al.*, 1996), with the ARM endangered threshold value corresponding to 5.0 mg/L.

Average alkalinity measures of Quabbin Reservoir and Ware River watershed tributaries during the month of April 2018 were below the ARM Endangered threshold at two EQA sites in the Quabbin Reservoir watershed (216D and 216-IX) and all EQA sites in the Ware watershed (115, 126A, 127, and 128). For sites 216C, 216E-1, and 216G, average April alkalinity values exceeded the ARM Endangered threshold of 5 mg/L, instead entering the classification category of Highly Sensitive (5-10 mg/L alkalinity), suggesting that these waters are less sensitive to the impacts of acid rain deposition than those that fall within the Endangered classification category. None of the sites monitored during 2018 were classified as Critical or Acidified, the two most sensitive classifications. Monitoring for alkalinity will continue in 2019.

Alkalinity in Quabbin Reservoir and Ware River watersheds generally peaks between late June and October. During 2018, alkalinity rose steadily through late spring (May), reaching maximum annual concentrations during July, before declining in the fall (September-November). Maximum alkalinity concentrations in 2018 ranged from 14.50 mg/L (Site 121B in Ware River watershed) to 21.60 mg/L (Boat Cove Brook in the Quabbin Reservoir watershed). A maximum alkalinity (12.30 mg/L) for the period of record was observed in July 2018 at site 216C in the Quabbin Reservoir watershed.

3.3.4 Specific Conductance and Dissolved Salts

Elevated levels of specific conductance in streams may indicate potential contamination from human-derived sources of salts to natural water systems such as septic system effluent, stormwater discharges, agricultural runoff, or road salt runoff from deicing activities. Specific conductance values measured in Quabbin Reservoir and Ware River watershed tributaries during 2018 were generally comparable to the historic ranges. Average annual conductivities measured in Quabbin Reservoir and Ware River watershed tributary Core sites during 2018 were lower than average, except for Site 121B in the Ware River Watershed, which demonstrated a relatively minor increase (4%) in average annual specific conductance. The maximum conductivity measured in the Quabbin Reservoir watershed was 353 µS/cm at Site 216E-1 on July 3, 2018. The maximum conductivity measured in the Ware River watershed was 358.6 µS/cm at Site 121B (Thayer Pond Inlet) on March 6, 2018.

Monitoring for chloride and sodium, the major constituents of anthropogenically-derived salts (e.g., road salt runoff and septic effluent), began in late summer of 2018 for Quabbin Reservoir Watershed tributaries. Concentrations of sodium in Quabbin Reservoir watershed tributaries ranged from 1.79 to 36.4 mg/L, with an average concentration of 10.66 mg/L. The average chloride concentration in Quabbin Reservoir watershed tributaries was 15.26 mg/L and ranged from 1.27 to 62.6 mg/L.

Concentrations of sodium and chloride were generally elevated during low flow conditions and exhibited a dilution response (decreasing concentrations) following precipitation events. Concentrations of chloride measured in tributaries to the Quabbin Reservoir were greater in tributaries with mixed land cover (e.g., more developed lands) than those with drainage areas comprised of largely DWSP-owned (e.g., Boat Cove and Gates Brooks). Monitoring for sodium and chloride will continue through 2019.

3.3.5 Turbidity

The standards for turbidity at drinking water intakes are five NTU under the SWTR, and one NTU under MassDEP regulations. While not directly applicable because the tributaries are not drinking water intakes, drinking water standards for turbidity were used as reference points in evaluating the tributary data.

Minimum, maximum, and average turbidity results for each tributary monitored in 2018 are summarized in **Table 9**. Results were generally consistent with the historical ranges of turbidity levels, with the annual average turbidity level observed in all sites falling within 1-standard deviation of average turbidity levels for the period of record. Historical maximum turbidity results were observed at several sites in the Ware River watershed (103A, 115, 126A, and 128), and at two locations (216C and Boat Cove Brook) in the Quabbin Reservoir Watershed during 2018. The new maximum results and corresponding sample dates are provided in **Table 9**.

Turbidity results for Quabbin Reservoir and Ware River watershed tributaries are shown on **Figure 9**. Turbidity levels in 2018 generally increase during the summer months and decrease during the winter, with peaks corresponding to precipitation events, increased algal growth, and/or higher sediment mobilization due to unfrozen ground during summer months. The relative variability in turbidity levels in Quabbin Reservoir and Ware River tributaries is illustrated in **Figure 9**. The annual peaks in both watersheds were of similar durations, from June through November. The timing and relative magnitude of seasonal changes (troughs and valleys) were similar in both watersheds. However, peak summer turbidity levels were generally more elevated in Ware River tributaries (approximately 2-4 NTU) than in Quabbin Reservoir tributaries (generally below 2 NTU), leading to a higher annual standard deviation in turbidity in Ware River tributaries. Turbidity exceeded 5 NTU in four samples from the Quabbin Reservoir watershed and in one sample from the Ware River watershed in 2018. Elevated levels of turbidity observed in surface water were likely attributable to recent flushing effects following heavy precipitation. The differences in turbidity dynamics observed across watersheds/sites may be a result of land use differences across sites, localized meteorological effects, and sub-catchment hydrology, thus are not necessarily indicative of long-term trends.

Table 9. Descriptive statistics (minimum, maximum, and average) of turbidity results and date of maximum result in Quabbin Reservoir and Ware River watershed tributary monitoring sites during 2018.

Watershed	Site Name	Turbidity (NTU)			Date(s) of Max. Result
		Min	Max	Average	
Ware River	101	0.40	4.00	1.60	7/10/2018
	103A	0.50	5.60	1.48	7/10/2018
	107A	0.34	2.20	0.96	9/19/2018
	108	0.49	4.60	1.45	7/10/2018
	115	0.37	2.50	0.97	7/24/2018
	121B	0.38	2.90	1.07	5/29/2018
	126A	0.44	2.10	1.01	6/12/2018
	127	0.31	1.70	0.72	7/10/2018
	128	0.51	3.60	1.11	5/29/2018
Quabbin Reservoir	211	0.19	1.50	0.44	9/11/2018
	212	0.39	2.80	0.94	6/19/2018, 9/11/2018
	213	0.34	2.20	0.80	6/19/2018
	215	0.32	1.80	0.71	9/11/2018
	216	0.36	1.40	0.74	9/11/2018
	216C	0.42	16.00	1.43	6/19/2018
	216D	0.43	1.90	0.89	6/5/2018
	216-E1	0.65	5.40	1.71	9/25/2018
	216G	0.46	3.20	1.18	6/19/2018
	216-IX	0.43	1.70	0.82	6/19/2018
	BC	0.46	23.00	2.26	8/14/2018
	GATE	0.13	1.30	0.33	9/11/2018

Figure 9. a. Turbidity levels measured in Quabbin Reservoir Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018. For visualization purposes, maximum turbidity values for sites BC (23 NTU on 08/14/2018) and 216C (16 NTU on 06/05/2018), respectively, have been excluded.

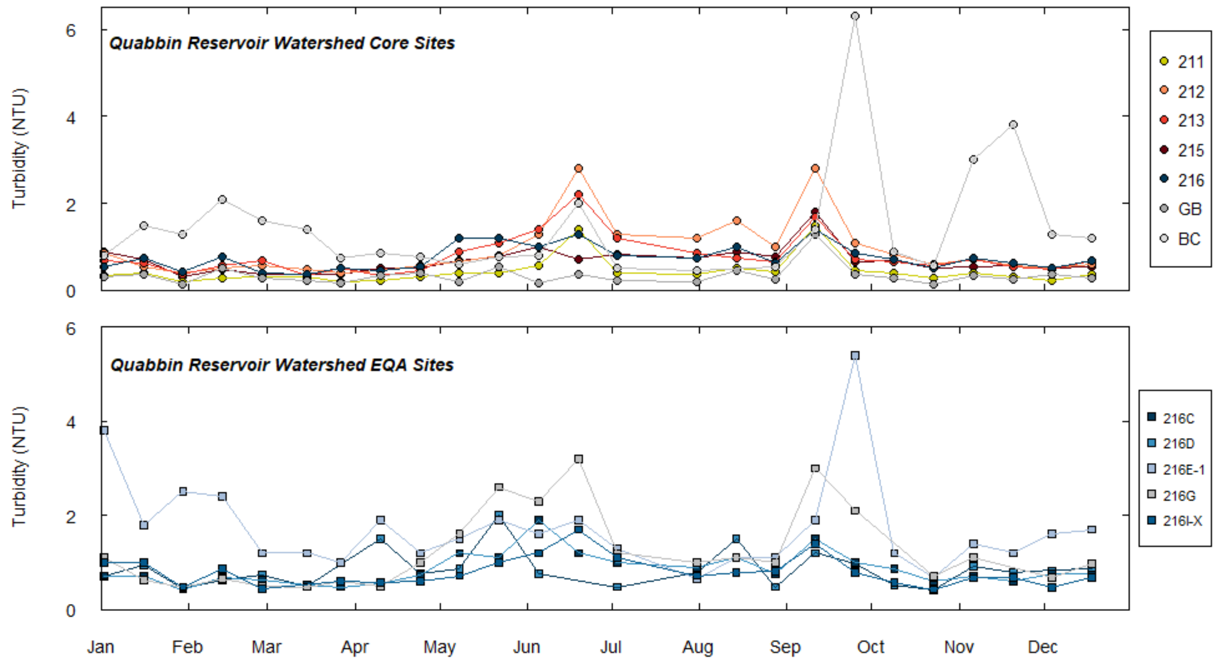
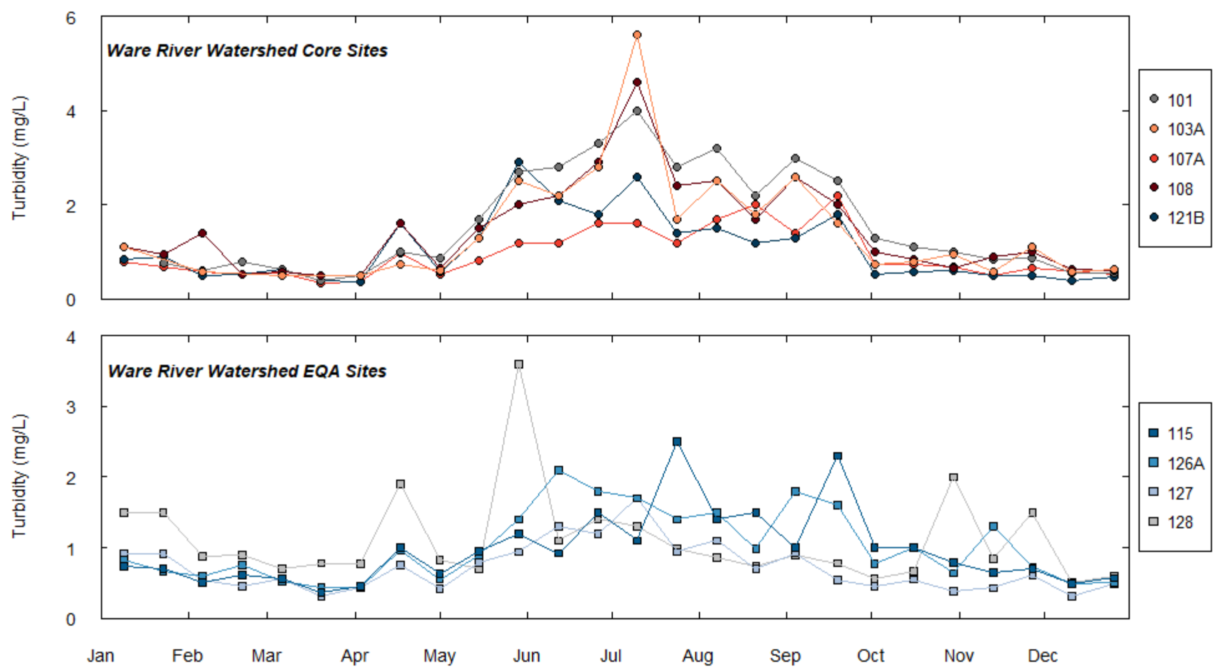


Figure 9. b. Turbidity levels measured in Ware River Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.



3.3.6 Total coliform, Fecal Coliform, and *E. coli* Bacteria in Tributaries

Massachusetts Class A surface water quality standards differentiate between bacteria standards for water supply intakes (discussed in **Section 3.0**), and other Class A waters, which rely on *E. coli* bacteria as the indicator of sanitary quality. The Massachusetts Class A standard for non-intake waters (314 CMR 4.05(3)(a)4.c) states that the geometric mean of all *E. coli* within the most recent six must remain below 126 MPN/100 mL (based on a minimum of five samples) and that no single sample shall exceed 235 MPN/100 mL.

Water quality monitoring in the Quabbin Reservoir and Ware River watershed tributary sites primarily includes *E. coli* and total coliform bacteria. In addition, monitoring for fecal coliform was performed on a limited basis to assess for potential sources of fecal coliform, other than wintering gulls, near the WDI. Fecal coliform monitoring was conducted weekly on two Quabbin Reservoir tributaries, Boat Cove Brook and Gates Brook, from September, 2017 through March, 2018.

Elevated bacteria results from Quabbin Reservoir and Ware River tributaries that cannot be attributed to a recent rain event are followed up with site inspection and re-sampling of the water. Bacteria detections may be attributable to wildlife activity and/or recent precipitation, or have no apparent source detected. Reports summarizing these inspections and the re-sample results are included in **Appendix C**.

3.3.6.1 Total Coliform Bacteria

Total coliform results in 2018 were generally consistent with historical ranges. Historical maximum levels were detected at only two sites, and both were in the Quabbin Reservoir watershed on June 20. These maximums were 12,000 MPN/100 mL at Site 215F and 19,000 MPN/100 mL at Site 215H. Follow-up assessments were not performed for samples collected on June 20, as the elevated levels were likely related to a precipitation event.

3.3.6.2 Fecal Coliform Bacteria

The primary potential source of fecal coliform near the WDI on the reservoir during the fall, winter, and early spring has been determined to be that of roosting gulls on the reservoir. To address this, the bird harassment program was designed to prevent gulls from roosting in the vicinity of the WDI and reduce the potential risk for contamination of reservoir source water. To further evaluate sources of fecal coliform to the reservoir, fecal coliform results from daily WDI monitoring and weekly tributary monitoring at Boat Cove and Gates Brooks were evaluated. The weekly fecal coliform results from the two tributary monitoring sites served to provide additional data about potential fecal coliform sources other than birds roosting on the reservoir.

Results from this monitoring program indicated fecal coliform bacteria levels were relatively low at these tributaries during fall through early spring. The maximum level at Boat Cove Brook was >200 CFU/100 mL on September 7, and the maximum level at Gates Brook was 37 CFU/100 mL on September 7. Approximately 1.4 in of rain fell during the day before the September 7 sample was collected, which suggests the result was likely related to rainfall.

3.3.6.3 *E. coli* Bacteria

E. coli results ranged from less than 10 to 9,210 MPN/100 mL in Quabbin Reservoir watershed tributaries and from less than 10 to 1,550 MPN/100 mL in the Ware River watershed tributaries in 2018. *E. coli* data from 2018 were compared to data from previous years at each tributary site, and the annual geometric means for these years are shown in **Table 10**. Single-sample exceedances and corresponding sample collection dates have been provided in **Tables 11a** and **11b**. The percentages of samples exceeding 126 and 235 MPN/100 mL are shown in **Tables 12a** and **12b**.

The annual maximum *E. coli* result in the Quabbin Reservoir watershed was measured in water collected from Boat Cove Brook on August 14, 2018. The maximum *E. coli* result detected in the Ware River watershed was collected from Site 101 on September 9, 2018. The two maximum results occurred following high intensity rainfall events and were attributed to resultant flushing, as no potential source of pollution was observed, and *E. coli* levels further decreased in subsequent samples. Single-sample exceedances were most frequently attributed to flushing during storm events and/or snow melt immediately prior to sample collection dates.

Historical maximum single-sample *E. coli* counts were recorded for sites 216G and 216I-X in the Quabbin Reservoir watershed and all but two sites (107A and 121B) in the Ware River watershed in 2018. Follow-up investigations were not performed after these instances of elevated results, as results were potentially related to precipitation and generally coincided with occurrence of elevated *E. coli* at several other sites.

Long-term trends in annual geometric mean E. coli counts for tributary monitoring sites

The annual geometric mean *E. coli* counts for most Quabbin Reservoir watershed tributary core sites were comparable from 2010 through 2018. The annual geometric mean *E. coli* counts for 2018 at Core sites in Quabbin Reservoir and Ware River Watersheds were generally greater than in the previous year, with annual geometric mean *E. coli* counts measured in 2018 in Ware River Core sites representing the historical maximum counts for the period of record. The extent to which annual geometric mean *E. coli* counts exceeded historical maximums for each site varied, likely as a function of land use, antecedent conditions related to the sample collection date, and local meteorological conditions. Two core sites and one EQA site in the Quabbin Reservoir Watershed had lower annual geometric mean *E. coli* counts than in previous years (216C, Boat Cove, and Gates Brooks). Historically, Boat Cove Brook has demonstrated an upward trend in annual mean *E. coli* counts. However, annual geometric mean *E. coli* counts in 2018 represent the lowest annual value since 2015. Work to assess potential bacteria sources near this sample location has been described in previous reports (DWSP, 2018e). The geometric means at Quabbin EQA sites in 2018 were greater than the previous monitoring period (2014).

The elevated annual geometric mean *E. coli* counts for core and EQA sites in Ware River Watershed observed during 2018 may be due in part to flushing of streams from rainfall or snowmelt that may occur under high stream flow conditions that were present for much of 2018. The results of future sampling may help distinguish whether the higher levels in 2018 represent an upward trend. *E. coli* counts in tributaries to the Quabbin and Ware River watersheds were generally below 235 MPN/100 mL for 2018 (**Table 12**). The percentage of samples above this threshold ranged from 0% at several sites to 19% (5 of 27 samples) at site 212.

Table 10. Annual geometric mean *E. coli* for Quabbin Reservoir and Ware River Watersheds (top) core sites, and (bottom) EQA sites during 2018. EQA sites in the Ware River watershed were not sampled in 2015. Values below detection limits (<10 MPN/100 mL) were substituted with the detection limit (MassDEP, 2018).

Watershed	Site Name	Annual Geometric Mean *E. coli* (MPN/100 mL)								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
Ware River	101	17.61	33.80	28.68	24.48	18.27	18.48	19.23	33.29	34.10
	103A	31.65	23.63	20.91	25.79	34.21	35.52	33.66	35.78	58.54
	107A	20.61	16.10	17.69	21.59	17.74	23.68	17.60	25.74	36.34
	108	30.92	31.89	21.22	24.92	21.68	24.92	24.98	29.25	39.55
	121B	35.17	33.99	36.47	32.79	24.83	27.67	47.40	31.37	60.51
Quabbin Reservoir	211	18.77	13.11	19.39	11.87	14.57	13.93	33.14	15.32	18.50
	212	24.44	24.79	27.66	16.48	19.90	39.37	56.52	23.12	34.21
	213	57.42	52.96	49.44	37.41	39.97	36.36	42.74	26.87	37.85
	215	18.53	18.96	22.84	16.31	16.95	11.43	31.12	17.83	18.05
	216	19.17	29.79	18.75	16.51	15.09	12.90	24.29	13.79	19.98
	BC	28.19	16.46	31.95	16.61	25.36	30.46	55.85	73.52	41.35
	GATE	20.47	15.39	24.18	13.51	10.84	12.97	14.17	9.81	9.54

Watershed	Site Name	Annual Geometric Mean *E. coli* (MPN/100 mL)			
		2010	2014	2015	2018
Ware River	115	10.63	7.26	-	15.24
	126A	16.12	12.13	-	21.31
	127	9.20	11.69	-	13.44
	128	6.75	8.52	-	12.50
Quabbin Reservoir	216C	15.42	8.20	14.74	10.54
	216D	21.07	19.24	9.83	34.52
	216-E1	28.62	19.41	33.99	38.06
	216G	13.73	15.98	18.14	32.02
	216-IX	28.89	23.45	22.75	33.21

Follow-up Assessments

Gates Brook and Site 212 (Hop Brook) were resampled following elevated *E. coli* results on March 27 and May 8, respectively. No obvious fecal sources were observed on the original sampling dates or during resampling efforts. Thus, the elevated *E. coli* results were attributed to flushing from a rain-on-snow event prior to March 27 (Gates Brook). Follow-up assessments included looking for signs of animal activity and evaluating antecedent meteorological and hydrologic conditions leading up to the initial elevated results. For detailed description of resampling results, refer to **Appendix C**. If elevated levels are detected at this site in 2019, assessments may include microbial source tracking to identify potential cause(s).

Comparison of E. coli measured in tributaries to Class A Standards for non-intake waters

Tributary *E. coli* data were compared to the Class A standards for non-intake waters. The six-month running geometric means of Boat Cove Brook in the Quabbin Reservoir Watershed exceeded 126 MPN/100 mL on January 2 and 23, 2018. The exceedance of the Class A standard on these dates likely resulted from a series of elevated *E. coli* results during the summer of 2017 which have been described previously (DWSP, 2018e). For the remainder of 2018, waters in Boat Cove Brook remained in compliance with the Class A standard for non-intake waters. The six-month running geometric mean of site 103A in the Ware River watershed exceeded the 126 MPN/100 mL Class A standard on three dates in 2018 (October 16, 30, and November 13th). This is likely due to two occurrences of *E. coli* in excess of 1,000 MPN/100 mL observed at this site following heavy precipitation events during July and September 2018, and not necessarily indicative of the emergence of a persistent source of *E. coli* to the tributary. Gates Brook (in the Quabbin Reservoir Watershed) was the only tributary site that did not have at least one *E. coli* result in exceedance of the Class A Standard for single samples (*E. coli* counts >235 MPN/100 mL) in 2018 (**Table 12**).

Table 11. List of sites in a) Quabbin Reservoir and b) Ware River Watersheds with *observed E. coli* counts greater than the Class A Standard for single samples (*E. coli* counts >235 MPN/100 mL) and corresponding sample collection date. An "X" indicates *E. coli* counts greater than the Class A Standard for single samples were observed. All dates correspond to 2018 monitoring period.

Date	a) Quabbin Reservoir Watershed											
	Core Sites							EQA Sites				
	211	212	213	215	216	BC	GB	216C	216D	216-E1	216G	216-IX
May-08		**X**										
Jun-05		**X**	**X**									**X**
Jun-29	**X**	**X**	**X**		**X**			**X**	**X**	**X**	**X**	
Aug-14		**X**		**X**		**X**			**X**			
Aug-11		**X**		**X**		**X**		**X**	**X**	**X**	**X**	
Sep-25						**X**			**X**			

Date	b) Ware River Watershed								
	Core Sites					EQA Sites			
	101	103A	107A	108	121B	115	126A	127	128
May-29								**X**	
Jun-12					**X**				
Jun-26		**X**							
Jul-10		**X**							
Jul-24	**X**	**X**							
Aug-7				**X**					
Aug-11									**X**
Sep-19	**X**	**X**	**X**	**X**	**X**	**X**	**X**		

Table 12. Percentage of samples exceeding a) 126 MPN/100 mL and b) 235 MPN/100 mL *E. coli* for Ware River and Quabbin Reservoir Watershed tributaries. Values below detection limits (<10 MPN/100 mL) were substituted with the detection limit (MassDEP, 2018).

Watershed	Site Name	a) Percentage of Samples Exceeding 126 MPN/100 mL *E. coli*								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
Ware River	101	4	19	15	15	12	8	4	7	8
	103A	23	10	4	17	25	22	27	19	30
	107A	8	8	4	4	12	8	8	4	8
	108	4	8	0	11	12	8	12	15	15
	121B	38	12	23	7	19	19	21	24	16
Quabbin Reservoir	211	12	8	12	8	4	4	19	4	15
	212	12	14	12	8	4	18	21	12	22
	213	31	30	19	15	12	19	22	15	15
	215	8	5	8	4	4	0	30	12	8
	216	8	9	4	8	4	4	4	8	12
	BC	25	10	15	12	22	19	33	48	19
	GB	8	9	15	4	4	4	12	0	7

Watershed	Site Name	b) Percentage of Samples Exceeding 235 MPN/100 mL *E. coli*								
		2010	2011	2012	2013	2014	2015	2016	2017	2018
Ware River	101	0	8	4	0	0	4	0	4	8
	103A	4	5	4	0	8	4	8	0	9
	107A	8	4	0	4	4	4	0	0	4
	108	4	4	0	4	0	4	0	4	8
	121B	19	0	8	4	0	4	4	0	4
Quabbin Reservoir	211	0	0	0	8	0	0	15	0	8
	212	4	5	12	4	0	14	11	4	19
	213	12	9	8	8	0	0	7	11	11
	215	0	0	0	0	0	0	7	0	0
	216	0	4	4	8	0	0	4	0	0
	BC	8	5	8	4	4	7	21	32	15
	GB	4	5	15	4	4	0	8	0	4

3.3.7 Tributary Nutrient Dynamics

Biweekly sampling for nutrients has been conducted on selected tributaries, including core sites, since March 2005. The goal of this monitoring was to establish a database of nutrient data by sanitary district in both watersheds. In 2018, EQA sites in the Quabbin Reservoir and Ware River watersheds were monitored for nutrients and UV_{254} on a biweekly basis. Core sites in the Quabbin Reservoir watershed were monitored for nutrients and UV_{254} on a quarterly basis, and core sites in the Ware River watershed were monitored for nutrients on a quarterly basis and

UV_{254} on a biweekly basis. The Quabbin Reservoir watershed and Ware River watershed EQA sites were previously monitored in 2014-2015 and 2014, respectively.

Nitrogen species (ammonia, nitrate, and TKN) in Quabbin and Ware River watershed tributaries

Ammonia concentrations in Quabbin Reservoir and Ware River Watershed tributaries ranged from <5 to 157 µg/L as N and <5 to 122 µg/L as N, respectively, in 2018. Concentrations of ammonia were generally within historical ranges for most sites. A historic maximum ammonia concentration was observed at site 216C (157 µg/L as N on January 2, 2018).

Nitrate concentrations ranged from <5 to 69 µg/L as N in Quabbin Reservoir watershed core sites, compared to a maximum of 1,200 µg/L as N at the EQA sites (**Table 13**). Maximum nitrate concentrations occurred at Site 216E-1, an EQA site that has exhibited elevated nitrate concentrations during previous monitoring periods. Concentrations of nitrate observed in Ware River watershed during 2018 ranged from <5 to 243 µg/L as N in core sites and from <5 to 103 µg/L as N in EQA sites. Nitrate concentrations observed in Core and EQA monitoring sites in Quabbin Reservoir and Ware River Watersheds during 2018 were generally within historic ranges, with historic maximum nitrate concentrations exceeded on a single date at Site 121B in the Ware River watershed.

TKN, the sum of organic nitrogen plus ammonia, often constitutes a significant proportion of the total nitrogen present in a natural water body. TKN concentrations in Quabbin Reservoir watershed core sites ranged from <100 to 450 µg/L and from <100 to 2,160 µg/L in EQA sites. Maximum TKN concentrations exceeded historical maximums at Boat Cove (core) and two EQA sites (216C and 216D) in the Quabbin Reservoir watershed during 2018. This historic maximum TKN concentrations observed during 2018 were 450 µg/L at Boat Cove, 2,160 µg/L at site 216C, and 995 µg/L at site 216D.

TKN concentrations in Ware River watershed core sites ranged from <100 to 440 µg/L during 2018, and from <100 to 670 µg/L at EQA sites. The majority of TKN concentrations observed in Ware River tributaries in 2018 were within historical ranges, although a single historic maximum concentration was observed (670 µg/L at Site 128).

Total Phosphorus in Quabbin and Ware River watershed tributaries

Phosphorus is the limiting nutrient in algal growth in many freshwater systems, and it can be a cause for concern when concentrations are in excess (Section 3.2.8). Total phosphorus concentrations in 2018 ranged from <5 to 288 µg/L in Quabbin Reservoir Watershed tributaries and from <6.3 to 117 µg/L in Ware River Watershed tributaries. Concentrations of total phosphorus in 2018 were generally consistent with historical ranges. Historic maximum concentrations of phosphorus were observed in five sites (one Core and four EQA sites) in the Quabbin Reservoir watershed and in four EQA sites in the Ware River Watershed in 2018.

Historic maximum concentrations of total phosphorus observed in 2018 were generally within 15% of previous historic maximum concentrations, except for Boat Cove Brook, sites 216C, and 216G in the Quabbin Reservoir watershed and sites 127 and 128 in the Ware River watershed. Median concentrations across sites, when compared to historic data, do not exhibit any widespread elevated trends. Monitoring for total phosphorus will continue in 2019.

UV_{254} in Quabbin and Ware River Watershed Tributaries

Mean UV_{254} provides a surrogate measure of organic matter that is easier to analyze than total organic carbon. Mean UV_{254} was previously analyzed at major tributaries to Quabbin Reservoir in 1998-1999, as part of a research study at University of Massachusetts (Garvey *et al.*, 2001), and has since been monitored quarterly at core sites beginning in 2009. The variation in sampling frequencies between the two monitoring periods may impact the ranges of mean UV_{254} results observed. The lower mean UV_{254} values in 1998-99 may be related to lower-than-usual rainfall during that year of monitoring, so the higher values in 2009-2018 are not necessarily indicative of degradation of water quality.

Mean UV_{254} values in Quabbin Reservoir Watershed tributary monitoring sites in 2018 ranged from 0.05 to 0.79 ABU/cm. This range reflects the different quality of waters, from oligotrophic to eutrophic, including productive wetlands (Reckhow, personal communication). Historic maximum mean UV_{254} values were observed at one Core Site and one EQA site on the Quabbin Reservoir watershed during 2018. Historical maximum exceedance in mean UV_{254} in Quabbin Reservoir Watershed Core and EQA sites coincides with seasonally elevated concentrations.

Mean UV_{254} values in Ware River Watershed tributary monitoring sites in 2018 ranged from 0.10 to 0.86 ABU/cm. The concentration ranges observed during 2018 were comparable at Core sites and EQA sites in Ware River tributaries. Maximum mean UV_{254} concentrations in 2018 exceeded the historical ranges in samples collected from three Core and four EQA sites. The timing of historical maximum exceedance in mean UV_{254} in Ware River tributaries corresponds to a recurring seasonally elevated period for all sites.

Calcium in Quabbin and Ware River Watershed Tributaries

Calcium concentrations in Quabbin Reservoir Watershed Core and EQA sites in 2018 ranged from 0.85 to 11.9 mg/L in core sites and from 1.51 to 16.9 mg/L in EQA sites. The 12 mg/L threshold (see Section 2.2.1) was exceeded at EQA Site 216E-1 in the Quabbin Reservoir Watershed on July 3 and 17 (12.9 and 16.9 mg/L, respectively). This timing of 12 mg/L calcium exceedances corresponds to a period of seasonally elevated stream calcium concentrations (e.g., greater summer concentrations), and seasonally low streamflow (**Figure 4**). The timing of seasonally elevated stream calcium concentrations relative to low streamflow conditions suggests that groundwater contributions may be a source of elevated calcium to streams in the watershed. Continued monitoring of calcium during 2019 will serve to better inform the drivers behind the seasonal and long-term trends in calcium concentrations observed in tributaries to the Quabbin Reservoir.

Calcium concentrations in Ware River Watershed Core and EQA sites ranged from 1.7 to 13.9 mg/L in 2018. The maximum calcium concentration observed during 2018 occurred at Site 121B, a site with markedly greater calcium concentrations than other Ware River tributary monitoring sites for the period of record. The median calcium concentration at Site 121B was 11.3 mg/L in 2018, a decrease from the median calcium concentration observed at this site in 2017 (12.30 mg/L), although remaining consistently elevated compared to average annual concentrations since 2010 (DWSP, 2018e). Land use surrounding this site is primarily forested with mixed institutional, residential, commercial, industrial, and agricultural use. The observed increase in average annual calcium concentrations may be related to increased inputs from road de-icing, lime applications to soil, and/or weathering processes in recent years. Calcium concentrations in Quabbin and Ware River tributary sites were generally elevated during mid-late winter (January to February) and during summer months (June through August), suggesting that elevated calcium concentrations may be the result of a combination of these factors. Calcium monitoring will be continued to help establish a longer-term dataset for trend analysis.

Summary of Watershed Nutrient Dynamics

In the Quabbin Reservoir and Ware River watersheds, nutrient concentrations in 2018 were generally within the historical ranges, with minor increases observed at select sites when compared to historic records (**Tables 13a** and **13b**). Nutrient concentrations between the two watersheds were generally comparable, with several exceptions. Nitrate levels were similar among sites in both watersheds. Average TKN concentrations were greater in Ware River tributaries but exhibited more variability in tributaries to the Quabbin Reservoir during 2018. Ammonia concentrations in tributaries of both watersheds were generally similar. Average total phosphorus concentrations and UV_{254} results were comparable across the two watersheds, with slightly more variable results in Quabbin Reservoir tributaries relative to Ware River tributaries. Ranges and medians of calcium concentrations were comparable among sites in both watersheds, apart from elevated annual median calcium concentrations at Site 121B in the Ware River watershed. The cause of this increase may be attributed to a combination of land usage and geologic factors and will continue to be monitored during 2019.

Table 13. Descriptive statistics of nutrients (ammonia, nitrate-as-N, total Kjeldahl nitrogen (TKN), total phosphorus (TP), mean UV_{254}, and calcium) measured in Quabbin Reservoir and Ware River tributary monitoring in a) core sites and b) EQA sites during 2018.

Watershed	Site Name	Ammonia (µg/L-N)			Nitrate (µg/L-N)			TKN (µg/L)			TP (µg/L)			Mean UV_{254} (ABU/cm)			Calcium (mg/L)		
		Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max
Ware River	101	<5	5.7	11.5	15.5	21.2	23.6	<100	139	269	13.0	14.7	27.1	0.14	0.27	0.60	1.97	3.30	4.72
	103A	6.1	7.2	8.7	9.2	25.9	29.2	205	255	304	16.7	21.8	26.8	0.14	0.24	0.59	1.91	2.44	3.36
	107A	<5	5.4	7.9	5.5	16.1	35.7	<100	122	332	12.5	13.4	20.2	0.18	0.32	0.86	2.04	2.76	4.12
	108	6.0	6.5	22.6	5.7	41.2	50.6	<100	206	335	10.3	12.4	21.4	0.12	0.23	0.46	2.51	3.37	6.56
	121B	<5	10.2	11.6	<5	45.55	243	<100	<100	440	8.4	14.3	26.9	0.10	0.21	0.36	8.68	11.3	13.9
Quabbin Reservoir	211	<5	<5	<5	10.2	18.4	22.1	<100	107	277	6.4	13.7	24.0	0.07	0.14	0.19	1.52	2	3.44
	212	<5	<5	5.4	34.7	44.6	61.7	<100	129	299	8.1	11.2	33.4	0.06	0.10	0.27	1.35	3.65	6.09
	213	<5	5.9	7.3	24.6	59.6	68.6	<100	123	306	7.9	11.2	27.4	0.08	0.17	0.21	2.17	3.83	6.62
	215	<5	<5	7.4	<5	9.4	14.7	<100	256	382	7.1	13.3	18.0	0.18	0.27	0.56	1.39	1.82	4.48
	216	<5	<5	5.1	29.5	33.5	47.5	<100	207	310	7.8	13.8	36.1	0.13	0.23	0.40	2.01	2.68	4.14
	BC	<5	<5	<5	7.5	8.7	45.5	<100	187	450	10.4	30.7	37.1	0.14	0.25	0.43	3.97	7.27	11.9
	GATE	<5	<5	<5	<5	<5	<5	<100	107	144	<5	11.0	17.1	0.06	0.09	0.18	0.85	1.04	1.31

Watershed	Site Name	Ammonia (µg/L-N)			Nitrate (µg/L-N)			TKN (µg/L)			TP (µg/L)			Mean UV254 (ABU/cm)			Calcium (mg/L)		
		Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max
Ware River	115	<5	5.5	38.3	<5	20.55	74.4	<100	270	517	9.0	15.7	31.6	0.153	0.283	0.605	1.92	2.51	3.28
	126A	<5	6.6	65.9	7.8	21.3	57.5	<100	305	483	10.1	18.4	45.5	0.176	0.334	0.634	1.78	2.25	3.06
	127	<5	6.6	25.7	5.8	17.05	103	<100	231	385	6.3	12.1	117	0.124	0.168	0.399	1.72	2.13	2.75
	128	<5	17.2	122	<5	37.8	92.4	137	356	670	10.0	17.6	57.0	0.207	0.344	0.552	2.1	2.39	3.54
Quabbin Reservoir	216C	<5	7.5	157	<5	42	145.0	<100	258	2160	8.5	18.9	288	0.10	0.20	0.41	3.11	4.09	6.72
	216D	<5	<5	20.9	<5	29	84.1	<100	263	995	12.2	22.0	43.3	0.13	0.26	0.57	1.95	2.47	3.60
	216-E1	<5	7.5	22	294	645	1200	<100	229	508	13.7	27.2	51.2	0.05	0.11	0.29	1.57	7.23	16.9
	216G	<5	9.5	81.6	39.9	75.25	416	115	276	527	8.8	19.5	53.2	0.11	0.22	0.49	3.56	5.16	7.79
	216-IX	<5	<5	21	<5	58.3	104	130	359	525	10.6	21.1	47.0	0.23	0.47	0.79	1.51	2.05	6.03

3.3.8 Monitoring for the Diatom *Didymosphenia geminata*

In response to alerts about new infestations of the potentially invasive diatom *Didymosphenia geminata* ("Didymo") in New England, Environmental Quality staff implemented a program to monitor for Didymo in 2007. This program relies on both artificial substrates (consisting of glass slides mounted in special samplers) and natural substrates. Artificial substrates provide a surface for colonization by algae and other organisms (periphyton), and deployment of glass slides is a standard technique for investigation of this component of aquatic communities. Natural substrates were sampled by gently removing periphyton growth off sections of rocks for analysis.

Artificial substrates were initially deployed in late 2007 at Quabbin on the three branches of the Swift River at existing sampling sites (West Branch Site 211 at Route 202, Middle Branch Site 213 at Gate 30, and East Branch Site 216 at Route 32A) and at a fourth location, downstream of Winsor Dam and a section of the Swift River popular for fly fishing, about one kilometer downstream of Route 9 off Enoch Sanford Road. On the Ware River, a sampling site near the Shaft 8 Intake (Site 101) was selected. Due to severe weather and the extreme changes in flow volume that adversely affect samplers, sampling sites and methods have been altered in recent years to facilitate continued monitoring. Weather patterns, and growing evidence that Didymo prefers to grow on substrates that have a well-established periphyton, led to further changes in sampling procedures. In 2013, slides were deployed for a two-month period to allow sufficient time for colonization by periphyton.

Didymo may now be considered a native species that occasionally produces numerous stalks in response to low phosphorus concentrations (Taylor and Bothwell, 2014). These stalks can cause serious ecological impacts by smothering other stream-dependent organisms. With this reevaluation of Didymo as a native species with only occasional impacts, the program of routine inspections, rock scrapings, and renewal of artificial substrates was reduced beginning in 2016. Monitoring efforts were reduced further during 2018. Monitored sites were checked several times during the year, and results were negative for Didymo. The monitoring program will likely continue at this reduced frequency to facilitate early detection of Didymo within the watersheds.

3.4 Aquatic Invasive Species Monitoring

AIS are "non-indigenous organisms that...have the ability to become established and spread rapidly within native aquatic communities," (DWSP, 2010). They generally have adaptations that enhance their survival and reproduction, as well as a lack of predators or diseases in the new environment to keep their populations in check. For the DWSP/MWRA system, the primary concerns that AIS pose are "loss of native species, habitat degradation, damage to infrastructure, disruption of ecosystem function, and impairments to water quality" (DWSP, 2010).

DWSP staff implemented various programs to monitor for and prevent the spread of AIS in response to the potential impacts of AIS on water quality. These programs include boat inspections and decontamination, monitoring of boat ramps, and aquatic macrophyte surveys. Brief reports on these programs are included in **Appendix C**. Aquatic macrophyte surveys were conducted annually during the summer at selected water bodies within the Quabbin and Ware River watersheds, as well as occasionally in water bodies outside of these watersheds that are in close proximity to Quabbin Reservoir.

Aquatic macrophyte surveys were performed on the Quabbin Reservoir in 2006 and 2010 and have been conducted on an annual basis since 2013. DWSP Environmental Quality staff work with an MWRA consultant to conduct these surveys. Until 2014, the primary AIS finding was variable-leaf milfoil (*Myriophyllum heterophyllum*), which was documented in Quabbin Reservoir prior to 1973 (DWSP, 2010). In 2014, brittle naiad (*Najas minor*) was discovered in O'Loughlin Pond, also known as the regulating pond, north of Fishing Area 2. The brittle naiad plants were removed, and an additional fragment barrier was installed to protect the reservoir. Subsequently, one primary fragment barrier was installed and periodically assessed for functionality. The pond and the fragment barrier were surveyed by DWSP and the MWRA consultant in 2018, and no brittle naiad plants were found.

Swollen bladderwort was discovered in Quabbin Reservoir in 2017. The 2018 survey did not yield any detections of swollen bladderwort in Quabbin Reservoir. No new AIS were observed in Quabbin Reservoir or Ware River watersheds. Variable-leaf milfoil and *Phragmites australis* (common reed) were observed in the Quabbin Reservoir, although at lower capacity than in previous years. Other AIS observed in watershed ponds (but not in the reservoir) included *Cabomba caroliniana* (fanwort), *Potamogeton crispus* (curly leaf pond weed), *Iris pseudacorus* (yellow flag iris), *Lithrum salicaria* (Purple Loosestrife), *Rorippa microphylla* (One Row Yellowcress), and *Myosotis scorpioides* (True Forget-me-not).

3.5 Forestry Water Quality Monitoring

Forest Management operations, when conducted with proper best management practices, should not have significant short- or long-term effects on water quality. Monitoring of harvest operations and water quality is conducted to ensure water quality standards are maintained on DWSP lands. Short-term monitoring focuses on direct water quality impacts that can occur during logging, while long-term monitoring involves evaluating water quality parameters as the forest regenerates following logging operations.

3.5.1 Short-term Monitoring

Short-term forestry monitoring involves monitoring forestry operations through site inspections and targeted water quality sampling. Inspections and water quality sampling were conducted prior to the start of logging in order to establish a baseline, during operations to monitor short-term effects, and after logging to assess for long-term effects. The Environmental Quality Section reviewed forestry lot proposals, inspected sites, collected samples, and updated the forestry water quality monitoring database in 2018. Field review of proposed DWSP timber lots was conducted in the Ware River and Quabbin Reservoir watersheds. Water quality testing occurred on one lot each in the Quabbin Reservoir watershed (Lot 3138) and the Ware River watershed (Lot 4393) for post-harvest monitoring (see **Appendix C**). No issues were identified.

3.5.2 Long-term Monitoring

Two sites in the Quabbin Reservoir watershed have been established for long-term monitoring of the potential impacts of forest harvesting on water quality. Monthly grab samples have been collected at the Middle Branch Dickey Brook and the East Branch Underhill Brook on Prescott Peninsula for over 10 years (the second Wednesday of each month, since April 2002). Samples from long-term monitoring sites were analyzed for nutrients (nitrate, nitrite, total Kjeldahl nitrogen, and total phosphorus); Since January 2014 total suspended solids, UV_{254}, ammonia, total organic carbon, and dissolved organic carbon have been analyzed. Monthly sampling at Underhill Brook and Dickey Brook continued through 2018.

Periodic stormwater sampling of Underhill and Dickey Brooks was initiated in 2014 to characterize stream response during precipitation events (e.g., rainfall and snowmelt). Primary data include rainfall depth and stream flow rate. Concentration results of samples collected during storm events serve to characterize the range of nutrient and sediment concentrations in storm-related flows. Ultimately, the hydrologic and concentration data will be used to estimate nutrient and sediment loads delivered during storms and more accurately inform the potential impacts of tree harvesting on water quality within the Quabbin Reservoir watershed.

Efforts during 2018 to implement the long-term forestry water quality monitoring included the annual re-installation and routine maintenance of water level loggers and precipitation gauges, downloading of field data, monitoring of weather forecasts and staff availability, continued development of field procedures, sample and data collection during three storms, and data analysis. Event-based sample collection at Underhill and Dickey Brooks for four events will be conducted in 2019.

4 Conclusions

The 2018 water quality data document the continued excellent water quality of the Quabbin Reservoir, Quabbin Reservoir watershed, and Ware River watershed. Moreover, the requirements of the filtration avoidance criteria under the SWTR were satisfied. Air temperatures in 2018 were close to average for the period of record. Monthly precipitation totals were below average for the months of March, April, and May, and above average for the duration of 2018. Annual geometric mean *E. coli* results in most Quabbin Reservoir and Ware River Watershed tributaries were elevated relative to 2017, with elevated results attributed to flushing of bacteria following precipitation events. Turbidity data indicated generally higher maximum turbidities in tributaries in the Ware River watershed than the Quabbin Reservoir watershed, which may be a function of land use differences. Water quality monitoring is ongoing to assess and document water quality in the reservoir and watersheds.

5 Proposed Schedule for 2019

Water sampling protocols, including field and analytical methods, will remain the same for 2019, with the addition of sodium and chloride monitoring on a biweekly basis at all tributary monitoring sites. Calcium monitoring will continue at tributary sites on a biweekly basis. UV_{254}, used as a surrogate measure for organic matter content in water, will continue to be monitored quarterly in Quabbin core tributary sites, and biweekly in Ware River core tributary sites and in all EQA sites. EQA monitoring in the Quabbin Reservoir watershed shifts to the Quabbin Reservation Sanitary District, previously monitored in 2010. Ware River watershed monitoring will shift to the East Branch Ware River Sanitary District, which was previously monitored in 2015.

Reservoir monitoring will continue to be conducted monthly in 2019 (April-December), with the addition of sodium and chloride monitoring at three depths for each site at quarterly intervals. Sampling at the three deep-water reservoir sites will continue, with profiles of temperature, dissolved oxygen, pH, and conductivity collected monthly. The reservoir nutrient sampling program and the plankton monitoring program will also continue in 2019. No other changes are proposed for in-reservoir monitoring during 2019.

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APPENDIX A

Selected Plots and Graphs

Quabbin Reservoir depth profiles (temperature, DO, pH, and SC) – Sites 202, 206, and Den Hill

Stream hydrographs

Time series of in-situ measurements (temperature, DO, pH, and SC) in tributaries

Bivariate plots of chloride vs. sodium and specific conductance

Figure A1. Monthly depth profiles (from left to right) of temperature, dissolved oxygen, pH, and specific conductance at Quabbin Reservoir Site 202 during 2018.

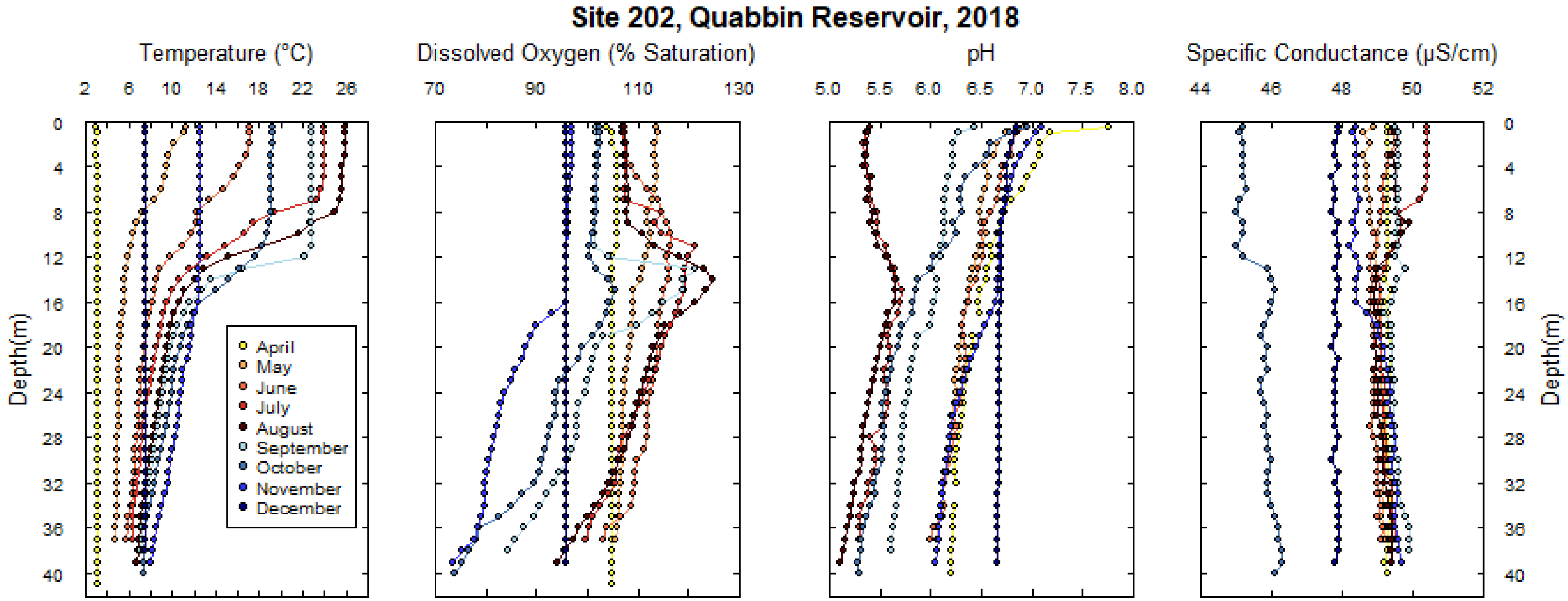


Figure A2. Monthly depth profiles (from left to right) of temperature, dissolved oxygen, pH, and specific conductance at Quabbin Reservoir Site 206 during 2018**.**

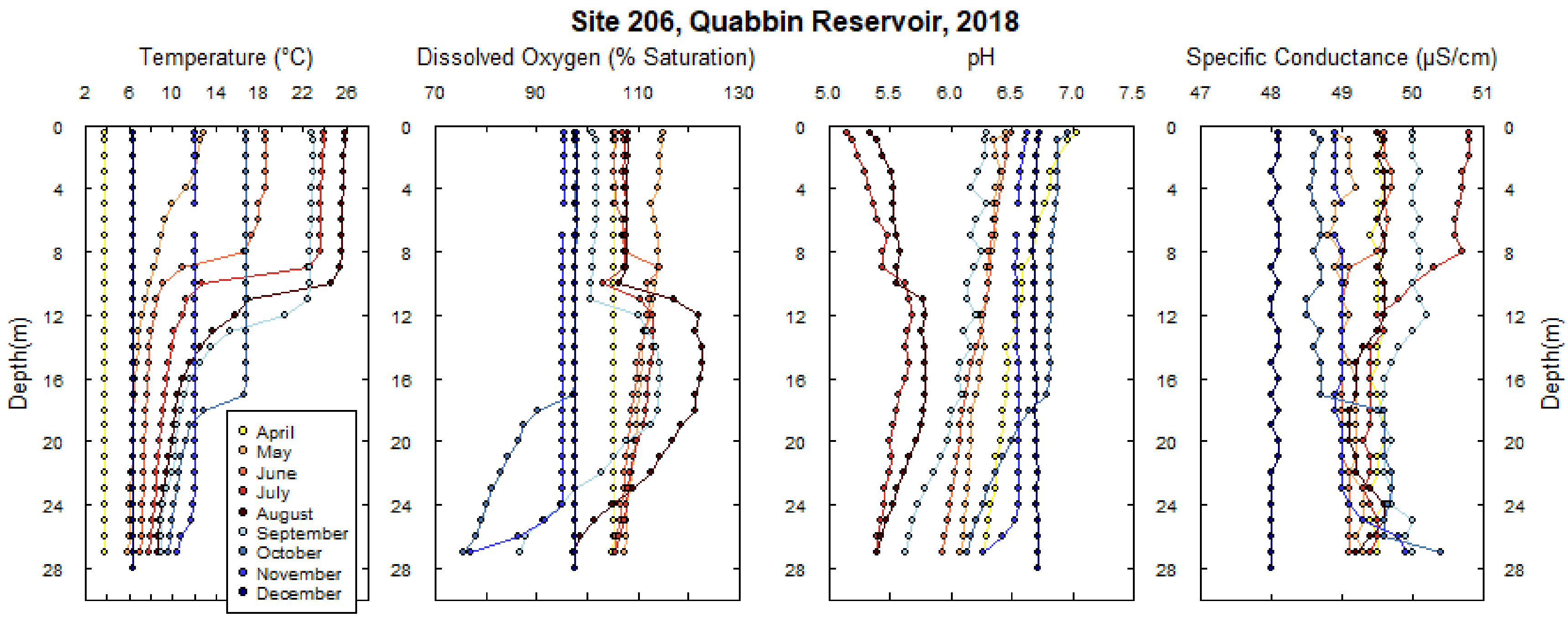


Figure A3. Monthly depth profiles (from left to right) of temperature, dissolved oxygen, pH, and specific conductance at Quabbin Reservoir Site Den Hill during 2018**.**

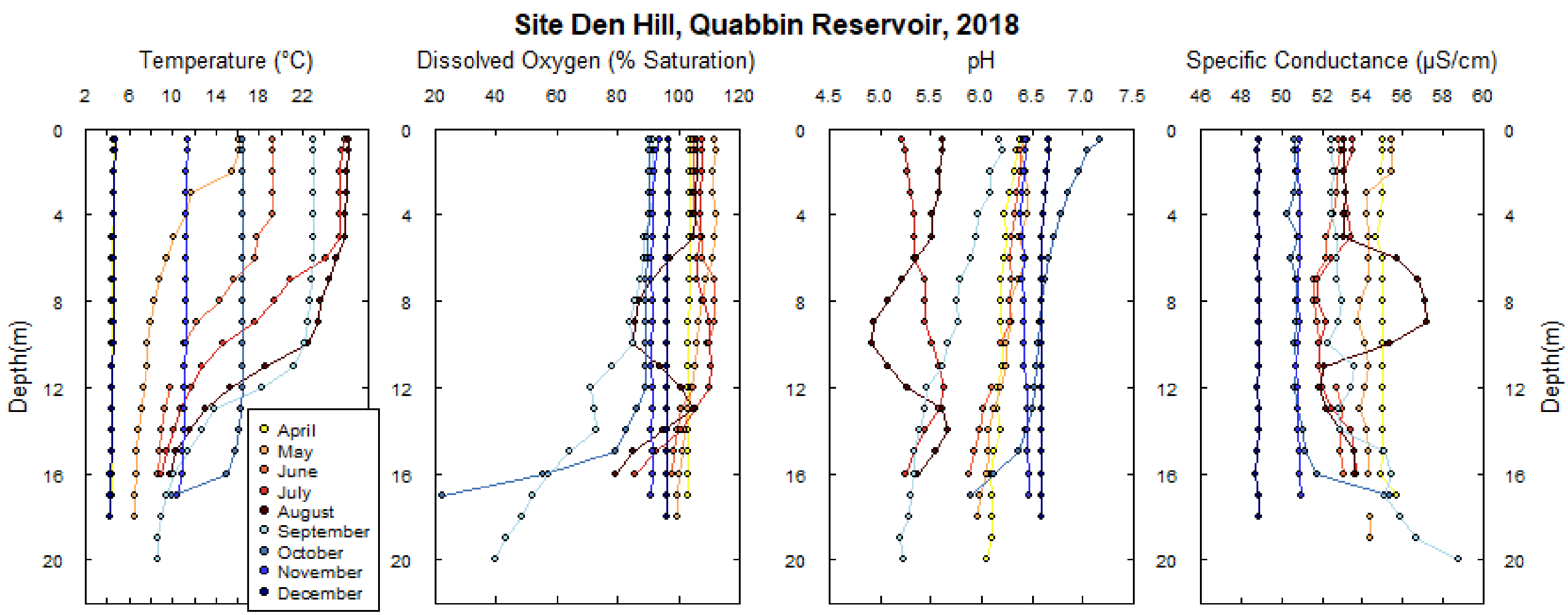


Figure A4. Hydrographs of mean daily streamflow for (top) Ware River near Barre (USGS Gauge No. 01172500), (middle) Ware River near Gibbs Crossing (01173500), and (bottom) Swift River at West Ware (No. 01175500). Vertical lines mark sample collection dates for each watershed. The average of mean daily flows for the period of record (1946-2018 for the Ware River near Barre and 1912-2018 for the Ware River near Gibbs Crossing and the Swift River at West Ware) are represented by the solid black line. The gray band denotes the normal (25th to 75th percentile) flow range for the period of record.

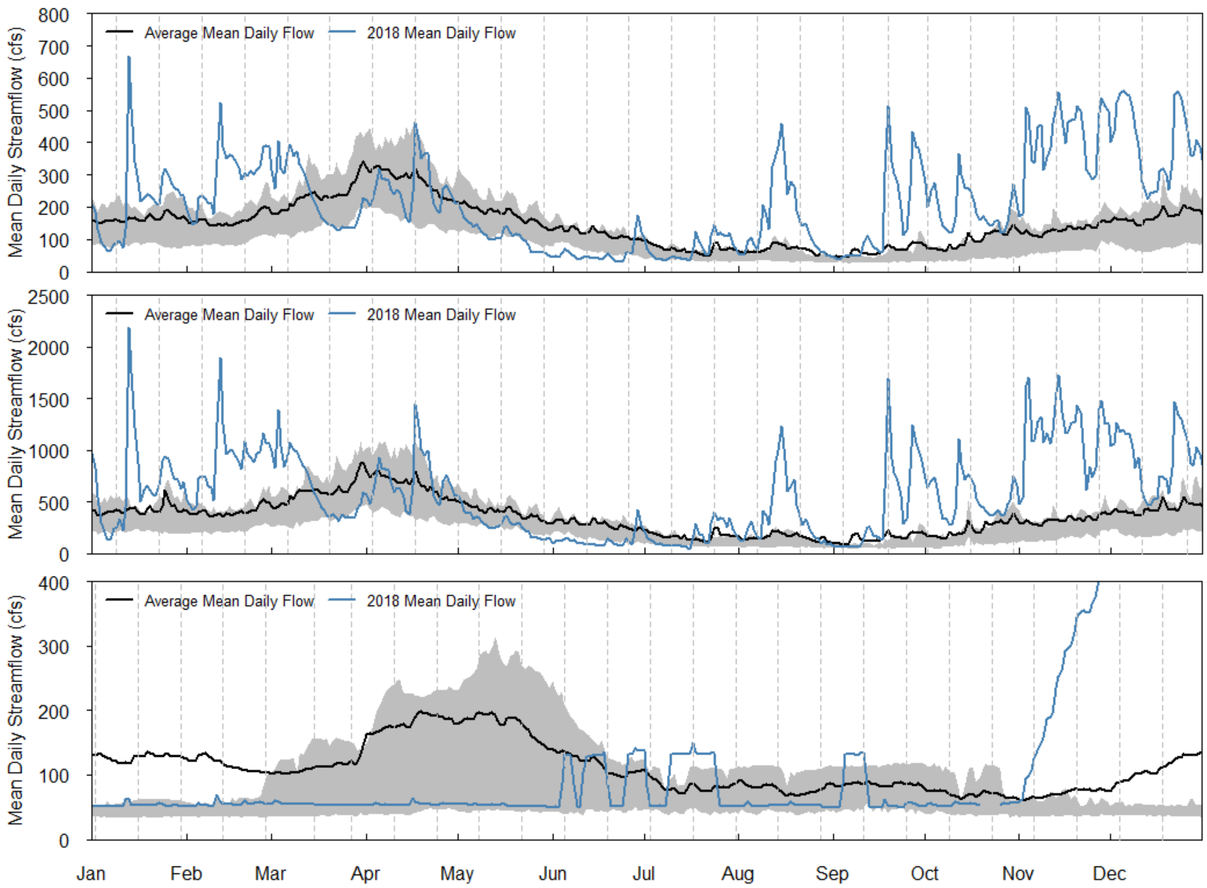


Figure A5a. Temperature measured in Quabbin Reservoir Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

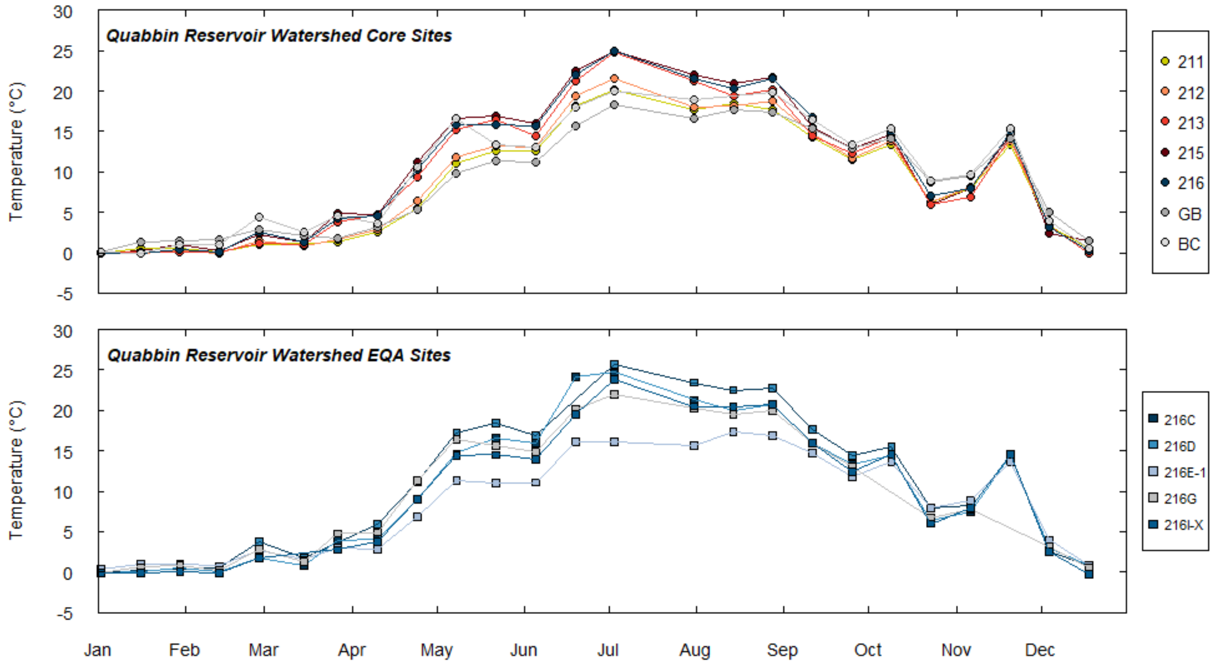


Figure A5b. Temperature measured in Ware River Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

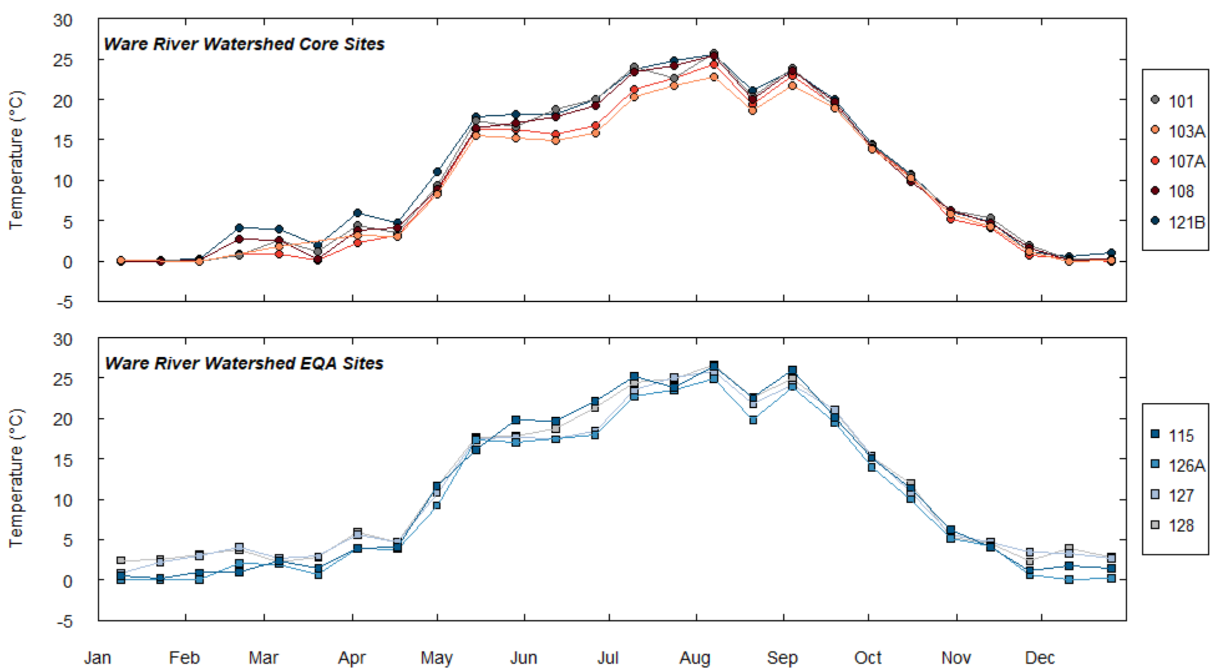


Figure A6a. Dissolved oxygen (percent saturation) measured in Quabbin Reservoir Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

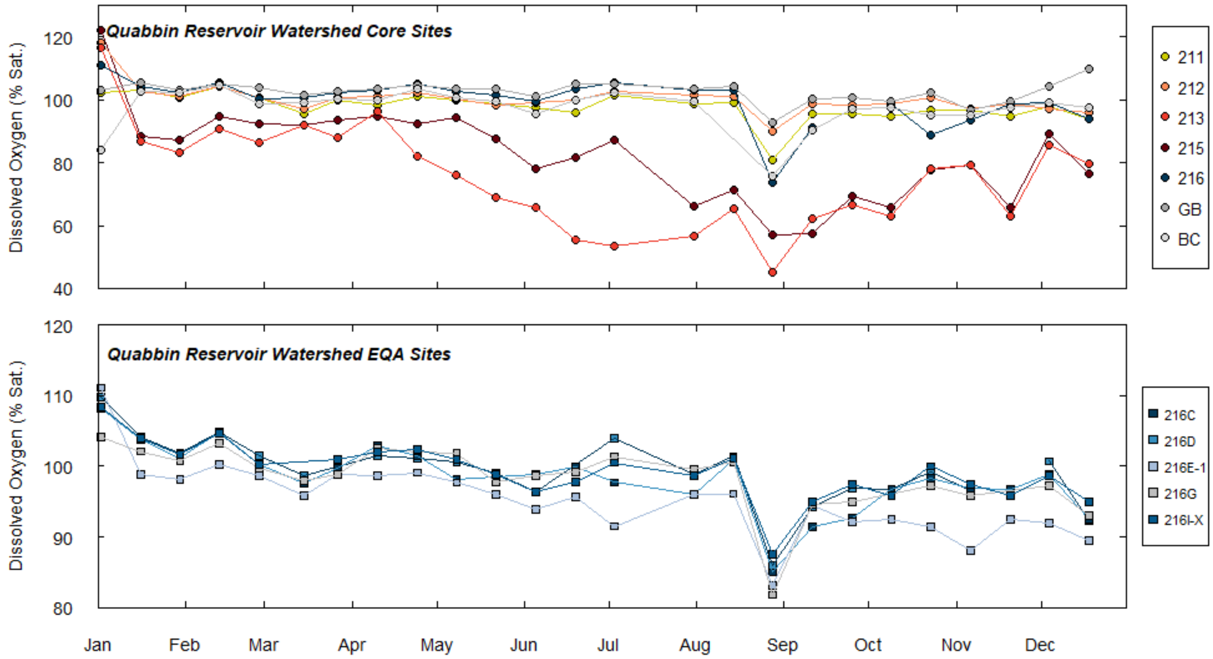


Figure A6b. Dissolved oxygen (percent saturation) measured in Ware River Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

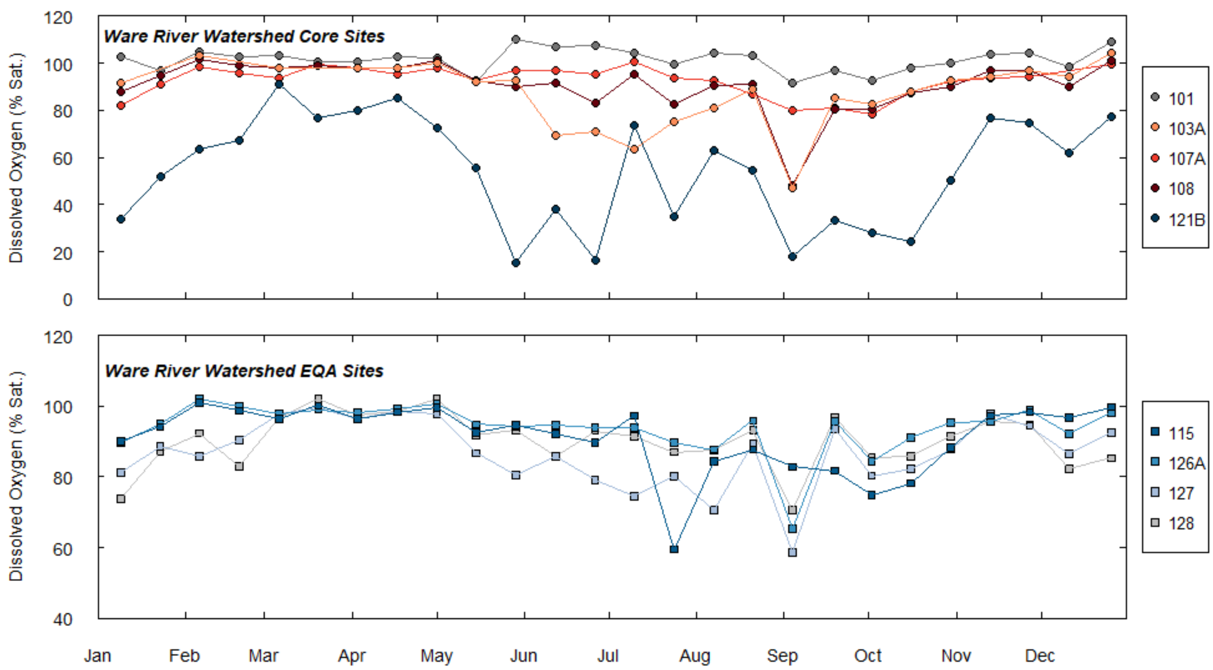


Figure A7a. pH measured in Quabbin Reservoir Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

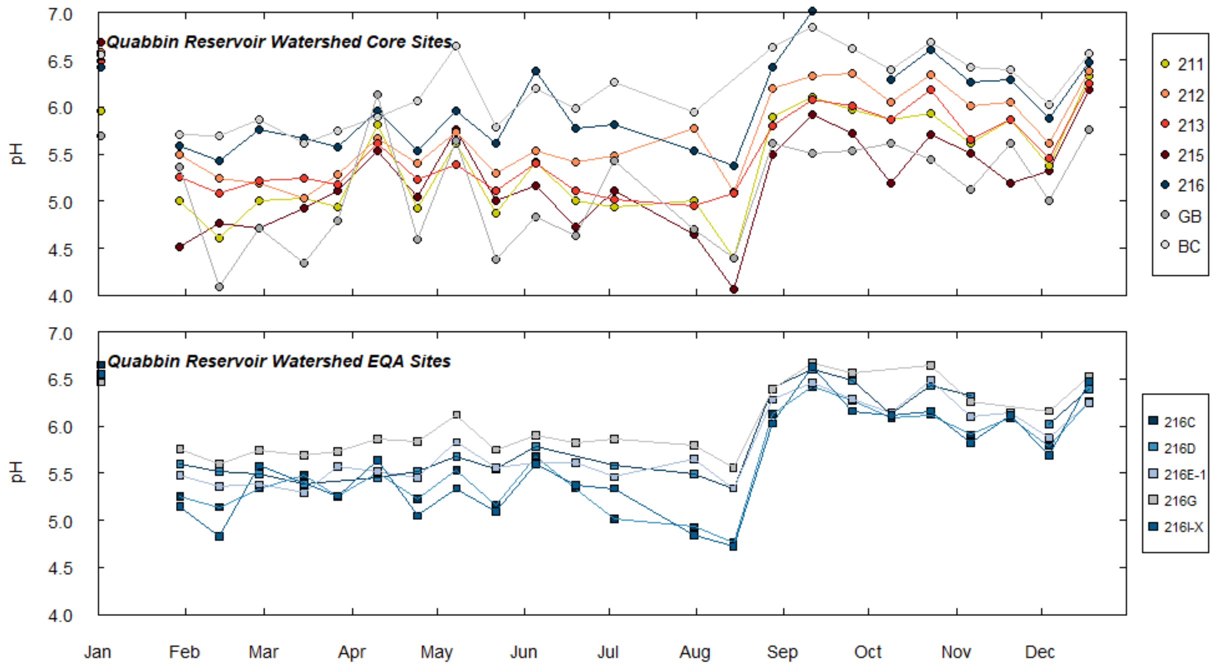


Figure A7b. pH measured in Ware River Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

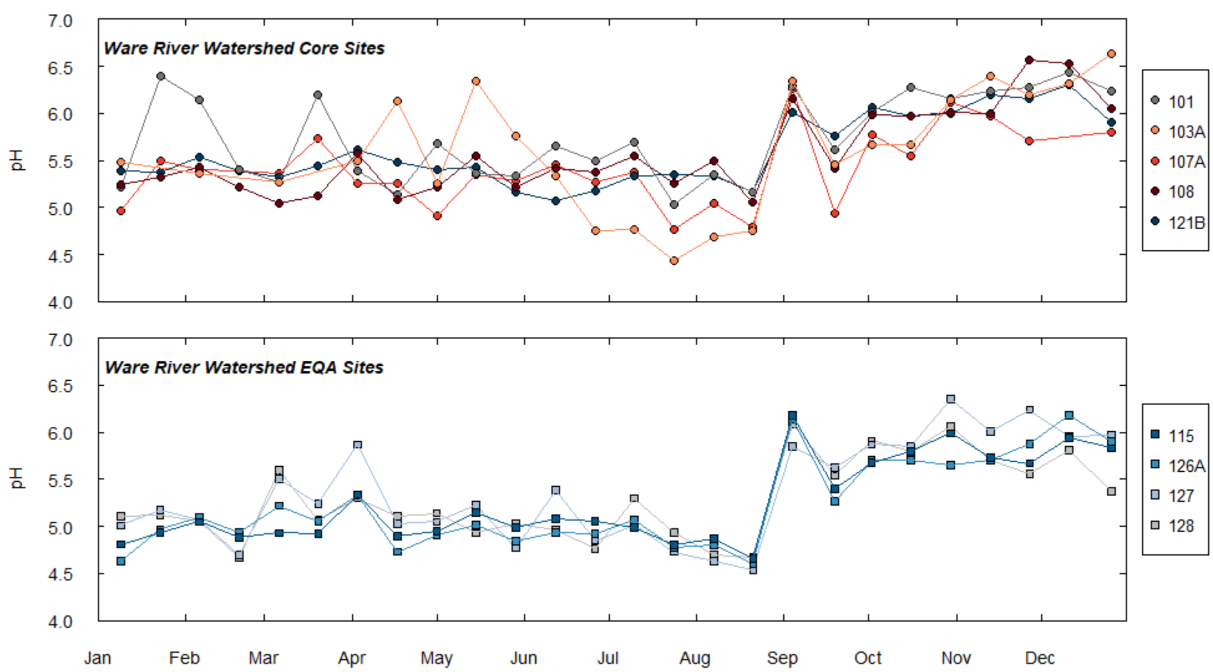


Figure A8a. Specific conductance measured in Quabbin Reservoir Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

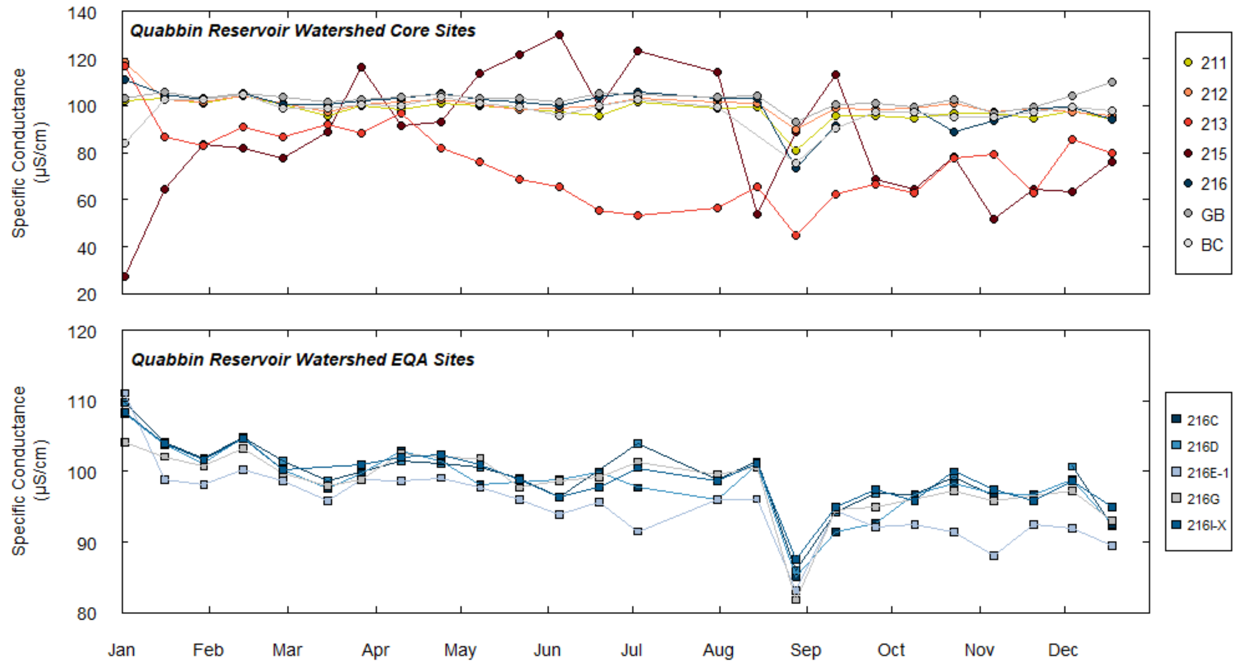


Figure A8b. Specific conductance measured in Ware River Watershed (top) Core and (bottom) EQA tributary monitoring sites during 2018.

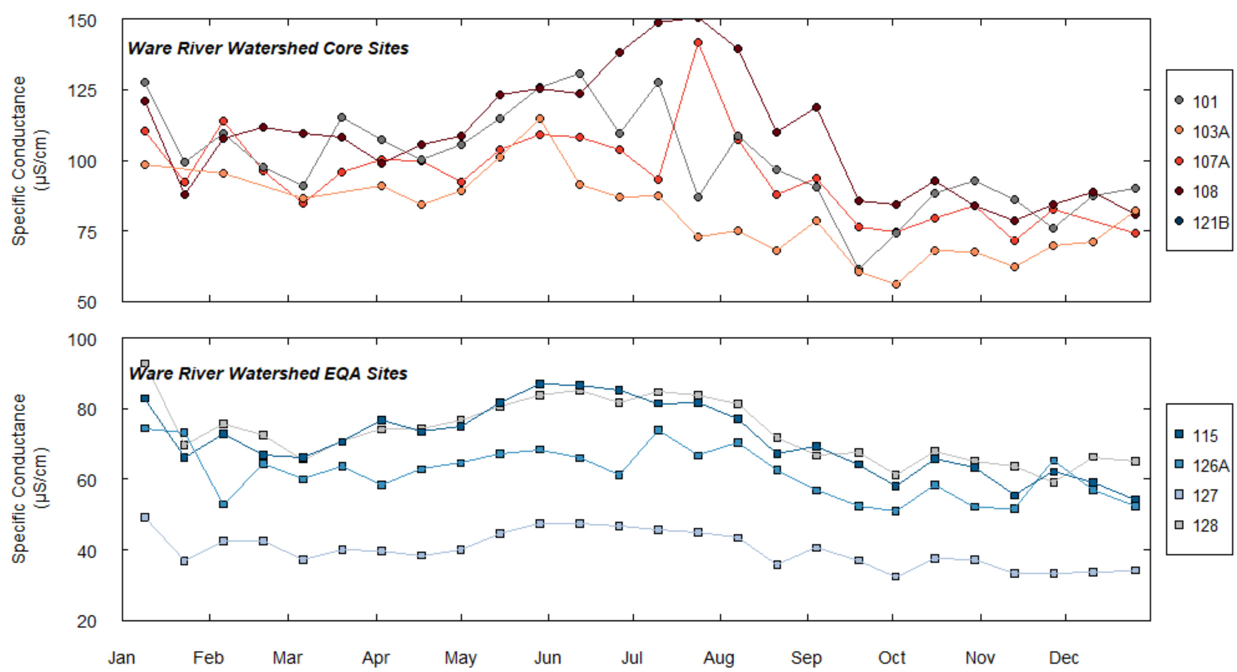
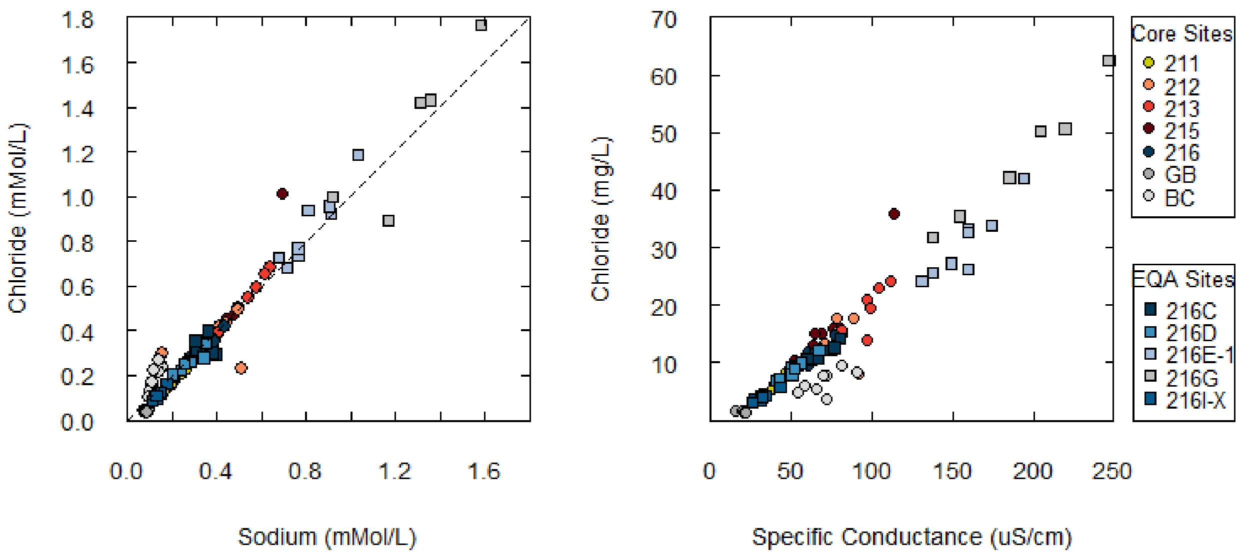


Figure A9. (left) Concentrations of sodium and chloride in Quabbin Reservoir Watershed tributaries (measured biweekly form September through December 2018). The dashed line denotes a 1:1 molar ratio of sodium to chloride. The clustering of surface water sites around the 1:1 line suggests that concentrations of sodium and chloride in most tributaries to the Quabbin Reservoir likely originate from halite sources (e.g. road salt). (right) Specific conductance and concentrations of chloride in Quabbin Reservoir Watershed tributaries (measured biweekly form September through December 2018). The observed linear relationship among variable suggests that specific conductance in Quabbin Reservoir watershed tributaries may be largely controlled by concentrations of dissolved chloride. Variations in the relationships between these variables observed across sites may be the result of differences in land cover, watershed characteristics, and/or local hydrogeology.



APPENDIX B

Water Quality Data Tables

Units of measure, unless noted otherwise on each table:
Temperature (degrees Celsius)
Dissolved Oxygen: DOPPM (milligrams per liter, mg/L) or DOSAT (% saturation)
Specific Conductance (microsiemens per centimeter, uS/cm)
Turbidity (nephelometric turbidity units, NTU)
Alkalinity (mg/L as $CaCO_3$)
Fecal Coliform Bacteria (colony forming units per 100 milliliters, CFU/100mL)
E. coli (most probable number per 100 mL, MPN/100mL)
Total Coliform Bacteria (most probable number per 100 mL, MPN/100mL)
Nutrients (mg/L), except calcium (ug/L)
UV254 (absorbance per centimeter, 1/cm)
Depth (meters) and Elevation (feet, Boston City Base)

Quabbin Laboratory Records, 2018

Site 211, West Branch Swift River, at Route 202

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.07	14.90	102	6.0	60.90	0.34	5		2800							
1/16/2018	0.62	14.58	103		61.70	0.41	10		2380							
1/30/2018	0.53	14.39	101	5.0	45.50	0.2	5		1760							
2/13/2018	0.01	15.15	104	4.6	39.70	0.28	5		1520							
2/27/2018	1.02	14.10	101	5.0	41.60	0.31	5		1560							
3/15/2018	1.19	13.30	96	5.0	53.70	0.3	121	2.6	1970	0.0716	0.0025	0.0221	0.05	0.024		
3/27/2018	1.30	14.21	100	4.9	56.90	0.19	5		2050							
4/10/2018	2.51	13.19	98	5.8	52.00	0.22	5		1850							
4/24/2018	5.56	12.75	101	4.9	49.70	0.300	5		1900							
5/8/2018	11.02	10.84	100	5.6	56.30	0.4	10		2010							
5/22/2018	12.63	10.46	99	4.9	58.50	0.4	10		2090							
6/5/2018	12.61	10.14	97	5.4	48.60	0.56	145		1790							
6/19/2018	18.13	8.89	96	5.0	58.40	1.4	546	3.78	2220	0.1944			0.277	0.0207		
7/3/2018	20.22	9.08	102	4.9	58.00	0.39	41		2510							
7/17/2018						0.41	31		3440							
7/31/2018	17.72	9.31	99	5.0	55.40	0.37	31		2310							
8/14/2018	18.53	9.15	99	4.4	33.60	0.51	201		1570							
8/28/2018	17.70	7.71	81	5.9	48.80	0.42	31		2190						6180	
9/11/2018	14.30	9.77	96	6.1	38.90	1.500	644		1720						4890	6.21
9/25/2018	11.50	10.40	95	6.0	47.00	0.460	30	3.54	2150	0.1616	0.0025	0.0184	0.113	0.0064	6020	8.37
10/9/2018	13.30	9.91	95	5.9	42.70	0.390	20		2040						5780	7.28
10/23/2018	6.20	12.00	97	5.9	51.30	0.290	5		1990						6090	8
11/6/2018	7.90	11.47	97	5.6	31.20	0.39	20		1570						3830	4.52
11/20/2018	13.30	9.91	95	5.9	42.70	0.31	5		1520						4660	5.73
12/4/2018	3.40	13.02	98	5.4	32.60	0.24	5	1.31		0.116	0.0025	0.0102	0.05	0.0067		4.51
12/18/2018	0.50	13.53	94	6.3	38.00	0.38	5									5.38
Average	8.47	11.69	97.76	5.40	48.15	0.44	74.85	2.81	2038	0.14	0.00	0.02	0.12	0.01	5350	6.25
Median	7.90	11.47	98.30	5.40	48.80	0.39	10.00	3.07	2000	0.14	0.00	0.02	0.08	0.01	5780	5.97
Minimum	-0.07	7.71	80.90	4.40	31.20	0.19	5.00	1.31	1520	0.07	0.00	0.01	0.05	0.01	3830	4.51
Maximum	20.22	15.15	104.20	6.33	61.70	1.50	644.00	3.78	3440	0.19	0.00	0.02	0.28	0.02	6180	8.37

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Site 212, Hop Brook, inside Gate 22

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.08	17.24	118	6.58	102.4	0.86	5		5340							
1/16/2018	-0.07	14.81	103		113.1	0.54	10		3170							
1/30/2018	0.31	14.55	101	5.50	98.6	0.39	5		3170							
2/13/2018	-0.06	15.18	104	5.24	104.8	0.52	10		2930							
2/27/2018	1.43	13.97	101	5.19	111.0	0.57	5		2850							
3/15/2018	0.85	13.67	97	5.03	123.9	0.49	10	4.16	3470	0.0596	0.0025	0.0617	0.05	0.0139		
3/27/2018	1.60	14.15	101	5.28	117.3	0.4	5		3820							
4/10/2018	2.80	13.49	101	5.66	120.0	0.46	20		3490							
4/24/2018	6.36	12.63	102	5.40	111.9	0.560	20		3410							
5/8/2018	11.79	10.71	100	5.73	110.9	0.66	481		3590							
5/10/2018							31									
5/22/2018	13.21	10.25	98	5.30	116.5	0.79	20		3960							
6/5/2018	13.06	10.20	99	5.54	112.2	1.3	455		4060							
6/19/2018	19.44	9.02	100	5.42	125.0	2.8	1660	9.64	4760	0.2654			0.299	0.033		
7/3/2018	21.57	8.95	103	5.48	123.7	1.3	199		5210							
7/17/2018						1.2	97		6090							
7/31/2018	17.92	9.53	102	5.77	138.1	1.2	30		5330							
8/14/2018	18.19	9.38	101	5.10	79.9	1.6	355		3230							
8/28/2018	18.80	8.37	90	6.19	105.2	0.990	74		4420						13200	
9/11/2018	14.80	9.97	99	6.33	89.0	2.800	2360		3720						11500	17.8
9/25/2018	11.60	10.68	98	6.35	91.2	1.100	41	8.7	4000	0.1209	0.0025	0.0347	0.105	0.0085	11700	8.16
10/9/2018	13.80	10.23	99	6.05	78.4	0.840	41		3700						10300	15.3
10/23/2018	6.30	12.44	101	6.34	81.4	0.61	5		3240						9520	14.7
11/6/2018	8.10	11.50	97	6.01	60.2	0.72	20		1350						3610	10.6
11/20/2018	13.80	10.23	99	6.05	78.4	0.58	31		2990						11500	17.6
12/4/2018	3.40	12.95	97	5.62	71.1	0.5	5	5		0.0876	0.0054	0.0446	0.152	0.0081		13.2
12/18/2018	-0.10	14.05	96	6.38	75.5	0.61	5									13.1
Average	8.75	11.93	100.28	5.73	101.59	0.94	222.22	6.93	3804	0.13	0.00	0.05	0.15	0.02	10190	13.81
Median	8.10	11.50	100.40	5.64	105.20	0.69	20.00	6.96	3645	0.10	0.00	0.04	0.13	0.01	11500	13.95
Minimum	-0.10	8.37	89.90	5.03	60.20	0.39	5.00	4.16	1350	0.06	0.00	0.03	0.05	0.01	3610	8.16
Maximum	21.57	17.24	118.30	6.58	138.10	2.80	2360.00	9.64	6090	0.27	0.01	0.06	0.30	0.03	13200	17.80

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Site 213, Middle Branch Swift River, at Gate 30

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (uS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.07	17.01	117	6.5	83.00	0.69	20		5960							
1/16/2018	0.03	12.47	87		88.30	0.62	41		2990							
1/30/2018	0.07	12.01	83	5.3	99.90	0.38	10		3370							
2/13/2018	0.02	13.19	91	5.1	89.90	0.56	5		2870							
2/27/2018	1.17	12.09	87	5.2	96.00	0.68	10		2820							
3/15/2018	1.06	12.87	92	5.2	119.00	0.34	5	4.52	3690	0.0813	0.0025	0.0686	0.05	0.0142		
3/27/2018	3.84	11.68	88	5.2	122.70	0.5	5		4250							
4/10/2018	4.64	12.24	97	5.6	112.90	0.34	20		3690							
4/24/2018	9.41	9.38	82	5.2	114.50	0.460	20		3800							
5/8/2018	15.22	7.51	76	5.4	124.70	0.88	20		4220							
5/22/2018	16.52	6.70	69	5.1	125.50	1.1	5		4540							
6/5/2018	14.42	6.56	66	5.4	110.10	1.4	2010		4490							
6/7/2018							63									
6/19/2018	21.16	4.83	55	5.1	130.40	2.2	3450	11.4	5790	0.2104			0.306	0.0274		
7/3/2018	24.78	4.36	53	5.0	133.40	1.2	52		5460							
7/17/2018						1.2	20		6620							
7/31/2018	21.23	4.96	57	5.0	125.00	0.86	30		4800							
8/14/2018	19.45	5.93	66	5.1	88.10	0.74	309		3210							
8/28/2018	20.20	4.07	45	5.8	125.60	0.670	108		2170						12600	
9/11/2018	14.40	6.36	62	6.1	111.70	1.700	1720		4450						14800	24.3
9/25/2018	12.30	7.13	67	6.0	103.90	0.720	30	6.9	3890	0.1905	0.0073	0.0246	0.146	0.0082	14200	23.0
10/9/2018	14.30	6.46	63	5.9	96.50	0.670	10		3860						13300	20.9
10/23/2018	6.00	9.69	78	6.2	99.10	0.58	63		3570						12500	19.4
11/6/2018	6.90	9.65	79	5.7	60.40	0.71	30		2510						7420	11.3
11/20/2018	14.30	6.46	63	5.9	96.50	0.53	41		2770						9570	13.9
12/4/2018	3.30	11.41	86	5.5	63.70	0.49	5	4.49		0.1448	0.0059	0.0596	0.05	0.0079		11.5
12/18/2018	0.00	11.66	80	6.3	80.70	0.68	109									15.7
Average	9.79	9.07	75.44	5.52	104.06	0.80	304.11	6.83	3991	0.16	0.01	0.05	0.14	0.01	12056	17.50
Median	9.41	9.38	77.90	5.40	103.90	0.68	30.00	5.71	3830	0.17	0.01	0.06	0.10	0.01	12600	17.55
Minimum	-0.07	4.07	45.00	4.95	60.40	0.34	5.00	4.49	2170	0.08	0.00	0.02	0.05	0.01	7420	11.30
Maximum	24.78	17.01	116.70	6.49	133.40	2.20	3450.00	11.40	6620	0.21	0.01	0.07	0.31	0.03	14800	24.30

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Site 215, East Branch of Fever Brook, at West Street

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.09	17.81	122	6.7	27.20	0.89	5		2960							
1/16/2018	0.22	12.67	89		64.60	0.7	10		1480							
1/30/2018	0.98	12.28	87	4.5	83.30	0.32	5		1800							
2/13/2018	0.30	13.69	95	4.8	81.80	0.48	5		1770							
2/27/2018	2.21	12.52	92	4.7	77.60	0.36	5		1550							
3/15/2018	1.29	12.77	92	4.9	88.90	0.38	5	1.47	1810	0.1773	0.0025	0.0094	0.05	0.0137		
3/27/2018	4.84	12.10	94	5.1	116.40	0.37	5		2420							
4/10/2018	4.68	12.02	95	5.5	91.50	0.5	5		1680							
4/24/2018	11.19	10.13	92	5.1	93.20	0.500	41		1790							
5/8/2018	16.59	9.04	94	5.8	113.40	0.68	5		2170							
5/22/2018	16.85	8.47	88	5.0	121.40	0.78	31		2130							
6/5/2018	16.00	7.53	78	5.2	130.30	1	41		2680							
6/19/2018	22.52	6.95	82	4.7	99.30	0.72	218	2.84	1800	0.3484			0.382	0.018		
7/3/2018	24.94	7.12	87	5.1	123.30	0.84	63		2690							
7/17/2018						1.7	20		3240							
7/31/2018	21.95	5.72	66	4.7	114.10	0.73	52		2340							
8/14/2018	20.88	6.28	71	4.1	53.70	0.9	63		1650							
8/28/2018	21.70	5.02	57	5.5	88.90	0.78	63		4480						16700	
9/11/2018	15.60	5.72	58	5.9	113.10	1.800	223		2790						16000	35.8
9/25/2018	12.90	7.31	69	5.7	68.80	0.670	74	2.4	1820	0.5568	0.0025	0.0025	0.372	0.0128	9850	15.2
10/9/2018	14.60	6.68	66	5.2	64.50	0.690	63		1850						10000	15.2
10/23/2018	6.00	9.68	78	5.7	78.10	0.500	31		1660						10900	16.7
11/6/2018	8.00	9.41	79	5.5	51.50	0.54	10		1500						6880	10.5
11/20/2018	14.60	6.68	66	5.2	64.50	0.58	5		1390						7640	10.5
12/4/2018	2.40	12.18	89	5.3	63.60	0.5	5	1.63		0	0.0074	0.0147	0.139	0.0071		13
12/18/2018	1.50	10.74	77	6.2	76.20	0.53	5									16.1
Average	10.51	9.62	82.48	5.25	85.97	0.71	40.69	2.09	2143.8	0.32	0.00	0.01	0.24	0.01	11138.57	16.63
Median	11.19	9.41	87.10	5.18	83.30	0.68	15.00	2.02	1815.0	0.27	0.00	0.01	0.26	0.01	10000.00	15.20
Minimum	-0.09	5.02	57.10	4.06	27.20	0.32	5.00	1.47	1390.0	0.18	0.00	0.00	0.05	0.01	6880.00	10.50
Maximum	24.94	17.81	122.10	6.68	130.30	1.80	223.00	2.84	4480.0	0.56	0.01	0.01	0.38	0.02	16700.00	35.80

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Site 216, East Branch Swift River at Route 32A

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.08	16.17	111	6.42		0.54	5		4010							
1/16/2018	-0.04	15.06	104		66.4	0.74	5		2180							
1/30/2018	0.44	14.66	103	5.59	79.8	0.42	5		2610							
2/13/2018	0.01	15.31	105	5.43	68.4	0.77	10		2210							
2/27/2018	2.48	13.51	100	5.76	72.5	0.41	5		2010							
3/15/2018	1.34	13.96	101	5.66	84.3	0.36	5	2.52	2520	0.1301	0.0025	0.0475	0.05	0.0125		
3/27/2018	4.20	13.41	102	5.58	85.5	0.5	20		2940							
4/10/2018	4.52	13.10	103	5.96	79.9	0.47	5		2360							
4/24/2018	10.25	11.79	105	5.54	79.9	0.550	10		2490							
5/8/2018	15.82	10.02	103	5.96	81.1	1.2	20		2670							
5/22/2018	15.78	10.04	102	5.62	82.0	1.2	20		2810							
6/5/2018	15.69	9.71	100	6.38	93.0	1	31		3260							
6/19/2018	22.07	8.88	104	5.77	88.3	1.3	295	6	3110	0.2712			0.304	0.0361		
7/3/2018	25.02	8.59	106	5.81	79.4	0.79	20		3220							
7/17/2018						0.64	185		4140							
7/31/2018	21.47	9.02	103	5.53	72.9	0.73	52		2860							
8/14/2018	20.29	9.18	103	5.37	57.5	1	85		2390							
8/28/2018	21.60	6.48	74	6.42	74.3	0.64	41		2870						9840	
9/11/2018	16.80	8.86	91	7.01	76.5	1.400	148		3150						9980	14.7
9/25/2018						0.870	108	4.56	2750	0.4008	0.0025	0.0295	0.31	0.0151	8160	12.4
10/9/2018	14.90	9.96	99	6.29	60.0	0.710	5		2690						8120	12
10/23/2018	7.10	10.75	89	6.60	68.0	0.520	5		2620						8930	12.4
11/6/2018	7.90	11.13	94	6.26	48.4	0.74	20		2280						5980	8.68
11/20/2018	14.90	9.96	99	6.29	60.0	0.64	52		2080						6830	9.47
12/4/2018	3.20	13.30	99	5.88	51.9	0.52	5	3.04		0	0.0051	0.0335	0.11	0.0078		9.65
12/18/2018	0.20	13.68	94	6.47	62.9	0.68	41									11.4
Average	10.24	11.52	99.64	5.98	72.73	0.74	46.27	4.03	2759.58	0.25	0.00	0.04	0.19	0.02	8263	11.34
Median	9.08	10.94	101.90	5.88	74.30	0.70	20.00	3.80	2680.00	0.23	0.00	0.03	0.21	0.01	8160	11.70
Minimum	-0.08	6.48	73.60	5.37	48.40	0.36	5.00	2.52	2010.00	0.13	0.00	0.03	0.05	0.01	5980	8.68
Maximum	25.02	16.17	110.90	7.01	93.00	1.40	295.00	6.00	4140.00	0.40	0.01	0.05	0.31	0.04	9980	14.70

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Gates Brook, at mouth

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	0.01	14.99	103	5.69	26.8	0.3	0.5	5		1270							
1/11/2018							0.5										
1/16/2018	1.25	14.70	106		23.1	0.36	1	10		1020							
1/26/2018							0.5										
1/30/2018	1.52	14.33	103	5.36	22.8	0.13	0.5	5		1070							
2/6/2018							0.5										
2/13/2018	1.63	14.59	105	4.09	23.0	0.52	0.5	5		984							
2/23/2018							0.5										
2/27/2018	2.84	13.84	104	4.71	21.3	0.280	18	5		917							
3/6/2018							1										
3/15/2018	2.13	13.79	102	4.34	22.2	0.24	1	5	0.25	1010	0.0585	0.0025	0.0025	0.05	0.0169		
3/21/2018							0.5										
3/27/2018	1.73	14.42	103	4.79	22.8	0.18	88	231		1050							
3/29/2018							12	55.6									
4/10/2018	3.13	13.67	104	6.13	22.3	0.33		10		1020							
4/24/2018	5.39	13.24	105	4.59	21.6	0.41		5		1080							
5/8/2018	9.76	11.55	103	5.64	21.8	0.2		5		1000							
5/22/2018	11.28	11.28	103	4.38	21.8	0.54		5		1040							
6/5/2018	11.17	10.90	101	4.83	22.9	0.180		5		1130							
6/19/2018	15.68	10.27	105	4.63	22.9	0.360		108	1.4	1290	0.1814			0.144	0.0171		
7/3/2018	18.37	9.72	105	5.43	24.0	0.220		5		1150							
7/17/2018						0.180		10		1310							
7/31/2018	16.66	9.97	104	4.70	23.3	0.19		5		1250							
8/14/2018	17.62	9.79	104	4.39	21.8	0.47		20		1230							
8/28/2018	17.40	8.91	93	5.61	26.8	0.26		5		1040						2470	
9/11/2018	15.30	10.06	100	5.51	20.9	1.3		530		1150						2220	1.74
9/25/2018	12.90	10.63	101	5.53	19.8	0.36		5	0.76	1020	0.103	0.0025	0.0025	0.05	0.0025	2260	1.64
10/9/2018	14.10	10.24	100	5.62	20.3	0.28		5		1010						2270	1.51
10/23/2018	8.80	11.89	102	5.44	15.3	0.15		5		1020						2340	1.57
11/6/2018	9.50	11.06	97	5.13	19.6	0.35		5		945						1790	1.54
11/20/2018	14.10	10.24	100	5.62	20.3	0.26		5		852						2040	1.29
12/4/2018	5.00	13.30	104	5.01	20.2	0.37		5	0.25		0.0745	0.0025	0.0025	0.114	0.0025		1.28
12/18/2018	1.50	15.39	110	5.76	21.3	0.28		5									1.27
Average	8.75	12.11	102.60	5.12	21.96	0.33	8.93	39.61	0.67	1077	0.10	0.00	0.00	0.09	0.01	2199	1.48
Median	9.50	11.55	103.30	5.25	21.80	0.28	0.50	5.00	0.51	1040	0.09	0.00	0.00	0.08	0.01	2260	1.53
Minimum	0.01	8.91	92.90	4.09	15.30	0.13	0.50	5.00	0.25	852	0.06	0.00	0.00	0.05	0.00	1790	1.27
Maximum	18.37	15.39	109.80	6.13	26.80	1.30	88.00	530.00	1.40	1310	0.18	0.00	0.00	0.14	0.02	2470	1.74

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
Boat Cove Brook, at mouth

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	0.03	12.23	84	6.6	85.10	0.79	26	75		7450							
1/16/2018	-0.03	14.81	103		55.30	1.5	16	31		4570							
1/26/2018							6										
1/30/2018	0.98	14.44	102	5.7	59.40	1.3	8	5		4830							
2/6/2018							6										
2/13/2018	1.01	14.77	105	5.7	46.40	2.1	6	20		3970							
2/23/2018							31										
2/27/2018	4.40	12.65	99	5.9	50.00	1.6	6	20		4060							
3/6/2018							8										
3/15/2018	2.57	13.30	99	5.6	57.30	1.4	2	5	10.5	4730	0.1435	0.0025	0.0087	0.05	0.0306		
3/21/2018							2										
3/27/2018	4.52	13.06	100	5.7	65.40	0.74	1	10		5740							
4/10/2018	3.70	13.02	100	5.9	64.20	0.85		10		5360							
4/24/2018	10.63	11.52	103	6.1	61.70	0.76		5		5330							
5/8/2018	16.63	9.66	101	6.7	72.40	0.6		10		6270							
5/22/2018	13.38	10.36	100	5.8	82.30	0.76		5		7490							
6/5/2018	13.08	9.84	96	6.2	92.40	0.79		173		8430							
6/19/2018	18.06	9.27	100	6.0	79.20	2		341	21.6	7690	0.3406			0.274	0.0307		
7/3/2018	19.98	9.18	102	6.3	110.80	0.510		20		10800							
7/17/2018						0.580		52		11900							
7/31/2018	18.87	9.14	99	6.0	112.00	0.460		85		11300							
8/14/2018	19.58	9.12	101	5.9	64.60	23.000		9210		7730							
8/28/2018	19.90	6.89	76	6.6	97.80	0.53		20		9040						3780	
9/11/2018	16.50	8.80	90	6.9	90.20	1.4		771		8510						3590	8.49
9/25/2018	13.40	10.13	97	6.6	65.80	6.3		3870	20.9	7310	0.4262	0.0025	0.0455	0.45	0.0371	2640	5.43
10/9/2018	15.30	9.76	98	6.4	72.30	0.89		63		7380						3220	7.69
10/23/2018	8.90	11.03	95	6.7	81.60	0.58		31		7230						3350	9.46
11/6/2018	9.60	10.82	95	6.4	54.30	3		52		5810						2350	4.73
11/20/2018	15.30	9.76	98	6.4	72.30	3.8		63		4180						2330	3.55
12/4/2018	3.90	13.03	99	6.0	58.40	1.3		10	11.8		0.1537	0.0025	0.0075	0.05	0.0104		6.07
12/18/2018	0.50	14.09	98	6.6	69.20	1.2		10									7.87
Average	10.03	11.23	97.56	6.19	72.82	2.26	9.83	575.65	16.20	6962.92	0.27	0.00	0.02	0.21	0.03	3037.14	6.66
Median	10.63	10.82	99.20	6.14	69.20	1.05	6.00	25.50	16.35	7270.00	0.25	0.00	0.01	0.16	0.03	3220.00	6.88
Minimum	-0.03	6.89	75.70	5.61	46.40	0.46	1.00	5.00	10.50	3970.00	0.14	0.00	0.01	0.05	0.01	2330.00	3.55
Maximum	19.98	14.81	104.50	6.85	112.00	23.00	31.00	9210.00	21.60	11900.00	0.43	0.00	0.05	0.45	0.04	3780.00	9.46

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018

216C, Carter Pond, below outlet (at Glen Valley Rd)

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (uS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.08	16.01	110	6.51		0.71	5	10.8	6720	0.096	0.157	0.145	0.286	0.0234		
1/16/2018	0.23	14.89	104		90.0	0.94	10	5.18	4100	0.1946	0.0573	0.0838	0.282	0.0173		
1/30/2018	0.42	14.58	102	5.60	91.8	0.45	5	6.38	4230	0.1013	0.0652	0.082	0.199	0.0178		
2/13/2018	0.50	15.05	105	5.52	80.5	0.63	5	3.75	3110	0.1556	0.0568	0.0735	0.235	0.0184		
2/27/2018	3.76	13.21	102	5.49	84.3	0.73	20	4.29	3250	0.1516	0.0416	0.0516	0.203	0.0196		
3/15/2018	1.76	13.53	99	5.39	92.1	0.49	5	5.53	4070	0.0976	0.0092	0.0522	0.05	0.0155		
3/27/2018						0.87	10	6.64	4910	0.1012	0.0086	0.0324	0.175	0.0189		
4/10/2018	5.90	12.46	102	5.45	92.0	1.5	5	5.63	3820	0.1386	0.0096	0.0324	0.175	0.0194		
4/24/2018	11.13	11.13	101	5.52	80.4	0.770	5	5.45	3530	0.1164	0.0074	0.0186	0.202	0.0163		
5/8/2018	17.17	9.54	101	5.68	87.2	0.86	5	4.21	3940	0.1636	0.0025	0.0139	0.306	0.0176		
5/22/2018	18.48	9.25	99	5.55	92.4	2	31	8.09	4170	0.197	0.0025	0.0137	0.416	0.0300		
6/5/2018	16.90	9.14	96	5.78	94.9	0.76	5	10.4	4840	0.2018	0.008	0.0386	0.314	0.0181		
6/19/2018	20.68	8.62	98	5.63	92.9	16	309	10.2	6430	0.2004	0.0025	0.111	2.16	0.2880		
7/3/2018	25.67	8.37	104	5.58	94.7	0.48	30	10.6	5070	0.2358	0.0025	0.0922	0.258	0.0205		
7/17/2018						0.58	30	12.3	5410	0.2396	0.007	0.0708	0.345	0.0194		
7/31/2018	23.45	8.31	99	5.49	87.8	0.78	5	8.1	4650	0.2655	0.0083	0.0484	0.373	0.0102		
8/14/2018	22.52	8.64	101	5.34	78.5	1.5	10	7.85	4020	0.4074	0.0025	0.0025	0.387	0.0259		
8/28/2018	22.70	7.42	86	6.40	71.8	0.48	5	6.63	3660	0.298	0.0069	0.0373	0.311	0.0208	8280	
9/11/2018	17.70	8.97	94	6.60	80.3	1.200	20	7.89	4310	0.2285	0.0025	0.0128	0.276	0.0208	9100	14.2
9/25/2018	14.40	9.90	97	6.48	61.5	0.980	30	6.08	3620	0.393	0.0025	0.0145			6900	10.4
10/9/2018	15.50	9.65	97	6.13	65.0	0.510	5	7.08	3700	0.249	0.0076	0.0304	0.228	0.0134	7590	11.5
10/23/2018	7.90	11.76	99	6.43	74.5	0.420	5	6.76	4750	0.2684	0.0025	0.0191	0.167	0.0148	8870	12.2
11/6/2018	8.30	11.35	97	6.32	59.8	0.92	10	5.34	3530	0.2974	0.0025	0.0166	0.467	0.0193	7100	10.7
11/20/2018	15.50	9.65	97	6.13	65.0	0.78	5	5.65	3370	0.1392	0.0115	0.0649	0.11	0.0090	7110	9.96
12/4/2018	2.60	13.70	101	6.02	66.8	0.83	31	5.06		0.1557	0.0057	0.0448	0.05	0.0085		10.9
12/18/2018	0.90	13.16	92	6.39	76.4	0.88	10	6.96		0.1127	0.0083	0.0718	0.122	0.0228		12.6
Average	11.42	11.18	99.21	5.89	80.90	1.43	23.69	7.03	4300.42	0.20	0.02	0.05	0.32	0.03	7850	11.56
Median	12.77	10.52	99.15	5.68	80.50	0.78	7.50	6.64	4085.00	0.20	0.01	0.04	0.26	0.02	7590	11.20
Minimum	-0.08	7.42	86.00	5.34	59.80	0.42	5.00	3.75	3110.00	0.10	0.00	0.00	0.05	0.01	6900	9.96
Maximum	25.67	16.01	109.80	6.60	94.90	16.00	309.00	12.30	6720.00	0.41	0.16	0.15	2.16	0.29	9100	14.20

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.

Total phosphorus MDL = 0.005 mg/L.

Nitrate MDL = 0.005 mg/L.

Total Kjeldahl nitrogen MDL = 0.100 mg/L.

Calcium MDL = 20 µg/L (0.020 mg/L).

Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
216D, Carter Pond, below outlet (at Glen Valley Rd)

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.05	15.76	108	6.65		0.72	5	4.29	3450	0.2536	0.0209	0.073	0.247	0.0216		
1/16/2018	0.10	14.89	104		53.6	0.72	41	1.63	1960	0.2756	0.0153	0.0766	0.279	0.0202		
1/30/2018	0.46	14.46	101	5.25	63.0	0.43	10	2.37	2230	0.1743	0.0096	0.0841	0.139	0.0174		
2/13/2018	0.07	15.23	105	5.14	56.5	0.69	75	2.19	2110	0.1874	0.0067	0.0664	0.192	0.0197		
2/27/2018	1.79	13.76	100	5.34	60.0	0.64	20	1.95	1950	0.1718	0.0025	0.0442	0.132	0.0214		
3/15/2018	0.76	13.77	98	5.48	64.9	0.52	5	2.5	2300	0.1435	0.0025	0.0443	0.05	0.0165		
3/27/2018	3.87	13.21	100	5.25	72.3	0.48	31	3.23	2610	0.1348	0.0025	0.0394	0.136	0.0209		
4/10/2018	4.05	13.26	103	5.51	63.1	0.55	20	3.01	2050	0.1644	0.0025	0.0307	0.123	0.022		
4/24/2018	8.98	11.75	102	5.23	66.6	0.730	20	2.84	2260	0.1678	0.0025	0.0162	0.198	0.0199		
5/8/2018	14.66	9.82	98	5.53	67.3	1.2	31	4.14	2420	0.2462	0.0085	0.0222	0.995	0.0244		
5/22/2018	16.60	9.55	98	5.16	69.4	1.1	41	4.65	2520	0.2673	0.0025	0.0201	0.285	0.0258		
6/5/2018	15.92	9.57	99	5.68	74.1	1.9	110	5.91	2810	0.2811	0.0025	0.0202	0.432	0.0433		
6/19/2018	24.09	8.25	100	5.34	72.8	1.2	384	5.73	3140	0.254	0.0025	0.0198	0.365	0.0356		
7/3/2018	24.69	8.01	98	5.02	60.6	0.99	63	4.63	2570	0.4777	0.0025	0.0144	0.387	0.042		
7/17/2018						1.7	5	7.09	3220	0.4187	0.0097	0.0025	0.5	0.0378		
7/31/2018	21.29	8.42	96	4.93	57.1	0.89	41	4.75	2580	0.5157	0.0088	0.0194	0.47	0.0284		
8/14/2018	19.94	9.05	101	4.76	48.4	1.1	134	2.97	2180	0.5683	0.0025	0.0129	0.37	0.0374		
8/28/2018	20.70	7.63	85	6.13	60.7	0.77	199	4.58	2580	0.4	0.0054	0.0235	0.323	0.0386	7240	
9/11/2018	16.00	9.02	91	6.42	67.1	1.500	250	6.29	3020	0.3126	0.0025	0.0193	0.297	0.0382		12.2
9/25/2018	13.30	9.71	93	6.27	53.6	1.000	52	4.23	2810	0.4458	0.0094	0.0326	0.29	0.0384	6490	9.5
10/9/2018	14.40	9.88	97	6.09	50.3	0.870	10	4.02	2390	0.3493	0.0108	0.0306	0.225	0.0204	6470	9.18
10/23/2018	6.40	12.12	98	6.12	56.4	0.610	5	3.54	3600	0.3006	0.0025	0.028	0.155	0.0188	7890	9.92
11/6/2018	7.50	11.63	97	5.91	40.9	0.7	31	3.16	2100	0.3491	0.0025	0.0258	0.292	0.0271	4780	6.97
11/20/2018	14.40	9.88	97	6.09	50.3	0.61	63	3	2000	0.2044	0.0025	0.051	0.144	0.0131	5550	7.9
12/4/2018	3.00	13.30	99	5.79	42.8	0.77	20	3		0.2037	0.0061	0.0337	0.05	0.0122		7.23
12/18/2018	0.80	13.23	93	6.26	51.8	0.75	109	3		0.1531	0.0062	0.0566	0.05	0.0168		8.9
Average	10.15	11.41	98.37	5.64	59.32	0.89	68.27	3.79	2535.83	0.29	0.01	0.03	0.27	0.03	6403.33	8.98
Median	8.98	11.63	98.40	5.52	60.30	0.76	36.00	3.39	2470.00	0.26	0.00	0.03	0.26	0.02	6480.00	9.04
Minimum	-0.05	7.63	85.00	4.76	40.90	0.43	5.00	1.63	1950.00	0.13	0.00	0.00	0.05	0.01	4780.00	6.97
Maximum	24.69	15.76	108.20	6.65	74.10	1.90	384.00	7.09	3600.00	0.57	0.02	0.08	1.00	0.04	7890.00	12.20

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
216E-1, Northern Tributary of 216E, at South St

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (uS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	0.32	16.00	111	6.53		3.8	10	10.9	10600	0.0472	0.022	1.18	0.257	0.0388		
1/16/2018	1.02	13.83	99		199.2	1.8	10	7.55	7140	0.0721	0.0153	1.2	0.234	0.0216		
1/30/2018	1.05	13.79	98	5.48	190.3	2.5	5	8.6	7010	0.0634	0.0076	0.954	0.201	0.0272		
2/13/2018	0.76	14.27	100	5.36	184.2	2.4	20	6.71	1570	0.0851	0.0085	0.796	0.229	0.0324		
2/27/2018	2.67	13.21	99	5.38	207.7	1.2	30	7.87	6480	0.0911	0.0058	0.713	0.154	0.024		
3/15/2018	1.53	13.22	96	5.29	214.8	1.2	5	8.8	6990	0.0725	0.0057	0.703	0.106	0.0221		
3/27/2018	2.99	13.38	99	5.57	215.6	1	30	9.32	7990	0.0779	0.0025	0.785	0.183	0.0238		
4/10/2018	2.82	13.13	99	5.52	213.1	1.9	10	8.77	7200	0.0745	0.0075	0.724	0.165	0.028		
4/24/2018	6.80	12.10	99	5.45	210.7	1.200	5	9.77	7600	0.079	0.0062	0.645	0.157	0.0239		
5/8/2018	11.32	10.53	98	5.83	216.6	1.5	31	10.9	7530	0.1244	0.0072	0.564	0.258	0.0282		
5/22/2018	10.99	10.54	96	5.56	246.8				8940							
6/5/2018	11.08	10.12	94	5.61	235.4	1.6	201	13.4	9050	0.1686	0.014	0.543	0.245	0.0388		
6/19/2018	16.06	9.26	96	5.61	221.5	1.9	565	11.6	8600	0.2782	0.0105	0.356	0.332	0.0512		
7/3/2018	16.06	8.89	92	5.46	353.0	1.3	41	15.2	12600		0.0071	0.655	0.237	0.034		
7/17/2018						1.5	98	16	16900	0.0586	0.0161	0.898	0.242	0.0328		
7/31/2018	15.61	9.45	96	5.65	304.0	0.65	41	15.4	10600	0.1386	0.0144	0.689	0.273	0.0148		
8/14/2018	17.35	9.08	96	5.34	170.5	1.1	548	13.2	6650	0.2899	0.0025	0.517	0.291	0.0284		
8/28/2018	16.90	8.04	83	6.28	200.1	1.1	20	16	7260	0.161	0.0095	0.486	0.154	0.0294	24500	
9/11/2018	14.70	9.58	95	6.46	159.5	1.900	738	13.4	6550	0.2716	0.0025	0.294	0.311	0.0447	18600	33.3
9/25/2018	11.80	9.97	92	6.29	194.2	5.400	256	15.8	8040	0.1324	0.0068	0.506	0.324	0.0433	23700	42
10/9/2018	13.60	9.61	93	6.14	159.4	1.200	86	15.8	6880	0.1826	0.0092	0.385	0.184	0.0209	20900	32.7
10/23/2018	7.90	10.86	91	6.49	174.5	0.680	5	14.6	6220	0.1162	0.0025	0.505	0.146	0.0169	20800	33.9
11/6/2018	8.90	10.20	88	6.10	130.8	1.4	74	13.4	6290	0.208	0.0025	0.355	0.508	0.0258	16400	24.1
11/20/2018	13.60	9.61	93	6.14	159.4	1.2	30	11	5520	0.1266	0.0055	0.472	0.05	0.0149	17600	26.2
12/4/2018	4.00	12.07	92	5.88	137.8	1.6	20	11		0.1115	0.0098	0.552	0.05	0.0137		25.7
12/18/2018	0.80	12.77	90	6.25	149.3	1.7	63	12		0.0835	0.018	0.647	0.151	0.0223		27.2
Average	8.43	11.34	95.28	5.82	202.02	1.71	117.68	11.89	7925.42	0.13	0.01	0.64	0.22	0.03	20357	30.64
Median	8.90	10.54	95.80	5.63	199.65	1.50	30.00	11.60	7230.00	0.11	0.01	0.65	0.23	0.03	20800	29.95
Minimum	0.32	8.04	83.10	5.29	130.80	0.65	5.00	6.71	1570.00	0.05	0.00	0.29	0.05	0.01	16400	24.10
Maximum	17.35	16.00	111.10	6.53	353.00	5.40	738.00	16.00	16900.00	0.29	0.02	1.20	0.51	0.05	24500	42.00

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
216G, Roaring Brook, Petersham Center

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.08	15.17	104	6.47		1.1	10	7.65	7790	0.1309	0.0816	0.216	0.283	0.0215		
1/16/2018	0.60	14.45	102		254.9	0.62	63	3.97	5030	0.1499	0.025	0.34	0.222	0.0142		
1/30/2018	0.84	14.24	101	5.76	233.6	0.46	10	4.79	4880	0.1053	0.0166	0.272	0.144	0.0151		
2/13/2018	0.22	14.92	103	5.60	205.0	0.66	20	3.65	3880	0.1414	0.0106	0.213	0.192	0.0171		
2/27/2018	2.89	13.27	100	5.74	248.5	0.49	20	3.91	4210	0.151	0.007	0.177	0.127	0.0167		
3/15/2018	1.30	13.60	98	5.69	279.8	0.48	30	4.75	5160	0.1065	0.0071	0.182	0.167	0.0188		
3/27/2018	4.78	12.78	99	5.73	275.5	0.6	20	5.26	5710	0.1079	0.0025	0.118	0.151	0.0179		
4/10/2018	4.91	12.90	103	5.86	258.5	0.49	5	5.13	4630	0.1349	0.0063	0.125	0.152	0.016		
4/24/2018	11.28	11.19	102	5.84	264.0	1.000	5	5.86	5030	0.1365	0.0025	0.0748	0.256	0.0196		
5/8/2018	16.38	9.82	102	6.12	256.8	1.6	41	7.9	5150	0.2146	0.0106	0.0561	0.349	0.0246		
5/22/2018	15.65	9.67	98	5.75	259.9	2.6	41	9.08	5480	0.268	0.0257	0.0598	0.419	0.031		
6/5/2018	14.88	9.76	99	5.90	264.1	2.3	185	9.87	5780	0.3304	0.0303	0.0757	0.484	0.0435		
6/19/2018	20.16	8.83	99	5.82	240.2	3.2	1260	10.1	5820	0.3703	0.0025	0.0565	0.527	0.0532		
7/3/2018	22.03	8.73	101	5.86	236.5	1.2	31	9.8	5430	0.4224	0.0122	0.0646	0.397	0.033		
7/17/2018						0.49	30	12.1	6150	0.2178	0.0082	0.416	0.349	0.0221		
7/31/2018	20.26	8.90	100	5.80	215.5	1	20	9.94	5260	0.4037	0.0198	0.0399	0.459	0.0269		
8/14/2018	19.50	9.10	101	5.56	164.8	1.1	187	5.96	3740	0.4883	0.0025	0.0614	0.402	0.025		
8/28/2018	20.00	7.44	82	6.39	241.6	1	10	10.4	5540	0.3635	0.0291	0.0458	0.32	0.027	34700	
9/11/2018	16.00	9.33	95	6.67	246.9	3.000	617	11.5	6130	0.2952	0.0088	0.0439	0.432	0.0483	36400	62.6
9/25/2018	13.10	9.99	95	6.56	204.4	2.100	41	8.37	5360	0.3266	0.0102	0.0518	0.31	0.0255	30100	50.3
10/9/2018						0.900	20	3.61	5100	0.2878	0.0138	0.0587	0.306	0.0164	30500	48.6
10/23/2018	6.70	11.89	97	6.64	219.7	0.700	10	8.57	5110	0.2465	0.0086	0.0568	0.205	0.0156	31200	50.7
11/6/2018						1.1	30	6.14	3560	0.36	0.0025	0.0661	0.269	0.0194	19100	31.7
11/20/2018						0.89	86	6	3960	0.168	0.0051	0.107	0.116	0.0108	26800	43.2
12/4/2018	3.10	13.04	97	6.16	154.1	0.68	5	6		0.1778	0.0071	0.105	0.115	0.0088		35.4
12/18/2018	0.50	13.42	93	6.53	185.2	0.98	41	6		0.1348	0.012	0.117	0.25	0.0178		42.2
Average	9.77	11.47	98.60	6.02	233.79	1.18	109.15	7.17	5162.08	0.24	0.01	0.12	0.28	0.02	29829	45.59
Median	8.99	11.54	99.35	5.86	241.60	0.99	30.00	6.32	5155.00	0.22	0.01	0.08	0.28	0.02	30500	45.90
Minimum	-0.08	7.44	81.80	5.56	154.10	0.46	5.00	3.61	3560.00	0.11	0.00	0.04	0.12	0.01	19100	31.70
Maximum	22.03	15.17	104.10	6.67	279.80	3.20	1260.00	12.10	7790.00	0.49	0.08	0.42	0.53	0.05	36400	62.60

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
216I-X, Moccasin Brook, above Quaker Road

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)	Sodium (µg/L)	Chloride (mg/L)
1/2/2018	-0.08	15.81	108	6.55		1	5	4.56	2960	0.5044	0.0208	0.104	0.36	0.0267		
1/16/2018	-0.07	15.01	104		32.1	1	75	1.52	1620	0.4191	0.018	0.071	0.305	0.0217		
1/30/2018	0.11	14.69	102	5.15	37.8	0.48	10	2.07	1940	0.3094	0.006	0.0973	0.205	0.0195		
2/13/2018	-0.07	15.25	105	4.83	34.0	0.86	5	1.64	6030	0.3112	0.0065	0.0639	0.24	0.0205		
2/27/2018	1.81	13.76	100	5.58	32.7	0.45	20	1.81	1510	0.2506	0.0025	0.0551	0.13	0.0174		
3/27/2018	2.77	13.75	101	5.26	40.0	0.6	31	2.93	1980	0.2276	0.0025	0.0832	0.182	0.0189		
4/10/2018	3.77	13.24	102	5.64	35.2	0.58	5	2.05	1560	0.2598	0.0025	0.0455	0.153	0.0156		
4/24/2018	8.97	11.87	102	5.05	35.8	0.6	10	2.45	1740	0.2675	0.0025	0.0446	0.151	0.014		
5/8/2018	14.41	10.17	101	5.34	38.4	0.720	41	3.54	1930		0.0025	0.0296	0.396	0.019		
5/22/2018	14.51	10.03	99	5.10	38.5	1	52	4.25	1980	0.4744	0.0088	0.0367	0.417	0.0238		
6/5/2018	13.99	9.74	96	5.60	42.9	1.2	241	5.8	2510	0.4668	0.007	0.0642	0.412	0.0377		
6/19/2018	19.55	8.82	98	5.37	48.4	1.7	3450	6.51	3260	0.43	0.0025	0.0882	0.444	0.0463		
7/3/2018	23.79	8.38	101	5.34	38.8	1.1	52	3.25	2510		0.0025	0.0606	0.506	0.047		
7/17/2018						1.2	20	6.61	3140	0.5172	0.006	0.0025	0.435	0.040		
7/31/2018	20.51	8.78	99	4.84	34.6	0.72	75	3.9	2250	0.7767	0.0025	0.0276	0.525	0.0239		
8/14/2018	20.39	8.98	101	4.72	29.5	0.79	75	6.86	1750	0.794	0.0025	0.0163	0.45	0.0232		
8/28/2018	20.70	7.86	88	6.03	35.8	0.82	41	4.06	2500	0.7572	0.0025	0.0501	0.412	0.0322	3780	
9/11/2018	16.00	9.37	95	6.63	43.0	1.4	857	5.95	3030	0.5676	0.0025	0.0432	0.446	0.0421	4080	5.76
9/25/2018	12.40	10.41	97	6.16	31.8	0.790	63	3.09	2280	0.7	0.0025	0.0517	0.404	0.0232	3120	4.32
10/9/2018	14.60	9.76	96	6.11	31.1	0.570	52	9.08	2170	0.6062	0.0025	0.0583	0.304	0.0199	3360	4.17
10/23/2018	6.00	12.47	100	6.16	34.4	0.430	5	3.45	2050	0.5108	0.0025	0.0726	0.266	0.0179	3420	4.34
11/6/2018	7.90	11.56	97	5.82	27.1	0.670	31	2.65	1880	0.5174	0.0025	0.0361	0.358	0.0203	2760	3.63
11/20/2018	14.60	9.76	96	6.11	31.1	0.68	10	3.1	1620	0.3424	0.0025	0.0764	0.177	0.0106	3060	3.52
12/4/2018	2.50	13.48	99	5.69	25.9	0.47	20	2		0.3219	0.0058	0.0592	0.163	0.0121		3.06
12/18/2018	-0.20	13.94	95	6.47	31.9	0.68	5	3		0.2735	0.0025	0.0846				3.9
Average	9.95	11.54	99.21	5.63	35.25	0.82	210.04	3.82	2356.52	0.46	0.00	0.06	0.33	0.02	3368.57	4.09
Median	10.69	10.99	99.40	5.60	34.60	0.72	31.00	3.25	2050.00	0.47	0.00	0.06	0.36	0.02	3360.00	4.04
Minimum	-0.20	7.86	87.60	4.72	25.90	0.43	5.00	1.52	1510.00	0.23	0.00	0.00	0.13	0.01	2760.00	3.06
Maximum	23.79	15.81	108.40	6.63	48.40	1.70	3450.00	9.08	6030.00	0.79	0.02	0.10	0.53	0.05	4080.00	5.76

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
101, Ware River, at Shaft 8 (intake)

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.00	14.86	103	5.22	127.4		10		4460	0.184				
1/23/2018	0.07	13.99	97	6.40	99.3	0.76	10		3450	0.2028				
2/6/2018	-0.06	14.94	105	6.14	109.5	0.61	10		3400	0.1673				
2/20/2018	0.68	14.33	103	5.40	97.6	0.79	5		2880	0.1583				
3/6/2018	2.55	13.80	103	5.27	90.9	0.62	10		2360	0.1848				
3/20/2018	1.18	13.96	101	6.19	115.3	0.4	5	2.85	3330	0.1372	0.0025	0.0208	0.05	0.0147
4/3/2018	4.44	12.88	101	5.39	107.5	0.51	10		3300	0.1588				
4/17/2018	3.49	13.40	103	5.14	100.4	1	63		2760	0.1755				
5/1/2018	9.42	11.46	102	5.68	105.6	0.860	10		3100	0.2068				
5/15/2018	17.41	8.69	92	5.36	115.0	1.7	20		3630	0.2572				
5/29/2018	16.67	10.55	110	5.33	125.8	2.7	41		4010	0.2962				
6/12/2018	18.84	9.83	107	5.65	130.7	2.8	41		4190	0.2585				
6/26/2018	20.06	9.58	108	5.50	109.6	3.3	86	6.89	4220	0.3178	0.0058	0.0215	0.269	0.0271
7/10/2018	23.98	8.68	104	5.69	127.7	4	63		4720	0.4126				
7/24/2018	22.69	8.50	100	5.03	86.9	2.8	1220		3120	0.4254				
8/7/2018	25.68	8.39	104	5.35	108.5	3.2	120		4130	0.4566				
8/21/2018	20.26	9.24	103	5.17	96.9	2.2	52		3550	0.5992				
9/4/2018	23.90	7.72	92	6.29	90.7	3	108		3690	0.382				
9/19/2018	19.14	8.75	97	5.62	61.4	2.500	1550	2.41	2470		0.0115	0.0155		
10/2/2018	14.30	9.50	93	6.01	74.4	1.300	98		2850	0.4572				
10/16/2018	10.60	10.90	98	6.28	88.2	1.100	74		2780	0.4295				
10/30/2018	6.20	12.38	100	6.16	92.6	1.000	85		3140	0.2906				
11/13/2018	5.40	13.08	104	6.23	86.2	0.85	20		1970	0.3024				
11/27/2018	2.00	14.44	104	6.27	76.0	0.87	63		2200					
12/11/2018	0.20	14.28	98	6.43	87.5	0.55	5			0.2732				
12/26/2018	0.30	15.84	109	6.24	90.3	0.56	5	3	3150	0.1846	0.0056	0.0236	0.139	0.013
Average	10.36	11.69	101.49	5.75	100.07	1.60	145.54	3.81	3314.40	0.29	0.01	0.02	0.15	0.02
Median	7.81	11.92	102.75	5.67	98.45	1.00	41.00	2.97	3300.00	0.27	0.01	0.02	0.14	0.01
Minimum	-0.06	7.72	91.60	5.03	61.40	0.40	5.00	2.41	1970.00	0.14	0.00	0.02	0.05	0.01
Maximum	25.68	15.84	110.20	6.43	130.70	4.00	1550.00	6.89	4720.00	0.60	0.01	0.02	0.27	0.03

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
103A, Burnshirt River, at Riverside Cemetery

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.04	13.27	92	5.48	98.6	1.1	20		3220	0.1663				
2/6/2018	-0.03	14.73	103	5.36	95.6	0.59	20		2650	0.1472				
3/6/2018	1.73	13.37	98	5.27	86.5	0.5	10		2070	0.1534				
4/3/2018	3.18	12.92	98	5.49	90.9	0.5	10		2920	0.1457				
4/17/2018	3.00	12.96	98	6.13	84.4	0.74	31		2120	0.1632				
5/1/2018	8.25	11.54	100	5.26	89.3	0.61	20		2340	0.1902				
5/15/2018	15.47	9.05	92	6.34	101.1	1.3	63		2770	0.243				
5/29/2018	15.19	9.13	92	5.76	115.0	2.5	135		3360	0.2952				
6/12/2018	14.91	6.91	69	5.34	91.3	2.200	110		2560	0.2734				
6/26/2018	15.81	6.88	71	4.75	87.1	2.8	243	4.76	3120	0.3452	0.0072	0.0259	0.304	0.0268
7/10/2018	20.33	5.65	63	4.76	87.6	5.6	282		3020	0.4576				
7/24/2018	21.73	6.53	75	4.43	73.1	1.7	602		2410	0.4684				
8/7/2018	22.75	6.87	81	4.69	75.1	2.5	183		2770	0.5052				
8/21/2018	18.59	8.25	89	4.75	68.2	1.8	52		2400	0.5871				
9/4/2018	21.70	4.14	47	6.34	78.7	2.6	199		3100	0.3986				
9/19/2018	18.85	7.73	85	5.45	60.6	1.6	749	1.96	2300		0.0087	0.0092		
10/2/2018	13.80	8.56	83	5.66	56.3	0.74	86		2150	0.3739				
10/16/2018	10.20	9.86	88	5.66	68.0	0.79	98		2010	0.3578				
10/30/2018	5.80	11.58	93	6.14	67.8	0.940	20		2420	0.2416				
11/13/2018	4.20	12.25	94	6.40	62.2	0.590	10		1990	0.2279				
11/27/2018	1.10	13.73	97	6.20	69.9	1.100	98		1910	0.1885				
12/11/2018	0.00	13.78	94	6.32	71.1	0.570	20			0.1377				
12/26/2018	0.10	15.18	104	6.63	82.2	0.64	10	3.08	2450	0.1832	0.0061	0.0292	0.205	0.0167
Average	10.29	10.21	87.21	5.59	80.90	1.48	133.52	3.27	2548.18	0.28	0.01	0.02	0.25	0.02
Median	10.20	9.86	92.10	5.49	82.20	1.10	63.00	3.08	2435.00	0.24	0.01	0.03	0.25	0.02
Minimum	-0.03	4.14	47.20	4.43	56.30	0.50	10.00	1.96	1910.00	0.14	0.01	0.01	0.21	0.02
Maximum	22.75	15.18	104.10	6.63	115.00	5.60	749.00	4.76	3360.00	0.59	0.01	0.03	0.30	0.03

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018

107A, West Branch Ware River, at Brigham Road

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.00	11.83	82	4.96	110.3	0.79	31		3470	0.2694				
1/23/2018	0.02	13.16	91	5.49	92.1	0.69	10		2760	0.2716				
2/6/2018	-0.03	14.02	98	5.40	113.9	0.57	10		2990	0.2244				
2/20/2018	0.90	13.25	96	5.39	96.2	0.52	20		2440	0.1958				
3/6/2018	0.86	13.14	94	5.36	84.6	0.56	10		2050	0.2389				
3/20/2018	0.06	14.28	100	5.73	95.9	0.34	10	1.81	2600	0.1766	0.0025	0.0218	0.05	0.0125
4/3/2018	2.27	13.24	98	5.26	100.4	0.38	51		2850	0.22				
4/17/2018	3.19	12.52	95	5.25	99.8	0.98	20		2370	0.2603				
5/1/2018	8.56	11.24	98	4.91	92.5	0.530	41		2520	0.2832				
5/15/2018	16.34	8.92	93	5.35	103.6	0.81	75		2970	0.344				
5/29/2018	16.27	9.35	97	5.28	109.0	1.2	52		3050	0.3614				
6/12/2018	15.71	9.50	97	5.45	108.4	1.2	63		3230	0.3356				
6/26/2018	16.77	9.07	95	5.27	103.6	1.6	74	5.75	3840		0.0025	0.0104	0.332	0.0202
7/10/2018	21.19	8.82	101	5.38	93.3	1.6	10		3480	0.4078				
7/24/2018	22.57	8.04	94	4.77	141.7	1.2	86		4120	0.6062				
8/7/2018	24.36	7.65	93	5.04	107.5	1.7	73		3570	0.5566				
8/21/2018	19.46	7.88	87	4.79	87.7	2	110		3340	0.8642				
9/4/2018	23.00	6.83	80	6.26	93.5	1.4	31		3570	0.522				
9/19/2018	19.30	7.31	81	4.94	76.3	2.200	1530	1.09	2360		0.0079	0.0055		
10/2/2018	14.10	8.04	78	5.77	74.8	0.740	41		2620	0.5654				
10/16/2018	10.40	9.79	88	5.55	79.3	0.750	20		2430	0.5715				
10/30/2018	5.20	11.69	92	6.11	83.8	0.680	20		2570	0.4301				
11/13/2018	4.10	12.23	94	5.97	71.4	0.490	41		2040					
11/27/2018	0.70	13.50	94	5.70	82.7	0.670	197		2060	0.2974				
12/26/2018	-0.10	14.57	99	5.80	74.2	0.52	5	2.12	2460	0.2335	0.0057	0.0357	0.122	0.0134
Average	9.81	10.79	92.48	5.41	95.06	0.96	105.2	2.69	2870	0.37	0.0047	0.0184	0.1680	0.0154
Median	8.56	11.24	93.90	5.38	93.50	0.75	41.0	1.97	2760	0.32	0.0041	0.0161	0.1220	0.0134
Minimum	-0.10	6.83	78.20	4.77	71.40	0.34	5.00	1.09	2040	0.18	0.0025	0.0055	0.0500	0.0125
Maximum	24.36	14.57	100.6	6.26	141.7	2.20	1530	5.75	4120	0.86	0.0079	0.0357	0.3320	0.0202

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.

Total phosphorus MDL = 0.005 mg/L.

Nitrate MDL = 0.005 mg/L.

Total Kjeldahl nitrogen MDL = 0.100 mg/L.

Calcium MDL = 20 µg/L (0.020 mg/L).

Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
108, East Branch Ware River, at Intervale Road

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	-0.03	12.70	88	5.24	121.2	1.1	10		4800	0.1863				
1/23/2018	-0.01	13.74	95	5.32	88.1	0.94	10		3370	0.1718				
2/6/2018	0.02	14.50	102	5.43	107.8	1.4	10		3720	0.151				
2/20/2018	2.66	13.08	99	5.21	111.7	0.54	41		3070	0.1345				
3/6/2018	2.58	13.07	98	5.04	109.5	0.58	10		2630	0.1514				
3/20/2018	0.27	14.11	99	5.13	108.4	0.49	20	3.19	3460	0.1222	0.0068	0.0506	0.05	0.0124
4/3/2018	3.83	12.72	98	5.58	99.1	0.49	5		3210	0.1412				
4/17/2018	4.11	12.58	98	5.09	105.6	1.6	52		3040	0.1585				
5/1/2018	8.91	11.46	101	5.22	108.7	0.650	10		3330	0.1725				
5/15/2018	16.39	8.90	92	5.55	123.0	1.5	52		3990	0.2293				
5/29/2018	17.13	8.50	90	5.21	125.5	2	41		4220	0.2442				
6/12/2018	17.88	8.58	92	5.41	123.7	2.2	108		4500	0.2543				
6/26/2018	19.19	7.56	83	5.37	138.4	2.9	199	8.64	5940	0.2673	0.0226	0.0392	0.335	0.0214
7/10/2018	23.34	7.99	95	5.55	149.0	4.6	110		5970	0.342				
7/24/2018	24.18	6.85	83	5.25	150.7	2.4	63		6560	0.329				
8/7/2018	25.33	7.32	90	5.50	139.6	2.5	336		5860	0.3801				
8/21/2018	20.06	8.20	91	5.06	109.9	1.7	98		4400	0.4622				
9/4/2018	23.60	4.10	48	6.16	118.9	2.6	75		5830	0.3766				
9/19/2018	19.74	7.20	81	5.42	85.9	2.000	1350	3.28	3070		0.006	0.0057		
10/2/2018	14.00	8.26	80	5.98	84.2	1.000	98		3360	0.3383				
10/16/2018	9.80	9.87	87	5.97	92.7	0.840	31		3270	0.3486				
10/30/2018	6.20	11.17	90	6.01	84.0	0.660	10		2870	0.2508				
11/13/2018	4.70	12.44	97	6.00	78.8	0.900	158		2780	0.2459				
11/27/2018	1.60	13.51	97	6.56	84.2	1.000	31		2510	0.2044				
12/11/2018	0.10	13.19	90	6.53	88.9	0.630	5			0.156				
12/26/2018	0.20	14.74	101	6.05	80.8	0.6	20	3.39	2940	0.1575	0.0061	0.0432	0.206	0.0103
Average	10.22	10.63	90.94	5.57	108.40	1.45	113.6	4.63	3948	0.24	0.0104	0.0347	0.1970	0.0147
Median	7.56	11.32	92.00	5.43	108.55	1.05	41.0	3.34	3370	0.23	0.0065	0.0412	0.2060	0.0124
Minimum	-0.03	4.10	48.30	5.04	78.80	0.49	5.00	3.19	2510	0.12	0.0060	0.0057	0.0500	0.0103
Maximum	25.33	14.74	101.80	6.56	150.70	4.60	1350	8.64	6560	0.46	0.0226	0.0506	0.3350	0.0214

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
121B, Thayer Pond, at inlet 2

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.05	4.86	34	5.39	319.7	0.84	5		13100	0.188				
1/23/2018	0.05	7.53	52	5.38	334.9	0.9	20		11000	0.2015				
2/6/2018	0.23	8.97	63	5.54	317.5	0.49	5		12700	0.1583				
2/20/2018	4.09	8.50	67	5.39	290.8	0.52	5		9640	0.1366				
3/6/2018	3.89	11.74	91	5.32	358.6	0.63	5		10100	0.1131				
3/20/2018	1.86	10.46	77	5.44	343.0	0.39	20	6.47	10900	0.1028	0.0025	0.0861	0.05	0.0084
4/3/2018	5.88	9.81	80	5.62	348.5	0.38	5		12300	0.1049				
4/17/2018	4.76	10.75	85	5.48	328.2	1.6	10		10400	0.1171				
5/1/2018	11.01	7.86	73	5.40	316.1	0.590	5		10400	0.1455				
5/15/2018	17.82	5.22	56	5.43	329.6	1.3	20		11800	0.3026				
5/29/2018	18.16	1.41	15	5.16	354.2	2.9	63		12700	0.3528				
6/12/2018	18.10	3.53	38	5.07	344.8	2.1	275		11900	0.221				
6/26/2018	19.93	1.46	16	5.18	320.1	1.8	155	13.6	13100		0.0088	0.0025	0.44	0.0269
7/10/2018	23.64	6.14	74	5.33	347.2	2.6	134		13900	0.3569				
7/24/2018	24.85	2.86	35	5.35	314.0	1.4	52		11500	0.2874				
8/7/2018	25.55	5.09	63	5.34	315.2	1.5	31		12600	0.2774				
8/21/2018	21.08	4.82	55	5.16	282.3	1.2	74		11300	0.2522				
9/4/2018	23.60	1.54	18	6.01	259.9	1.3	63		12700	0.2375				
9/19/2018	20.07	2.96	33	5.76	249.6	1.800	988	14.5	10900		0.0116	0.0025		
10/2/2018	14.50	2.84	28	6.06	233.3	0.540	41		11600	0.2053				
10/16/2018	10.80	2.70	24	5.97	236.2	0.570	74		10100	0.2174				
10/30/2018	6.10	6.23	50	6.00	236.3	0.610	85		10500	0.2517				
11/13/2018	4.90	9.82	77	6.20	195.3	0.500	41		8680	0.2664				
11/27/2018	1.10	10.59	75	6.16	252.3	0.490	20		9120					
12/11/2018	0.50	8.90	62	6.30	219.8	0.390	10			0.1926				
12/26/2018	1.00	11.02	78	5.91	276.2	0.47	5	9.59	11200	0.1331	0.0116	0.243	0.05	0.0143
Average	10.90	6.45	54.55	5.59	297.06	1.07	85.0	11.04	11366	0.21	0.0086	0.0835	0.1800	0.0165
Median	8.45	6.19	58.80	5.44	315.65	0.74	25.5	11.60	11300	0.21	0.0102	0.0443	0.0500	0.0143
Minimum	0.05	1.41	15.20	5.07	195.30	0.38	5.00	6.47	8680	0.10	0.0025	0.0025	0.0500	0.0084
Maximum	25.55	11.74	91.00	6.30	358.60	2.90	988	14.50	13900	0.36	0.0116	0.2430	0.4400	0.0269

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
115, Brigham Pond Outlet

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.57	12.82	90	4.81	82.9	0.74	5	3.62	3130	0.2782	0.0383	0.0744	0.27	0.02
1/23/2018	0.28	13.54	94	4.94	66.1	0.7	5	1.78	2380	0.2679	0.0242	0.0712	0.22	0.02
2/6/2018	0.92	14.04	101	5.05	72.9	0.51	5	2.3	2510	0.2142	0.0103	0.0743	0.167	0.014
2/20/2018	0.93	13.64	99	4.88	66.8	0.61	5	1.78	1960	0.1525	0.007	0.0602	0.106	0.013
3/6/2018	2.34	12.98	96	4.93	66.1	0.56	5	1.5	1920	0.21	0.0025	0.0388	0.121	0.016
3/20/2018	1.40	13.82	100	4.92	70.6	0.37	10	1.86	2400	0.1714	0.0025	0.0296	0.103	0.013
4/3/2018	3.96	12.50	97	5.34	76.8	0.46	20	2.39	2540	0.1839	0.0025	0.0263	0.153	0.012
4/17/2018	4.10	12.62	98	4.90	73.4	1	30	2.09	2290	0.1875	0.0025	0.0275	0.135	0.013
5/1/2018	11.67	10.61	100	4.95	75.0	0.630	10	2.42	2370	0.2174	0.0025	0.0096	0.186	0.015
5/15/2018	16.10	8.97	93	5.15	81.8	0.95	5	4.02	2620	0.2831	0.0025	0.0064	0.296	0.018
5/29/2018	19.85	8.48	95	4.99	87.0	1.2	52	4.7	2820	0.3088	0.0082	0.0092	0.326	0.016
6/12/2018	19.65	8.31	92	5.08	86.7	0.92	10	4.68	2880	0.326	0.0055	0.0119	0.272	0.021
6/26/2018	22.14	7.67	90	5.06	85.2	1.5	20	5.56	3250	0.3352	0.0063	0.0105	0.344	0.02
7/10/2018	25.25	7.90	97	4.99	81.5	1.1	5	5.4	3180	0.4224	0.0074	0.0025	0.404	0.027
7/24/2018	23.82	4.98	60	4.80	81.6	2.5	20	5.87	3280	0.4362	0.0025	0.0062	0.448	0.032
8/7/2018	26.46	6.70	84	4.87	77.0	1.4	5	5.45	3230	0.4396	0.0055	0.0069	0.412	0.016
8/21/2018	22.54	7.52	88	4.66	67.3	1.5	98	3.81	2830	0.6051	0.0166	0.0149	0.517	0.031
9/4/2018	26.00	6.72	83	6.18	69.2	1	5	4.86	3100	0.4974	0.007	0.0056	0.375	0.024
9/19/2018	20.13	7.24	82	5.40	64.2	2.300	1170	3.62	2540		0.0153	0.0193		
10/2/2018	15.10	7.52	75	5.68	58.1	1.000	63	2.91	2350	0.4952	0.0058	0.0205	0.354	0.019
10/16/2018	11.40	8.53	78	5.80	65.7	1.000	52	3.07	2420	0.4911	0.0025	0.0176	0.33	0.019
10/30/2018	6.20	10.95	88	5.99	63.3	0.790	31	2.46	2320	0.3867	0.0025	0.0206	0.219	0.017
11/13/2018	4.10	12.74	97	5.73	55.4	0.650	20	1.61	2110	0.3555	0.0025	0.0252	0.271	0.016
11/27/2018	1.20	13.89	98	5.67	62.1	0.700	20	1.77	2010	0.2672	0.0025	0.047	0.05	0.009
12/11/2018	1.80	13.48	97	5.94	59.2	0.490	5	2.02		0.254	0.0053	0.0434	0.05	0.014
12/26/2018	1.50	13.97	100	5.83	54.3	0.57	10	1.97	2180	0.2326	0.0056	0.0383	0.12	0.015
Average	11.13	10.47	91.17	5.25	71.16	0.97	64.8	3.21	2585	0.32	0.0075	0.0276	0.2500	0.0178
Median	8.80	10.78	94.30	5.06	69.90	0.86	10.0	2.69	2510	0.28	0.0055	0.0206	0.2700	0.0157
Minimum	0.28	4.98	59.50	4.66	54.30	0.37	5.00	1.50	1920	0.15	0.0025	0.0025	0.0500	0.0090
Maximum	26.46	14.04	101.10	6.18	87.00	2.50	1170	5.87	3280	0.61	0.0383	0.0744	0.5170	0.0316

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
126A, Moosehorn Pond Outlet

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	-0.02	13.00	90	4.63	74.4	0.82	5	3.71	2830	0.3034	0.0659	0.0509	0.317	0.0193
1/23/2018	0.11	13.74	95	4.97	73.2	0.66	10	2.57	2420	0.2618	0.0321	0.053	0.229	0.0178
2/6/2018	0.02	14.53	102	5.10	52.9	0.59	5	2.68	2460	0.2172	0.0172	0.0575	0.174	0.0166
2/20/2018	2.10	13.38	100	4.94	64.4	0.75	5	2.21	2110	0.2002	0.0095	0.04	0.05	0.0192
3/6/2018	1.98	13.32	98	5.22	60.0	0.53	5	1.59	1780	0.2088	0.0025	0.0235	0.101	0.0152
3/20/2018	0.72	13.92	99	5.06	63.8	0.44	5	1.96	2250	0.1763	0.0025	0.0191	0.113	0.014
4/3/2018	3.95	12.74	98	5.33	58.5	0.44	10	2.46	2140	0.1928	0.0025	0.0112	0.167	0.0114
4/17/2018	3.83	12.81	99	4.73	62.8	0.97	41	1.93	1870	0.2103	0.0025	0.0096	0.188	0.013
5/1/2018	9.23	11.36	101	4.91	64.6	0.550	5	2.74	2130	0.2673	0.0025	0.0078	0.213	0.0142
5/15/2018	17.38	8.94	95	5.02	67.2	0.9	63	3.75	2340	0.3463	0.0025	0.012	0.309	0.0192
5/29/2018	17.06	8.94	94	4.84	68.4	1.4	41	4.35	2520	0.4188	0.0188	0.0337	0.421	0.0259
6/12/2018	17.44	8.94	95	4.94	66.0	2.1	75	4.5	2560	0.4334	0.0089	0.0249	0.382	0.032
6/26/2018	17.94	8.74	94	4.92	61.3	1.8	52	4.8	3060	0.4428	0.0025	0.0117	0.436	0.0321
7/10/2018	22.68	8.01	94	5.07	73.9	1.7	10	4.47	3020	0.5506	0.0156	0.0089	0.471	0.046
7/24/2018	23.56	7.55	90	4.78	66.7	1.4	75	4.67	2800	0.463	0.006	0.0117	0.482	0.0432
8/7/2018	24.92	7.16	88	4.80	70.4	1.5	20	5.02	2970	0.5177	0.0143	0.0183	0.483	0.0337
8/21/2018	19.83	8.67	96	4.60	62.7	0.98	20	3.12	2460	0.6336	0.0078	0.0105	0.479	0.028
9/4/2018	23.90	5.52	65	6.14	56.8	1.8	108	4.76	2700	0.4987	0.0144	0.015	0.425	0.0413
9/19/2018	19.55	8.57	96	5.27	52.5	1.600	1100	1.73	2200		0.0077	0.0099		
10/2/2018	13.90	8.71	84	5.71	51.1	0.770	20	2.72	2210	0.4685	0.0067	0.027	0.305	0.0169
10/16/2018	10.00	10.28	91	5.70	58.3	1.000	51	2.28	1980	0.506	0.0025	0.0238	0.377	0.0193
10/30/2018	5.20	12.11	95	5.65	52.2	0.640	20	2.11	1970	0.3491	0.0025	0.0129	0.285	0.0153
11/13/2018	4.20	12.47	96	5.70	51.7	1.300	31	1.77	1910	0.3337	0.0025	0.051	0.277	0.0184
11/27/2018	0.60	14.19	99	5.88	65.3	0.730	96	1.5	1860	0.2882	0.0025	0.0316	0.132	0.0101
12/11/2018	0.10	13.44	92	6.18	57.1	0.490	5	2.08		0.2582	0.0068	0.0379	0.185	0.0131
12/26/2018	0.20	14.25	98	5.90	52.4	0.5	5	2.28	2250	0.2368	0.0065	0.0314	0.317	0.0139
Average	10.01	10.97	93.95	5.23	61.87	1.01	72.4	2.99	2352	0.35	0.0102	0.0248	0.2927	0.0219
Median	7.22	11.74	95.15	5.07	62.75	0.86	20.0	2.63	2250	0.33	0.0066	0.0213	0.3050	0.0184
Minimum	-0.02	5.52	65.40	4.60	51.10	0.44	5.00	1.50	1780	0.18	0.0025	0.0078	0.0500	0.0101
Maximum	24.92	14.53	102.00	6.18	74.40	2.10	1100	5.02	3060	0.63	0.0659	0.0575	0.4830	0.0455

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
127, Waite Pond Outlet

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	0.85	11.47	81	5.01	49.1	0.92	5	5.38	2750	0.2419	0.0215	0.0412	0.231	0.0139
1/23/2018	2.22	12.09	89	5.17	36.9	0.91	10	3.22	2250	0.2252	0.0186	0.103	0.195	0.0177
2/6/2018	2.96	11.26	86	5.07	42.6	0.55	5	4.78	2610	0.168	0.0061	0.0457	0.16	0.0141
2/20/2018	4.03	11.49	90	4.70	42.6	0.45	5	3.37	2130	0.1428	0.0052	0.0496	0.05	0.0131
3/6/2018	2.72	13.03	98	5.51	37.3	0.56	5	2.16	1720	0.1518	0.0025	0.0206	0.05	0.0119
3/20/2018	2.93	13.16	100	5.24	40.0	0.31	5	2.55	1990	0.1282	0.0025	0.0123	0.05	0.0123
4/3/2018	5.67	11.94	96	5.87	39.8	0.43	5	3.01	2060	0.1243	0.0025	0.0058	0.149	0.0104
4/17/2018	4.65	12.45	99	5.03	38.4	0.76	5	3.07	1880	0.1351	0.0025	0.0084	0.05	0.010
5/1/2018	10.78	10.64	98	5.05	39.9	0.420	5	2.83	1900	0.1397	0.0025	0.0072	0.156	0.0106
5/15/2018	17.52	8.16	87	5.23	44.6	0.79	10	4.22	2180	0.1548	0.0114	0.0121	0.246	0.0105
5/29/2018	17.63	7.54	80	4.77	47.4	0.94	269	4.92	2290	0.154	0.0257	0.0189	0.272	0.117
6/12/2018	17.44	8.12	86	5.39	47.4	1.3	30	5.7	2380	0.1482	0.0238	0.0295	0.257	0.011
6/26/2018	18.41	7.28	79	4.85	46.8	1.2	20	5.34	2750	0.146	0.0099	0.0178	0.298	0.0116
7/10/2018	23.46	6.27	75	5.01	45.8	1.7	10	6.45	2690	0.1934	0.0207	0.0192	0.286	0.014
7/24/2018	25.08	6.56	80	4.73	44.9	0.94	10	5.16	2550	0.168	0.0118	0.0148	0.376	0.0153
8/7/2018	25.79	5.68	71	4.63	43.4	1.1	84	6.33	2600	0.2105	0.0139	0.0165	0.358	0.0063
8/21/2018	21.82	7.76	89	4.54	35.8	0.7	31	3.84	2320	0.3992	0.0101	0.008	0.385	0.0148
9/4/2018	24.10	4.92	59	5.85	40.6	0.92	20	5.49	2620	0.3234	0.0228	0.0176	0.308	0.0163
9/19/2018	21.05	8.14	94	5.62	37.0	0.540	52	2.9	2130		0.0051	0.0058		
10/2/2018	15.30	8.04	80	5.87	32.4	0.450	41	3.53	2050	0.3858	0.0068	0.0101	0.299	0.0081
########	10.80	9.13	82	5.85	37.6	0.550	20	3.24	1940	0.3466	0.0025	0.0106	0.284	0.0112
########	5.60	11.04	88	6.35	37.2	0.380	10	3.14	1980	0.3022	0.0025	0.0075	0.303	0.0121
########	4.70	12.58	98	6.01	33.2	0.430	31	2.72	1890	0.3075	0.0025	0.0137	0.222	0.013
########	3.50	12.53	94	6.24	33.3	0.610	20	2.64	1840	0.2536	0.0025	0.0234	0.103	0.007
########	3.30	11.54	86	5.96	33.7	0.310	5	3.32		0.1869	0.007	0.0281	0.12	0.018
########	2.70	12.55	93	5.97	34.2	0.49	5	3.52	2020	0.139	0.0064	0.0206	0.103	0.0119
Average	11.35	9.82	86.78	5.37	40.07	0.72	27.6	3.96	2221	0.21	0.0096	0.0218	0.2124	0.0165
Median	8.23	10.84	87.20	5.24	39.85	0.59	10.0	3.45	2130	0.17	0.0066	0.0171	0.2310	0.0121
Minimum	0.85	4.92	58.50	4.54	32.40	0.31	5.00	2.16	1720	0.12	0.0025	0.0058	0.0500	0.0063
Maximum	25.79	13.16	99.50	6.35	49.10	1.70	269	6.45	2750	0.40	0.0257	0.1030	0.3850	0.1170

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
128, Lovewell Pond Outlet

Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)	pH	Specific Conductance (µS/cm)	Turbidity (NTU)	E. coli (MPN/100 mL)	Alkalinity (mg/L)	Calcium (µg/L)	Mean UV254 (ABU/cm)	Ammonia (mg/L)	Nitrate (mg/L)	TKN (mg/L)	TP (mg/L)
1/9/2018	2.45	9.97	74	5.11	92.8	1.5	41	4.58	3540	0.4245	0.122	0.0924	0.511	0.0292
1/23/2018	2.58	11.76	87	5.12	69.6	1.5	10	3.78	3100		0.087	0.0578	0.367	0.0238
2/6/2018	3.17	12.06	92	5.06	75.7	0.88	5	4.12	3030	0.3108	0.0495	0.0625	0.356	0.0211
2/20/2018	3.72	10.65	83	4.67	72.6	0.89	10	3.32	2730	0.2756	0.0316	0.058	0.208	0.0176
3/6/2018	2.21	13.05	97	5.60	65.6	0.7	5	2.29	2100	0.2354	0.0025	0.0419	0.137	0.0169
3/20/2018	2.82	13.55	102	5.07	70.6	0.78	5	2.01	2400	0.217	0.0025	0.0249	0.15	0.0167
4/3/2018	5.95	12.01	98	5.30	74.1	0.77	5	2.32	2540	0.2235	0.0025	0.0136	0.235	0.0166
4/17/2018	4.72	12.44	99	5.11	74.3	1.9	20	2.17	2370	0.2071	0.0025	0.015	0.251	0.017
5/1/2018	11.66	10.88	102	5.14	76.7	0.830	5	1.72	2240	0.221	0.0025	0.0025	0.21	0.0137
5/15/2018	17.67	8.60	92	4.93	80.5	0.7	20	2.43	2340	0.2468	0.0086	0.0108	0.248	0.0126
5/29/2018	17.77	8.72	93	5.03	83.9	3.6	20	2.58	2500	0.2599	0.0276	0.0254	0.67	0.057
6/12/2018	18.71	7.90	86	4.96	85.1	1.1	20	2.39	2350	0.2786	0.0025	0.0397	0.331	0.0281
6/26/2018	21.29	8.09	93	4.76	81.8	1.4	5	1.93	2600	0.3482	0.0025	0.008	0.467	0.0308
7/10/2018	24.38	7.55	92	5.30	84.7	1.3	31	2.57	2480	0.344	0.033	0.0309	0.415	0.032
7/24/2018	24.87	7.13	87	4.94	83.8	0.98	30	2.65	2520	0.348	0.025	0.0327	0.435	0.0328
8/7/2018	26.65	6.91	87	4.70	81.4	0.86	41	2.45	2540	0.3442	0.0181	0.0307	0.367	0.0181
8/21/2018	22.65	7.98	93	4.67	71.7	0.74	20	2.62	2370	0.5015	0.117	0.0107	0.44	0.0203
9/4/2018	24.90	5.84	71	6.09	66.7	0.9	5	3.08	2590	0.4972	0.0188	0.0359	0.407	0.0215
9/19/2018	20.86	8.45	97	5.54	67.6	0.780	135	2.47	2280		0.0159	0.0137		
10/2/2018	15.20	8.57	85	5.91	61.2	0.560	10	2.8	2270	0.5254	0.0388	0.0398	0.393	0.0116
10/16/2018	12.00	9.24	86	5.80	67.9	0.670	5	2.48	2240	0.5524	0.0586	0.0573	0.431	0.0158
10/30/2018	5.30	11.59	91	6.06	65.1	2.000	5	1.9	2340	0.488	0.0343	0.0718	0.295	0.0209
11/13/2018	4.60	12.36	96	5.70	63.7	0.840	5	1.98		0.4808	0.0108	0.064	0.371	0.0172
11/27/2018	2.30	13.00	95	5.56	59.0	1.500	201	2.21	2250	0.4344	0.0149	0.0715	0.242	0.01
12/11/2018	3.90	10.80	82	5.81	66.3	0.510	5	3.01			0.0162	0.0743	0.184	0.0145
12/26/2018	2.80	11.53	85	5.37	65.1	0.59	5	3.19	2380	0.2792	0.009	0.0492	0.163	0.0145
Average	11.74	10.02	90.17	5.28	73.37	1.11	25.7	2.66	2504	0.35	0.0290	0.0398	0.3314	0.0212
Median	8.81	10.31	91.60	5.13	72.15	0.87	10.0	2.48	2390	0.34	0.0172	0.0378	0.3560	0.0176
Minimum	2.21	5.84	70.50	4.67	59.00	0.51	5.00	1.72	2100	0.21	0.0025	0.0025	0.1370	0.0100
Maximum	26.65	13.55	102.10	6.09	92.80	3.60	201	4.58	3540	0.55	0.1220	0.0924	0.6700	0.0570

NOTES

Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
1/1/18	3.7	6.85	5.20	*0.00*	0.5
1/2/18	3.7	6.91	1.00	1.00	0.5
1/3/18	3.5	6.93	3.10	*0.00*	0.5
1/4/18	3.4	6.89	3.10	*0.00*	0.5
1/5/18	2.9	6.92	3.10	*0.00*	0.5
1/6/18	2.3	6.96	2.00	1.00	0.5
1/7/18	1.7	7.01	*0.00*	*0.00*	0.5
1/8/18	2.3	7.01	1.00	*0.00*	0.5
1/9/18	2.3	7.05	3.10	2.00	1
1/10/18	2.2	7.01	1.00	*0.00*	0.5
1/11/18	1.8	7.04	2.00	*0.00*	1
1/12/18	2.2	7.04	3.10	*0.00*	0.5
1/13/18	2.3	7.01	7.50	*0.00*	0.5
1/14/18	2.1	7.01	74.30	2.00	2
1/15/18	1.5	7.07	72.80	1.00	1
1/16/18	1.3	7.04	23.10	1.00	0.5
1/17/18	1.5	6.96	18.70	*0.00*	2
1/18/18	1.1	7.00	34.10	*0.00*	0.5
1/19/18	1.3	7.00	29.20	1.00	0.5
1/20/18	1.5	6.99	20.30	1.00	1
1/21/18	1.5	7.02	12.10	*0.00*	0.5
1/22/18	1.6	6.98	13.50	1.00	0.5
1/23/18	1.6	7.10	24.60	*0.00*	0.5
1/24/18	1.4	7.09	17.30	*0.00*	0.5
1/25/18	1.3	7.09	9.80	1.00	0.5
1/26/18	1.2	7.08	19.70	1.00	2
1/27/18	1.3	7.08	11.00	2.00	0.5
1/28/18	1.5	7.07	20.30	6.00	5.2
1/29/18	1.7	7.01	7.50	1.00	0.5
1/30/18	1.4	7.06	11.00	2.00	2
1/31/18	1.2	7.10	14.60	6.00	5.2
2/1/18	1.1	7.10	13.10	1.00	0.5
2/2/18	1.4	7.08	22.60	4.00	8.5
2/3/18	1.2	7.10	7.50	5.00	3.1
2/4/18	1.1	7.09	14.40	2.00	5.2
2/5/18	1.3	7.09	13.40	5.00	6.3
2/6/18	1.2	7.07	6.30	1.00	2
2/7/18	1.2	7.10	4.10	2.00	1
2/8/18	1.2	7.07	6.30	*0.00*	1
2/9/18	1.2	7.08	3.10	*0.00*	0.5
2/10/18	1.1	7.06	4.10	*0.00*	0.5
2/11/18	1.2	7.14	3.00	*0.00*	0.5
2/12/18	1.2	7.16	11.00	1.00	2
2/13/18	1.3	7.14	8.60	1.00	2
2/14/18	1.3	7.12	7.50	1.00	1
2/15/18	1.6	7.16	8.50	1.00	2
2/16/18	1.3	7.13	5.20	*0.00*	1
2/17/18	1.6	7.14	1.00	*0.00*	0.5
2/18/18	1.4	7.12	3.10	1.00	1

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
2/19/18	1.4	7.11	4.10	1.00	1
2/20/18	1.4	7.10	4.10	*0.00*	1
2/21/18	1.5	7.10	4.10	*0.00*	0.5
2/22/18	1.5	7.00	4.10	*0.00*	1
2/23/18	1.5	6.99	6.30	*0.00*	3
2/24/18	1.6	7.02	1.00	*0.00*	0.5
2/25/18	1.7	7.00	3.10	1.00	0.5
2/26/18	1.6	6.96	3.00	2.00	1
2/27/18	1.6	7.00	8.40	2.00	2
2/28/18	1.9	6.98	4.10	1.00	1
3/1/18	1.9	7.00	2.00	1.00	1
3/2/18	1.9	6.90	7.50	3.00	3.1
3/3/18	2.2	7.05	16.90	3.00	6.3
3/4/18	2.2	7.07	11.90	5.00	3.1
3/5/18	2.1	7.08	7.50	*0.00*	2
3/6/18	2.1	7.11	4.10	1.00	1
3/7/18	2.2	7.12	6.30	1.00	2
3/8/18	1.7	7.09	9.80	3.00	3.1
3/9/18	2.0	6.96	7.40	2.00	0.5
3/10/18	2.0	7.01	4.10	1.00	1
3/11/18	1.9	7.01	6.30	*0.00*	3.1
3/12/18	2.0	7.00	*0.00*	*0.00*	0.5
3/13/18	2.1	7.00	2.00	*0.00*	0.5
3/14/18	2.0	7.07	6.30	1.00	0.5
3/15/18	2.0	7.04	3.00	*0.00*	1
3/16/18	1.9	7.06	3.10	*0.00*	2
3/17/18	1.9	7.08	3.10	*0.00*	0.5
3/18/18	2.0	7.07	7.50	1.00	2
3/19/18	1.9	7.08	4.10	*0.00*	0.5
3/20/18	1.9	7.10	2.00	*0.00*	1
3/21/18	1.8	7.09	4.10	*0.00*	1
3/22/18	1.8	7.08	9.80	2.00	4.1
3/23/18	2.1	7.11	1.00	*0.00*	0.5
3/24/18	2.1	7.10	1.00	1.00	0.5
3/25/18	2.2	7.12	3.10	*0.00*	0.5
3/26/18	2.2	7.12	2.00	*0.00*	0.5
3/27/18	2.2	7.12	1.00	*0.00*	0.5
3/28/18	2.2	7.12	*0.00*	*0.00*	0.5
3/29/18	2.4	7.10	3.10	*0.00*	0.5
3/30/18	2.5	7.10	2.00	*0.00*	0.5
3/31/18	2.6	7.09	1.00	*0.00*	0.5
4/1/18	2.9	7.11	3.10	*0.00*	0.5
4/2/18	2.8	7.04	3.10	*0.00*	0.5
4/3/18	2.9	6.99	*0.00*	*0.00*	0.5
4/4/18	2.9	7.01	1.00	*0.00*	0.5
4/5/18	2.9	7.01	3.10	*0.00*	0.5
4/6/18	2.8	7.06	4.10	*0.00*	0.5
4/7/18	2.8	7.01	3.10	*0.00*	0.5
4/8/18	2.9	7.05	2.00	*0.00*	0.5
4/9/18	2.8	6.81	4.10	*0.00*	1

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
4/10/18	3.1	6.85	6.30	3.00	3.1
4/11/18	3.0	6.83	1.00	2.00	0.5
4/12/18	3.3	6.84	1.00	*0.00*	0.5
4/13/18	3.3	6.94	4.10	*0.00*	0.5
4/14/18	3.4	6.88	2.00	*0.00*	0.5
4/15/18	3.7	6.97	1.00	*0.00*	0.5
4/16/18	3.7	6.99	5.20	*0.00*	0.5
4/17/18	3.6	7.01	5.20	*0.00*	0.5
4/18/18	3.7	6.96	8.50	*0.00*	2
4/19/18	3.9	6.96	9.50	*0.00*	0.5
4/20/18	3.9	6.97	9.80	*0.00*	1
4/21/18	4.1	7.07	5.20	*0.00*	0.5
4/22/18	4.4	7.04	3.00	*0.00*	0.5
4/23/18	4.8	7.02	1.00	*0.00*	0.5
4/24/18	4.5	7.07	6.30	*0.00*	0.5
4/25/18	4.2	7.07	4.10	*0.00*	0.5
4/26/18	4.2	7.13	3.00	*0.00*	1
4/27/18	5.0	7.16	1.00	*0.00*	0.5
4/28/18	4.8	7.12	2.00	*0.00*	0.5
4/29/18	4.6	7.18	2.00	*0.00*	0.5
4/30/18	5.0	7.07	6.30	*0.00*	1
5/1/18	5.4	7.13	8.60	*0.00*	
5/2/18	5.5	7.21	8.60	*0.00*	
5/3/18	5.0	7.20	*0.00*	*0.00*	
5/4/18	4.6	7.12	2.00	*0.00*	
5/5/18	4.6	7.17	7.50	2.00	
5/6/18	5.7	7.15	3.00	*0.00*	
5/7/18	6.4	7.20	12.20	*0.00*	
5/8/18	6.3	7.26	11.00	*0.00*	
5/9/18	5.6	7.19	5.20	*0.00*	
5/10/18	5.6	7.24	12.00	*0.00*	
5/11/18	5.1	7.20	5.20	*0.00*	
5/12/18	7.9	7.25	11.00	*0.00*	
5/13/18	6.7	7.22	7.50	*0.00*	
5/14/18	5.9	7.23	3.00	*0.00*	
5/15/18	5.6	7.17	13.00	*0.00*	
5/16/18	6.9	7.16	21.30	*0.00*	
5/17/18	6.3	7.21	9.80	*0.00*	
5/18/18	6.4	7.25	12.10	*0.00*	
5/19/18	6.5	7.25	17.30	*0.00*	
5/20/18	6.6	7.23	9.80	*0.00*	
5/21/18	6.8	7.25	6.30	*0.00*	
5/22/18	6.7	7.27	8.60	*0.00*	
5/23/18	6.3	7.31	6.30	*0.00*	
5/24/18	6.8	7.21	7.50	*0.00*	
5/25/18	7.0	7.34	14.60	*0.00*	
5/26/18	6.4	7.28	17.30	*0.00*	
5/27/18	7.2	7.41	6.30	*0.00*	
5/28/18	7.6	7.43	6.30	*0.00*	
5/29/18	6.7	7.40	8.60	*0.00*	

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
5/30/18	7.6	7.31	16.00	*0.00*	
5/31/18	7.0	7.34	6.30	*0.00*	
6/1/18	7.2	7.28	4.10	*0.00*	0.5
6/2/18	7.3	7.43	14.60	*0.00*	0.5
6/3/18	7.6	7.37	4.10	*0.00*	0.5
6/4/18	7.2	7.36	8.60	*0.00*	0.5
6/5/18	8.4	7.35	5.20	*0.00*	0.5
6/6/18	7.6	7.39	7.50	*0.00*	0.5
6/7/18	7.8	7.38	3.10	*0.00*	*0*
6/8/18	7.5	7.35	3.10	*0.00*	0.5
6/9/18	8.2	7.38	12.10	*0.00*	0.5
6/10/18	7.8	7.28	3.10	*0.00*	0.5
6/11/18	7.4	7.36	9.80	*0.00*	0.5
6/12/18	7.7	7.34	2.00	*0.00*	0.5
6/13/18	7.6	7.36	6.30	*0.00*	0.5
6/14/18	8.4	7.29	6.30	*0.00*	0.5
6/15/18	8.1	7.25	4.10	*0.00*	0.5
6/16/18	8.1	7.30	11.00	*0.00*	0.5
6/17/18	8.3	7.29	5.20	*0.00*	0.5
6/18/18	8.3	7.28	4.10	*0.00*	0.5
6/19/18	8.4	7.31	6.30	*0.00*	0.5
6/20/18	8.8	7.35	7.40	*0.00*	0.5
6/21/18	8.1	7.24	6.30	*0.00*	0.5
6/22/18	8.8	7.26	4.10	*0.00*	0.5
6/23/18	8.5	7.26	3.10	*0.00*	0.5
6/24/18	8.8	7.20	7.40	*0.00*	0.5
6/25/18	8.6	7.20	7.30	*0.00*	0.5
6/26/18	9.2	7.30	6.20	*0.00*	0.5
6/27/18	8.3	7.29	3.10	*0.00*	0.5
6/28/18	9.2	7.35	14.80	*0.00*	0.5
6/29/18	9.7	7.29	20.90	*0.00*	0.5
6/30/18	9.3	7.29	25.60	*0.00*	0.5
7/1/18	9.1	7.24	22.60	*0.00*	0.5
7/2/18	9.3	7.32	15.80	*0.00*	0.5
7/3/18	8.9	7.24	16.10	*0.00*	0.5
7/4/18	9.0	7.24	24.90	*0.00*	0.5
7/5/18	9.1	7.27	26.90	*0.00*	0.5
7/6/18	9.2	7.21	24.10	*0.00*	0.5
7/7/18	10.8	7.24	32.30	*0.00*	0.5
7/8/18	9.0	7.11	25.30	*0.00*	0.5
7/9/18	9.3	7.25	29.50	*0.00*	0.5
7/10/18	9.8	7.25	59.80	*0.00*	0.5
7/11/18	9.9	7.24	53.80	*0.00*	1
7/12/18	9.6	7.25	37.90	*0.00*	0.5
7/13/18	10.4	7.24	52.10	*0.00*	0.5
7/14/18	9.6	7.28	48.80	*0.00*	0.5
7/15/18	10.2	7.22	36.80	*0.00*	0.5
7/16/18	10.0	7.23	60.90	*0.00*	0.5
7/17/18	9.7	7.17	54.60	*0.00*	0.5
7/18/18	9.8	7.22	60.20	*0.00*	0.5

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
7/19/18	9.9	7.21	54.80	0.00	0.5
7/20/18	10.2	7.19	82.30	0.00	0.5
7/21/18	10.2	7.19	68.30	0.00	0.5
7/22/18	10.4	7.21	48.80	0.00	1
7/23/18	10.5	7.11	47.30	0.00	0.5
7/24/18	10.2	7.21	27.50	0.00	0.5
7/25/18	9.7	7.16	36.40	0.00	0.5
7/26/18	9.8	7.16	29.50	0.00	0.5
7/27/18	10.2	7.10	26.90	0.00	0.5
7/28/18	10.3	7.11	30.10	0.00	0.5
7/29/18	10.2	7.12	14.60	0.00	0.5
7/30/18	10.1	7.08	18.30	0.00	1
7/31/18	10.3	7.08	39.30	0.00	0.5
8/1/18	10.5	7.10	28.50	0.00	0.5
8/2/18	10.4	7.10	19.90	0.00	0.5
8/3/18	10.5	7.09	19.90	0.00	0.5
8/4/18	10.6	7.12	140.00	0.00	0.5
8/5/18	10.5	7.02	51.20	0.00	0.5
8/6/18	10.6	7.11	48.10	0.00	0.5
8/7/18	10.7	7.09	68.30	0.00	1
8/8/18	10.7	7.18	41.40	0.00	0.5
8/9/18	10.7	7.13	42.60	0.00	0.5
8/10/18	10.7	7.09	50.40	1.00	0.5
8/11/18	11.0	7.12	51.20	0.00	0.5
8/12/18	10.8	7.15	101.00	0.00	1
8/13/18	10.6	7.16	59.10	0.00	0.5
8/14/18	10.8	7.20	67.00	0.00	1
8/15/18	11.2	7.17	71.40	0.00	0.5
8/16/18	10.7	7.17	61.30	0.00	0.5
8/17/18	10.9	7.14	50.40	0.00	0.5
8/18/18	10.6	7.15	68.30	0.00	0.5
8/19/18	11.3	7.22	59.10	0.00	0.5
8/20/18	10.7	7.23	60.20	0.00	0.5
8/21/18	11.0	7.20	167.00	0.00	1
8/22/18	11.0	7.16	155.00	0.00	0.5
8/23/18	11.2	7.17	199.00	2.00	1
8/24/18	10.7	7.16	276.00	0.00	0.5
8/25/18	11.1	7.07	548.00	0.00	0.5
8/26/18	11.3	7.11	579.00	0.00	1
8/27/18	10.9	7.00	1200.00	1.00	0.5
8/28/18	11.1	7.05	>2420	0.00	0.5
8/29/18	11.0	7.03	>4840	0.00	1
8/30/18	11.5	7.00	>9680	0.00	2
8/31/18	11.4	7.14	>24200	0.00	5
9/1/18	11.1	7.05	>48400	0.00	10
9/2/18	11.4	7.05	46100.00	0.00	50
9/3/18	11.4	6.95	68700.00	1.00	50
9/4/18	11.9	7.00	54800.00	0.00	50
9/5/18	11.7	7.02	81600.00	0.00	50
9/6/18	11.6	7.02	57900.00	0.00	50

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
9/7/18	12.2	7.06	120000.00	*0.00*	50
9/8/18	11.6	6.96	105000.00	*0.00*	50
9/9/18	12.5	7.02	72700.00	1.00	50
9/10/18	12.3	6.99	46100.00	*0.00*	50
9/11/18	12.5	6.99	46100.00	*0.00*	50
9/12/18	11.7	6.98	48800.00	*0.00*	50
9/13/18	11.8	6.96	34500.00	*0.00*	50
9/14/18	11.6	7.04	34500.00	*0.00*	50
9/15/18	11.5	7.03	24800.00	1.00	50
9/16/18	11.6	7.02	21900.00	*0.00*	50
9/17/18	11.7	7.02	22800.00	1.00	50
9/18/18	11.8	6.99	14100.00	1.00	5
9/19/18	11.8	7.07	10500.00	*0.00*	5
9/20/18	12.0	7.03	11200.00	*0.00*	5
9/21/18	11.9	7.02	6490.00	*0.00*	5
9/22/18	11.0	6.93	5480.00	*0.00*	5
9/23/18	12.4	7.06	5480.00	*0.00*	5
9/24/18	12.3	6.93	3260.00	*0.00*	5
9/25/18	12.6	7.00	2400.00	*0.00*	5
9/26/18	12.1	6.95	3080.00	*0.00*	5
9/27/18	12.0	6.87	1300.00	*0.00*	2
9/28/18	12.5	6.95	1550.00	*0.00*	2
9/29/18	12.4	6.94	1550.00	*0.00*	2
9/30/18	12.4	6.87	992.00	*0.00*	2
10/1/18	12.0	6.87	944.00	*0.00*	2
10/2/18	12.8	6.84	770.00	1.00	0.5
10/3/18	12.6	6.87	770.00	*0.00*	0.5
10/4/18	12.5	6.83	866.00	*0.00*	0.5
10/5/18	12.2	6.77	365.00	6.00	2
10/6/18	12.8	6.88	613.00	*0.00*	0.5
10/7/18	11.5	6.74	435.00	*0.00*	0.5
10/8/18	13.2	6.74	144.00	*0.00*	0.5
10/9/18	12.2	6.72	326.00	*0.00*	0.5
10/10/18	12.5	6.66	248.00	*0.00*	0.5
10/11/18	12.1	6.71	172.00	1.00	0.5
10/12/18	13.0	6.73	122.00	*0.00*	0.5
10/13/18	13.7	6.98	326.00	*0.00*	0.5
10/14/18	12.2	6.72	156.00	*0.00*	0.5
10/15/18	12.5	6.71	140.00	*0.00*	0.5
10/16/18	11.0	6.66	120.00	*0.00*	0.5
10/17/18	12.5	6.73	166.00	*0.00*	1
10/18/18	12.1	6.62	127.00	1.00	0.5
10/19/18	14.8	7.04	105.00	*0.00*	0.5
10/20/18	11.2	6.60	99.00	*0.00*	0.5
10/21/18	12.3	6.57	98.80	1.00	0.5
10/22/18	14.8	6.98	46.40	1.00	0.5
10/23/18	11.4	6.93	61.60	*0.00*	0.5
10/24/18	13.5	6.64	98.70	*0.00*	0.5
10/25/18	14.0	7.03	60.20	*0.00*	0.5
10/26/18	13.6	7.25	21.60	1.00	0.5

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
10/27/18	13.3	7.26	50.40	*0.00*	0.5
10/28/18	13.0	7.24	59.40	2.00	1
10/29/18	12.9	7.27	47.30	1.00	0.5
10/30/18	12.7	7.09	68.30	*0.00*	2
10/31/18	12.5	7.17	28.20	*0.00*	0.5
11/1/18	11.8	7.12	42.00	*0.00*	1
11/2/18	12.3	6.83	24.30	*0.00*	2
11/3/18	11.9	6.84	27.90	*0.00*	0.5
11/4/18	12.2	6.87	35.90	*0.00*	2
11/5/18	12.1	7.00	43.50	*0.00*	0.5
11/6/18	12.0	6.99	41.70	*0.00*	1
11/7/18	11.9	6.98	49.60	1.00	7.5
11/8/18	11.8	6.94	46.40	*0.00*	2
11/9/18	11.7	6.98	27.50	1.00	1
11/10/18	11.6	6.96	32.80	*0.00*	0.5
11/11/18	11.2	6.94	28.50	*0.00*	1
11/12/18	11.0	6.95	18.50	*0.00*	0.5
11/13/18	10.9	6.93	25.30	1.00	0.5
11/14/18	10.6	6.91	33.60	1.00	0.5
11/15/18	10.3	6.96	33.20	*0.00*	0.5
11/16/18	10.0	6.94	37.90	3.00	0.5
11/17/18	9.8	6.95	44.10	*0.00*	4.1
11/18/18	9.7	6.96	36.40	1.00	0.5
11/19/18	9.6	6.97	23.10	*0.00*	0.5
11/20/18	9.6	6.97	25.60	*0.00*	2
11/21/18	9.3	6.96	20.10	*0.00*	0.5
11/22/18	9.0	6.95	27.90	2.00	1
11/23/18	8.6	6.98	19.90	*0.00*	1
11/24/18	8.5	6.99	27.90	*0.00*	1
11/25/18	8.4	6.99	21.10	2.00	2
11/26/18	8.4	7.01	34.10	*0.00*	1
11/27/18	8.3	7.01	39.30	*0.00*	1
11/28/18	8.1	7.02	38.80	1.00	1
11/29/18	8.0	7.02	45.70	1.00	0.5
11/30/18	7.8	7.05	17.50	1.00	1
12/1/18		7.04	18.50	*0.00*	2
12/2/18	7.7	7.02	10.80	1.00	0.5
12/3/18	7.7	7.06	25.90	*0.00*	1
12/4/18	7.7	7.06	35.50	3.00	2
12/5/18	7.5	7.06	17.30	1.00	0.5
12/6/18	7.4	7.05	10.80	*0.00*	0.5
12/7/18	7.2	7.06	14.20	1.00	0.5
12/8/18	7.0	7.05	14.60	*0.00*	0.5
12/9/18	6.8	7.08	15.60	1.00	0.5
12/10/18	6.6	7.07	9.60	*0.00*	0.5
12/11/18	6.4	7.07	20.90	*0.00*	1
12/12/18	6.4	7.09	16.00	*0.00*	0.5
12/13/18	6.2	7.10	12.10	*0.00*	0.5
12/14/18	6.1	7.09	3.10	*0.00*	0.5
12/15/18	6.1	7.17	13.20	*0.00*	0.5

Quabbin Laboratory Records, 2018
MWRA William A. Brutsch Water Treatment Facility (BWTF)

Date	Temperature (°C)	pH	Confirmed Total Coliform (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	E. coli (MPN/100 mL)
12/16/18	6.1	7.17	7.50	*0.00*	0.5
12/17/18	5.9	7.18	52.80	1.00	2
12/18/18	5.8	7.19	52.90	2.00	2
12/19/18	5.4	7.18	16.00	*0.00*	1
12/20/18	5.4	7.19	9.70	*0.00*	2
12/21/18	5.4	7.16	6.30	2.00	0.5
12/22/18	5.5	7.16	9.80	*0.00*	1
12/23/18	5.5	7.15	16.00	*0.00*	0.5
12/24/18	5.4	7.18	8.40	*0.00*	0.5
12/25/18	5.4	7.11	5.20	1.00	0.5
12/26/18	5.1	7.11	6.30	*0.00*	0.5
12/27/18	5.1	7.13	7.50	*0.00*	2
12/28/18	5.0	7.13	9.60	1.00	0.5
12/29/18	5.1	7.11	12.20	*0.00*	2
12/30/18	5.0	7.11	7.30	*0.00*	2
12/31/18	5.0	7.11	6.30	*0.00*	2
Average	7.13	7.08	2693.58	0.40	3.47
Median	7.60	7.08	14.60	0.00	0.50
Minimum	1.06	6.57	0.00	0.00	0.00
Maximum	14.81	7.43	120000	6.00	50.00

Notes:
Detection limit of 1 CFU/100 mL for Fecal Coliform.
Total Coliform detection limit = 1 MPN/100 mL.
E. coli detection limit varied from 1 to 2 MPN/100 mL based on dilution.

Quabbin Laboratory Records, 2018
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Depth (m)	Dissoled Oxygen (% Saturation)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	104.0	113.5	107.2	107.1	107.2	101.6	102.4	96.7	95.9
1	105.0	113.8	107.2	107.1	107.3	101.7	102.4	96.7	95.9
2	105.0	113.1	107.3	107.2	107.5	102.0	102.4	96.7	95.9
3	106.0	113.2	107.3	107.3	107.6	101.8	102.2	96.8	95.9
4	106.0	113.5	108.7	107.4	107.6	101.8	102.2	96.8	95.9
5	106.0	113.5	109.6	107.5	107.8	101.7	101.9	96.6	95.9
6	106.0	113.4	111.9	107.4	108.0	101.4	101.9	96.4	95.8
7	106.0	113.0	114.0	107.2	108.0	101.3	101.8	96.3	95.8
8	106.0	112.0	114.5	114.5	107.8	101.3	101.6	96.2	95.8
9	106.0	112.0	115.6	113.1	108.0	101.4	101.3	96.1	95.7
10	106.0	112.6	116.4	114.7	110.7	101.4	101.0	96.1	95.8
11	106.0	112.2	116.4	121.2	113.4	101.3	100.5	95.9	95.8
12	105.0	111.6	115.8	119.7	118.0	104.3	100.2	95.8	95.8
13	105.0	110.9	115.9	119.3	123.2	121.2	101.8	95.8	95.8
14	105.0	110.3	115.9	119.2	124.8	118.7	104.2	95.9	95.8
15	105.0	109.2	114.9	119.2	123.3	118.8	105.6	95.8	95.7
16	105.0	109.0	114.6	118.0	121.4	115.1	104.3	95.7	95.8
17	105.0	108.9	114.2	117.3	118.5	112.8	103.7	93.1	95.8
18	105.0	108.8	113.9	116.5	115.4	109.8	102.4	89.9	95.8
19	105.0	108.6	113.8	115.2	114.4	103.0	100.9	88.7	95.8
20	105.0	108.3	113.7	114.5	113.0	101.9	99.0	87.9	95.8
21	105.0	107.9	113.6	113.9	112.6	101.1	98.1	87.0	95.8
22	105.0	107.5	113.4	113.5	111.9	100.7	96.0	85.6	95.8
23	105.0	107.3	112.9	112.3	111.1	100.1	94.5	85.0	95.8
24	105.0	107.2	112.5	111.2	110.3	99.5	93.9	83.6	95.8
25	105.0	107.1	112.0	110.3	109.7	98.4	93.7	83.1	95.8
26	105.0	107.1	111.9	109.2	109.3	98.0	93.6	82.7	95.7
27	105.0	107.0	111.8	108.4	109.0	97.9	92.8	82.2	95.7
28	105.0	106.9	111.7	107.1	108.1	97.8	92.4	81.7	95.8
29	105.0	106.9	111.1	106.2	107.3	96.9	91.8	81.1	95.8
30	105.0	106.8	109.7	105.8	106.3	96.0	91.1	80.4	95.8
31	105.0	106.7	109.5	105.7	105.3	94.3	90.7	80.0	95.7
32	105.0	106.6	109.4	105.5	104.2	93.3	89.6	79.8	95.7
33	105.0	106.4	109.2	104.2	103.0	92.0	87.2	79.7	95.7
34	105.0	106.3	108.8	102.5	101.3	90.6	84.9	79.7	95.7
35	105.0	106.1	106.7	101.2	100.1	89.4	82.6	79.1	95.7
36	105.0	105.8	103.7	100.5	98.2	87.5	78.9	78.5	95.7
37	105.0	105.7	103.0	99.7	97.3	85.6	77.9	77.6	95.7
38	105.0				95.6	84.3	76.5	75.2	95.7
39	105.0				94.2		75.3	73.5	95.7
40	105.0						73.8		
41	105.0								

Depth (m)	pH								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	7.75	6.91	6.95	5.40	5.41	6.43	6.95	7.09	6.85
1	7.18	6.75	6.85	5.37	5.39	6.27	6.77	7.04	6.83
2	7.08	6.66	6.80	5.34	5.37	6.22	6.59	6.96	6.79
3	7.08	6.62	6.79	5.35	5.36	6.23	6.56	6.89	6.76
4	7.02	6.54	6.71	5.36	5.33	6.23	6.44	6.83	6.75
5	6.95	6.57	6.69	5.38	5.42	6.17	6.35	6.79	6.74
6	6.90	6.54	6.67	5.41	5.39	6.16	6.29	6.77	6.74
7	6.80	6.50	6.65	5.40	5.38	6.14	6.29	6.75	6.72
8	6.71	6.49	6.59	5.47	5.43	6.13	6.30	6.72	6.71
9	6.70	6.50	6.54	5.47	5.41	6.14	6.22	6.70	6.70
10	6.66	6.55	6.50	5.48	5.45	6.13	6.26	6.68	6.70
11	6.59	6.48	6.52	5.56	5.48	6.10	6.15	6.68	6.70
12	6.60	6.45	6.51	5.56	5.58	6.10	6.03	6.67	6.69
13	6.56	6.41	6.46	5.64	5.62	6.02	5.99	6.67	6.69
14	6.55	6.39	6.44	5.67	5.64	6.06	5.88	6.66	6.69
15	6.48	6.37	6.37	5.72	5.65	6.06	5.86	6.66	6.70
16	6.47	6.36	6.37	5.70	5.65	6.03	5.82	6.64	6.69
17	6.48	6.33	6.32	5.68	5.58	6.02	5.83	6.60	6.68
18		6.30	6.30	5.59	5.56	5.99	5.72	6.53	6.68
19	6.42	6.31	6.33	5.57	5.53	5.87	5.70	6.48	6.68
20	6.42	6.28	6.34	5.60	5.50	5.85	5.68	6.44	6.68
21	6.36	6.29	6.34	5.60	5.48	5.82	5.62	6.40	6.68
22	6.37	6.26	6.32	5.55	5.45	5.80	5.62	6.36	6.67
23	6.35	6.24	6.30	5.55	5.43	5.78	5.57	6.33	6.68
24	6.33	6.26	6.29	5.57	5.40	5.79	5.56	6.29	6.67
25	6.32	6.24	6.29	5.57	5.38	5.75	5.53	6.26	6.67
26	6.31	6.21	6.23	5.56	5.36	5.74	5.52	6.23	6.67
27	6.29	6.22	6.25	5.52	5.34	5.73	5.55	6.21	6.67
28	6.28	6.20	6.24	5.41	5.33	5.72	5.54	6.19	6.67
29	6.25	6.17	6.20	5.45	5.31	5.72	5.53	6.18	6.67
30	6.24	6.18	6.18	5.46	5.31	5.72	5.52	6.16	6.67
31	6.24	6.17	6.14	5.43	5.29	5.70	5.48	6.15	6.67
32	6.25	6.13	6.12	5.39	5.25	5.69	5.44	6.12	6.67
33		6.12	6.12	5.39	5.25	5.68	5.45	6.12	6.66
34	6.24	6.11	6.13	5.32	5.22	5.66	5.40	6.10	6.66
35	6.23	6.08	6.12	5.29	5.21	5.65	5.36	6.10	6.66
36	6.22	6.07	6.03	5.30	5.17	5.63	5.33	6.09	6.66
37	6.22	6.06	6.00	5.30	5.16	5.62	5.32	6.09	6.66
38	6.21				5.14	5.61	5.31	6.06	6.66
39	6.20				5.11		5.28	6.05	6.66
40	6.20						5.29		
41									

Depth (m)	Specific Conductance (µS/cm)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	49.3	48.9	49.5	50.4	49.5	49.5	45.2	48.4	47.9
1	49.3	48.6	49.4	50.4	49.5	49.6	45.1	48.3	47.9
2	49.3	48.8	49.5	50.4	49.6	49.6	45.2	48.4	47.8
3	49.3	48.6	49.3	50.4	49.4	49.6	45.2	48.4	47.8
4	49.3	48.7	49.3	50.4	49.5	49.6	45.2	48.4	47.9
5	49.3	48.7	49.2	50.4	49.5	49.5	45.2	48.4	47.7
6	49.3	48.7	49.1	50.4	49.5	49.6	45.3	48.4	47.8
7	49.3	48.8	49.2	50.2	49.6	49.6	45.1	48.5	47.8
8	49.3	48.8	49.1	49.6	49.5	49.5	45.0	48.4	47.7
9	49.3	48.8	49.1	49.7	49.9	49.6	45.2	48.3	47.9
10	49.3	49.0	48.9	49.6	49.7	49.5	45.2	48.4	47.8
11	49.3	49.0	49.0	49.5	49.5	49.6	45.0	48.2	47.9
12	49.3	48.9	48.8	49.3	49.3	49.5	45.2	48.4	47.9
13	49.3	49.0	48.8	49.2	49.0	49.8	45.9	48.5	47.8
14	49.2	49.0	48.9	49.0	49.0	49.6	46.0	48.4	47.9
15	49.4	49.1	48.8	49.1	48.9	49.5	46.1	48.4	47.9
16	49.2	49.1	48.8	49.0	48.9	49.4	46.0	48.4	47.8
17	49.3	49.1	48.8	49.0	49.0	49.2	46.0	48.7	47.8
18	49.3	49.1	48.9	49.1	49.0	49.4	45.8	49.0	47.9
19	49.3	49.1	48.9	49.1	49.0	49.4	45.7	49.0	47.8
20	49.4	49.1	48.9	49.1	48.9	49.4	45.9	49.2	47.7
21	49.4	49.1	49.0	49.1	49.0	49.4	45.8	49.2	47.9
22	49.3	49.1	48.9	49.1	48.9	49.4	45.9	49.3	47.8
23	49.4	49.1	48.9	49.2	49.0	49.5	45.7	49.3	47.8
24	49.3	49.1	48.9	49.2	49.0	49.4	45.7	49.4	47.8
25	49.3	49.2	48.9	49.1	49.0	49.5	45.8	49.3	47.8
26	49.3	49.2	48.9	49.2	49.0	49.4	45.9	49.4	47.8
27	49.2	49.1	48.8	49.2	49.1	49.5	45.8	49.4	47.8
28	49.3	49.2	48.9	49.2	49.1	49.5	45.9	49.5	47.9
29	49.3	49.2	49.0	49.3	49.2	49.4	45.9	49.5	47.8
30	49.3	49.2	49.0	49.2	49.1	49.6	46.0	49.4	47.7
31	49.3	49.2	49.0	49.2	49.2	49.6	45.9	49.4	47.9
32	49.4	49.2	49.0	49.4	49.2	49.6	45.9	49.5	47.8
33	49.4	49.1	49.0	49.4	49.3	49.6	45.9	49.6	47.9
34	49.3	49.2	49.1	49.4	49.3	49.7	46.0	49.5	47.9
35	49.4	49.1	49.0	49.4	49.4	49.8	46.1	49.5	47.9
36	49.3	49.2	49.2	49.5	49.4	49.9	46.2	49.5	47.9
37	49.3	49.2	49.1	49.5	49.4	49.9	46.2	49.6	47.9
38	49.3				49.4	49.9	46.3	49.6	47.9
39	49.2				49.4		46.3	49.7	47.8
40	49.3						46.1		
41									

Depth (m)	Water Temperature (°C)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	3.02	11.26	17.16	23.95	25.91	22.86	19.18	12.51	7.48
1	3.03	11.07	17.15	23.96	25.91	22.86	19.18	12.51	7.49
2	3.02	10.07	17.10	23.96	25.91	22.86	19.16	12.50	7.49
3	3.02	9.63	16.81	23.95	25.84	22.87	19.14	12.50	7.49
4	3.03	9.50	16.11	23.95	25.60	22.87	19.12	12.50	7.48
5	3.03	9.36	15.60	23.91	25.55	22.85	19.11	12.50	7.48
6	3.03	9.05	14.61	23.68	25.51	22.84	19.07	12.50	7.49
7	3.03	8.32	13.34	23.33	25.48	22.84	19.02	12.50	7.49
8	3.03	7.22	12.28	19.33	24.92	22.83	19.00	12.49	7.48
9	3.04	6.75	12.19	17.41	22.60	22.82	18.90	12.48	7.48
10	3.05	6.34	11.75	16.61	21.66	22.81	18.79	12.49	7.48
11	3.04	6.15	10.89	14.83	18.18	22.79	18.31	12.48	7.48
12	3.03	5.91	9.78	13.17	15.12	22.16	17.58	12.48	7.48
13	3.04	5.76	8.81	11.56	12.95	16.44	16.16	12.47	7.48
14	3.03	5.59	8.51	10.58	12.00	13.58	15.10	12.47	7.48
15	3.04	5.51	8.35	9.90	11.13	12.75	14.07	12.47	7.48
16	3.04	5.49	8.13	9.47	10.56	11.59	12.43	12.32	7.48
17	3.04	5.34	7.87	9.20	10.05	11.12	11.95	12.14	7.47
18	3.04	5.23	7.64	8.99	9.81	10.51	11.42	11.69	7.48
19	3.04	5.17	7.51	8.79	9.57	10.10	10.98	11.67	7.47
20	3.04	5.14	7.42	8.55	9.39	9.79	10.78	11.61	7.48
21	3.04	5.09	7.30	8.34	9.25	9.63	10.34	11.36	7.47
22	3.05	5.09	7.05	8.09	9.14	9.48	10.12	10.99	7.47
23	3.05	5.07	7.00	7.92	8.95	9.31	9.97	10.89	7.47
24	3.05	5.05	6.95	7.76	8.82	9.14	9.87	10.72	7.47
25	3.04	5.03	6.89	7.53	8.68	8.98	9.75	10.58	7.47
26	3.04	5.00	6.86	7.39	8.47	8.87	9.54	10.53	7.48
27	3.04	4.99	6.81	7.15	8.31	8.65	9.42	10.45	7.48
28	3.04	4.97	6.73	7.13	8.14	8.48	9.19	10.30	7.48
29	3.04	4.93	6.58	7.07	7.92	8.31	8.91	10.03	7.48
30	3.04	4.92	6.53	6.98	7.80	8.09	8.67	9.84	7.47
31	3.04	4.91	6.45	6.86	7.65	8.00	8.46	9.67	7.47
32	3.04	4.86	6.44	6.70	7.46	7.87	8.28	9.59	7.47
33	3.04	4.86	6.38	6.62	7.39	7.65	8.08	9.25	7.47
34	3.04	4.84	6.13	6.40	7.11	7.56	7.76	9.04	7.46
35	3.04	4.82	5.86	6.37	7.09	7.33	7.63	8.89	7.46
36	3.04	4.80	5.81	6.35	6.96	7.22	7.52	8.55	7.46
37	3.04	4.80	5.78	6.33	6.88	7.14	7.46	8.31	7.46
38	3.04				6.84	7.09	7.37	8.17	7.46
39	3.04				6.74		7.31	8.00	
40	3.04						7.30		
41	3.05								

NOTES

Quabbin Laboratory Records, 2018
202, Winsor Dam, Quabbin Reservoir

Site	Location	Date	Alkalinity (mg/L)	Ammonia (mg/L)	Calcium (µg/L)	E. coli (MPN/100 mL)	Fecal Coliform (CFU/100	Mean UV254 (ABU/cm)	Nitrate (mg/L)	Silica (µg/L)	TKN (mg/L)	TP (mg/L)	Turbidity (NTU)
202	Surface	4/9/2018	4.19			5	0.5						0.27
202	Surface	5/10/2018	3.86	0.0025		5	0.5	0.0238	0.0056	1770	0.126	0.0025	0.26
202	Surface	6/13/2018	3.93			5	0.5						0.32
202	Surface	7/13/2018	3.93	0.0025		5	0.5	0.0225	0.0025	1660	0.05	0.0025	0.24
202	Surface	8/16/2018	3.81			5	0.5						0.24
202	Surface	9/12/2018	3.7			5	0.5						0.3
202	Surface	10/10/2018	3.75	0.0025		5	0.5	0.0269	0.0025	1850	0.05	0.0025	0.32
202	Surface	11/1/2018	3.69			5	2						0.27
202	Surface	12/5/2018	3.78	0.0025		5	0.5	0.0277	0.0132	1940	0.05	0.0025	0.31
202	Mid	4/9/2018	4.4			5	0.5						0.26
202	Mid	5/10/2018	4.04	0.0025	1930	5	0.5	0.0228	0.0062	1620	0.162	0.0025	0.28
202	Mid	6/13/2018	3.8			5	0.5						0.26
202	Mid	7/13/2018	3.96	0.0025	2170	5	0.5	0.0245	0.0025	1670	0.05	0.0055	0.35
202	Mid	8/16/2018	4.09			5	0.5						0.28
202	Mid	9/12/2018	3.73			10	1						0.29
202	Mid	10/10/2018	3.67	0.0064	2050	5	0.5	0.0289	0.0025	1630	0.112	0.0025	0.32
202	Mid	11/1/2018	3.78			5	0.5						0.29
202	Mid	12/5/2018	3.65	0.0025		5	0.5	0.0272	0.0129	1980	0.05	0.0025	0.28
202	Deep	4/9/2018	4.44			5	0.5						0.27
202	Deep	5/10/2018	4.06	0.0025		5	0.5	0.0221	0.0069	1630	0.13	0.0025	0.26
202	Deep	6/13/2018	3.93			5	0.5						0.24
202	Deep	7/13/2018	3.84	0.0025		5	0.5	0.0236	0.0025	1740	0.05	0.0059	0.4
202	Deep	8/16/2018	3.9			5	1						0.25
202	Deep	9/12/2018	3.57			5	0.5						0.3
202	Deep	10/10/2018	3.73	0.0128		10	0.5	0.0227	0.0097	1850	0.05	0.0025	0.23
202	Deep	11/1/2018	3.9			5	0.5						0.2
202	Deep	12/5/2018	3.92	0.0025		5	2	0.0269	0.0125	1980	0.05	0.0025	0.27

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018
206, Shaft 12, Quabbin Reservoir

Depth (m)	Dissoled Oxygen (% Saturation)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	105.3	115	105.4	107.1	107.9	101.2	97.7	95.5	97.8
1	105.35	114.7	105.4	107.2	108	101.6	97.7	95.5	97.8
2	105.3	114.4	105.3	107.2	107.9	101.7	97.8	95.6	97.8
3	105.3	114.2	105.3	107	107.5	101.8	97.8	95.5	97.8
4	105.2	113.8	105.4	107.4	107.6	101.8	97.7	95.5	97.8
5	105.3	112.6	105.4	107.55	107.7	101.8	97.7	95.3	97.8
6	105.2	113.4	106.8	107.5	107.6	101.6	97.8		97.8
7	105.3	114	106.8	107.4	107.7	101.5	97.8	95.2	97.7
8	105.3	114.1	107.4	107.4	107.7	101.2	97.6	95.2	97.7
9	105.3	113.8	114.2	107.3	107.6	101	97.7	95.2	97.7
10	105.3	113.3	111.95	103.2	106.2	100.8	97.7	95.2	97.6
11	105.3	112.9	112.3	110.6	117.2	100.7	97.6	95.2	97.7
12	105.2	112.5	111.9	112.9	122.1	110.1	97.7	95.1	97.7
13	105.2	111.3	111.5	112.8	121.4	111.9	97.7	95.2	97.7
14	105.2	110.9	110.5	112.8	122.7	113.7	97.6	95.1	97.6
15	105.2	110.7	109.7	112.5	122.8	114.2	97.6	95	97.6
16	105.1	110.4	109.6	112	122.3	114.3	97.6	95	97.6
17	105.2	110.1	109.15	111.9	121.3	114	97.3	95	97.6
18	105.15	109.9	108.75	111.6	121.1	113.8	90.2	95	97.6
19	105.2	109.6	108.4	111.1	118.5	112.7	87.4	95	97.5
20	105.1	109.25	108	109.7	116.7	107.8	86.4	95	97.5
21	105.1	109.1	107.7	109	114.4	105.2	84.3	95	97.5
22	105.1	108.8	107.4	108.5	112.5	102.9	82.9	95.05	97.5
23	105.1	108.4	107.2	108	109.2	97.7	81.3	95.1	97.5
24	105.1	107.8	106.7	107.8	105	94.9	80.1	95	97.5
25	105.1	107.7	106.6	107.3	101.3	91.3	79	91.5	97.4
26	105.1	107.5	105.6	106.3	98.5	87.8	78.1	86.3	97.4
27	105	107.4	105.4	105.5	97.1	86.7	75.7	76.9	97.4
28									97.5

Depth (m)	pH								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	7.04	6.46	6.49	5.15	5.34	6.3	6.96	6.62	6.73
1	6.96	6.35	6.46	5.19	5.4	6.28	6.87	6.61	6.72
2	6.88	6.36	6.46	5.24	5.44	6.28	6.88	6.58	6.7
3	6.81	6.41	6.43	5.29	5.51	6.22	6.87	6.57	6.7
4	6.81	6.37	6.41	5.32	5.52	6.17	6.87	6.55	6.69
5	6.77	6.35	6.38	5.365	5.53	6.29	6.86	6.55	6.68
6	6.71	6.35	6.365	5.4	5.53	6.21	6.84		6.68
7	6.69	6.36	6.34	5.48	5.55	6.17	6.83	6.545	6.67
8	6.67	6.34	6.31	5.44	5.58	6.25	6.82	6.54	6.67
9	6.59	6.29	6.32	5.44	5.56	6.185	6.81	6.53	6.68
10	6.59	6.31	6.305	5.62	5.55	6.13	6.81	6.54	6.69
11	6.58	6.29	6.29	5.66	5.77	6.13	6.81	6.54	6.68
12	6.52	6.24	6.26	5.68	5.78	6.2	6.81	6.54	6.68
13	6.54	6.25	6.25	5.64	5.75	6.1	6.8	6.54	6.69
14	6.46	6.28	6.2	5.63	5.78	6.16	6.8	6.54	6.69
15	6.47	6.24	6.17	5.65	5.79	6.08	6.81	6.55	6.69
16	6.46	6.23	6.13	5.62	5.79	6.055	6.8	6.56	6.7
17	6.45	6.21	6.115	5.57	5.79	6.09	6.79	6.55	6.7
18	6.42	6.17	6.09	5.55	5.77	6.01	6.64	6.55	6.69
19	6.42	6.16	6.08	5.52	5.75	5.99	6.56	6.555	6.7
20	6.41	6.17	6.07	5.5	5.71	5.98	6.49	6.56	6.7
21	6.37	6.15	6.05	5.51	5.66	5.91	6.42	6.56	6.7
22	6.36	6.15	6.03	5.5	5.61	5.86	6.36	6.56	6.71
23	6.37	6.14	6.01	5.45	5.55	5.78	6.3	6.56	6.7
24	6.32	6.12	5.99	5.45	5.52	5.73	6.265	6.56	6.7
25	6.31	6.11	5.98	5.42	5.46	5.68	6.2	6.52	6.71
26	6.29	6.1	5.95	5.39	5.42	5.66	6.17	6.43	6.71
27	6.27	6.08	5.93	5.4	5.4	5.63	6.14	6.26	6.71
28									6.71

Depth (m)	Specific Conductance (µS/cm)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	49.5	48.9	49.6	50.8	49.5	50	48.6	48.9	48.1
1	49.55	49.1	49.6	50.8	49.6	50	48.7	48.9	48.1
2	49.5	49.1	49.6	50.8	49.5	50	48.6	48.9	48.1
3	49.5	49.1	49.7	50.7	49.6	50.1	48.6	48.9	48
4	49.6	49.2	49.7	50.7	49.6	50	48.55	48.9	48.1
5	49.5	48.9	49.6	50.65	49.6	50	48.6	49	48
6	49.5	48.9	49.65	50.6	49.5	50.1	48.7		48.1
7	49.4	48.8	49.6	50.6	49.6	50	48.7	48.9	48.1
8	49.5	49	49.5	50.7	49.6	50.1	48.6	49	48.1
9	49.55	48.9	49.1	50.3	49.5	50.1	48.7	49	48
10	49.5	49	49.05	50	49.6	50	48.7	49	48.1
11	49.5	49	49	49.8	49.6	50.1	48.5	49	48
12	49.5	49.1	49	49.5	49.6	50.2	48.5	49	48
13	49.6	49	49	49.6	49.5	50	48.7	49	48.1
14	49.5	49	49	49.4	49.3	49.8	48.6	49	48.1
15	49.5	49.1	49	49.4	49.2	49.7	48.7	49	48
16	49.4	49.2	49	49.4	49.2	49.6	48.7	49	48.1
17	49.5	49.2	49	49.4	49.2	49.6	48.7	48.9	48
18	49.55	49.2	49	49.4	49.1	49.5	49.6	48.9	48.1
19	49.6	49.2	49	49.4	49.1	49.6	49.6	49	48
20	49.6	49.2	49	49.3	49.1	49.7	49.6	49	48.1
21	49.5	49.2	49	49.4	49.2	49.6	49.6	49	48.1
22	49.5	49.1	49.1	49.4	49.2	49.6	49.7	49	48
23	49.4	49.3	49.1	49.3	49.4	49.7	49.7	49	48
24	49.6	49.3	49.1	49.4	49.6	49.7	49.65	49.1	48
25	49.4	49.3	49.1	49.5	49.6	50	49.6	49.3	48
26	49.5	49.2	49.1	49.5	49.4	49.9	49.6	49.8	48
27	49.5	49.3	49.1	49.4	49.2	50	50.4	49.9	48
28									48

Depth (m)	Water Temperature (°C)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	3.71	12.81	18.55	24	25.87	22.89	16.85	12.1	6.38
1	3.715	12.5	18.55	23.94	25.85	22.91	16.87	12.1	6.37
2	3.7	12.3	18.54	23.85	25.74	22.91	16.87	12.1	6.38
3	3.72	12	18.53	23.76	25.68	22.9	16.87	12.1	6.38
4	3.73	11.26	18.54	23.68	25.67	22.89	16.87	12.09	6.37
5	3.69	9.96	17.99	23.66	25.66	22.86	16.86	12.09	6.37
6	3.69	9.28	17.855	23.65	25.63	22.75	16.86		6.37
7	3.69	8.93	17.23	23.64	25.59	22.7	16.86	12.09	6.37
8	3.69	8.67	16.56	23.56	25.56	22.69	16.86	12.09	6.37
9	3.69	8.3	10.96	22.51	25.45	22.67	16.86	12.08	6.37
10	3.69	7.8	9.085	12.78	24.65	22.65	16.85	12.08	6.37
11	3.7	7.53	8.52	11.26	16.93	22.56	16.85	12.08	6.36
12	3.7	7.11	8.28	10.86	15.78	20.42	16.85	12.08	6.37
13	3.72	6.85	8.05	10.19	13.77	15.25	16.85	12.08	6.37
14	3.71	6.8	7.88	10.02	12.54	13.48	16.85	12.08	6.36
15	3.71	6.69	7.82	9.57	11.61	12.48	16.85	12.08	6.34
16	3.71	6.54	7.69	9.51	10.87	11.575	16.74	12.07	6.35
17	3.71	6.48	7.665	9.33	10.51	11.04	16.7	12.08	6.37
18	3.705	6.36	7.525	9.1	10.3	10.79	12.82	12.08	6.36
19	3.71	6.35	7.47	8.95	10.14	10.44	11.61	12.07	6.39
20	3.71	6.335	7.39	8.85	9.89	10.29	11.26	12.07	6.38
21	3.7	6.29	7.36	8.69	9.66	10.2	10.73	12.07	6.37
22	3.69	6.21	7.36	8.51	9.48	9.94	10.56	12.07	6.37
23	3.71	6.1	7.27	8.44	9.19	9.5	10.36	12.07	6.37
24	3.695	6.02	7.24	8.35	8.96	9.17	10.14	11.97	6.38
25	3.72	6.01	7.21	8.17	8.81	8.99	9.94	11.73	6.39
26	3.69	6.01	7.13	8.06	8.71	8.96	9.79	10.78	6.39
27	3.69	5.9	7.08	7.87	8.58	8.94	9.6	10.51	6.38
28									6.35

NOTES

Quabbin Laboratory Records, 2018
206, Shaft 12, Quabbin Reservoir

Site	Location	Date	Alkalinity (mg/L)	Ammonia (mg/L)	Calcium (µg/L)	E. coli (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	Mean UV254 (ABU/cm)	Nitrate (mg/L)	Silica (µg/L)	TKN (mg/L)	TP (mg/L)	Turbidity (NTU)
206	Surface	4/9/2018	4.27			5	0.5						0.31
206	Surface	5/10/2018	4.11	0.0025		5	0.5	0.0246	0.0025	1550	0.133	0.0025	0.26
206	Surface	6/13/2018	3.99			5	0.5						0.3
206	Surface	7/13/2018	3.93	0.0025		5	0.5	0.0232	0.0025	1610	0.05	0.0025	0.24
206	Surface	8/16/2018	4.17			5	0.5						0.26
206	Surface	9/12/2018	3.91			5	0.5						0.3
206	Surface	10/17/2018	3.79	0.0025		5	0.5	0.0266	0.0071	1510	0.146	0.0025	0.34
206	Surface	11/1/2018	3.86			5	0.5						0.38
206	Surface	12/5/2018	4.21	0.0025		5	0.5	0.0301	0.0153	1910	0.05	0.0025	0.44
206	Mid	4/9/2018	4.33			5	0.5						0.31
206	Mid	5/10/2018	4.27	0.0025	2080	5	0.5	0.0243	0.0025	1600	0.122	0.0025	0.31
206	Mid	6/13/2018	3.75			5	0.5						0.26
206	Mid	7/13/2018	4.05	0.0025	2160	5	0.5	0.0257	0.0025	1550	0.05	0.0069	0.31
206	Mid	8/16/2018	3.95			5	0.5						0.29
206	Mid	9/12/2018	3.91			5	0.5						0.37
206	Mid	10/17/2018	3.74	0.0025	1930	5	0.5	0.0265	0.0114	1530	0.124	0.0025	0.36
206	Mid	11/1/2018	4.31			5	0.5						0.46
206	Mid	12/5/2018	3.85	0.0025		5	0.5	0.03	0.0151	1910	0.128	0.0025	0.4
206	Deep	4/9/2018	4.13			5	0.5						0.3
206	Deep	5/10/2018	4.11	0.0025		5	0.5	0.0242	0.0025	1530	0.114	0.0025	0.3
206	Deep	6/13/2018	3.76			5	0.5						0.32
206	Deep	7/13/2018	4.06	0.0025		5	0.5	0.0241	0.0025	1610	0.05	0.0056	0.41
206	Deep	8/16/2018	5.51			5	0.5						0.33
206	Deep	9/12/2018	3.85			5	0.5						0.28
206	Deep	10/17/2018	3.79	0.0096		5	1	0.0258	0.0182	1580	0.183	0.0025	0.34
206	Deep	11/1/2018	4.27			5	0.5						0.36
206	Deep	12/5/2018	3.96	0.0025		5	0.5	0.0302	0.0153	1890	0.124	0.0025	0.28

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

Quabbin Laboratory Records, 2018

DH, Den Hill, Quabbin Reservoir

Depth (m)	Dissoled Oxygen (% Saturation)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	103.9	112	104.8	107.5	105.8	91.7	90.6	93.6	96.9
1	103.8	112.1	104.8	107.5	105.9	91.6	90.6	92.6	96.9
2	103.9	111.3	104.8	107.5	105.8	91.4	90.4	91.8	96.8
3	103.9	111.4	104.8	107.3	105.6	91.4	90.2	91.5	96.7
4	103.8	112.6	104.8	107.1	105.3	90.9	90.1	91.4	96.45
5	103.6	111.5	107.8	107	104.8	88.7	89.9	91.2	96.4
6	103.5	111.2	107.8	106.2	97.1	88.4	89.6	91.1	96.4
7	103.4	108.9	111.8	106	90.7	87.6	89.4	91.1	96.3
8	103.4	107.7	111.8	108.5	87	85.5	89.1	91.2	96.2
9	103.3	106.5	112	110	85.9	83.9	89.1	91.2	96.1
10	103.2	105.9	109.7	109.9	85	84.8	89.1	91	96
11	103.2	105.4		110.6	93.6	78.4	89.1	91.1	96
12	103.2	104.1	104.6	110.1	100.7	71.1	89	91.2	96.1
13	103.2	103.2	100.9	105.6	104.9	72.3	86.5	91.2	96.1
14	103.2	101.9	99.8	100.5	95	72.9	82.8	91.1	96.2
15	103.2	101.3	98.55	92.5	84.8	64.2	79.45	91.2	96.2
16	103.2	100.4	98	85.6	79.3	57.5	55.75	91.4	96.1
17	103.2	99.8				51.9	22.15	90.7	96.1
18		99.6				48.3			96.1
19						43.15			
20						40.1			

Depth (m)	pH								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	6.38	6.41	6.46	5.21	5.62	6.17	7.16	6.43	6.67
1	6.35	6.39	6.39	5.25	5.61	6.21	7.04	6.43	6.665
2	6.33	6.43	6.38	5.275	5.58	6.09	6.95	6.42	6.64
3	6.28	6.45	6.35	5.31	5.58	6.08	6.86	6.4	6.63
4	6.23	6.46	6.33	5.33	5.51	5.96	6.79	6.39	6.615
5	6.25	6.37	6.29	5.33	5.51	5.95	6.72	6.4	6.6
6	6.23	6.43	6.27	5.34	5.36	5.9	6.66	6.41	6.59
7	6.2	6.36	6.29	5.45	5.22	5.79	6.62	6.4	6.59
8	6.2	6.28	6.28	5.44	5.08	5.75	6.6	6.41	6.59
9	6.2	6.29	6.28	5.44	4.94	5.77	6.57	6.41	6.59
10	6.21	6.24	6.2	5.52	4.92	5.67	6.55	6.42	6.6
11	6.21	6.25		5.58	5.08	5.62	6.54	6.42	6.6
12	6.16	6.2	6.1	5.63	5.27	5.46	6.53	6.45	6.59
13	6.15	6.12	6.01	5.58	5.61	5.44	6.5	6.45	6.59
14	6.19	6.07	5.98	5.44	5.67	5.39	6.44	6.45	6.59
15	6.13	6.07	5.925	5.34	5.54	5.33	6.37	6.45	6.59
16	6.09	6.06	5.87	5.26	5.38	5.34	6.115	6.47	6.59
17	6.11	5.99				5.3	5.9	6.47	6.59
18	6.11	5.96				5.28			6.6
19	6.11					5.2			
20	6.06					5.24			

Depth (m)	Specific Conductance (µS/cm)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	55	55.5	52.85	53.5	53.1	52.5	50.6	50.9	48.9
1	55	55.5	52.9	53.5	53.1	52.5	50.6	50.8	48.8
2	54.9	55.5	52.7	53.1	53.1	52.6	50.7	50.8	48.9
3	55	54.2	52.7	53.2	53.2	52.5	50.6	50.9	48.8
4	54.9	54.2	52.6	53.3	53.1	52.5	50.3	50.9	48.8
5	54.65	54.3	52.2	53.4	53.1	52.7	50.8	50.9	48.9
6	55	54.3	52.2	52.5	55.7	52.75	50.5	50.9	48.8
7	55	54.3	51.6	51.8	56.8	52.7	50.7	50.8	48.9
8	55	53.9	51.6	51.8	57.1	53	50.7	50.8	48.9
9	55	53.8	51.8	52.2	57.2	52.8	50.7	50.9	48.9
10	55	54.1	51.9	51.9	55.4	52.3	50.6	50.8	48.9
11	55	54.3		51.9	52.1	53.6	50.7	50.7	48.9
12	55	54.1	52.75	52	51.9	53.4	50.6	50.8	48.8
13	55	53.9	53	52.5	52.2	52.8	50.8	50.8	48.9
14	55	54.2	52.9	53.4	52.9	52.9	51.1	50.8	48.9
15	55	54.3	52.9	53.6	53.6	55.1	51.2	50.9	48.8
16	54.9	54.3	53.1	53.7	53.6	55.5	51.8	50.9	48.7
17	55.7					55.1	55.4	51	48.9
18		54.4				55.9			48.9
19		54.4				56.65			
20						58.8			

Depth (m)	Water Temperature (°C)								
	04/09/18	05/10/18	06/13/18	07/13/18	08/16/18	09/12/18	10/10/18	11/01/18	12/05/18
0.5	55	55.5	52.85	53.5	53.1	52.5	50.6	50.9	48.9
1	55	55.5	52.9	53.5	53.1	52.5	50.6	50.8	48.8
2	54.9	55.5	52.7	53.1	53.1	52.6	50.7	50.8	48.9
3	55	54.2	52.7	53.2	53.2	52.5	50.6	50.9	48.8
4	54.9	54.2	52.6	53.3	53.1	52.5	50.3	50.9	48.8
5	54.65	54.3	52.2	53.4	53.1	52.7	50.8	50.9	48.9
6	55	54.3	52.2	52.5	55.7	52.75	50.5	50.9	48.8
7	55	54.3	51.6	51.8	56.8	52.7	50.7	50.8	48.9
8	55	53.9	51.6	51.8	57.1	53	50.7	50.8	48.9
9	55	53.8	51.8	52.2	57.2	52.8	50.7	50.9	48.9
10	55	54.1	51.9	51.9	55.4	52.3	50.6	50.8	48.9
11	55	54.3		51.9	52.1	53.6	50.7	50.7	48.9
12	55	54.1	52.75	52	51.9	53.4	50.6	50.8	48.8
13	55	53.9	53	52.5	52.2	52.8	50.8	50.8	48.9
14	55	54.2	52.9	53.4	52.9	52.9	51.1	50.8	48.9
15	55	54.3	52.9	53.6	53.6	55.1	51.2	50.9	48.8
16	54.9	54.3	53.1	53.7	53.6	55.5	51.8	50.9	48.7
17	55.7					55.1	55.4	51	48.9
18		54.4				55.9			48.9
19		54.4				56.65			
20						58.8			

NOTES

Quabbin Laboratory Records, 2018
DH, Den Hill, Quabbin Reservoir

Site	Location	Date	Alkalinity (mg/L)	Ammonia (mg/L)	Calcium (µg/L)	E. coli (MPN/100 mL)	Fecal Coliform (CFU/100 mL)	Mean UV254 (ABU/cm)	Nitrate (mg/L)	Silica (µg/L)	TKN (mg/L)	TP (mg/L)	Turbidity (NTU)
DH	Surface	4/9/2018	3.84			5	0.5						0.4
DH	Surface	5/10/2018	3.82	0.0025		5	0.5	0.0679	0.0068	2630	0.201	0.012	0.37
DH	Surface	6/13/2018	3.99			5	1						0.45
DH	Surface	7/13/2018	3.99	0.0025		5	0.5	0.0365	0.0025	1480	0.114	0.0025	0.36
DH	Surface	8/16/2018	5.1			10	0.5						0.52
DH	Surface	9/12/2018	3.97			5	0.5						0.43
DH	Surface	10/17/2018	4.32	0.0186		5	3	0.1201	0.0261	2860	0.202	0.0067	0.44
DH	Surface	11/1/2018	4.42			5	0.5						0.45
DH	Surface	12/5/2018	3.78	0.0054		5	0.5	0.1195	0.0368	3750	0.05	0.0025	0.54
DH	Mid	4/9/2018	3.87			5	0.5						0.41
DH	Mid	5/10/2018	3.73	0.0025	2110	5	0.5	0.0658	0.0196	3000	0.154	0.0025	0.41
DH	Mid	6/13/2018	3.9			5	0.5						0.46
DH	Mid	7/13/2018	4.01	0.0025	2140	5	0.5	0.0369	0.0025	1620	0.05	0.0025	0.4
DH	Mid	8/16/2018	4.07			5	6						0.51
DH	Mid	9/12/2018	4.26			5	0.5						0.47
DH	Mid	10/17/2018	4.21	0.0206	2080	5	1	0.1161	0.0336	3020	0.449	0.0065	0.58
DH	Mid	11/1/2018	4.28			5	0.5						0.54
DH	Mid	12/5/2018	3.79	0.0025		5	1	0.1252	0.0387	3840	0.182	0.0054	0.43
DH	Deep	4/9/2018	3.95			5	0.5						0.42
DH	Deep	5/10/2018	3.78	0.0025		5	0.5	0.0647	0.0251	3060	0.141	0.0025	0.33
DH	Deep	6/13/2018	3.85			5	0.5						0.53
DH	Deep	7/13/2018	3.9	0.0025		5	0.5	0.0483	0.0025	2510	0.101	0.0063	0.47
DH	Deep	8/16/2018	4.21			5	1						0.65
DH	Deep	9/12/2018	4.52			5	0.5						0.72
DH	Deep	10/17/2018	4.19	0.0197		20	4	0.1166	0.0337	2960	0.205	0.0071	0.5
DH	Deep	11/1/2018	4.5			5	0.5						0.48
DH	Deep	12/5/2018	3.8	0.0025		10	2	0.1285	0.0388	3970	0.169	0.0077	0.44

NOTES
Fecal coliform MDL = varies, 1-10 CFU/100mL; E. coli and total coliform MDL = 10 MPN/100mL. "TNTC" indicates Too Numerous To Count.
Total phosphorus MDL = 0.005 mg/L.
Nitrate MDL = 0.005 mg/L.
Total Kjeldahl nitrogen MDL = 0.100 mg/L.
Calcium MDL = 20 µg/L (0.020 mg/L).
Ammonia MDL = 0.005 mg/L.

APPENDIX C

Monitoring Reports, Inspection Reports, and Field Reports

2018 Phytoplankton Monitoring at Quabbin Reservoir

2018 Quabbin Boat Inspection Programs

2018 Quabbin Self Certification and Boat Ramp Monitor Program

2018 Quabbin and Ware River Aquatic Macrophyte Assessments

Field Report for Sample Site 212, 05/10/18

Field Report for Sample Site Gates Brook, 03/29/18

2018 Monitoring Report for Forestry Lot 3138

2018 Monitoring Report for Forestry Lot 4393

2018 Quabbin Reservoir Phytoplankton Monitoring

Paula Packard

December 20, 2018

Monitoring efforts focused on two locations (Table 1) with two grab samples collected at each as follows: in the epilimnion at a depth of three or four meters and near the interface between the epilimnion and metalimnion at a depth generally around eight to ten meters depending on dissolved oxygen, chlorophyll a and phycocyanin readings. Field and laboratory procedures for collecting and concentrating plankton are identical to those conducted at Wachusett Reservoir (see 2014 Wachusett annual report for details), however the method used for microscopic analysis and enumeration of phytoplankton at the Wachusett Reservoir has been changed slightly. The Quabbin Reservoir methods have remained consistent with those used in previous years.

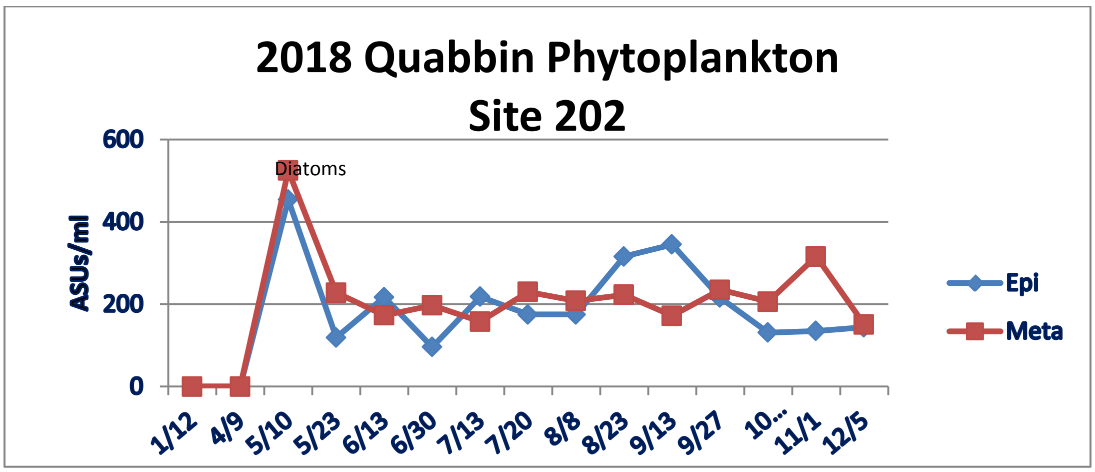
Plankton samples were collected each month excluding January, February and March due to ice cover. Similar trends in plankton numbers and species composition have been observed annually with only slight shifts in timing.

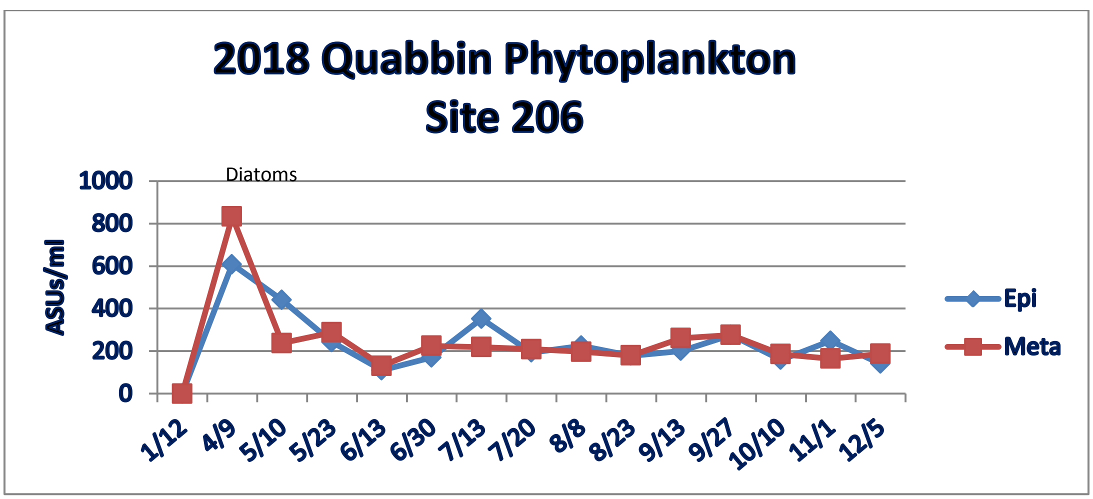
TABLE 1 - QUABBIN PLANKTON MONITORING PROGRAM		
Sampling Stations	**Sampling Frequency**	**Field Tasks**
1) CVA/#202 (Winsor Dam) 2) Shaft 12/#206 (Mt. Pomeroy)	Twice per month from May - Sept. (weather permitting); then decreasing to Once per month from Oct. – April (weather and ice conditions permitting)	1) Multiprobe profile 2) Collection of two grab samples: epilimnion and near epi-metalimnion interface 3) Secchi transparency

Results show that the Quabbin Reservoir supports a phytoplankton community typical of many oligotrophic systems located in the temperate zone. The most common organisms observed consisted of the diatoms *Asterionella*, *Cyclotella,* and *Urosolenia,* the chlorophytes (green alga) *Gloeocystis* and *Sphaerocystis*, and the cyanophytes (blue-green alga) *Microcystis, Rhabdoderma* and *Aphanocapsa*. Consistent with its status as an "ultra-oligotrophic" system (Wetzel, 1983), Quabbin phytoplankton densities are still considered low, with averages for 2018 being very similar at both sites. However, numbers at both locations were lower than those found during previous year of sampling. Site #202 averaged 221 ASUs/ml, down significantly from 421 ASUs/ml in 2017. Sampling site #206 averaged 255 ASUs/ml, down from 466 ASUs/ml in 2017. See graphs below.

Diatoms dominated the phytoplankton community until the end of August which is later than usual when their numbers began to decline and samples became more diverse. The highest diatom numbers (760ASUs/ml) of the year were observed in April, earlier than is typical, at sampling site #206. This is less than the number observed last year with the highest total phytoplankton numbers (833 ASUs/ml) observed during this month as well, at sampling site #206. Diatom numbers declined steadily from then on, reaching their lowest point in August. Interestingly diatom densities remained relatively steady throughout the remainder of the year. In August, cyanophyte densities began to increase, continuing the same trend as observed in the past, where a proliferation of *Aphanocapsa, Rhabdoderma* and *Microcystis*, occurred at approximately the same time period. In 2018, as seen in previous years, this increase in cyanophytes was very brief. Cyanophyte densities, especially *Rhabdoderma,* were observed to peak at the end of September at 184 ASU/ml in the epilimnion sample collected at sampling site #206. Subsequent sampling showed a decline of the cyanophytes and a more even representation of all taxa.

There were no taste and odor complaints during the year and similar to last year, no exceptionally low numbers of plankton were documented. Plans for plankton monitoring in 2018 call for a continuation of the program outlined above.





<u>Reference Cited</u>

Wetzel, R.G. 1983. <u>Limnology</u>, Second Edition. CBS College Publishing.

2018 Quabbin Boat Inspection Programs

January 10, 2019

Paula Packard

The Quabbin Boat Decontamination program was initiated in 2009, in response to a rise in the number of aquatic invasive species (AIS) nationwide as well as to the introduction of zebra mussels into a water body in Western Massachusetts. This program was designed to minimize the risk of transporting AIS into the reservoir while still allowing for recreational use for fishing. Many anglers prefer to use their own privately owned boats over the DCR boats for fishing at Quabbin, and while many boats are used exclusively at Quabbin, some anglers prefer to fish different water bodies as well. The Warm Weather Decontamination (WWD) program and the Cold Weather Quarantine (CWQ) processes are in place to reduce the risks associated with boats being used in multiple locations, some of which may be infested with aquatic invasive species.

In 2018, 183 boats were inspected and decontaminated through the WWD process. This is down slightly from last year. Four boats had carpeted bunks. Boaters removed the carpet while at House of Wax where the Warm Weather Decontamination is held, and then passed upon reinspection. One boat was failed because the horsepower of the motor exceeded half the horse power rating for the boat.

One hundred and six boats were inspected and sealed through the Cold Weather Quarantine Program in anticipation of the 2019 fishing season. This number was slightly lower than last year when 120 boats went through CWQ. Many fishermen who went through CWQ in 2018 have used this process each year since its inception. This has enabled them to fish at Quabbin for part of the season as well as other water bodies later on, while providing them with an easy means of getting their boats tagged at no cost.

CWQ was held on October 27th and November 8th in New Salem, and in Belchertown on November 10th, November 15th and December 8th. . Dates were moved up again slightly in 2018 to avoid dealing with potential weather events and to appease some boaters who continue to request earlier dates. A snow date was set but not needed.

Interestingly, each year we see the return of numerous anglers who have resisted our program. Again in 2018, some of the boaters who utilized the WWD program and CWQ did so for the first time since the boat access restrictions were implemented. Approximately 78 boaters used the warm weather decontamination for the first time. Thirty boaters, who had never participated in CWQ, took advantage of the program this year. Participation in the WWD program was down slightly from last year but participation in the CWQ program was up from 2017.

Quabbin Fishing areas had a total of 73,503 visits since the start of our boat decontamination program with 8,076 during the 2018 boating season. This is an increase when compared to the number of private boats launched in 2016 and 2017.

In past years, few, if any, boaters had heard about spiny water flea and the risks associated with this invasive zooplankton. Presently, some boaters still believe our boat decontamination program is due mainly to the threat of zebra mussels. Beginning in 2012, we began to see an interesting change take place regarding how our program was perceived. Most boaters utilizing the decontamination program understand and support our efforts to minimize the risks associated with transport of AIS. Our programs continue to gain acceptance and have now gone from being an annoyance to something we are praised for. Other states have implemented inspection and decontamination programs and are also actively educating the public through outreach. This has indirectly aided us with our efforts to inform people about AIS and has improved public perception of our programs.

Samples of biological substances collected off of boats inspected during both the Boat Decontamination and Cold Weather Quarantine Programs were identified whenever possible. During the WWD, biologicals were found on 25 boats. These samples were determined to be desiccated portions of terrestrial plants, mud, pine needles, fungi and insects.

Aquatic plants were found on 5 boats. Most plants documented during the inspection process were native species. *Eleocharis sp.* (spike rush), *Potamogeton sp*. (water weed) and *Fontinalis* (water moss) were found. One boat was contaminated with *Myriophyllum heterophyllum* (variable leaf milfoil). Another boat had small, desiccated, plant fragments attached to it that were difficult to identify but could have possibly been *Cabomba* (fanwort).

Marine species or severely degraded freshwater plants pose little to no risk of being successfully introduced to Quabbin. However, seeds, microscopic organisms and small plant fragments that may go undetected continue to pose significant risks. We must continue to pay close attention to the temperature of the water used during boat washing and require sufficient water pressure to effectively wash all areas of the boat's hull, rollers, bunks and difficult-to-reach places of the trailer. Contact time of the water should also be noted and lengthened especially if the boat was recently launched at a site known to have aquatic invasive species of concern. Education, outreach and the boat decontamination/quarantine programs help to ensure that the Quabbin Reservoir remains free of new AIS infestations.

2018 Quabbin Self-Certification/Boat Ramp Monitor Program

P. Packard

January 9, 2019

In 2010, DCR implemented a successful Boat Ramp Monitor Program utilizing two full-time seasonal positions to educate boaters and to inspect watercraft at ponds with boat access. Monitors concentrated on Comet Pond in Hubbardston and Long Pond in Rutland but also spent some time at White Hall, Demond, Brigham and Moosehorn Ponds, as well as at Lake Mattawa and Queen Lake.

Beginning in 2011, DCR did not have the funding to hire full-time Boat Ramp Monitors so the process was streamlined to encourage compliance with our requests with a minimal amount of effort and staff. Every opportunity to speak directly to boaters was taken but because our presence was reduced, a self-certification program was begun. Forms were printed and distributed to boaters. They were asked to record where they launched their boat last, when, how they cleaned it and what, if any, aquatic invasive species (AIS) were in the place they last boated.

Self-certification forms continue to be prominently displayed at both Comet and Long Ponds in a box on the kiosk near each boat ramp, along with signage directing boaters to self-certify their watercraft before launching. Parking areas at both ponds were periodically checked throughout the boating season to see if each vehicle had a self-certification form on the windshield. A letter explaining our program with directions for filling out a Self-Certification Form, as well as a blank form, was placed on any vehicle that did not display a completed form.

Since actual contact time with boaters was limited to several hours per week, efforts were concentrated at Comet and Long Ponds. These two ponds are used by a large number of boaters and therefore are at risk for the introduction of aquatic invasive species.

The AIS free status of Comet Pond in Hubbardston changed this year. An isolated patch of *Myriophyllum heterophyllum* (variable leaf milfoil) approximately 20 feet long and 10 feet wide, was documented during the annual macrophyte survey. The milfoil was found along the western shoreline in front of a private residence. Members of the pond association were notified of the finding. A quick response was coordinated. Several residents met with the DCR Aquatic Biologist at the site of the infestation. All visible plants were hand harvested. The same group of people will return to the spot in the spring of 2019 to remove any new plants. DCR will do additional plant surveys as well.

A boat with numerous large, healthy fragments of *Cabomba* (fanwort) was launched during the 2017 season. No fanwort was documented during this survey. See the 2017 report for additional details. Comet Pond will continue to be closely monitored for the presence of fanwort, milfoil and other AIS and if observed, requests for quick action and removal of plants will be submitted.

Unlike Comet Pond, where the use of large boat motors is prohibited, Long Pond is utilized by a variety of motor craft in a range of sizes from kayaks, canoes and small boats up to larger boats with powerful motors used to tow water skiers. Canoes and kayaks, although not completely risk-free, do not pose the same level of risk as motorized boats do for introducing invasive species because there are fewer places where AIS may be concealed plus they tend to dry completely between uses. Larger boats have more areas where organisms may remain undetected. They may have areas that remain wet for longer periods of time therefore the risk of introducing new invasive species to Long Pond is potentially greater. This fact was realized in 2016 with the introduction of *Utricularia inflata* (swollen bladderwort) to Long Pond. This AIS may have been introduced by water fowl but it is more likely that it was introduced as a stowaway on a boat. The 2018 macrophyte survey showed swollen bladderwort to be widely distributed in Long Pond with plant densities especially high along the northern shoreline.

Some types of plants use fragmentation as a means of spreading throughout a water body. (*Myriophyllum heterophyllum*), variable leaf water milfoil, the dominant species of plant found at Long Pond, utilizes fragmentation as one means of dispersal. Toward the end of the growing season, these plants become brittle, stems fragment, float to new locations and rapidly grow roots eventually colonizing other locations. In their new location, they compete with and displace native species.

Motorized boats have the potential to effectively aid in the dispersal of plants that use this means of propagation. Boat activity at Long Pond has undoubtedly added to the number of variable water milfoil plants. At any time during the boating season, numerous milfoil fragments may be seen floating along the shore line especially near the launch areas. Repeated trips back and forth by boats towing water skiers, chop up and disperse plant fragments. Areas of the littoral zone suitable for plant growth have been colonized and while there are many native species found at Long Pond, variable water milfoil is the dominant species of plant. This makes the self-certification program more difficult to administer because many of the impacts associated with AIS have already been realized. It is important that boaters not only think about the potential introduction of a new invasive species to Long Pond but also of the very real possibility of carrying fragments of milfoil from Long Pond to other water bodies.

Education continues to be the key to success for this program. By focusing on the overall program and not the specific organisms we are concerned about, boaters are beginning to think about the impacts of moving boats from one area to another, ultimately reducing the risk of introducing spiny water flea, Eurasian milfoil, hydrilla or many of the other aquatic invasive species of concern. Overall, the self-certification program has been successful.

2018 Quabbin and Ware River Aquatic Macrophyte Assessments

Paula D. Packard

January 10, 2019

During the 2018 field season, a total of 16 water bodies were assessed for the presence of aquatic invasive species (AIS). Of the 16, 8 were in the Quabbin watershed and 8 were in the Ware River watershed. Due to an exceptionally wet summer, macrophyte assessments were begun later, on July 11th, and ended on September 24th 2018. In addition, the West Arm of the reservoir, Fishing Area 2 and the Ware River above Shaft 8 were surveyed in conjunction with ESS Consulting Group. ESS was hired by MWRA to assist DCR with early detection of AIS and have been surveying portions of the reservoir on an annual basis.

Many water bodies within the watershed are monitored yearly while others are done as a component of the current Environmental Quality Assessment. The Environmental Quality Assessments are conducted on a five-year schedule. The Quabbin Reservoir consists of four separate Environmental Quality Assessment sections so with each five-year rotation, there is one year that does not have an assigned area of the reservoir watershed. Due to this, fewer water bodies were surveyed in 2018. The normal rotation will begin again in 2019.

Approximately 35 miles of shoreline was assessed for the presence of AIS by visually observing the littoral zone from a kayak or small boat. This total does not include areas surveyed within the reservoir or portions of the Ware River. See Table below for a complete list of water bodies assessed in 2018.

Eleven water bodies contained *Myriophyllum hetrophyllum* (variable leaf water milfoil). In these water bodies, this plant was abundant and widely distributed. It is also well established in sections of the reservoir and is an ongoing problem in the Ware River (ESS, 2016).

The continued presence of *Myriophyllum heterophyllum* in the basin above the Shaft 8 intake at the Ware River and in sections above the railroad bridge has been an ongoing problem that has proven itself to be very difficult to overcome despite yearly attempts at control. Control methods are restricted to hand harvesting and draw downs. The use of chemicals is currently disallowed. Attempts at long term number reductions have failed even though at times, these attempts appear to be successful only to have the milfoil rebound the following year.

A drawdown of the Ware River was done over the winter of 2015/2016. Heavy precipitation and consistently high water levels hampered efforts. It seemed that the drawdown would not be effective however, when the area was assessed in July of 2016 for the presence of milfoil, plant density and distribution was reduced, indicating that the drawdown was successful. MWRA hired contractors to hand harvest milfoil not affected. Upon completion, not a single milfoil plant was observed.

A macrophyte survey was done of the same area in July of 2017. In locations where contractors harvested all or most plants in 2016, very few milfoil plants were found, however, upstream sections had dense, relatively large patches of milfoil in areas where it had not been previously observed. Plants had also become reestablished along the shoreline above the fragment barrier. Below the rail road bridge, plants were sparse. Some previously infested areas were devoid of milfoil.

Contractors were again hired to hand harvest the milfoil. Upon completion and re-inspection, no milfoil plants were observed.

The summer of 2016 was extremely dry so no drawdown was planned for the winter of 2016/2017 because of concerns over water conservation. A drawdown was not done over the winter of 2017/2018 as well. Quabbin elevation was still below the normal operational band and water conservation rose to a higher level of importance. Ideally, if conditions are suitable, a drawdown each winter may reduce the cost of labor associated with keeping milfoil numbers in check; however, complete eradication is highly unlikely.

The annual drawdown for maintenance occurred in July of 2018 as scheduled. However, heavy rains repeatedly filled the river to its banks. Hand harvesting crews were behind schedule. The heavy rains, and the breaking of a large dam upstream, flooded the river, carrying with it many new milfoil fragments. These recolonized the basin portion of the river where crews had already removed all the milfoil. Small, rooted milfoil plants also became reestablished because of being repeatedly inundated. Crews had to redo large areas in sections that never dried out completely, which also made work conditions very difficult.

Upriver of Route 122, a significant increase in plant numbers was documented. Crews were behind schedule because of the rain events, mud, slippery banks and dealing with much higher plant densities than were initially believed to be there. These factors reduced the length of time they could devote to hand harvesting plants above Route 122. These upriver infestations will provide a continuing source of plant fragments able to recolonize the Shaft 8 basin. Depopulating the entire river above Shaft 8 would be unpractical, daunting and extremely expensive. This is an ongoing issue with no foreseeable permanent solution. For this reason, the focus will be on keeping the basin above the intake as free of milfoil as is feasible.

Phragmites australis (common reed) is an invasive species which is widely distributed throughout the watershed and the reservoir. This species spreads using three different methods: seeds, stolons and rhizomes. As more plants mature to reproductive age, seed production and dispersal increases. Not only will plant numbers within a pond increase as seeds are spread but the likelihood of seeds being carried to other water bodies also increases. Stolons, runners that are on the top of the soil, and rhizomes, which grow beneath the soil surface, enable small patches to rapidly spread out, becoming larger with each successive year. A single seed that successfully germinates can form a large patch, eventually displacing native species. Phragmites, once established, aggressively colonizes the shoreline and is nearly impossible to eradicate using methods such as cutting below the surface of the water, hand pulling or covering with black plastic. Herbicide use would be the easiest and most effective means of reducing plant numbers but is currently not being considered. Some success has been documented using a combination of several different methods especially if stands are small and newly established. Ideally, small, isolated populations should be eradicated before they become firmly established. Early removal is far more effective, utilizes fewer resources and has less of an environmental impact. This is especially important in pristine water bodies such as Bassett Pond, which supports incredible biodiversity or in the reservoir before a monoculture is formed.

Five water bodies had stands of *Phragmites*. In the reservoir, it was widely distributed. In the watershed, small patches of this invasive have cropped up in locations where they had not been found previously.

In 2011, the presence of several pink water lily plants was documented along the northern shoreline of Comet Pond. USGS does not list the pink color phase of this plant in its invasive species data base, most likely because the pink color phase is thought to be a color variant of the native *Nymphaea odorata*. The density and distribution in this water body does seem to be changing slightly each year. In the past, plant numbers were increasing. In 2017 and 2018, no pink lilies were observed. There are two impossible explanations: one is that residents have begun to remove plants when they see them, or the survey may have been conducted during a time when there were no blossoms. The second explanation is unlikely because lilies typically bloom continuously towards the end of summer. Several pink water lily plants were found in Lake Mattawa for the second year as well.

Hardware stores, nurseries, big-box stores as well as online sources carry several different color phases of water lilies. These colorful pond lilies may begin to crop up in more locations because pond residents are probably unaware of the risks associated with the introduction of non native plants. Monitoring will be ongoing.

Of the water bodies assessed, Queen Lake in Phillipston and Demond Pond in Rutland were the only water bodies found to be infested with *Cabomba caroliniana* (fanwort). At Queen Lake, numerous rooted plants and fragments were found in the boat launch and beach area, along the western shoreline, and in the northeastern sections including several of the coves. Fanwort distribution and density appears to be increasing each year. Plants were especially abundant in the large cove on the eastern shoreline. If this trend continues unchecked, fanwort may become more problematic in this water body.

Members of the Demond Pond Association contracted with Solitude to treat the fanwort in 2018. Plant numbers were reduced but fanwort was not eradicated. New growth was evident during the survey. Plans are in place to treat again in 2019 if sufficient funds can be raised.

Hardwick Pond is approximately 2.5 miles from the Quabbin Reservoir and despite being off-watershed, periodic monitoring for AIS is ongoing. The threat of waterfowl carrying viable fragments of fanwort to the reservoir is significant, and because many birds travel between Hardwick Pond and the Quabbin Reservoir, additional measures are being taken both by landowners at the pond and by DCR. Residents at Hardwick Pond formed a non-profit pond association called the Hardwick Pond Preservation Association (HPPA) and then hired consultants to assess the AIS issues. The consultants provided quotes and made recommendations. HPPA has also been in contact with Senator Ann Gobi and her office staff and have been working closely with DCR Lakes and Ponds Program in an effort to acquire some funding to treat the pond for AIS.

To assist HPPA with their efforts, in 2016, a letter of support was written to the Hardwick Preservation Pond Association, the Hardwick Select Board and Senator Ann Gobi's office. In this letter from DCR, we stated our concerns with this AIS being in such close proximity to the reservoir and made them aware of our support of the HPPA's plans to treat for this aggressive species. While DCR Water Supply Protection was unable to provide them with monetary consideration, this letter assisted HPPA in the acquisition of funding from sources outside their group. HPPA's plans to treat for fanwort in 2017 or 2018 did not come to fruition, but the group is hopeful that they will be able to carry out plans in 2019. Documentation of a rare species of plant and the uncertainty of the effects of herbicides on this plant prompted a closer look at this project by MA NHESP. If these issues are resolved in a timely manner, the pond may be treated in 2019. If successful, the threat of fanwort being carried to the reservoir by waterfowl will be significantly reduced.

Smaller types of watercraft are less likely to carry AIS but are not risk-free. The potential introduction of aquatic invasive species through this means was realized in 2013, as *Potamogeton crispus* (curly pond weed) was found in White Hall Pond in Rutland. A small patch of this AIS was found near the access road, a sample taken and identification confirmed. Tom Flannery, from the DCR Lakes & Ponds Program, removed the plants soon after they were found. Using dive gear, he found additional infestations near the swimming area as well as a small patch on the other side of the pond. All visible plants were removed. However, *P. crispus* grows predominantly early in the season, senesces during the summer months, and then towards fall, has a moderate growth spurt. As can be expected, additional plants were found in the spring of 2014. Staff from the Lakes and Ponds Program hand-harvested observed plants. Plant numbers increased significantly in 2015 but could not be removed because of plant density and lack of Lakes & Ponds staff time. Over the winter tentative plans were made to contract with a consulting firm to have them assess the situation, make recommendations and harvest or treat the pond. In 2016, ESS Consulting Group acquired all necessary permits and treatment was conducted in May of 2017. The treatment reduced but did not eliminate the curly pond weed. Plants numbers rebounded after treatment and were numerous along the road and dam and scattered in other areas. Numbers were lower in 2018, but this was most likely due to timing of the survey.

Utricularia inflata (swollen bladderwort), was documented at White Hall Pond, Long Pond and at Boat Launch Area 2 during the 2017 macrophyte surveys. It was not found at Area 2 in 2018. This plant has been on our radar but had not been observed previously. The 2018 surveys did not result in finding that this AIS was more widely distributed than previously thought.

Chinese mystery snails were first documented during macrophyte surveys at Quabbin in 2011 and are mentioned here since they are an invasive species. Numerous snails were found near the boat dock at Fishing Area 1 where snail numbers continue to be high despite predation by ducks. In 2012, snails were found near the hangar at the Quabbin Administration Building in Belchertown. Snails were also documented in Long Pond in Rutland during the 2016 survey and also at Lake Mattawa in 2017. These snails displace native species of snails and are thought to compete for resources; however, few studies have been conducted, so actual impacts have not been adequately determined. Snails may serve as the intermediate host for some parasites. To date, no problems have been associated with their presence, although there is anecdotal evidence that they are an intermediate host for a fish parasite.

In 2013, *Iris pseudacorus* (yellow flag iris) a relatively aggressive invasive species that very closely resembles our native species of iris, blue flag iris, was documented at Connor Pond in Petersham where it has colonized large stretches of the western shoreline and has become densely distributed in many small coves. This plant continues to spread at an accelerated rate. It is now found along the shores of the East Branch Swift, in Pottapaug Pond and occasionally at the boat launch at Fishing Area 3 in Hardwick. A steady supply of seed pods continues to be produced and released from the plants established in Connor Pond. These pods have the ability to float along with water currents. Infestations may worsen as plant density and distribution increases. In 2018, plans to reposition the fragment barrier at Area 3 to more effectively catch floating seed pods did not come to fruition but are again in place for 2019. This will be an ongoing problem with no readily available solution.

Several small patches of yellow flag iris were documented at Demond Pond. Members of the pond association were notified of the locations of each patch of plants. Plants were hand harvested. These locations will be closely monitored during 2019.

Lithrum salicaria (purple loosestrife) was found at four locations this year as well as in the reservoir. This plant is somewhat difficult to notice when not in bloom so it is possible that the presence of this invasive may be more widespread than believed. Ongoing annual surveys, conducted at different times of the season, may facilitate documentation of infestations not previously observed. At the time of the survey, populations were sparse at all locations. Low population densities of purple loosestrife are not conducive to the introduction of *Galerucella*, the predatory beetle that is widely used to control this invasive plant. Because this beetle feeds exclusively on purple loosestrife, to be an effective method of control, plant numbers must be significant enough to support a reproducing population.

Rorippa microphylla or onerow yellowcress, had been previously found at Pepper Mill Pond, the east branch of the Swift River, and in a small tributary inside gate 16. It was also documented in Demond and Harvard Ponds in 2016. It has become widely distributed and was found in many streams and ponds within the watershed.

Interestingly and for reasons not yet fully understood, plant density does not seem to increase significantly in areas where it has become established. It is edible and may be kept in check by herbivores. In the past, this observation did not seem to be holding true for the population established in Peppers Mill Pond. In 2016, the patch there had increased in size from several plants to a large patch which was approximately 50 feet by 10 feet in size. One possible explanation is related to the water depth where plants were growing. This plant tends to grow mostly in shallow water where herbivores can easily feed. In Peppers Mill Pond, the patch of onerow yellowcress was in a relatively deep section of the pond where herbivory would be difficult for many animals except for beavers, muskrats or other wildlife that are excellent divers. Interestingly, not a single onerow yellowcress plant was found in Peppers Mill Pond during the 2017 survey but it was once again documented in 2018.

To date, impacts from infestations of onerow yellow cress seem to be minor. It is widespread throughout the Quabbin and Ware River watersheds and all of New England and has subsequently been found in the Wachusett watershed. It is most likely being transported as seeds by wildlife, water currents, and possibly with gear used by anglers.

Myosotis scorpioides (true forget-me-not) is not truly an aquatic plant but inhabits wet, disturbed shorelines. It was first documented at Quabbin approximately 11 years ago and is found throughout New England. During the 2013 macrophyte survey conducted by ESS Group, Inc., several small patches of this plant were found along the eastern shoreline of Pottapaug Pond (ESS, 2014). These infestations, as well as several others found at a later date by DCR staff, were removed by hand pulling. Additional plants have been documented in Pottapaug Pond each year. Forget-me-nots were also found in the upper section of Long Pond, Pepper's Mill Pond, Connor Pond, Lake Mattawa, in a small pond inside Gate 20, Demond and Brigham Ponds. Populations will be monitored and if possible, removed as they are documented. However, plants multiply by seed production and spread by an extensive, shallow, underground root system. These reproductive methods make complete eradication of this invasive species difficult. Known impacts associated with this plant are minimal at this time.

Najas minor (brittle naiad) was documented by ESS Group in 2014 at O'Loughlin Pond. Plants were harvested using diver assisted suction harvesting (DASH). Brittle naiad plants closely resemble the native naiads, and the difference between the seeds of the native and invasive plants are virtually indiscernible to the birds that feed on them. Literature indicates that 25 or more species of waterfowl readily consume the seeds, which can remain viable through the gut of the bird and are therefore easily transported. This is most likely the method of introduction to O'Loughlin Pond.

The infestation was small and dealt with quickly but to be certain that no infestation remained, the fragment barrier at Boat Area 2 was checked approximately every two weeks during the 2018 field season. Complete macrophyte surveys were conducted on August 6th and September 19th, 2018. No brittle naiad fragments or whole plants were found for the fourth year in a row.

No additional aquatic invasive species were documented in 2018. Plans to assess water bodies in the Ware River and Quabbin Reservoir watersheds are in place for the 2019 field season.

List of Water Bodies Surveyed in 2018

Water Body	**Location**
Bassett Pond	New Salem
Boat Area 2 shoreline	New Salem
Brigham Pond	Hubbardston
Comet Pond	Philipston
Connor	Petersham
Demond Pond	Rutland
Harvard Pond	Petersham
Long Pond –main body	Rutland
Long Pond-upper	Rutland

Water Body	**Location**
Mattawa Lake	Orange
Moosehorn Pond	Hubbardston
O'Loughlin Pond	New Salem
Pepper's Mill Pond	Ware
Pottapaug Pond	Petersham
Queen Lake	Phillipston
South Spectacle Pond	New Salem
Ware River-above Shaft 8	Barre
West Arm of Reservoir	Pelham
White Hall Pond	Rutland

Literature cited

ESS Group, 2014. Aquatic Macrophyte Surveys-MWRA/DCR Source and Emergency Reservoirs 2014

ESS Group, 2016. Aquatic Macrophyte Surveys-MWRA/DCR Source and Emergency Reservoirs 2016

EQ FILE REPORT

Inspector: P. Reyes

[x]	Field Investigation	Site: Gates Brook
[ ]	Meeting	Date: 3-29-2019
[ ]	Phone Conversation	Weather: Cloudy, windy, 30's

Activity

[ ] Wastewater	[ ] Construction	[ ] Hazardous Waste
[ ] Agricultural	[ ] Sedimentation/Erosion	[ ] Recreation
[ ] Wildlife	[ ] Trash/Dumping	[x] Other – Snowmelt Runoff

Results from biweekly sampling at Gates Brook on 3-27-18 revealed the presence of high levels of both fecal and *E. coli* bacteria. Levels for fecal bacteria were 88 CFU/100 ml, and those for *E. Coli* were 231 MPN/100 ml.

Follow up sampling on 3-29-18 showed levels of fecal bacteria were down to 12 CFU/100 ml, and those for *E. coli* were down to 55.6 MPN/100 ml.

No obvious fecal sources were observed on the original sampling date, March 27th, or during resampling on March 29th."

One possible explanation for the spike in bacteria levels is that snowmelt accelerated with warming temperatures, and that in turn flushed out bacteria from the watershed. In addition, between March 8 and March 27 total, a total of 1.12" of rain were recorded.

The table below lists E. coli and fecal coliform bacteria levels for the first 3 months of 2018, and The one below lists rain data during March 2018.the graph following it shows average air temperatures for the first 3 months of 2018. The last table lists daily precipitation totals for March.

Bacteria Counts

Date	Fecal Coliform	*E. Coli*
1/2/2018	<1	<10
1/16/2018	1	<10
1/30/2018	<1	<10
2/6/2018	<1	
2/13/2018	<1	<10
2/23/2018	<1	
3/13/18	1	
2/27/2018	18	<10
3/21/2018	<1	<10
3/27/2018	88	231
3/29/2018	55.6	12

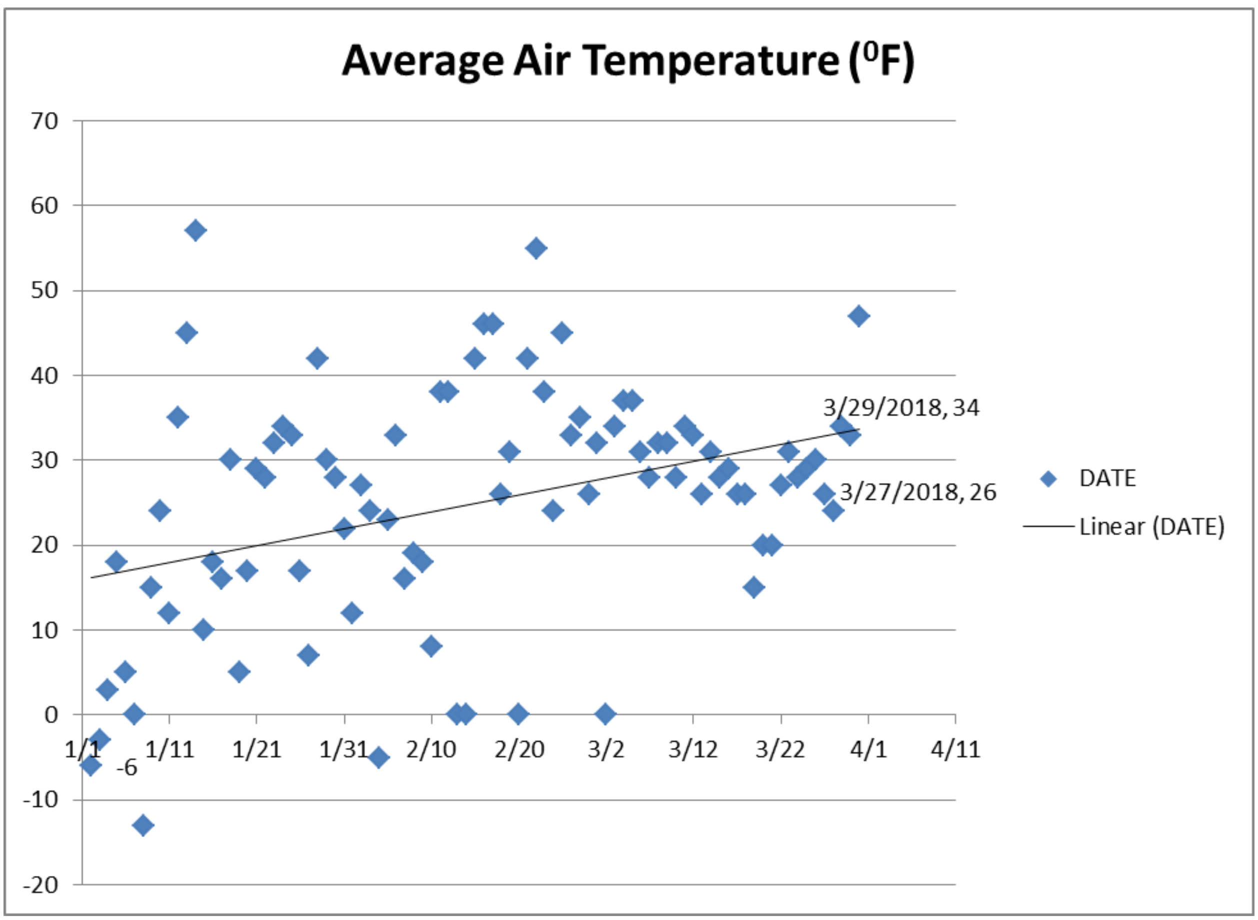


Figure 1

Date	Rainfall (in)	Snow (in)
3/1/2018	0.00	
3/2/2018	1.19	
3/3/2018	0.00	
3/4/2018	0.00	
3/5/2018	0.00	
3/6/2018	0.00	
3/7/2018	0.01	
3/8/2018	0.78	
3/9/2018	0.00	
3/10/2018	0.00	
3/11/2018	0.00	
3/12/2018	0.00	
3/13/2018	0.32*	2.5
3/14/2018	0.00	
3/15/2018	0.00	
3/16/2018	0.00	
3/17/2018	0.01	
3/18/2018	0.00	
3/19/2018	0.00	
3/20/2018	0.00	
3/21/2018	0.00	
3/22/2018	0.00	
3/23/2018	0.00	
3/24/2018	0.00	
3/25/2018	0.01	
3/26/2018	0.00	
3/27/2018	0.00	
3/28/2018	0.00	
3/29/2018	0.04	
3/30/2018	0.06	
3/31/2018	0.00	

*Precipitation fell as snow, converted water equivalent

dcr
Massachusetts

WATERSHED SAMPLING FOLLOW-UP REPORT

To be completed when additional documentation of field conditions is warranted or requested.

Watershed:	Quabbin Reservoir	**Sampling date:**	5/8/18, 5/10/18
Samplers:	BB & GM (5/8) EK (5/10)	**Report date:**	5/11/18
		Prepared by:	EK
Reason for report:	Elevated bacteria result in sample from Hop Brook (212), especially relative to the other results		

Rainfall Data		
Date	**Amount**	**Station**
5/7/18	0.12	Belchertown
5/8/18	0.00	Belchertown
5/9/18	0.00	Belchertown
5/10/18	0.00	Belchertown

Field observations at sample sites			
Date	**Site ID**	**E. Coli (MPN/100mL)**	**Observations**
5/8/18	212	481	Very good flow
5/10/18	212	31	Good flow; additional observations below

Other notes, comments or observations

Rainfall data are measured at 7 am each day, so amounts listed above are from 7 am the day before through 7 am the day of measurement.

Based on the relatively small amount of rain received on the days prior to May 8, it does not seem likely that the elevated bacteria level was related to precipitation. The area in the vicinity of the sample location, as well as the culvert upstream of the sample location, was visually assessed on May 10. No signs of recent beaver activity were observed. Several deer footprints were observed near the culvert. The cause of the elevated result in the May 8 sample is unclear. Field observations and the significantly lower result in the May 10 sample do not support the presence of an ongoing source of bacteria in this area.

Photographs from the May 10 assessment are attached.

PHOTOGRAPHS

Photo 1: View of sample location viewed from upstream.

Photo 2: View of culvert upstream of sample location.

MEMORANDUM

To: Yuehlin Lee, Environmental Analyst IV
From: Paul Reyes
Date: June 29, 2018
Subject: Forestry Lot 3138 Update

The Massachusetts Department of Conservation and Recreation, Division of Watershed Protection (DWSP), manages forested lands to protect water quality as part of comprehensive watershed protection and land management plans. The DWSP Forest Management Program allows silvicultural activities that focus on forest diversity (in terms of age and tree type) and regeneration for resilient forests that naturally filter water pollutants.

Environmental Quality staff members are charged with monitoring the effects of forestry on soil and water by conducting periodic inspections of forestry lots and collecting water samples for turbidity measurements from streams affected by logging. Turbidity is a measure of suspended matter in water, and the affected streams are those which are spanned by a temporary bridge used for transporting equipment and timber.

Weather and road conditions allowing, monthly background samples are collected upstream and downstream from the stream crossing prior to logging in order to set a baseline. Samples are then collected during harvesting, followed by post-harvest sampling.

This memorandum covers Lot 3138, inside of Gate 27 in New Salem, and in which one stream crossing, SC-1, was sampled. The other stream crossing, at an intermittent brook (SC-2) was not sampled. See **Figure 1** for stream crossing locations.

Background Phase

Background sampling at Lot 3138 began on September 15, 2014. Further sampling was conducted on a monthly basis through June 30, 2016. After that, during the months of July, August and September of 2016, there was no flow on the stream. Very low flows resumed in October and further sampling was conducted on October 31 and December 14, 2016. **Table 1** shows the results of turbidity testing. These results are also shown in **Figure 2**. Site S1 was upstream of stream crossing SC-1, and Site S2 was downstream.

Active Logging Phase

Samples were taken on December 29, 2016, during active logging. No other samples were collected during this phase.

Post-Logging Phase

Post-logging, monthly sampling attempts were made from January 2017 through March 2018. During this period, samples were successfully collected, except for November 2017 because of extremely low flow, and January 2018 because the site was inaccessible because of snow.

Discussion

A total of 29 attempts to collect water samples were made from September 14, 2014 to March 30, 2018. Out of the 29 attempts, 24 were successful. In general, turbidity at downstream Site S2 was comparable to or lower than turbidity at upstream Site S1. Turbidity at S1 ranged from 0.10 to 0.76 NTU during the background phase, while S2 turbidity ranged from 0.09 to 0.68 NTU. During active logging, S1 and S2 turbidities were comparable, at 0.10 and 0.07 NTU, respectively. Post-logging, turbidity ranged from 0.09 to 0.78 NTU at Site S1, and 0.10 to 0.77 NTU at Site S2.

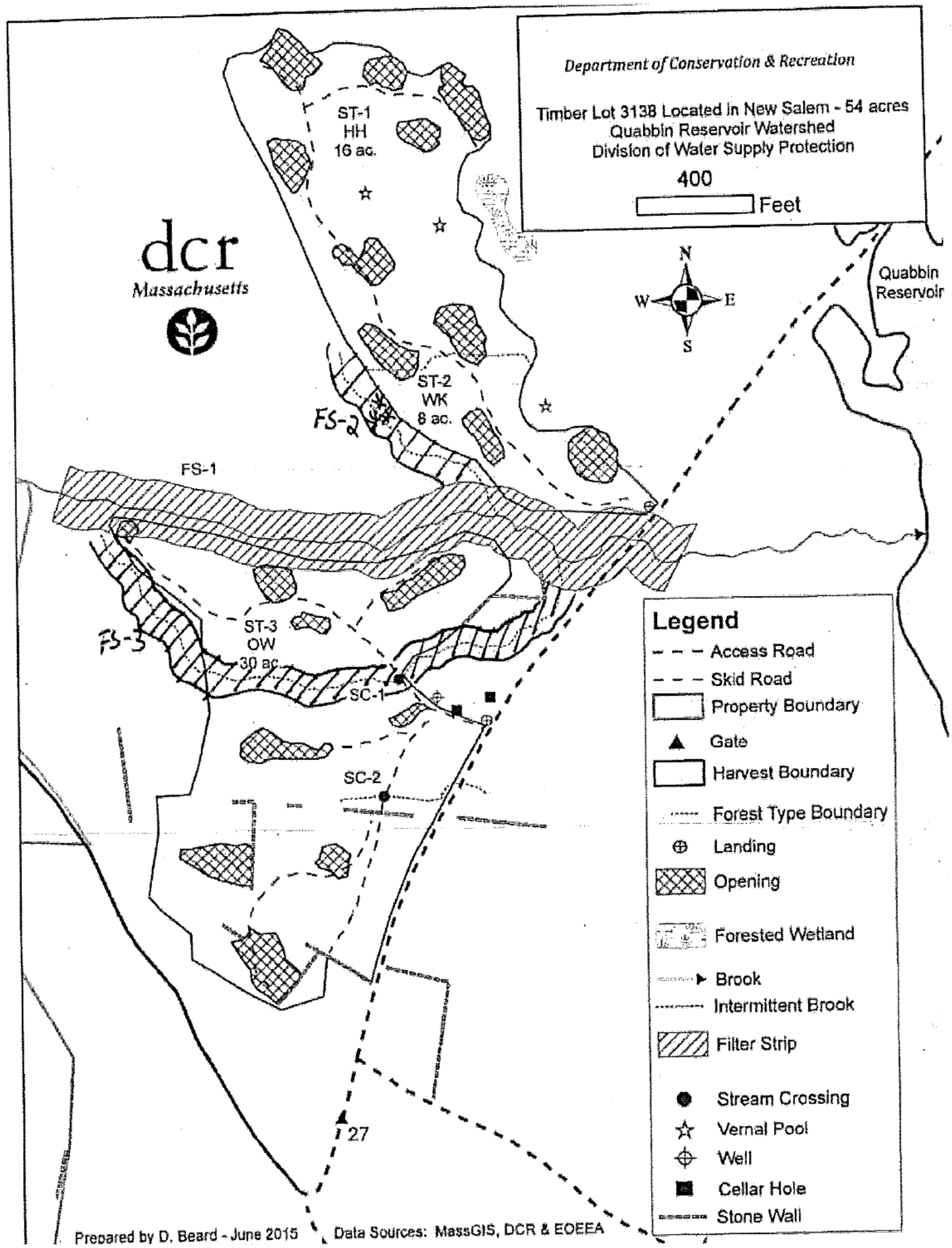


Figure 1. Forestry/Timber Lot 3138.

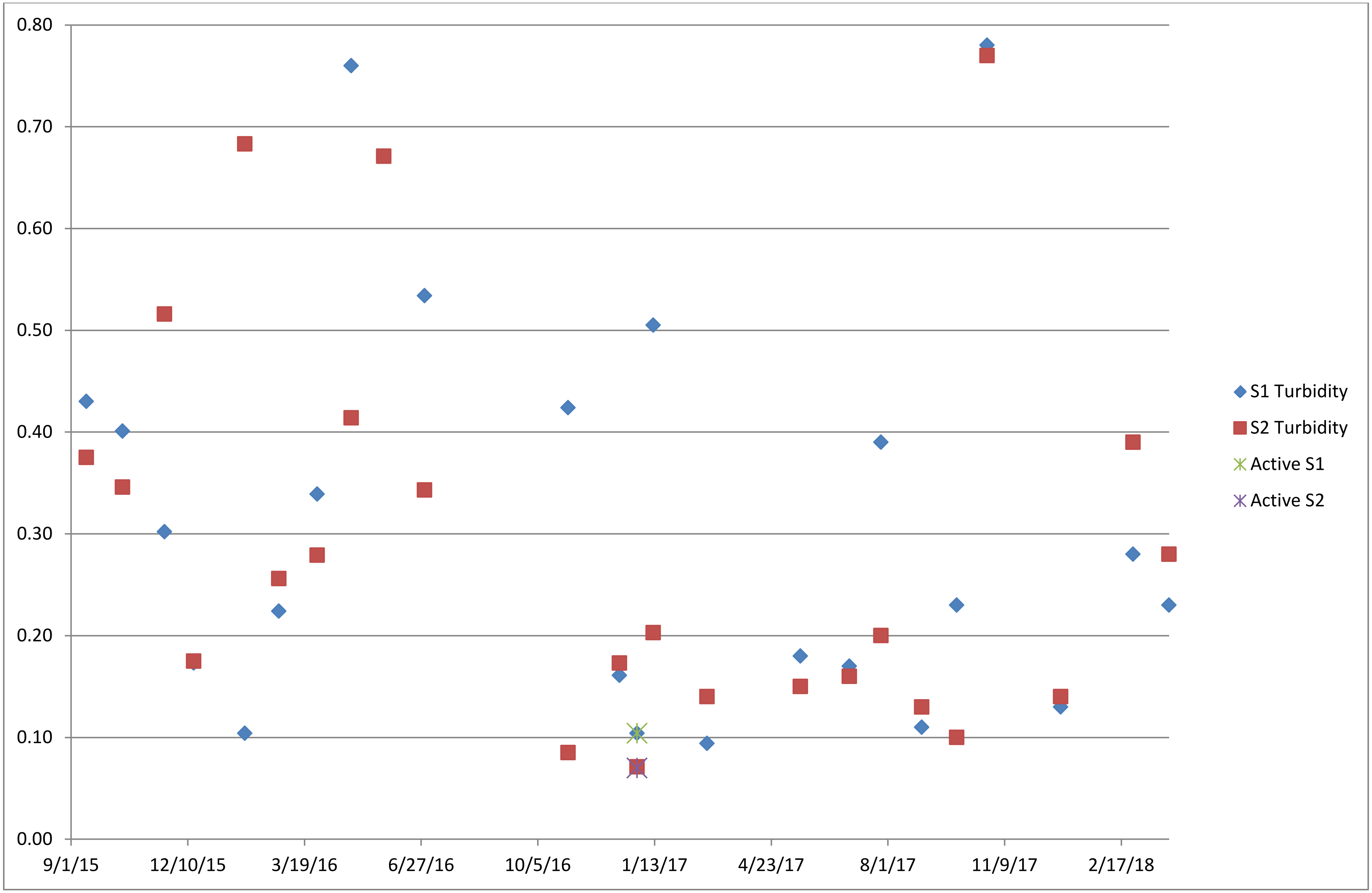


Figure 2. Turbidity upstream (Site S1) and downstream (Site S2) of stream crossing SC-1.

Table 1. Forestry Lot 3138 turbidity during background phase, active logging phase, and post-harvesting phase.

Active Lot?	Sample Date	Sample Site Number	Type of Sample	Turbidity	Flow? (Yes/No)	Pictures? (Yes/No)	BMPs	Comments	Lot Number	Precipitation Previous 7 Days
No	9/14/15	S1	Background	0.43	Yes	Yes	None	Good Flow	3138	3.20"
No	9/14/15	S2	Background	0.38	Yes	Yes	None	Good Flow	3138	3.20"
No	10/15/15	S1	Background	0.40	Yes	No	None	Good Flow	3138	0.45"
No	10/15/15	S2	Background	0.35	Yes	No	None	Good Flow	3138	0.45"
No	11/20/15	S1	Background	0.30	Yes	No	None	Good Flow	3138	0.63"
No	11/20/15	S2	Background	0.52	Yes	No	None	Good Flow	3138	0.63"
No	12/15/15	S1	Background	0.17	Yes	No	None	Good Flow	3138	0.51"
No	12/15/15	S2	Background	0.18	Yes	No	None	Good Flow	3138	0.51"
No	1/28/16	S1	Background	0.10	Yes	No	None	Good Flow	3138	0.00"
No	1/28/16	S2	Background	0.68	Yes	No	None	Good Flow	3138	0.00"
No	2/26/16	S1	Background	0.22	Yes	No	None	Good Flow	3138	2.16"
No	2/26/16	S2	Background	0.26	Yes	No	None	Good Flow	3138	2.16"
No	3/30/16	S1	Background	0.34	Yes	No	None	Good Flow	3138	1.22"
No	3/30/16	S2	Background	0.28	Yes	No	None	Good Flow	3138	1.22"
No	4/28/16	S1	Background	0.76	Yes	No	None	Medium Flow	3138	0.43"
No	4/28/16	S2	Background	0.41	Yes	No	None	Medium Flow	3138	0.43"
No	5/26/16	S1	Background	0.67	Yes	No	None	Low Flow	3138	0.47"
No	5/26/16	S2	Background	0.67	Yes	No	None	Low Flow	3138	0.47"
No	6/30/16	S1	Background	0.53	Yes	Yes	None	Very low flow	3138	0.19"
No	6/30/16	S2	Background	0.34	Yes	Yes	None	Very low flow	3138	0.19"
No	7/28/16	S1	Background		No	No	None	No precipitation during the previous 13 days.	3138	0"
No	7/28/16	S2	Background		No	No	None	No precipitation during the previous 13 days.	3138	0"
No	8/26/16	S1	Background		No	No	None	0.13" on 8/20, 0.38" on 8/21, 0.80" 8/22 and 0.01" 8/23.	3138	1.31"

Table 2 (cont'd). Forestry Lot 3138 turbidity during background phase, active logging phase, and post-harvesting phase.

Active Lot?	Sample Date	Sample Site Number	Type of Sample	Turbidity	Flow? (Yes/No)	Pictures? (Yes/No)	BMPs	Comments	Lot Number	Precipitation Previous 7 Days
No	8/26/16	S2	Background		No	No	None	0.13" on 8/20, 0.38" on 8/21, 0.80" 8/22 and 0.01" 8/23.	3138	1.31"
No	9/29/16	S1	Background		No	No	None	0.05 on 9/23, 0.53 on 9/27, and 0.01 9/28.	3138	0.59"
No	9/29/16	S2	Background		No	No	None	0.05 on 9/23, 0.53 on 9/27, and 0.01 9/28.	3138	0.59"
No	10/31/16	S1	Background	0.42	Yes	No	None	Extremely low flow, barely a trickle.	3138	0.74"
No	10/31/16	S2	Background	0.09	Yes	No	None	Extremely low flow, barely a trickle.	3138	0.74"
No	12/14/16	S1	Background	0.16	Yes	Yes	None	Very low flow, 2.25" of rain and snow over previous 14 days.	3138	.07"
No	12/14/16	S2	Background	0.17	Yes	Yes	None	Very low flow.	3138	.07"
Yes	12/29/16	S1	Active/Crossing	0.10	Yes	No	In Place	Good Flow	3138	0.44"
Yes	12/29/16	S2	Active/Crossing	0.07	Yes	No	In Place	Good Flow	3138	0.44"
No	1/12/17	S1	Post Harvesting	0.51	Yes	Yes	None	Good Flow	3138	0.53"
No	1/12/17	S2	Post Harvesting	0.20	Yes	Yes	None	Good Flow	3138	0.53"
No	2/27/17	S1	Post Harvesting	0.09	Yes	No	None	Good Flow	3138	.051”
No	2/27/17	S2	Post Harvesting	0.14	Yes	No	None	Good Flow	3138	.051"
No	5/18/17	S1	Post Harvesting	0.18	Yes	No	None	Good Flow	3138	.183"
2	5/18/17	S2	Post Harvesting	0.15	Yes	No	None	Good Flow	3138	.183"
No	6/29/17	S1	Post Harvesting	0.17	Yes	Yes	None	Low Flow	3138	0.85"
No	6/29/17	S2	Post Harvesting	0.16	Yes	Yes	None	Low Flow	3138	0.85"
No	7/26/17	S1	Post Harvesting	0.39	Yes	No	None	Low Flow	3138	1.04"
No	7/26/17	S2	Post Harvesting	0.20	Yes	No	None	Low Flow	3138	1.04"

Table 3 (cont'd). Forestry Lot 3138 turbidity during background phase, active logging phase, and post-harvesting phase.

Active Lot?	Sample Date	Sample Site Number	Type of Sample	Turbidity	Flow? (Yes/No)	Pictures? (Yes/No)	BMPs	Comments	Lot Number	Precipitation Previous 7 Days
No	8/30/17	S1	Post Harvesting	0.11	Yes	No	None	Very low flow	3138	.46"
No	8/30/17	S2	Post Harvesting	0.13	Yes	No	None	Very low flow	3138	.46"
No	9/29/17	S1	Post Harvesting	0.23	Yes	Yes	None	Good Flow	3138	0"
No	9/29/17	S2	Post Harvesting	0.10	Yes	Yes	None	Good Flow	3138	0"
No	10/25/17	S1	Post Harvesting	0.78	Yes	No	None	Low Flow	3138	.254"
No	10/25/17	S2	Post Harvesting	0.77	Yes	No	None	Low Flow	3138	.254"
No	11/27/17	S1	Post Harvesting		Yes	No	None	Very low flow, no sample collected	3138	0.26"
No	11/27/17	S2	Post Harvesting		Yes	No	None	Very low flow, no sample collected	3138	0.26"
No	12/27/17	S1	Post Harvesting	0.13	Yes	No	None	Very low flow, no sample collected	3138	0.43"
No	12/27/17	S2	Post Harvesting	0.14	Yes	No	None	Very low flow, no sample collected	3138	0.43"
No	1/29/18	S1	Post Harvesting				None	Inaccessible	3138	0.88"
No	1/29/18	S2	Post Harvesting				None	Inaccessible	3138	0.88"
No	2/27/18	S1	Post Harvesting	0.28	Yes	Yes	None	Low flow	3138	0.92"
No	2/27/18	S2	Post Harvesting	0.39	Yes	Yes	None	Low flow	3138	0.92"
No	3/30/18	S1	Post Harvesting	0.23	Yes	Yes	None	Low flow	3138	0.05"
No	3/30/18	S2	Post Harvesting	0.28	Yes	Yes	None	Low flow	3138	0.05"

Photo 1. Forestry Lot 3138 Stream Crossing Prior to Active Logging.

Photo 2. Upstream Site S1.

Photo 3. Downstream Site S2.

MEMORANDUM

To: Yuehlin Lee, Environmental Analyst IV

From: Bernadeta Susianti

Date: June 11, 2018

Subject: Monitoring Report for Forestry Lot 4393 (WR17-17-03)

The main purpose of the DWSP forest management program in Quabbin and Ware River watersheds is to conduct silviculture which supports and maximizes water quality. Present management focuses on forest diversity and regeneration.

As a compliance measure to protect soil and water quality, EQ section staff conducts short-term forestry monitoring program which collects water samples to measure and monitor turbidity at the stream affected by the logging activities. Turbidity is a measure of the amount of suspended sediment in water column.

Forestry Lot WR-17-17-3 is located in Coldbrook Road, Oakham, MA. Three sample locations were determined on the stream where the crossing was located. One sample location was located at the far upstream of the crossing (SS_1), one at right above the crossing (SS_2), and one was located far downstream of the crossing (SS_3).

Monthly sampling events were conducted through three different phases; prior, during, and post active work. "Prior" sampling events were conducted in the three months prior to the active logging work occurred and served as baseline turbidity data. The post-work sampling was conducted for a 12-month period after the active work ended. The short-term forestry monitoring program at this specific lot occurred from March 2017 to June 2018.

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The results of the turbidity sampling (in NTU) are shown on Table 1 below. The locations of the sample sites are shown on Figure 1.

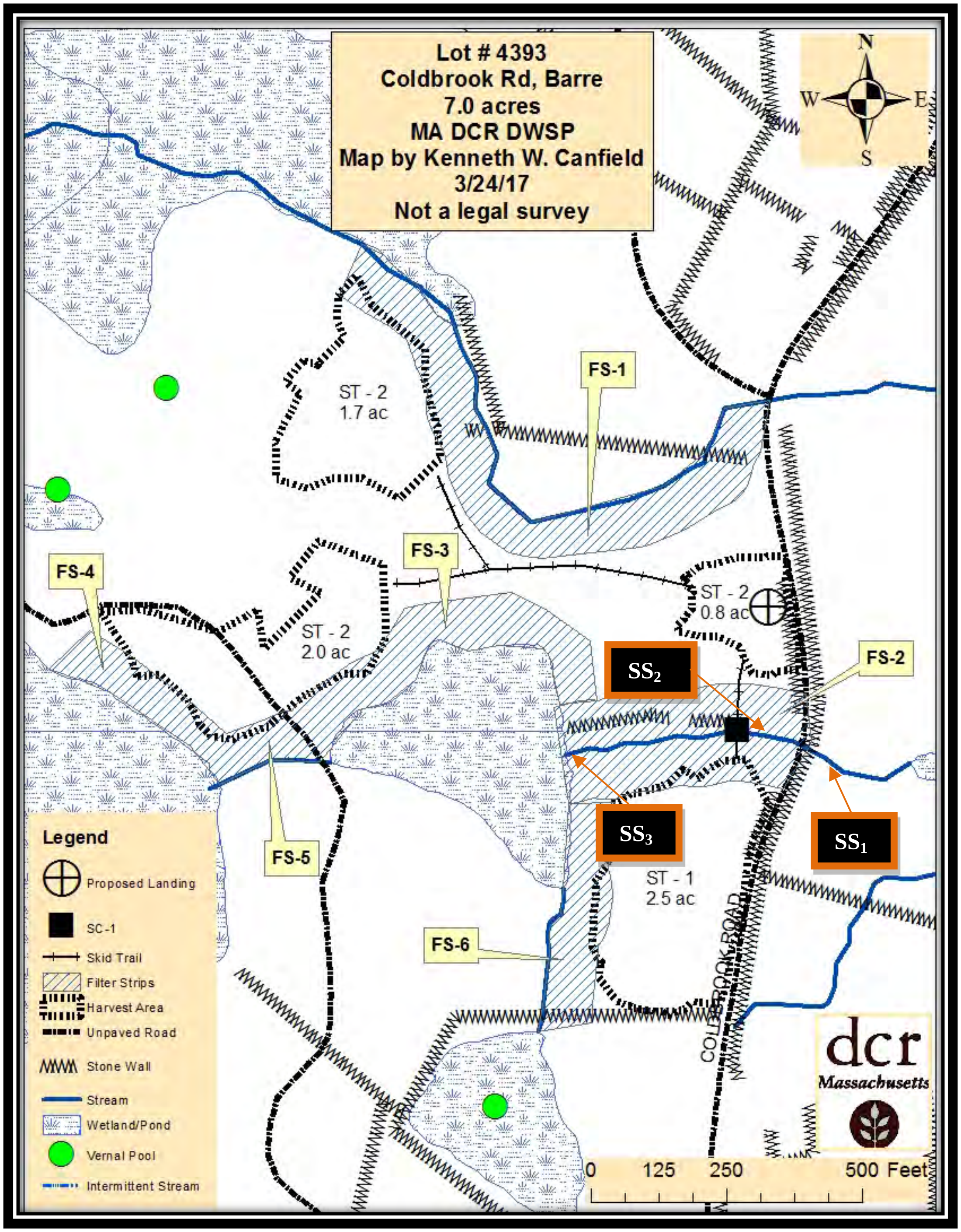
Table 1. Turbidity Results (NTU)

Sample Phase	Sample Date	SS_1 Upstream	SS_2 Upstream Just above the crossing	SS_3 Far Downstream
Baseline	March 3, 2017	0.269	0.403	0.205
	April 21, 2017	0.304	0.316	0.187
	May 15, 2017	0.453	0.441	0.332
Active Work	June 19, 2017	0.246	0.23	0.133
Post Monitoring	July 13, 2017	0.396	0.344	***Not sampled- no flow***
	August 18, 2017	***NOT SAMPLED- Dry stream***		
	Sept 11, 2017	0.305	0.723	0.199
	Oct 31, 2017	0.293	0.333	0.342
	Nov 21, 2017	0.193	0.180	0.211
	Dec 13, 2017	0.317	0.424	0.206
	Jan 19, 2018	0.236	0.791	0.324
	Feb 23, 2018	0.266	0.267	0.330
	Mar 23, 2018	0.135	0.155	0.140
	Apr 18, 2018	0.198	0.194	0.186
	May 17, 2018	0.414	0.486	0.429
	June 6, 2018	0.348	0.330	0.276

The lowest turbidity of 0.133 NTU was measured at the far downstream location of SS_3 during active logging work on June 19, 2017. The highest turbidity was observed at SS_2, just above the crossing at 0.791 NTU during post monitoring period on January 19, 2018.

For comparison purposes, turbidity at Shaft 8 in March 2017 through April 2018 ranged from 0.4 to 4.0 NTU. The highest turbidity for year 2017 was 4.0 NTU which was recorded in July 25, 2017. Based on the Ten Year Water Quality Data Review 2000-2009 report, the lowest turbidity observed in Ware River Sampling Sites was 0.15 NTU at Asnacomet Pond outlet and the highest was 55 NTU at Moulton Pond Tributary at Britney Dr during the 10 year period. Variations in turbidity can be affected by many factors such as storm events, beaver dam breach, construction works, etc.

Figure 1. Sampling Locations



SS_1 : Sampling Location 1 - Upstream of crossing

SS_2 : Sampling Location 2 - Just above the crossing

SS_3: Sampling Location 3 – Far downstream

ATTACHMENTS

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SS_1 (April 21, 2017)

SS_2 (April 21, 2017)

SS_3 (April 21, 2017)

Stream Crossing (June 16, 2017)

Stream Crossing (June 26, 2017)

Stream Crossing (May 16, 2018)