City of Cambridge Water Department
2014 Source Water Quality Report

November, 2015

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List of Abbreviations

CWD	Cambridge Water Department
DO	Dissolved oxygen
EPA	Environmental Protection Agency
HDPE	High density polyethylene
IC	Ion chromatography
JFA	Joint-Funding Agreement
LEED	Leadership in Energy and Environmental Design
LOWESS	Locally Weighted Scatterplot Smoothing
MassDOT	Massachusetts Department of Transportation
MassGIS	Massachusetts Office of Geographic Information
MCL	Maximum contaminant level
MPN	Most probable number
MWRA	Massachusetts Water Resource Authority
ORP	Oxidation reduction potential
QC	Quality Control
SMCL	Secondary maximum contaminant level
SPC	Specific conductance
TKN	Total Kjeldahl nitrogen
TSI	Trophic State Index
TDS	Total dissolved solids
TOC	Total organic carbon
TP	Total phosphorus
UMass	University of Massachusetts
USGS	United States Geological Survey

Executive Summary

This report presents the results of the City of Cambridge, MA Water Department (CWD) Source Water Quality Monitoring Program, an ongoing study to assess reservoir and tributary-stream quality in the Cambridge drinking water source area. Calendar year 2014 sampling results are compared to Federal and Massachusetts ambient and drinking water quality standards, as well as with past data primarily from 2013, 2012 and 2008-2011 CWD reports and a USGS/CWD comprehensive assessment conducted from September, 1997 – November, 1998. This report is intended to aid managers and decision makers, and educate those who are interested in the Cambridge water supply.

Non-mandated source water sampling was conducted to assess the quality and trophic state of the three primary storage reservoirs: the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs. Additionally, water quality data was collected from 12 streams feeding the reservoirs. The goals of source water quality sampling are to provide information on the state of water supply resources, determine their vulnerability to increased loads of nutrients and other contaminants, and inform the drinking water treatment process.

Reservoir waters in 2014 were of good quality and generally met Massachusetts Class A Surface Water Quality Standards. The few instances when Class A water quality standards were violated included: four percent of weekly *E. coli* samples from the Stony Brook Reservoir, and, under periods of reservoir thermal stratification, dissolved oxygen at the lower depths of the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs. Low dissolved oxygen near the reservoir bottom was coincident with releases of iron (Fe) and manganese (Mn) from bed sediments. Weekly samples from the Hobbs Brook and Stony Brook reservoirs met the chloride (Cl^-) Secondary Maximum Contaminant Level (SMCL) drinking water standard, although two samples from Hobbs Brook Reservoir were at the SMCL threshold value of 250mg/L. The highest chloride concentrations of all three reservoirs were measured at Hobbs Brook Reservoir, which is strongly influenced by runoff from deicing salt-treated impervious surfaces, most notably Route 2 and Interstate 95.

Water quality improved as it flowed through the reservoir system from the Hobbs Brook and Stony Brook reservoirs in Weston/Waltham to Fresh Pond in Cambridge. Water at the intake to the treatment plant in Fresh Pond had consistently low concentrations of nutrients and selected total metals.

In general, tributary water quality in dry weather met Class A standards. However, salt concentrations at Salt Depot Brook, Lexington Brook, Industrial Brook, Tracer Lane, and WA-17 consistently exceeded the SMCL for chloride and all tributary sites had sodium (Na^+) concentrations well in excess of the 20 mg/L Massachusetts Drinking Water Guideline. All tributary sites met the 10 mg/L SMCL for nitrate but exceeded the EPA 0.31 mg/L nutrient criteria at least once, indicating anthropogenic impacts to source water bodies. While only one third of tributary baseflow samples exceeded the EPA nutrient criteria for total phosphorus (TP), nearly all wet weather samples exceeded the criteria, which demonstrates the importance of stormwater management in controlling phosphorus loads in the reservoirs.

An analysis of tributary pollutant loads and yields revealed that Hobbs Brook Reservoir was more affected by stormwater pollution than Stony Brook Reservoir. The majority of TP loading (64 percent) at Hobbs occurred during stormflow, whereas only 41 percent was attributable to stormflow at Stony. The majority of sodium, chloride, and nitrate loads at both reservoirs was attributable to baseflow. While total tributary pollutant loads were higher at Stony Brook Reservoir than at Hobbs Brook Reservoir due to the large drainage area of the Stony Brook Reservoir, nearly all pollutant yields were higher for tributaries discharging into the Hobbs Brook Reservoir. This reflects the highly developed landscape in the Hobbs Brook catchments.

In this study period, the Cambridge watershed received 51.44 inches of rain, as measured at the Hobbs Brook Dam USGS precipitation gage. This is greater than the 48.82 inch NOAA 1981-2010 Climate Normal for precipitation at the Bedford, MA Station, but within the expected range of precipitation for the Boston-area. For a portion of this period, CWD finished (treated) water was supplemented with Massachusetts Water Resource Authority (MWRA) supply to support State and local construction projects. The water balance estimates in Hobbs Brook Reservoir show that the time required for complete flushing of the reservoir (retention time) in 2014 was 12 months. The average retention time of Stony Brook Reservoir was approximately 15 days, with total annual diversion to the Charles River of roughly 5.5 billion gallons. The residence time for Fresh Pond during this period was approximately 5 months.

Introduction

This report describes the results of the City of Cambridge Water Department's source water quality monitoring efforts in the year 2014, as part of a long-term ongoing study of the health and overall state of the City's drinking water supply. The report was adapted from the 2013 Source Water Quality Report.

The City obtains water from the Stony Brook watershed located in the towns of Lincoln, Weston, and Lexington and the City of Waltham. Water travels by gravity to the Walter J. Sullivan Purification Facility in Cambridge through a network of reservoirs, tributaries, and an underground aqueduct (Figure 1). The Stony Brook watershed is relatively urbanized and its unmitigated growth has the potential to negatively impact water quality. The City of Cambridge only owns and controls approximately 10 percent of watershed lands. This lack of ownership and high development potential requires environmental monitoring to ensure long-term water resources protection and water supply security for the City of Cambridge.

The water quality monitoring program, as implemented, was designed by the U.S. Geological Survey (USGS), in cooperation with the Cambridge Water Department (CWD), and is based in part on the results of a 1997 - 1998 comprehensive assessment of reservoir and stream quality (Waldron and Bent, 2001). The assessment, conducted jointly by the USGS and the CWD, included a detailed analysis of the watershed and the identification of subbasins exporting disproportionate amounts of pollutants to the reservoirs. This information was then used to design the monitoring network which now makes up CWD's long-term source water quality monitoring program.

The USGS/CWD partnership continues to this day and funds "real-time" water quantity and quality monitoring stations, data collection, and interpretive analysis. All data by USGS is public record and can be retrieved online at this URL.

http://waterdata.usgs.gov/ma/nwis/current?type=cambrid&group_key=NONE&search_site_no_station_nm=&format=html_table

Purpose

The purpose of this report is to characterize Cambridge watershed source water quality for calendar year 2014. The report uses water quality data from the CWD 2013, 2012 and 2008-2011 monitoring reports for comparison, as well as data compiled from historical water quality monitoring databases for trend analyses and illustration. Obtaining long-term water quality information is essential in guiding watershed management practices and informing water treatment operations. By understanding where certain water quality problems exist, City resources can be better focused and targeted. Watershed staff can use water quality data to evaluate the efficacy of management initiatives and re-prioritize their efforts if necessary.

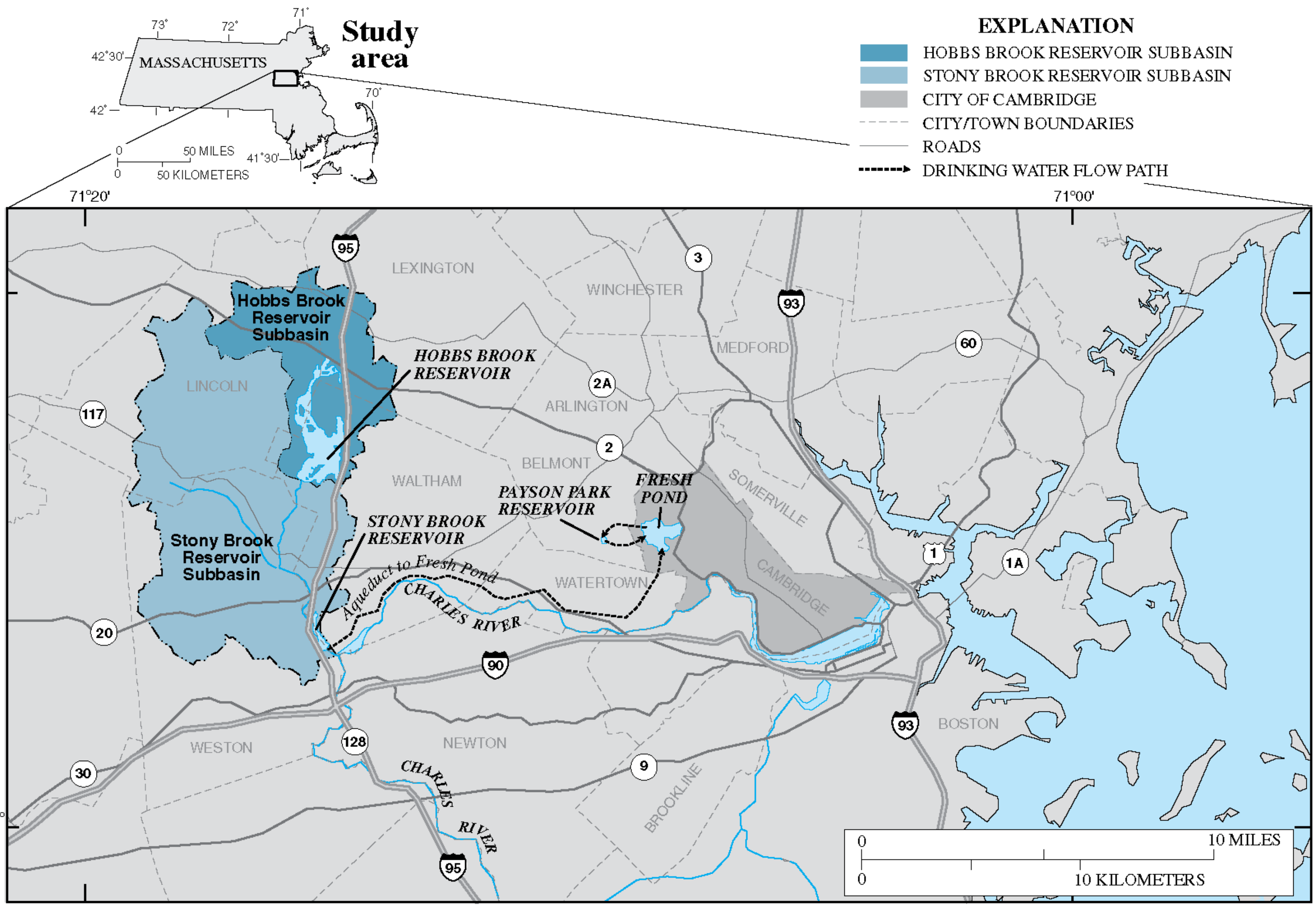


Figure 1: Cambridge Water Supply Source Area

Water Supply Network

The City of Cambridge obtains its water from the 24-square mile Stony Brook watershed located in the towns of Lincoln, Weston, Lexington and the City of Waltham. This “upcountry” watershed is nested within the Charles River Basin and contains two major impoundments constructed in the 1890’s, the Hobbs Brook and Stony Brook Reservoirs. The Hobbs Brook Reservoir (also known as the Cambridge Reservoir) receives water from a 7-square mile subbasin and discharges into Hobbs Brook through a gatehouse on Winter Street in Waltham. Hobbs Brook joins Stony Brook further downstream, which flows into the Stony Brook Reservoir on the Weston, Waltham town line. From the Stony Brook Reservoir, water is fed by gravity through a 7.7 mile underground pipeline to Fresh Pond, a kettle pond in western Cambridge, located in the Mystic River Basin.

During high flow periods (mainly winter and spring), the primary source area for the water supply is the Stony Brook Reservoir and its subbasin. During low flow periods (mainly summer and autumn), water is released at the Hobbs Brook dam to supply most of the City’s daily water demand.

The Walter J. Sullivan Water Purification Facility within the Fresh Pond Reservation treats water from the Fresh Pond Reservoir. Treated water is pumped to Payson Park underground storage/treatment facility in Belmont, where it is then fed by gravity to the City’s distribution system. Capacity at full pool for the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs is roughly 2.5 billion, 418 million, and 1.5 billion gallons respectively.

In the event of an emergency, the City has a back-up connection to the MWRA (Massachusetts Water Resources Authority) supply. The MWRA supply was used exclusively during the construction of the current Water Treatment Plant from 1999-2001. During the 2014 calendar year, the City of Cambridge supplemented its supply with MWRA to support infrastructure repairs in Watertown and Cambridge. Supplemental MWRA water was supplied starting in September of 2013 and continued through May of 2014.

Methodology

Monitoring Parameters and Standards

CWD monitors source water quality to assess general stream and reservoir health and to inform treatment plant operators during the water treatment process. The most common parameters are listed and explained below. The various standards and regulations applicable are provided in addition to the descriptions.

<u>*E. coli*</u> – This *E. coli* bacteria serotype is found in the digestive systems of warm-blooded animals and is used as an indicator for sewage-related pathogens. Massachusetts Class A ambient water quality standards state that no single sample shall exceed 235 Colonies/100mL (measured as *most probable number* [MPN] by the CWD laboratory).

<u>Phosphorus</u> – In the Cambridge water supply, phosphorus is the limiting nutrient for aquatic plant and algae growth. Excessive phosphorus input can cause increased rates of eutrophication (water body productivity), leading to water quality impairments including, but not limited to, taste and odor problems

and low dissolved oxygen availability for fish and wildlife. EPA (Environmental Protection Agency) total phosphorus (TP) targets in this region are 0.02375 mg/L for streams and 0.008 mg/L for lakes/reservoirs.

Nitrate – Nitrate (NO_3^-), is a common inorganic form of nitrogen. In ambient waters, it is a nutrient for plant and algae growth, with EPA targets set at 0.31 mg/L for the combined nitrate and nitrite (NO_2^-) concentration for area streams and 0.05 mg/L for lakes/reservoirs. Sources include septic systems and fertilizer runoff from agricultural uses, lawn maintenance, and turf-management. The drinking water maximum containment level (MCL) is 10 mg/L.

Chlorophyll-*a* – The measured amount of chlorophyll-*a* in the water column is indicative of suspended algae biomass and is used to characterize a reservoir's productivity/trophic state.

Dissolved Oxygen (DO) – Dissolved oxygen in water is critical to supporting a healthy fish and wildlife population. Low dissolved oxygen and anoxic conditions can mobilize nuisance metals such as iron and manganese and release nutrients from sediments. Massachusetts Class A ambient water quality standards state that dissolved oxygen should not be less than 6 mg/L in cold water fisheries and 5 mg/L in warm water fisheries, unless natural background conditions are lower.

pH – pH is a measure of acidity in water and is defined as the $-\log[H^+]$. Water with a pH level of 7 is considered neutral; water with a pH below 7 is acidic and above 7 is basic. The acceptable range of pH levels for Massachusetts Class A freshwater systems is 6.5 to 8.3, although pH levels must be no more than 0.5 units outside of the background range for the system. Waters with pH levels outside of this range can be harmful to fish and wildlife, and high pH levels can be indicative of algae blooms.

Specific Conductance (SPC) – Specific conductance is the ability of water to conduct electrical current, normalized to 25°C. In the field, it is used as a surrogate for sodium and calcium chloride deicing agents. Abrupt changes in specific conductance can also be an indicator of pumping, dumping or other activities requiring investigation.

Iron/Manganese – Iron (Fe) and manganese (Mn) in drinking water are not considered health hazards, but an excess can lead to staining and other aesthetic issues. These metallic elements are naturally-occurring in the earth's crust and soils. MA Secondary Maximum Contaminant Levels (SMCLs) are 0.3 mg/L for iron and 0.05 mg/L for manganese.

Sodium/Chloride – Sodium chloride (NaCl) is the most commonly used winter deicing agent in the Cambridge source watershed. Tracking sodium and chloride levels in the water supply helps steer efforts to reduce their use without significantly compromising public roadway safety, thereby protecting long term water quality. According to EPA, chloride is considered toxic to aquatic life at 230 mg/L (four day average exceeds criteria at least once every three years, considered chronic toxicity). Chloride concentrations in drinking water above 250 mg/L (SMCL) typically correspond with sodium levels high enough to impart a noticeably "salty" taste.

Total Organic Carbon (TOC) – TOC is used to quantify naturally-occurring organic matter in the water supply. When mixed with chlorine, carbon can react to form disinfection byproducts (haloacetic acids and trihalomethanes) nationally regulated and monitored by CWD.

Reservoir Trophic State (TSI) - Carlson's trophic state index (TSI) is a dimensionless numerical index ranging from 0 – 100, indicating the degree of nutrient enrichment of a water body (Table 1). TSI values less than 40 indicate a low productivity state (oligotrophic) and minimal external nutrient loading. Values ranging between 40 and 50 indicate moderate productivity (a mesotrophic state) and intermediate external nutrient loading. Values greater than 50 indicate a water body that is considered highly productive (eutrophic) and likely to produce algal blooms.

The TSI of a water body can be estimated using chlorophyll-*a* (chl-*a*) concentrations, TP concentrations (TP), or measured secchi depths (SD). As TSI is an estimator of algal biomass weight in the reservoir, chlorophyll-*a* concentration is the best parameter to use to calculate TSI.

Table 1: Trophic State Index Explanation, Water Quality Implications

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

TSI	Chl (µg/L)	SD (m)	TP (ug/L)	Attributes	Water Supply
<30	<0.95	>8	<6	Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for an unfiltered water supply.
30 - 40	0.95 - 2.6	8 - 4	6 - 12	Hypolimnia of shallower lakes may become anoxic.	
40 - 50	2.6 - 7.3	4 - 2	12 - 24	Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	Iron, manganese, taste, and odor problems worse. Raw water turbidity requires filtration.
50 - 60	7.3 - 20	2 - 1	24 - 48	Eutrophy: Anoxic hylpolimnia, macrophyte problems possible.	
60 -70	20 - 56	0.5 - 1	48 - 96	Blue-green algae dominate, algal scums and macrophyte problems.	Episodes of severe taste and odor possible.
70 - 80	56 - 155	0.25 - 0.5	96 - 192	Hypereutrophy: (light limited productivity). Dense algae and macrophytes.	
>80	>155	<0.25	192 - 384	Algal scums, few macrophytes.	

*http://www.secchidipin.org/tsi/htm#Relating%20Trophic%20State%20to%20the%20State%20of%20the%20Waterbody

Monitoring Equipment

CWD measures *in situ* parameters, such as temperature, dissolved oxygen (DO), specific conductivity, pH, and oxidation reduction potential (ORP), using a calibrated Eureka Water Probes (formerly Eureka Environmental and Measurement Specialties) Manta2™ Multiprobe. Grab samples are taken from streams and reservoirs using 1 Liter Teflon bottles for nutrients and high density polyethylene (HDPE) bottles for all other parameters. A peristaltic pump and pre-cleaned Tygon tubing is used for taking bottom samples from the reservoirs. All samples are transported back to the Walter J. Sullivan Purification Facility on ice for processing and are analyzed through a contracted laboratory for nutrients and chlorophyll-*a*, and in-house for all other parameters.

Monitoring Procedure and Schedule

Water samples for chemical analysis were collected at 12 tributary and 11 reservoir sampling stations using *Clean Water* protocols (Wilde and others, 1999) for all aspects of sample collection, preservation, and transport. For a more detailed discussion on the methods and process overview of the water quality monitoring program, refer to Appendix A.

Reservoir Sampling

The Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs were sampled to assess overall reservoir health four times during 2014 (Table 2). Hobbs Brook Reservoir had four monitoring sites, two of which were sampled from the shoreline (HB @ Upper & HB @ Middle), and the other two (HB @ DH and HB @ Intake), were sampled by boat at fixed mooring locations (Figure 2). Stony Brook Reservoir had two sites sampled by boat (SB @ DH, and SB @ Intake), and Fresh Pond Reservoir had three sites (FP @ Cove, FP @ DH, FP @ Intake) all sampled by boat.

Surface samples of chlorophyll-*a*, nutrients, bacteria, and selected metals were taken at each reservoir's deep hole (DH) buoy (deepest point of the reservoir) along with Secchi depth measurements. During periods of thermal stratification, additional samples were taken from the bottom layer (hypolimnion) of the reservoir. Depth profiles of dissolved oxygen, temperature, pH, and specific conductance were taken at both the DH sites and buoys close to the gatehouse intake structures. The profiles were used to monitor thermal and chemical stratification within the reservoirs, and to inform the operation of the aeration system at Fresh Pond and Stony Brook Reservoirs (see the *Reservoir Water Quality* section for more information). *E. coli* bacteria samples were also collected at "intake" buoys.

In addition to the reservoir monitoring program, weekly surface grab samples were collected from inside the Hobbs Brook Dam gatehouse, or when the reservoir was frozen over, from the dam outlet (Table 2). Weekly grab samples were also collected from inside the Stony Brook Dam gatehouse. The weekly monitoring events helped capture seasonal and climatic water quality variability and were used to track chemical concentration changes over time. Weekly samples were analyzed primarily for *E. coli* bacteria, select metals, TOC, and specific conductance.

Table 2: Reservoir Sampling Program, 2014

Reservoir Monitoring Site	2014 Sample Frequency	Surface Grab*	Bottom Grab**	Composite Depth Sample	Depth Profile***
Hobbs Brook					
Upper	4x / yr	X			
Middle	4x / yr	X			
Deep Hole (DH)	4x / yr	X	X		X
Intake	4x / yr	X			X
Gatehouse	Weekly	X			
Stony Brook					
Deep Hole (DH)	4x / yr	X	X		X
Intake	4x / yr	X			X
Gatehouse	Weekly			X	
Fresh Pond					
Deep Hole (DH)^	9x / yr	X	X		X
Intake	8x / yr	X			X
Cove	7x/ yr				X

*Intake grab samples test for *E. coli* only. All other grab samples test for *E. coli*, select metals and nutrients, turbidity, and TOC. Chl-*a* is also measured in grab samples at all deep hole sites as well as at HB @ Middle and HB @ Upper.

**Only collected during periods of thermal stratification

***Depth profiles include measurments of temperature, pH, DO, and specific conductance

^Five sampling events contained grab samples and depth profiles, four sampling events were depth profiles only.

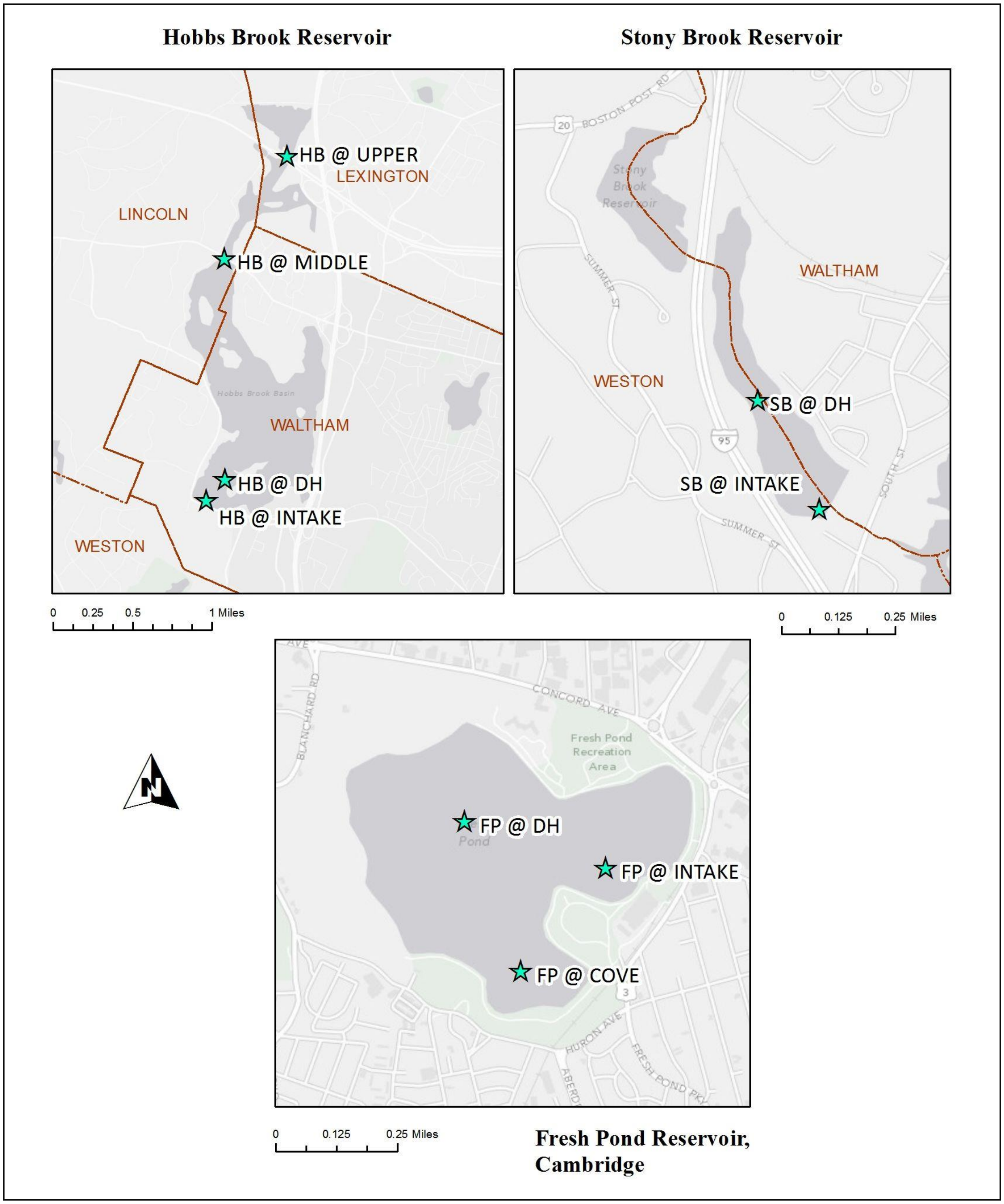


Figure 2: Reservoir Sampling Locations

Reservation Pond Sampling

As part of the Fresh Pond Reservation Master Plan implementation, water quality monitoring was conducted at three small ponds within the Fresh Pond Reservation: Black's Nook, Little Fresh Pond (LFP), and North Pond (Figure 3). Each of the ponds drains the nine-hole Cambridge Municipal Golf Course. There are no natural surface water connections between Fresh Pond Reservoir and any of these ponds. However, the potential exists for groundwater communication between them. Under the Massachusetts State regulations, these ponds are considered Class B water bodies since they support primary contact recreation and are not considered to be part of the drinking water supply.

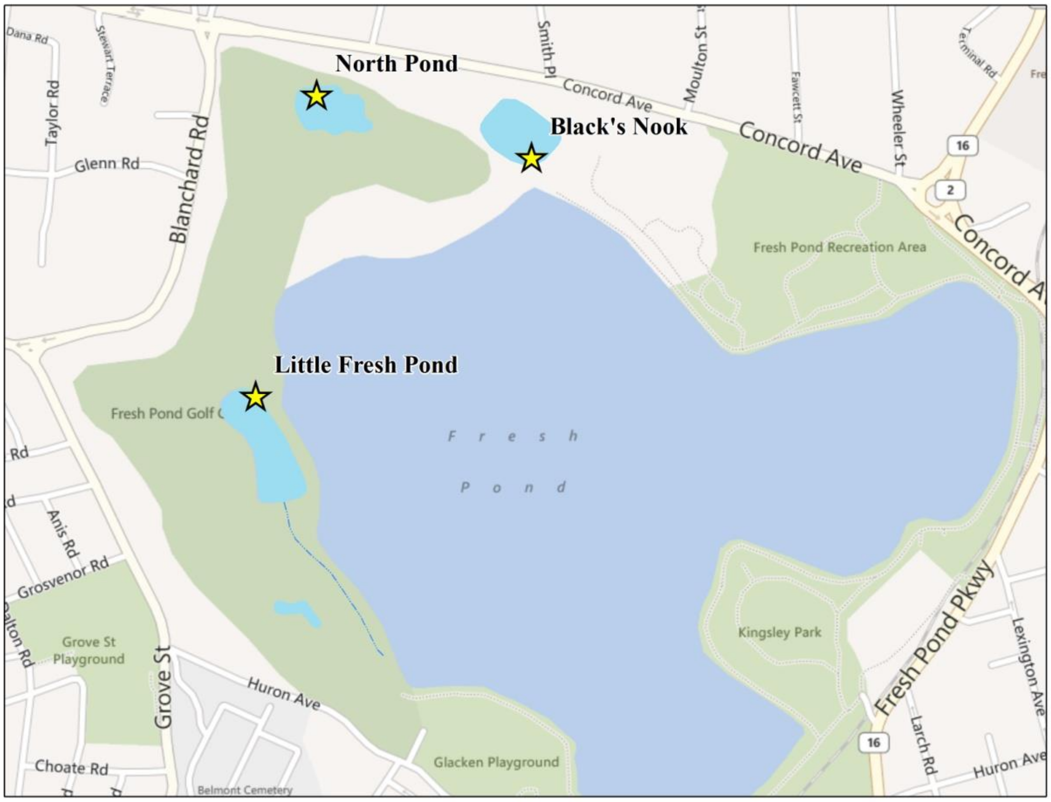


Figure 3: Fresh Pond Reservation Sampling Locations

During this period, reservation ponds were sampled three times. The samples were taken from Little Fresh Pond and North Pond through shoreline wading and taking a surface grab sample with an extended telescoping pole; the samples were taken from Black's Nook using the pole from the viewing deck. No wet weather samples were taken. These ponds are physically, chemically, and ecologically different from the reservoirs in the drinking water supply in that they are significantly smaller, shallower, and more productive. Average pond depth is approximately 6 feet. See Appendix B for 2014 results and analysis.

Tributary Sampling

Twelve primary tributary sampling sites (Figure 4) were sampled five to six times under dry conditions in 2014 (see Appendix A for sampling dates). Samples were physically collected from the streams by the centroid dip technique (Edwards and Glysson, 1999). On two occasions, samples were collected simultaneously by CWD and USGS staff: the WA – 17 site on June 10th and HB @ Mill St. on June 12th.

Comparison of water quality results between the CWD and USGS samples serve as a broad quality control (QC) measure to gauge the inherent variability in surface water samples.

Nine of the 12 primary tributary sites are also equipped with USGS monitoring stations that continuously monitor stream stage, discharge (estimated based on stage), temperature, and specific conductance as part of a joint-funding agreement (JFA) between the CWD and USGS (Figure 4). Data from these sites are available on line in real time (http://waterdata.usgs.gov/ma/nwis/current/?type=cambrid&group_key=basin_cd&site_no_name_select=siteno).

The USGS took wet weather water quality samples 4 to 7 times at five monitoring sites in 2014. CWD measured water quality during one storm event on April 8, 2014. These samples were used to assess water quality during storm events in the watershed tributaries. See Appendix A for the 2014 stormwater sampling schedule and Appendix C for sample quality control.

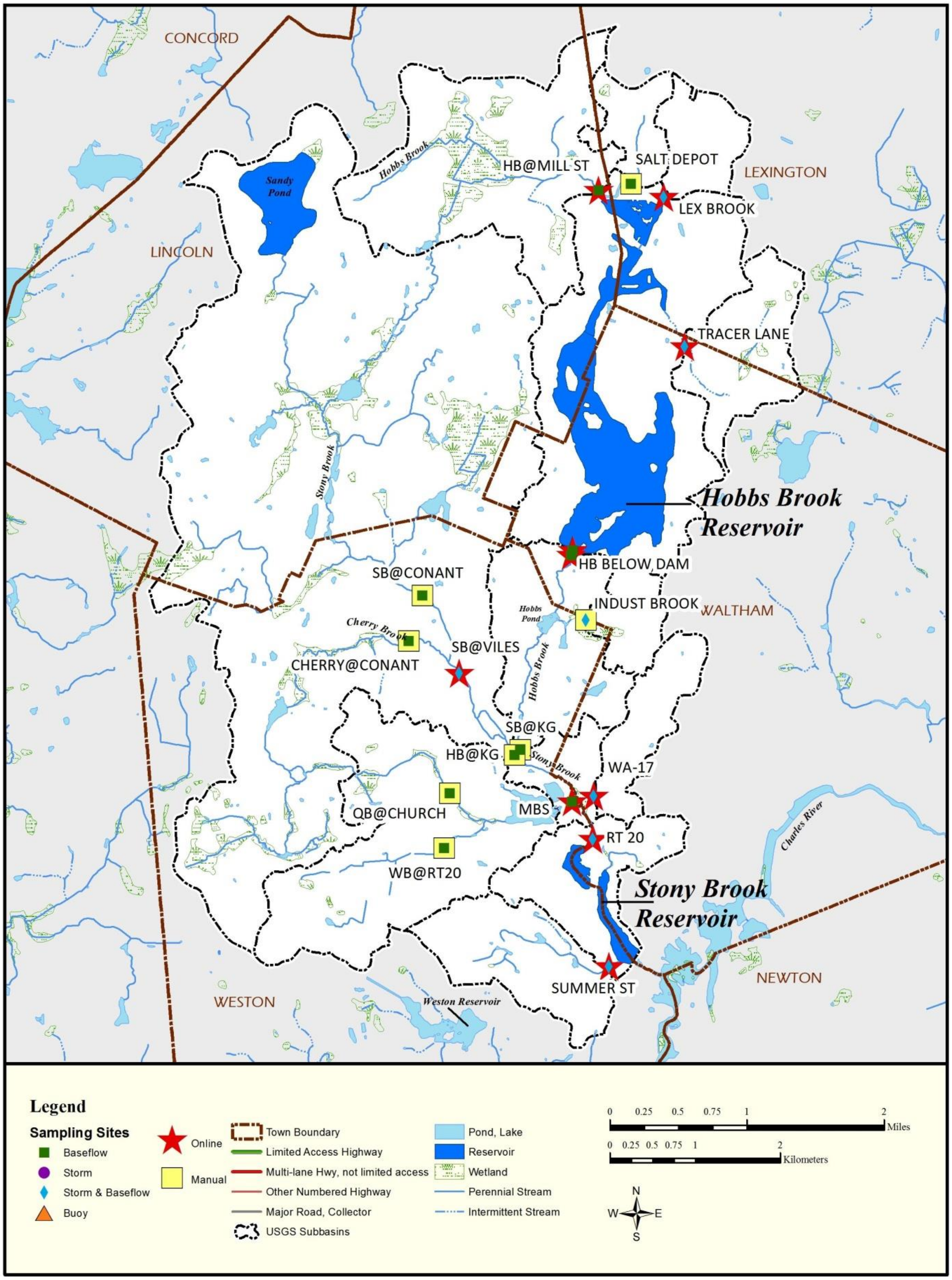


Figure 4: Tributary Monitoring Station Locations within the Watershed

Load and Yield Calculations

The water quality monitoring program described above measures the concentration of pollutants in tributaries at specific points in time. However, the impact of a pollutant on reservoir water quality depends not only on pollutant concentration, but also on the volume of water discharging into the reservoir. For example, a small (low flow) tributary with a high salt concentration may contribute less sodium than a large (high flow) tributary with a lower concentration of sodium. Therefore, to account for the effect of tributary water volume on reservoir water quality, the annual load and yield of sodium, chloride, nitrate, and TP were calculated for each tributary that discharges directly into the Hobbs Brook and Stony Brook reservoirs, as well as WA-17. The annual load (total pollutant mass) and yield (load standardized by catchment area) were calculated separately for base-flow and stormflow using the formulas below:

$Load_{base\text{-}flow} = \mu_{CWD} \times Q_{base\text{-}flow}$
$Load_{stormflow} = \mu_{USGS} \times Q_{stormflow}$

Where:
μ_{CWD} = 2014 geometric mean concentration of Na^+, Cl^-, NO_3^-, or TP measured by CWD during dry conditions, in mg/L
$Q_{base\text{-}flow}$ = 2014 base-flow, in L/yr

μ_{USGS}[1] = 2014 geometric mean concentration of Na^+, Cl^-, NO_3^- or TP measured by USGS during storm events,[2] in mg/L
$Q_{stormflow}$ = 2014 stormflow, in L/yr

See Appendix D for the methodology used to separate base-flow and stormflow from total discharge at each site.

The following sections describe selected results of the water quality analyses conducted for all sampling locations in 2014 and provide a comparison to the water quality monitoring conducted from the 2013, 2012 and 2008-2011 reports. A complete list of sample results is provided in Appendix E.

[1] USGS did not perform stormwater sampling at the Salt Depot site during 2014. The mean stormflow concentrations of sodium, chloride, and TP from 2005-2007 (Smith, 2013) were used instead.
[2] USGS did not collect nitrate stormwater samples in 2014, so the CWD geometric mean nitrate concentration for base-flow was used as a proxy. According to Smith (2013), concentrations of total nitrogen are generally uncorrelated with streamflow. Therefore, it is reasonable to use the CWD base-flow nitrate concentration as a proxy for the stormflow concentration.

Reservoir Water Quality

Since the 1970s, CWD has been monitoring seasonal thermal stratification, which occurs in all three reservoirs with implications on water quality. In the spring, surface water begins to warm, forming a distinct upper layer (epilimnion) of less dense water that will not mix with colder, denser bottom waters (hypolimnion). Biochemical processes in the isolated bottom waters require oxygen and can create reduced (anoxic) conditions which stress fish and other aquatic fauna. Nuisance metals, such as iron and manganese, and nutrients normally bound to sediments can be released into the hypolimnion in the absence of an oxygenated environment. These metals and nutrients are then introduced into the water supply during the fall "turn over", or mixing of the two isothermal layers. Chemical stratification may also occur in the reservoirs as a result of the hypolimnion trapping the denser, more saline water. Specific conductance readings from reservoir depth profiles illustrate chemical stratification development in the warmer months. The following sections describe water quality in the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs throughout all seasons in 2014.

Hobbs Brook Reservoir

The Hobbs Brook Reservoir is divided into three basins by State Route 2, Trapelo Road, and Winter Street (Figure 2). In a typical year, the water column at the deep hole buoy in the lower basin of Hobbs shows signs of thermal and chemical stratification in April and fully stratifies by July. The water column generally mixes by November and exhibits relatively uniform temperature, although dissolved oxygen concentrations may still decrease with increasing depth, indicating incomplete physical mixing.

2014 depth profiles exhibit the expected behavior of thermal stratification during the warmer months (June and September profiles, Figure 5), complete mixing conditions in colder months (November profile, Figure 5), and slight stratification in spring as separation and mixing of the water column occurs. Winter profiles were not collected in 2014, when weather conditions made profiles difficult and unsafe to obtain. Slight winter stratification may occur during years with ice cover, but this stratification tends to be less stable than summer stratification due to the coldest layer forming on top of the denser 4°C layer on bottom. The decreased stability may allow more mixing between layers and may prevent anoxic conditions from forming in the bottom layer.

During the April 22nd and June 19th 2014 sampling events, DO readings were greater than 100 percent at depths less than 5 meters. These values could be attributed to increased algal productivity at the surface of the reservoir. This theory is supported by the high pH levels ranging from 7.42 to 7.90 in the super-saturated layers (compared to pH levels of 6.56-7.27 at the unsaturated depths). The photosynthesis process removes dissolved carbon dioxide from the water column and reduces concentrations of carbonic acid, thus increasing the pH of the water. The April 22nd profile also shows elevated specific conductance in the surface layers of the reservoir. This timing suggests that road salt applied during the winter months may be entering the reservoir with snow melt and spring storm events.

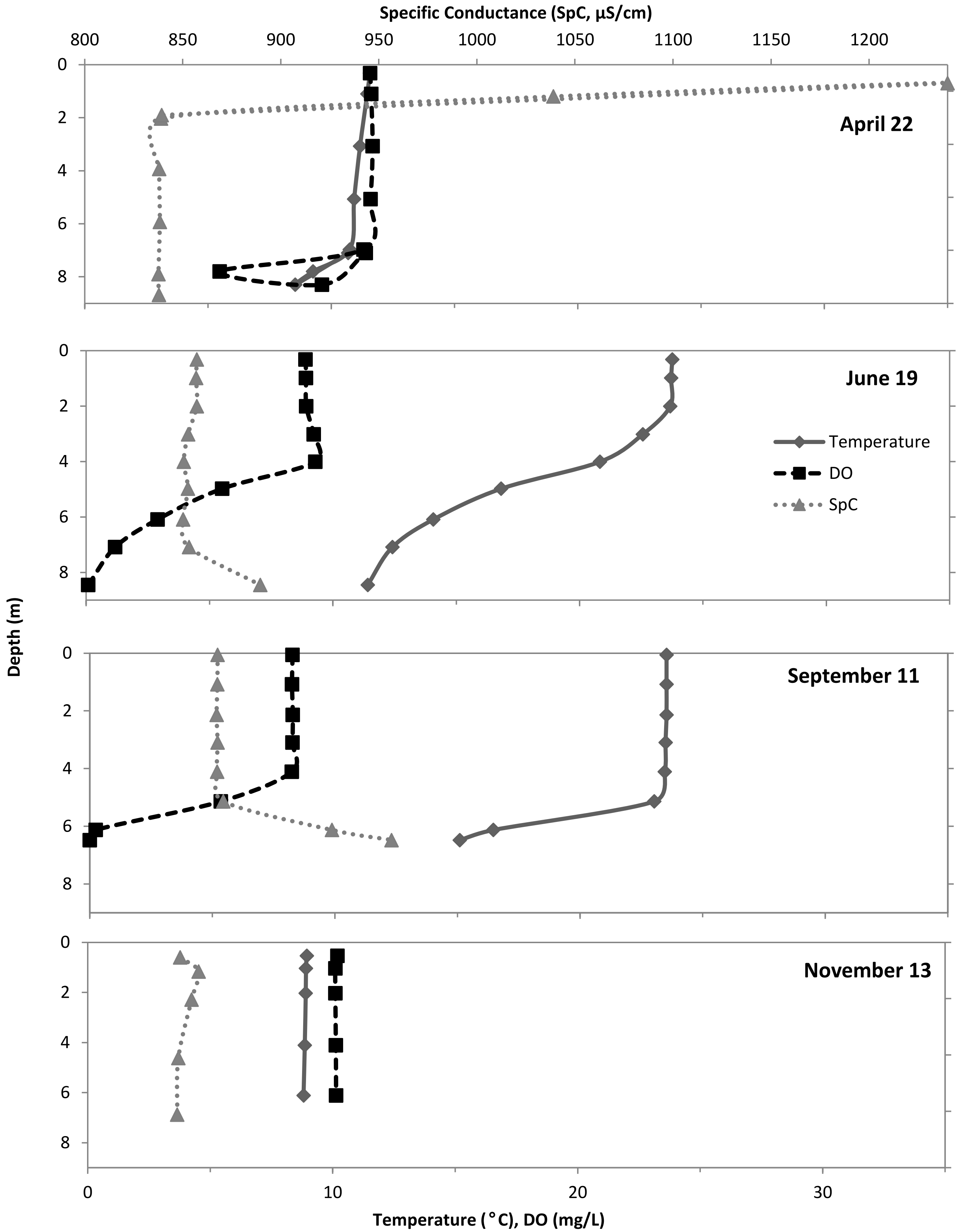


Figure 5: Hobbs Brook @ Deep Hole (HB @ DH) Depth Profiles, April-November 2014

The summer stratification evident in the September 11th profile created anoxic conditions in the hypolimnion. This hypoxia was coincident with an elevated level of manganese (15.6 mg/L) in the HB @ DH bottom sample, which was approximately 270 times greater than the surface concentration of manganese and well above the SMCL of 0.05 mg/L. The HB @ DH bottom chlorophyll-*a* sample was also the highest of the year at 64.3 mg/m^3 (all other bottom and surface samples were below 9 mg/m^3). The elevated chlorophyll-*a* could indicate a subsurface algal bloom. However, the elevated manganese concentration, which was more than double all but one reservoir sample collected by CWD since 2000, along with a relatively high turbidity reading (10.9 NTU), suggests that the water sample was contaminated with bottom bed sediments.

Overall, water quality in Hobbs Brook reservoir for 2014 was very good. The lower basin of the reservoir had the highest water quality, meeting all Massachusetts Class A standards (Table 3). TP levels decreased as the water moved through the reservoir basins, starting in the upper basin at 100 percent exceedance of the EPA nutrient criteria, to 50 percent in the middle basin, and then all samples meeting the EPA criteria in the lower basin. The lower basin contains the deep hole sampling site and is the largest of the three basins, which means that phospohrous pollution is mitigated by reservoir dilution.

MA secondary drinking water standards were exceeded more frequently than the MA Class A Water Quality Standards. The middle basin exceeded all SMCLs at least once in 2014 and was the only site in Hobbs Reservoir to exceed the standard for chloride.

Notably, both the upper and middle basins exceeded iron and manganese targets in every sample. It is possible that the relatively smaller volume of water in these basins results in higher concentrations of these metals under conditions where they would be diluted in the lower basin. Additionally, the shallow nature of both basins allows for greater penetration of wind, and thus more suspended sediment. It is likely that the iron and manganese present in the samples come from suspended particles that are not dissolved in the water. Samples in the lower basin only exceeded the manganese standard during the stratified September 11th sampling event. In the lower basin, manganese concentrations typically met the standards in surface samples and exceeded the standard in bottom samples (Figure 6). Iron concentrations were below the SCML standard in all but one sample (Figure 6). Despite exceedances of iron and manganese, finished (treated) water in Cambridge meets the SMCL standards.

Table 3: Hobbs Brook Reservoir Summary of Exceedances, 2014

Standard	Parameter	Standard	Periodic Reservoir Sampling Sites*				Weekly Sample Site
			HB @ Upper	HB @ Middle	HB @ DH	HB @ Intake	Outlet (intake) Samples
MA Class A Water Quality	DO	> 5 mg/L	0%	0%	0%	0%	NS
	Temp	< 28.3 °C	0%	0%	0%	0%	NS
	pH	Between 6.5 - 8.3	0%	0%	0%	0%	0%
	E.coli, single sample	< 235 MPN	NS	NS	NS	0%	0%
MA Secondary Maximum Contaminant Level (SMCL)	Cl^-	< 250 mg/L	0%	25%	0%	NS	0%
	Mn	< 0.05 mg/L	100%	100%	25%	NS	16%
	Fe	< 0.3 mg/L	100%	100%	0%	NS	8%
	Total Dissolved Solids (TDS)*	< 500 mg/L	0%	75%	100%	100%	NS
EPA Nutrient Criteria for Upper Watershed	NO_3^- + NO_2^- - N	< 0.05mg/L	50%	50%	50%	NS	NS
	TP	< 0.02375 mg/L	100%	50%	0%	NS	NS
Number of Sampling events			**4**	**4**	**4**	**4**	**51**

NS = Not sampled for parameter
*Only surface samples were used for evaluation purposes

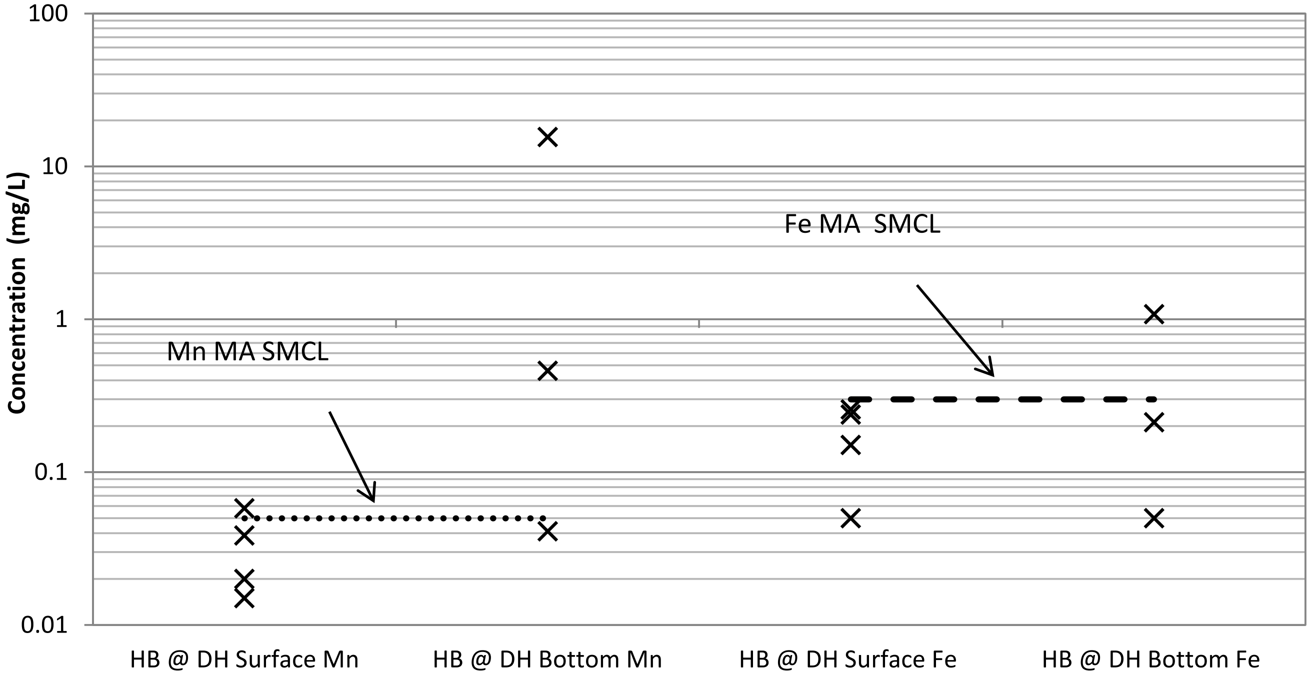


Figure 6: 2014 Hobbs Brook Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Iron (Fe) and Manganese (Mn) Nuisance Metal Concentrations (mg/L) During Periods of Thermal Stratification (Log scale)

Stony Brook Reservoir

The Stony Brook Reservoir is bisected by Interstate 95, with twin box culverts under the interstate directly connecting the two basins. Samples are taken from the deepest part of Stony Brook (SB @ DH) and at the southern gatehouse (SB@INTAKE, Figure 2). Samples are not taken from the upper portion of the reservoir due to lack of boat access.

Water-column sampling at the Stony Brook Reservoir was conducted by CWD staff four times in 2014. Stony Brook has an aeration system designed to aid mixing throughout the reservoir and to help avoid thermal stratification and anoxic conditions from forming in the hypolimnion. The aeration system typically operates during the spring, summer, and fall months. However, in 2014, the system was partially operational during June and was completely shut down from July onwards for repairs.

Surface samples taken from the Stony Brook Reservoir met all Class A water quality standards, with the exception of 4 percent of weekly samples exceeding the standard for *E.coli* (Table 4). Similar to the Hobbs Brook Reservoir, bottom samples from the Stony Brook Reservoir exceeded the manganese SMCL (Figure 8). However, all four surface samples collected from the Stony Brook deep hole buoy exceeded the manganese SMCL, while only one Hobbs Brook surface sample exceeded the SMCL (Figures 6 and 8).

Standard	Parameter	Standard	Periodic Reservoir Sampling Sites		Weekly Samples
			SB @ DH	SB @ Intake	Output (Intake) Samples
MA Class A Water Quality	DO	> 5 mg/L	0%	0%	NS
MA Class A Water Quality	Temperature	< 28.3 °C	0%	0%	NS
MA Class A Water Quality	pH	Between 6.5 - 8.3	0%	0%	0%
MA Class A Single Sample	*E. coli*	< 235 MPN	NS	0%	4%
MA Secondary Maximum Contaminant Level (SMCL)	Cl^-	< 250 mg/L	0%	NS	0%
MA Secondary Maximum Contaminant Level (SMCL)	Mn	< 0.05 mg/L	100%	NS	84%
MA Secondary Maximum Contaminant Level (SMCL)	Fe	< 0.3 mg/L	25%	NS	8%
MA Secondary Maximum Contaminant Level (SMCL)	Total Dissolved Solids (TDS)*	< 500 mg/L	0%	0%	NS
EPA Nutrient Criteria for Upper Watershed	$NO_3^- + NO_2^-$ - N	< 0.05mg/L	100%	NS	NS
EPA Nutrient Criteria for Upper Watershed	TP	< 0.02375 mg/L	0%	NS	NS
Number of Sampling Events			**4**	**4**	**51**

Table 4: Stony Brook Reservoir Summary of Exceedances, 2014

Chemical stratification is evident in the April profile, with slight chemical stratification observed in the June and November profiles (Figure 7). Physical stratification occurred in the spring and late fall; however, the partial operation of the aeration system minimized stratification in the June profile, which showed a consistent decline in temperature with depth rather than complete thermal stratification. A naturally occurring turnover event resulted in complete mixing of the reservoir waters in the fall, visible in the September profile.

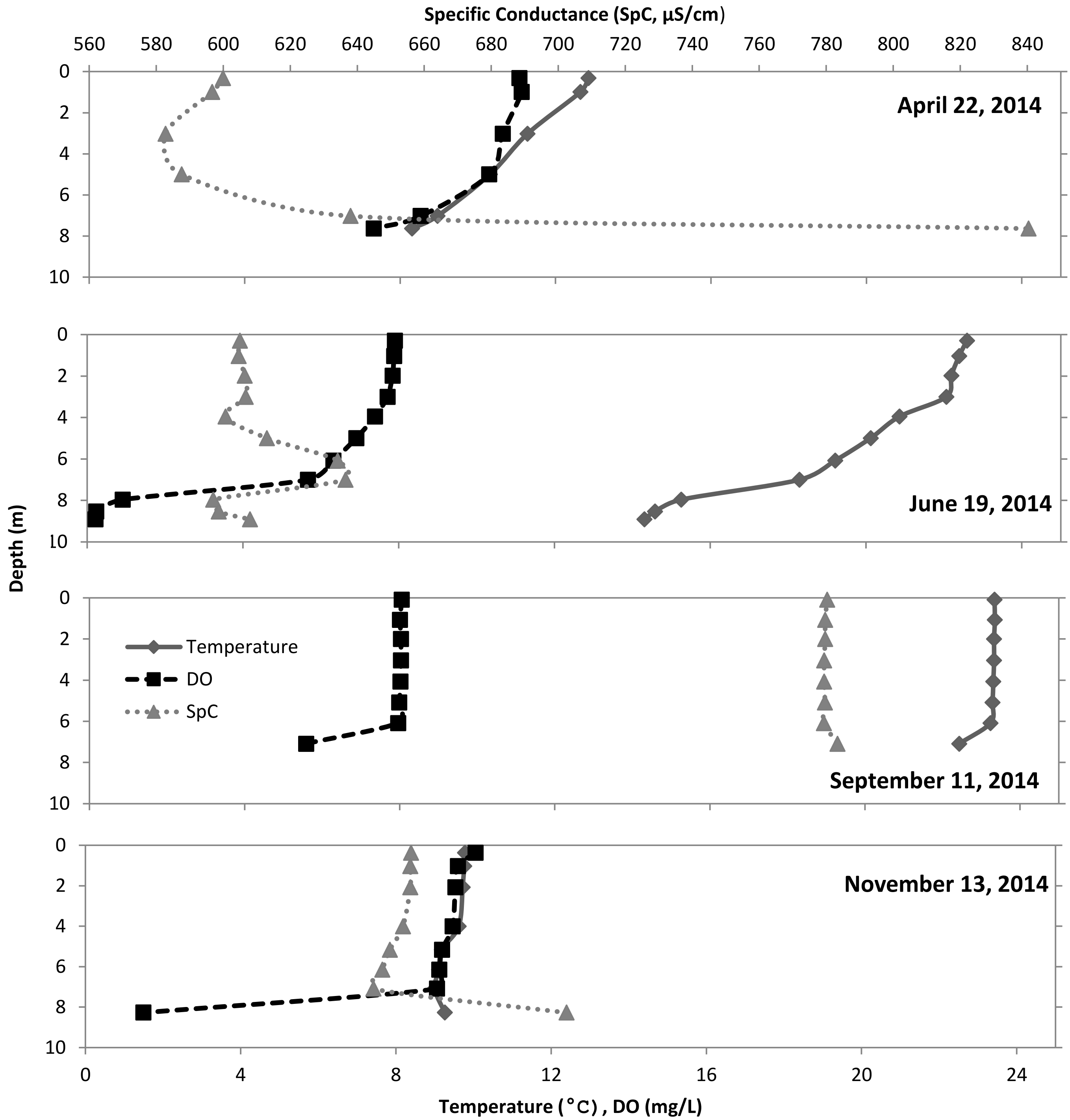


Figure 7: Stony Brook @ Deep Hole (SB @ DH) Depth Profiles, April-November 2014

As in the Hobbs Brook Reservoir, under hypoxic conditions, nuisance iron and manganese were reduced and released from benthic sediments into the water column. The median surface and bottom iron and manganese concentrations are shown in Figure 8. A greater magnitude of difference between the surface and bottom heavy metal samples during thermal stratification is generally measured at the Stony Brook Reservoir as compared to the Hobbs Brook Reservoir. This is likely due to differences in bed-sediment composition (Waldron and Bent, 2001), although a larger difference between surface and bottom median concentrations were observed in Hobbs Brook Reservoir in 2014 than in Stony Brook Reservoir.

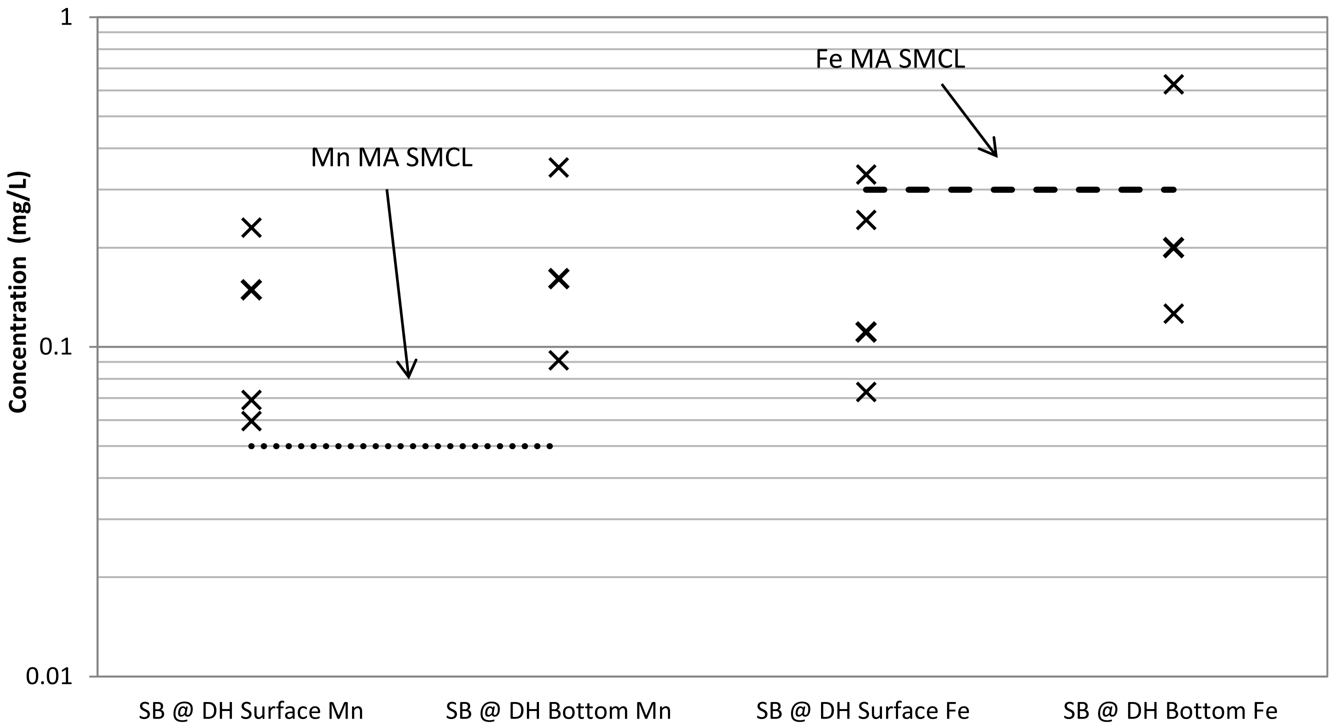


Figure 8: 2014 Stony Brook Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Iron (Fe) and Manganese (Mn) Nuisance Metal Concentrations (mg/L) During Periods of Thermal Stratification (Log scale)

Fresh Pond Reservoir

Monitoring and managing thermal stratification is particularly important in Fresh Pond because it is the terminal water supply reservoir in the system. Water is pumped directly from Fresh Pond and treated in the Walter J. Sullivan Purification Facility for potable uses. Spikes in nuisance metal concentrations, if not controlled in a timely fashion through the treatment process, could produce drinking water with taste, odor, color, or other aesthetic issues. Similar to the Stony Brook Reservoir, an aeration system at Fresh Pond operates continuously (overnight) throughout spring until the autumn turnover to help avoid anoxic conditions in the reservoir.

Water quality grab samples were collected five times in 2014; water-column profiles were taken a total of nine times to monitor reservoir stratification and guide aeration system management. In general, even with the aeration system running, Fresh Pond will start to stratify in April and will begin to mix towards the end of September or beginning of October, depending on the severity of the summer. In 2014, Fresh Pond exhibited slight thermal stratification April through June, and was fully stratified July through September (Figure 9). All surface samples taken from Fresh Pond met Class A water quality standards for DO, temperature, pH, and *E. coli* (taken from FP @ INTAKE) (Table 5).

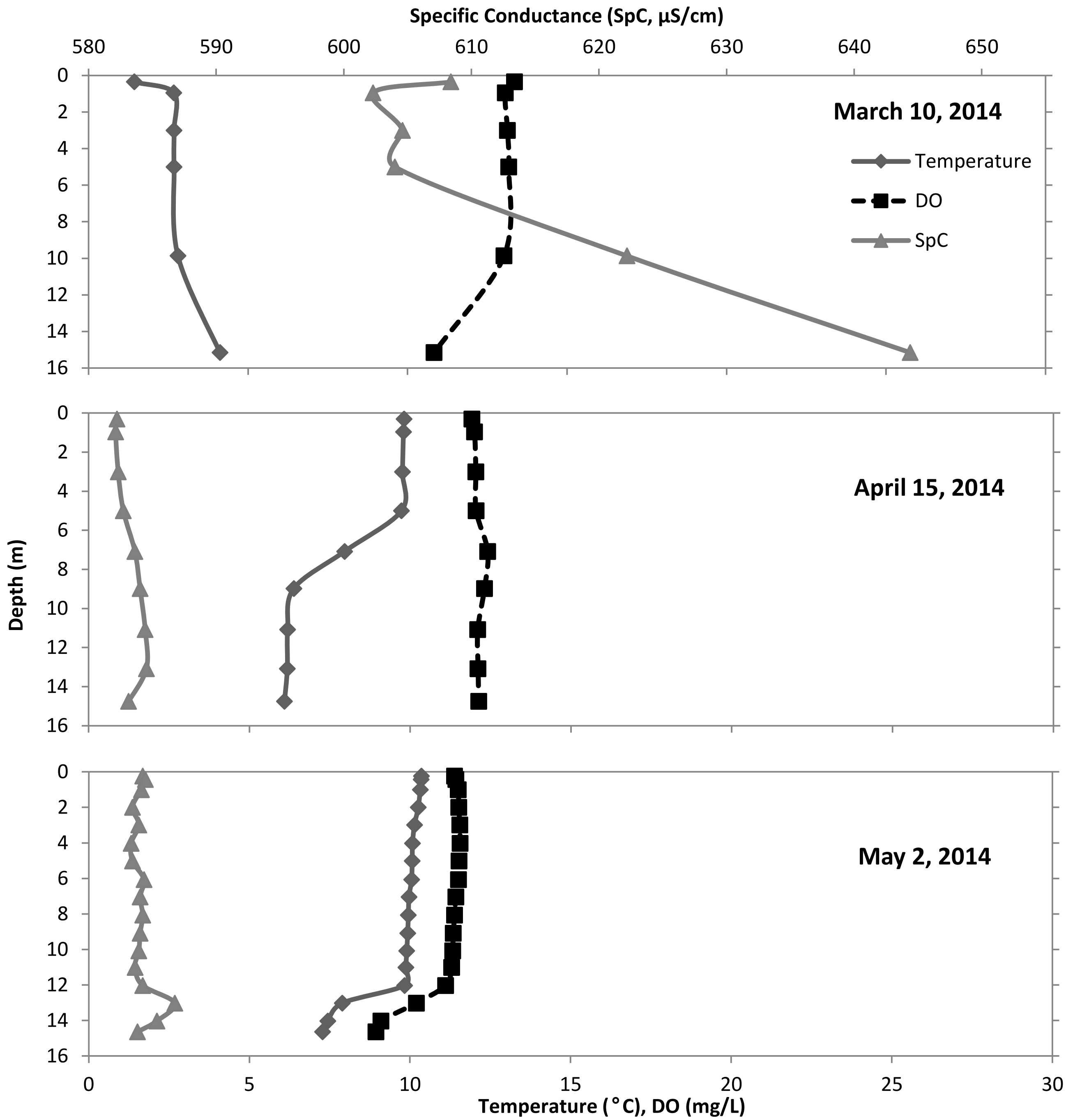


Figure 9: Fresh Pond @ Deep Hole (FP @ DH) Profiles March-November 2014

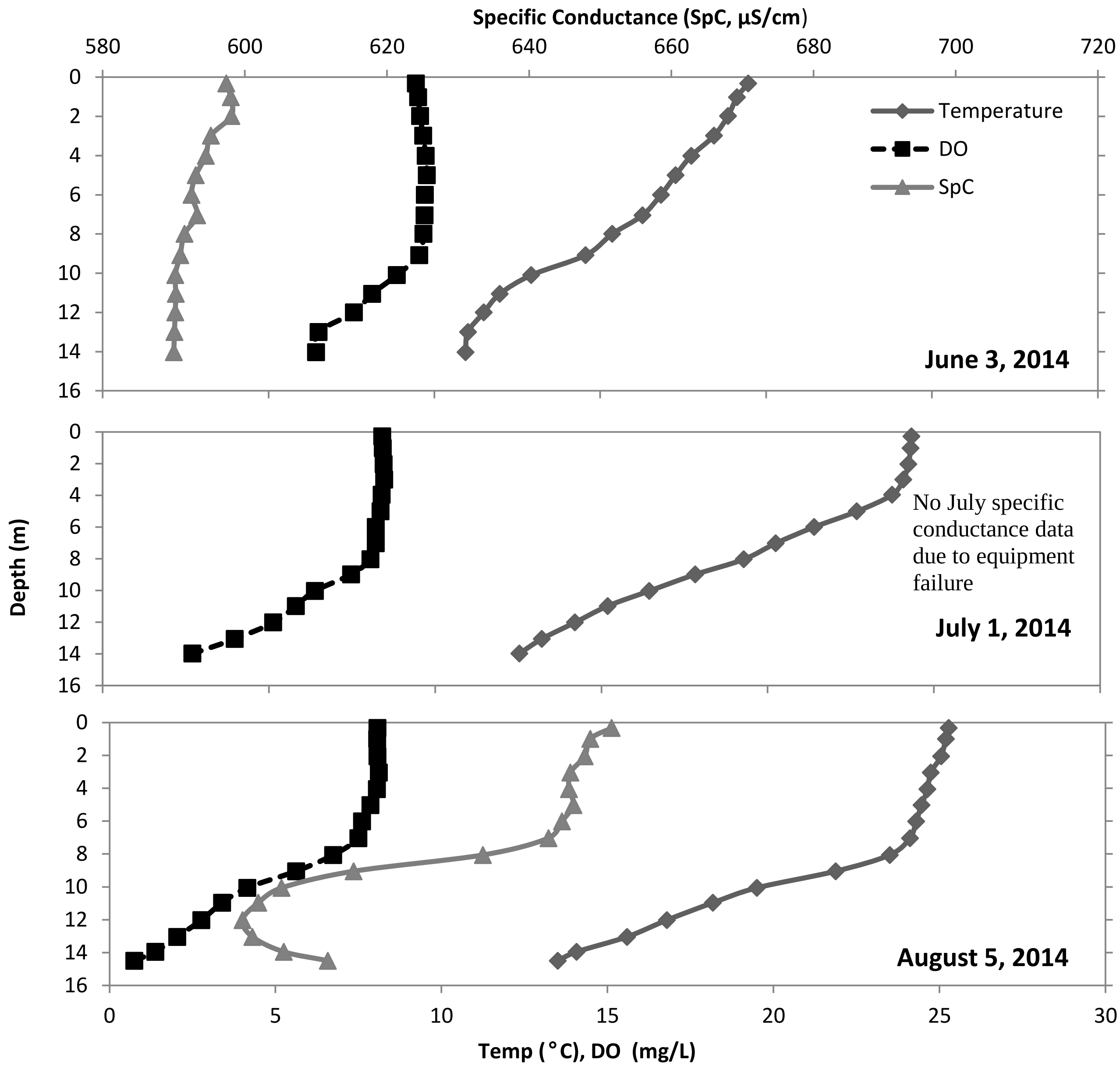


Figure 9: Fresh Pond at Deep Hole (FP @ DH) Profiles March-November 2014 Cont.

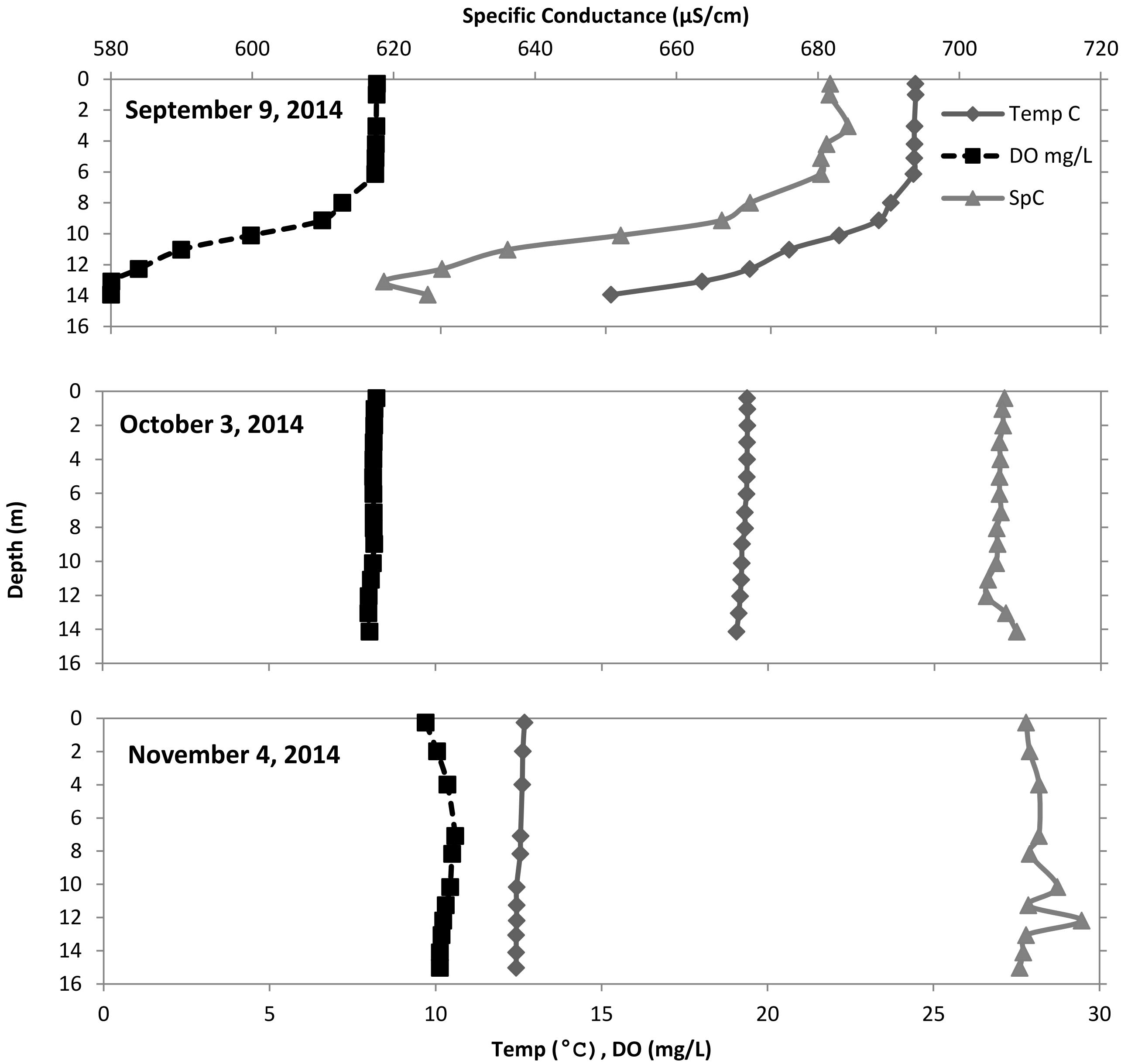


Figure 9: Fresh Pond at Deep Hole (FP @ DH) Profiles March-November 2014 Cont.

Table 5: Fresh Pond Reservoir Summary of Exceedances, 2014

Standard	Parameter	Standard	FP @ Intake	FP @ DH*
MA Class A Water Quality	DO	> 5 mg/L	0%	0%
	Temperature	< 28.3 °C	0%	0%
	pH	Between 6.5 - 8.3	0%	0%
	E. coli (single sample)	< 235 MPN	0%	NS
MA Secondary Maximum Contaminant Level (SMCL)*	Cl^-	< 250 mg/L	NS	0%
	Mn	< 0.05 mg/L	NS	0%
	Fe	< 0.3 mg/L	NS	0%
	Total Dissolved Solids (TDS)*	< 500 mg/L	69%	6%
EPA Nutrient Criteria for Upper Watershed	$NO_3^- + NO_2^-$ - N	< 0.05mg/L	NS	50%
	TP	< 0.02375 mg/L	NS	0%
Number of Sampling events			**8**	**9**

* The 9 sampling events at FP @ DH were comprised of 5 full sampling events, and four events when only physical parameters were measured in profile with a Manta Probe. NS=Not sampled for parameter

Similar to past years, the aeration system provided enough oxygen in the hypolimnion to avoid reducing iron from the sediments (Figure 10). Slightly elevated concentrations of manganese were measured in bottom samples during the summer months, though these concentrations were all a magnitude lower than the manganese concentrations measured in both the Hobbs Brook and Stony Brook Reservoirs.

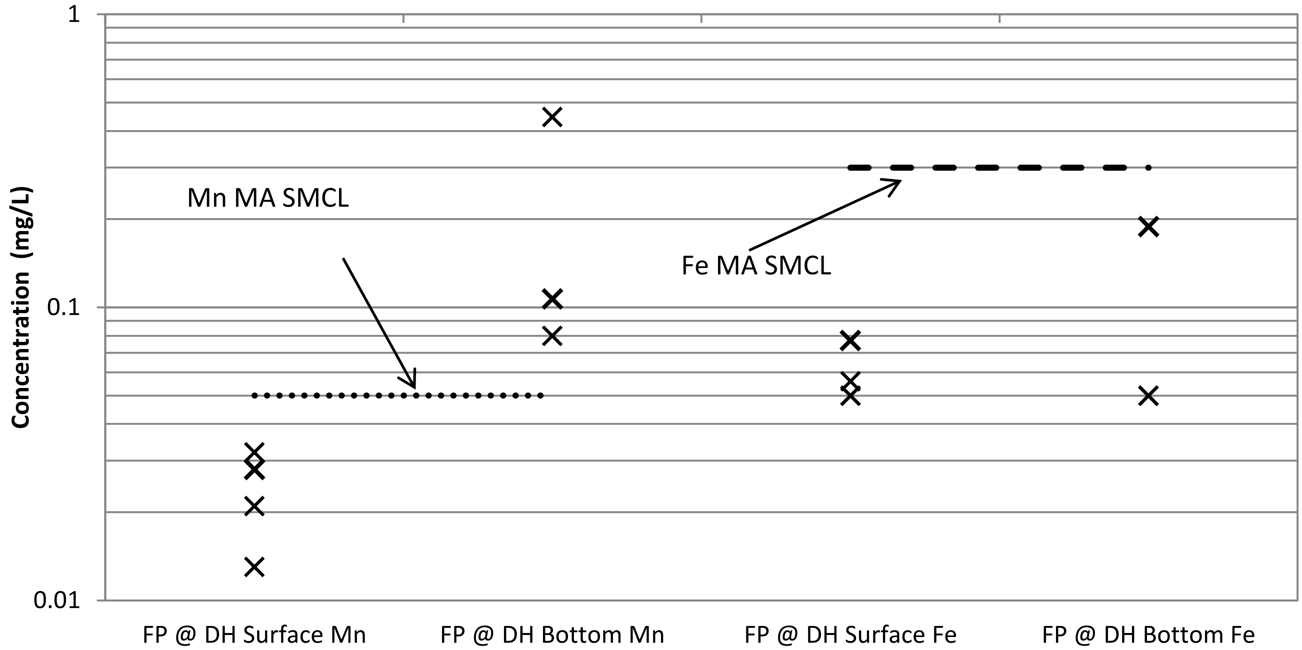


Figure 10: Fresh Pond Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Iron (Fe) and Manganese (Mn) Nuisance Metal Concentrations During Periods of Thermal Stratification (Log scale)

Originally designed to be operated non-stop, the aeration system is operated overnight to reduce energy costs at the treatment plant. Even with reduced operation of the aeration system, the treatment plant is capable of removing marginal increases in iron and manganese released from the bottom of the Reservoir. However, more aggressive usage of the aeration system may be needed in future years if ambient temperatures increase during the summer months or the duration of stratification in Fresh Pond increases. Thorough cleaning and maintenance of the lines was performed over the summer of 2015, so improved performance should be observed in future years.

Reservoir Water Quality Comparison

In general, the Cambridge water supply system exhibits an overall cascade effect as water travels from Hobbs Brook Reservoir to Fresh Pond. Each reservoir acts as a settling basin which allows suspended sediments and associated constituents to settle to the bottom of each reservoir. Settling also occurs as water passes through the Upper and Middle basins of the Hobbs Brook Reservoir. In addition, reservoirs also improve water quality by diluting concentrated flows of pollutant inputs. The quality of water improves as it moves through the watershed reservoirs, and by the time source water reaches Fresh Pond, it is relatively free of suspended solids.

As shown in Figure 11, median TSI values for the deep hole sites at Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs were 42, 43, and 38, respectively. These values indicate good water quality within the reservoirs, as Fresh Pond is oligotrophic and the upper reservoirs are low in the mesotrophic zone (Table 1 and Figure 11). The TSI values are similar to results from previous years and exhibit the expected decrease from Hobbs Brook to Fresh Pond Reservoir. The 2014 chlorophyll-*a* concentrations, TP concentrations, secchi depths, and corresponding TSI values are provided in Appendix E.

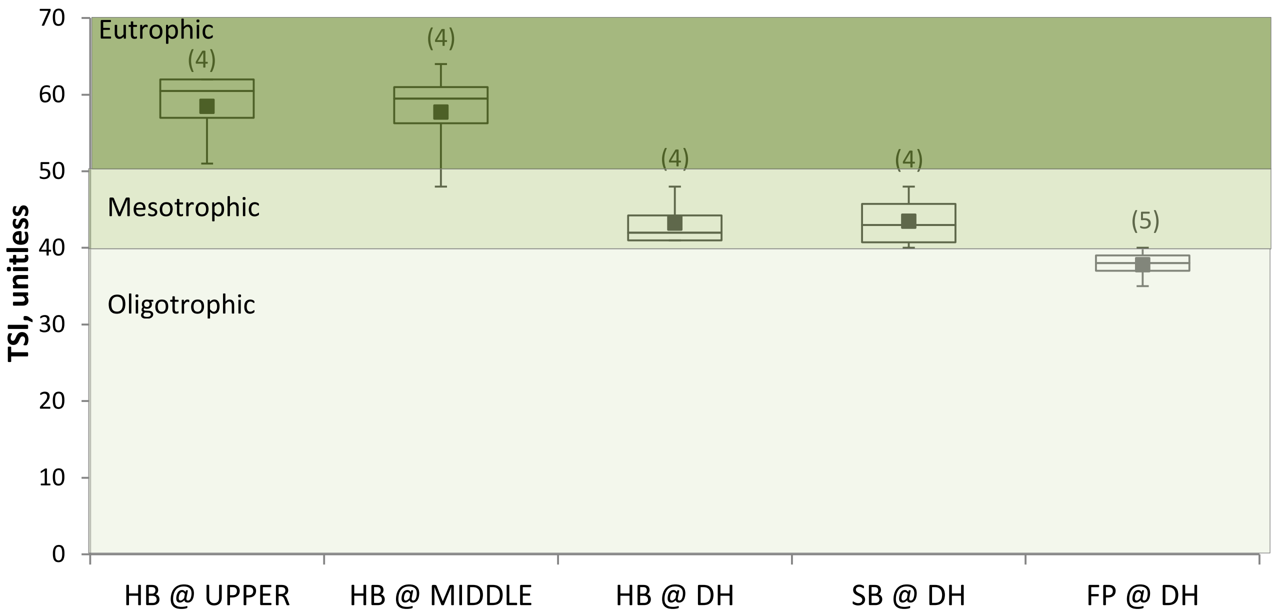
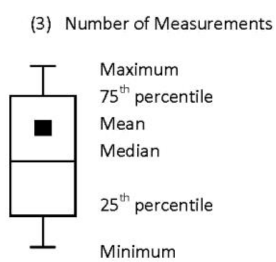


Figure 11: Reservoir Trophic State Index, from Chlorophyll-*a* and Total Phosphorus Concentrations, 2014



All three reservoirs exhibited slightly supersaturated dissolved oxygen conditions (greater than 100 percent) in the surface layer during some spring and summer months: April 15th, May 2nd, June 3rd, and July 1st at Fresh Pond Reservoir, April 22nd and June 19th at Hobbs Brook Reservoir, and April 22nd at Stony Brook Reservoir. This, in addition to increased pH, can be indicative of algal photosynthesis.

In 2014, 100 percent of the weekly samples from the Hobbs Reservoir met Massachusetts Class A water quality standards for bacteria (*E. coli* <235 MPN). All but two samples from Stony Brook Reservoir met the standard. Distributions of bacteria results for 2014, along with the results from the 2013, 2012 and 2008-2011 reporting periods, are illustrated in Figure 12. The logarithmic scale is shown in Figure 11 as a visual aid to better represent the majority of the *E. coli* counts, which fall in the 1 – 1,100 range. The data was transformed by adding one to each value, allowing for values of zero to be displayed on a logarithmic scale.

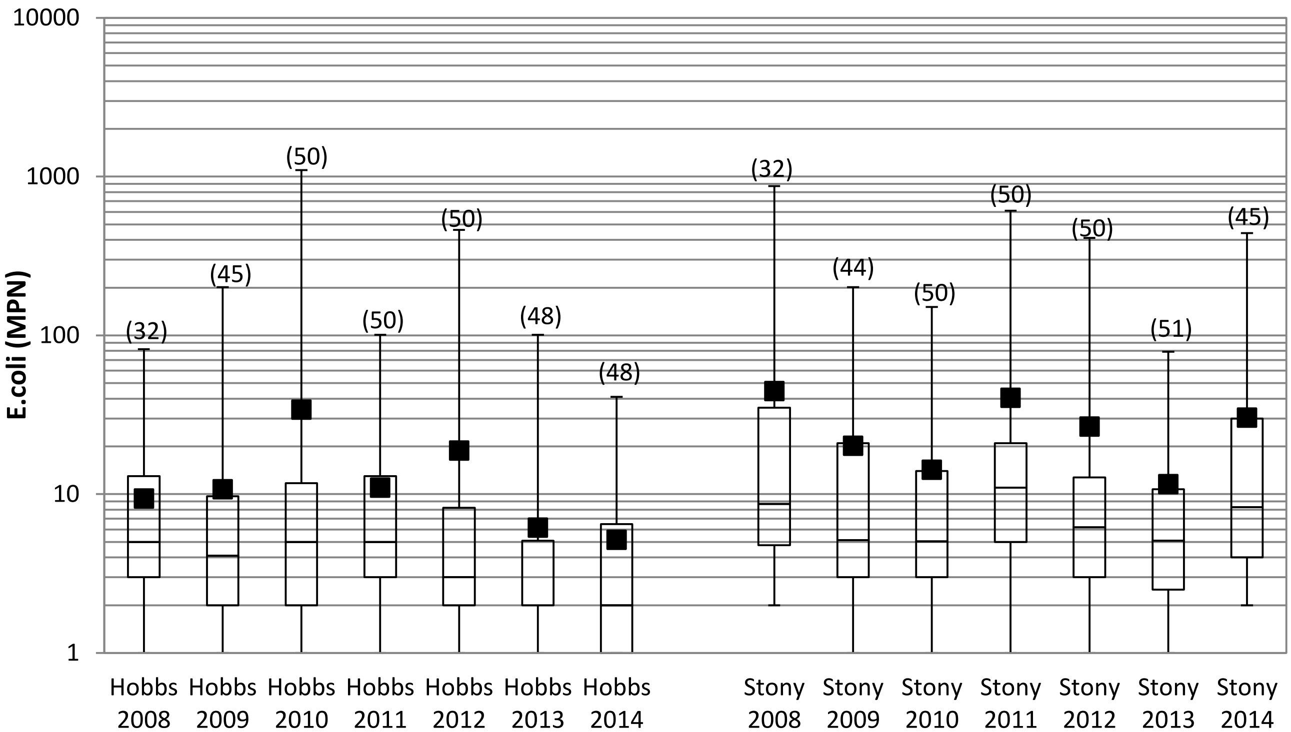
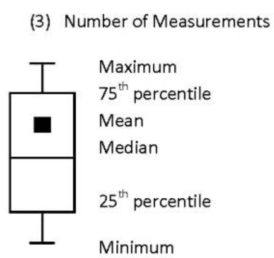


Figure 12: Weekly Bacteria Monitoring of *E. coli* in Hobbs and Stony Brook Reservoirs, 2008-2014

***Data transformed by adding 1 to each sample result so that zero values can be shown on log scale**



Review of the total organic carbon results from 2008 - 2014 (Figure 13) showed consistently lower median concentrations at both Hobbs Brook and Stony Brook Reservoirs when compared to the 1997-1998 median results (5.8, 7.4 mg/L respectively). Ranges of values are similar with no clear indicators of significant changes over time in the both the Hobbs Brook and Stony Brook Reservoirs. The maximum from 2008 was due to a single sampling event in April of that year, at 40.2 mg/L. The slight increase seen in medians from 2011-2013 at the Hobbs Brook Reservoir was not continued in 2014. While not significantly outside the range of expectations, the TOC results from both reservoirs in 2014 were the lowest of years sampled to date. This could be anomalous, or an indication of changing conditions. We will continue to monitor this in the coming years.

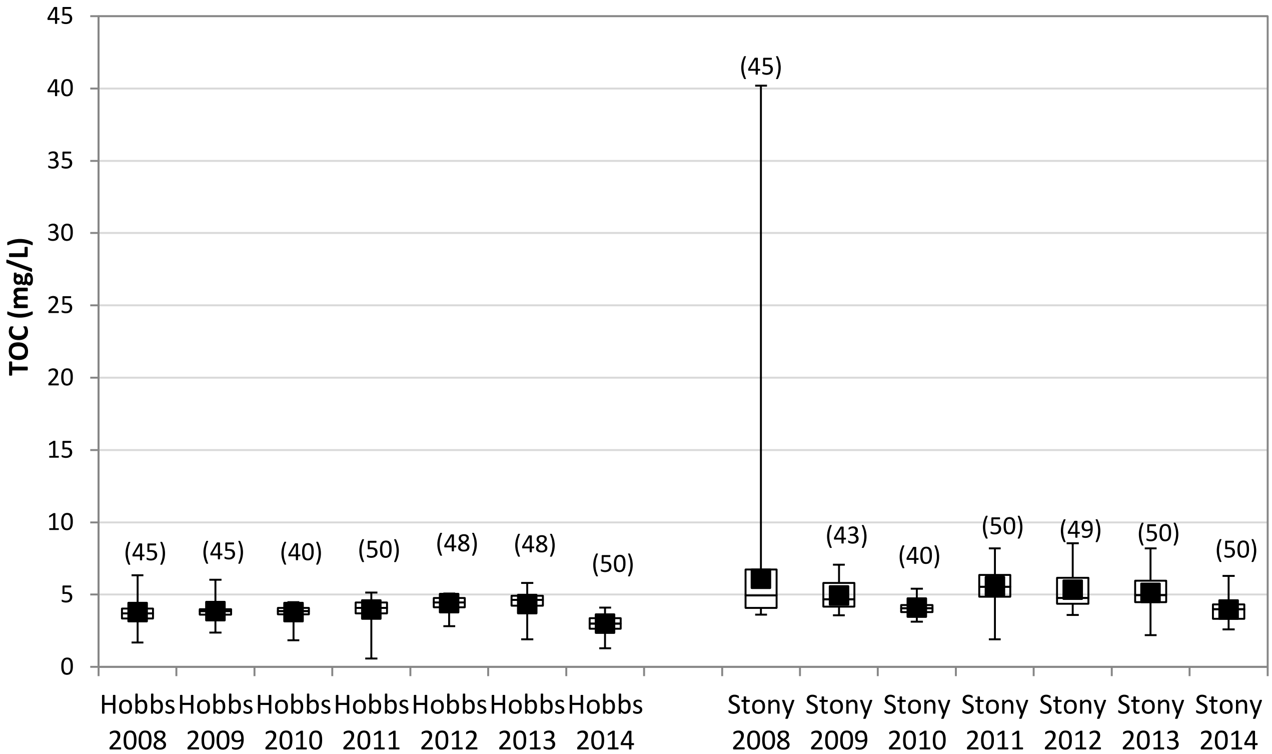


Figure 13: 2008-2014 Weekly Hobbs and Stony Brook Reservoir Total Organic Carbon

Commonly used in the watershed for deicing materials, sodium and chloride ions have shown increasing concentrations over the years in the Cambridge watershed. Fresh water dilution continues to maintain secondary drinking water standards, but controlled use of deicing substances in the watershed is crucial to maintaining a viable drinking water source. The Cambridge source watershed contains a high percentage of impervious cover in the form of major highways (State Routes 2 and 128), smaller roads, and parking areas that contribute deicing chemicals to the water supply. Because neither ion can be removed in the water treatment process, CWD strongly encourages MassDOT (Massachusetts Department of Transportation), watershed municipalities, and large commercial properties to adopt technologies that quantify, minimize, and target applications to decrease the amount of chemical used, and ultimately, reduce the burden placed on receiving waters in their attenuation.

The median chloride concentration in the Hobbs Brook Reservoir for 2014 was above the EPA limit for chronic aquatic life exposure, but below the State and Federal drinking water and ambient toxicity standards (Figure 14). In 2008, 21% of samples were above the EPA/DEP chronic aquatic life exposure limit, 11% in 2009, zero in 2010, 12% in 2011, zero in 2012, and 2% in 2013. However in 2014, 63% of samples taken at Hobbs Brook Reservoir exceeded the chronic aquatic life exposure limit. No chloride standard exceedances were observed in weekly samples collected at Stony Brook Reservoir between 2008 and 2014. Median chloride concentrations in both reservoirs from this study period are consistent with results from the 2008-2012 samples and are higher than 1997/1998 USGS results.

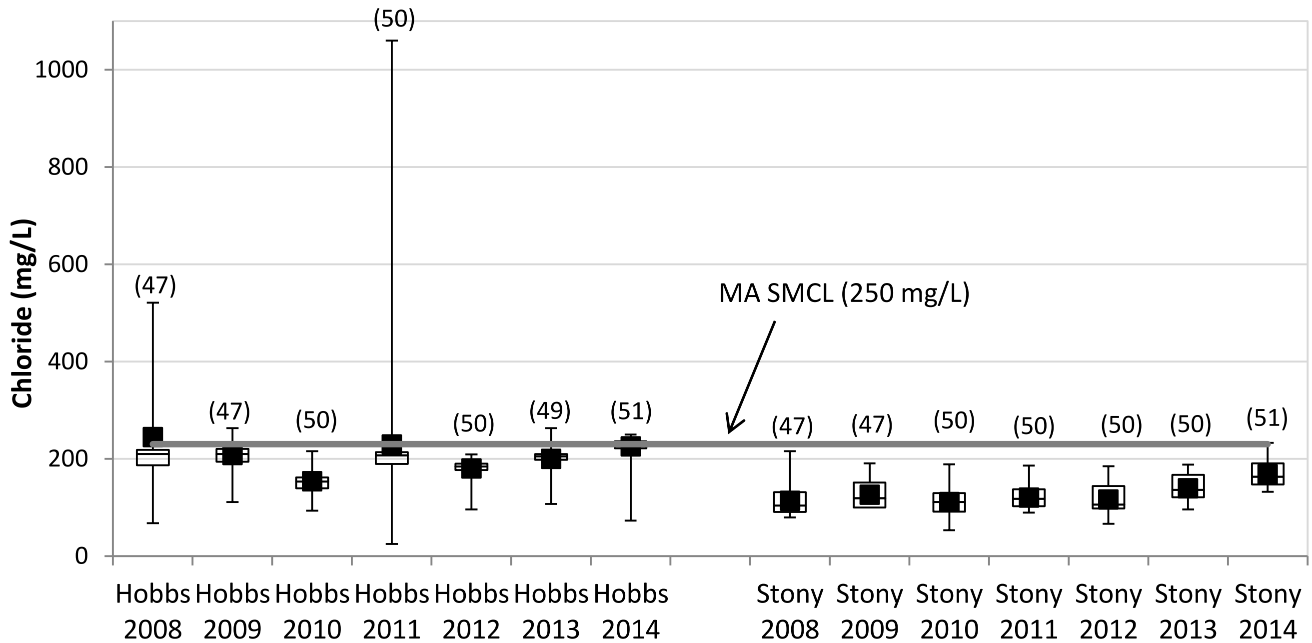


Figure 14: Weekly Chloride Monitoring, Hobbs and Stony Brook Reservoirs, 2014

Tributary Base-flow Water Quality

Through the tributary monitoring program, sources of sewage-related bacteria, sodium, chloride, nitrate, total phosphorous (TP), and manganese (among other parameters) entering Hobbs Brook and Stony Brook Reservoirs are identified and quantified throughout the watershed. In addition to nutrient, ion, and heavy metal samples, *in situ* measurements are taken concurrently with a calibrated water quality multiprobe for temperature, pH, specific conductance, and dissolved oxygen. Each of the 12 tributary monitoring sites (Figure 4) was monitored five to six times during base-flow conditions in 2014, resulting in a total of 70 watershed sampling events. The following sections highlight select results from tributary monitoring. Appendix E contains boxplots and numerical results from all samples collected in 2014.

Tributary Base-flow Water Quality Overview

When compared against Massachusetts Class A water quality standards, tributary water samples in 2014 were overall of good quality. Less than 10 percent of samples violated the Class A standards for DO, pH, and temperature (Table 6). Exceedances of *E. coli*, while still low (16 percent), doubled from 2013 when only 8 percent of samples exceeded the standard. However, median *E. coli* levels were below the exceedance threshold for all tributary sites in 2014 (Table 7).

While tributary water quality rarely violated Massachusetts Class A water quality standards, samples regularly exceeded MA SMCLs for chloride, manganese, iron, and total dissolved solids (TDS) (Table 6). Nearly half (43 percent) of tributary samples exceeded the chloride SMCL, and 100 percent of samples and sample medians exceeded the MA Drinking Water Guideline for sodium (20 mg/L), indicating widespread salt impairment (Table 6 and 7). Samples exceeded the TDS standard in 62 percent of samples, increasing from 44 percent in 2013. The exceedance rates for the nuisance metals iron and manganese, while high (67 and 87 percent, respectively), were likely due to naturally occurring deposits in sediments since tributary waters were rarely anoxic.

Watershed nutrient levels give reason for concern. Seventy nine percent of samples exceeded the EPA regional nutrient criteria for nitrate and 33 percent of samples exceeded the criteria for total phosphorous. In addition, median nitrate levels at all but one site exceeded the EPA nutrient criteria and one quarter of sites had median TP levels exceeding the EPA criteria (Table 6).

Table 6: Summary of Exceedances for Primary Tributaries, 2014

Standard	Parameter	Standard	Number Sampling Events	Number Exceedances	Percent Exceedances
MA Class A Water Quality	DO	> 5 mg/L	58	5	9%
	DO- Cold Water Fisheries	> 6 mg/L	12	0	0%
	Temperature	< 28.3 °C	58	0	0%
	Temperature- Cold Water Fisheries	< 20.0 °C	12	1	8%
	pH	Between 6.5 - 8.3	70	2	3%
	E. coli, single sample	< 235 MPN	70	11	16%
MA Secondary Maximum Contaminant Level (SMCL)	Cl^-	< 250 mg/L	70	30	43%
	Mn	< 0.05 mg/L	70	60	86%
	Fe	< 0.3 mg/L	70	47	67%
	TDS*	< 500 mg/L	65	40	62%
EPA Nutrient Criteria for Upper Watershed	$NO_3^- + NO_2^-$	< 0.31 mg/L	70	55	79%
	TP	< 0.02375 mg/L	70	23	33%

*only 65 sample events due to broken sensor on 7/3/2014

Table 7: Primary Tributary Median Base-flow Concentrations [mg/L], 2014

	HB @ MILL ST	SALT DEPOT BROOK	LEX BROOK	TRACER LANE	HB BELOW DAM	INDUST BROOK	SB @ VILES	HB @ KG	MBS	WA-17	RT-20	SUMMER ST
Cl^-	112	**381**	**662**	**467**	238	**759**	81	237	179	**383**	160	74
DO	9.88	11.08	9.77	**4.28**	9.74	7.73	12.27	10.33	6.23	8.76	9.02	10.98
E. coli (MPN)	92	37	214	163	2	78	70	24	4	34	77	60
Fe	0.823	0.759	0.344	1.18	0.216	1.36	0.285	0.436	0.549	0.356	0.401	0.127
Mn	**0.062**	**0.383**	**0.350**	**0.707**	**0.089**	**0.521**	0.041	**0.238**	**0.085**	**0.245**	**0.199**	0.019
Na^+	**69**	**222**	**365**	**264**	**138**	**375**	**40**	**141**	**112**	**212**	**81**	**44**
NO_3^-	**0.49**	**0.51**	**1.22**	**0.41**	**0.46**	**0.35**	**1.30**	0.07	**1.10**	**3.40**	**0.43**	**1.98**
SpC (uS/cm @ 25ºC)	453	1327	2196	1614	858	2548	381	849	679	1429	613	353
TKN*	**0.70**	**<0.5**	**<0.5**	**0.55**	**<0.5**	**0.65**	**<0.50**	**<0.50**	**0.62**	**<0.5**	**0.54**	**<0.5**
TOC	8.7	2.9	1.9	4.8	2.9	2.1	5.5	3.2	6.8	2.2	3.9	2.5
TP	**0.029**	**0.025**	0.013	**0.024**	0.010	**0.028**	0.018	0.018	0.018	0.018	0.021	0.015

BOLD: Exceeds Massachusetts Water Quality Standard or EPA Nutrient Criteria

*The detection limit for TKN was 0.5 mg/l. However, the EPA nutrient criteria was 0.3 mg/l. Therefore, it is possible that medians reported at the detection limit of 0.5 represent samples that were below the EPA nutrient criteria for TKN.

The following sections highlight select site-level tributary monitoring results by parameter for 2014.

De-Icing Pollutants (Sodium and Chloride)

Salt impairment within the Cambridge watershed is a growing concern, especially since removal of sodium and chloride during water treatment is prohibitively expensive. In 2014, 43 percent of samples exceeded the MA SMCL for chloride and 100 percent of samples exceeded the MA Drinking Water Guideline of 20 mg/L for sodium (Table 6, Figure 15 and 16). The five most salt impaired sites in 2014 were: Industrial Brook, Lexington Brook, Tracer Lane, Salt Depot, and WA-17 (Figures 15 and 16). Every sample collected from these sites exceeded the MA SMCL for chloride of 250 mg/L. Lexington Brook, Industrial Brook, WA-17, and Tracer Lane have the highest areal percentages of transportation corridors in their corresponding drainage basins (Appendix F), exposing these sites to deicing agents used on roadways during the winter months. USGS found a high correlation between mean chloride concentration and roadway coverage in the Camberidge watershed basins from 2005-2007 (Smith, 2013), which is consistant with the findings in this report.

Salt Depot has minimal roadway coverage in its catchment area, but contains the MassDOT (Massachusetts Department of Transportation) road salt storage facility that previously stored deicing salt uncovered on bare ground. Over the years, salt has leached into the surrounding soils and groundwater, thereby creating a hyper-saline groundwater plume that was studied and mapped in 1985. Therefore, the high specific conductance, sodium and chloride results at Salt Depot are likely due to the continuous movement of the hyper-saline groundwater plume from the MassDOT salt storage facility.

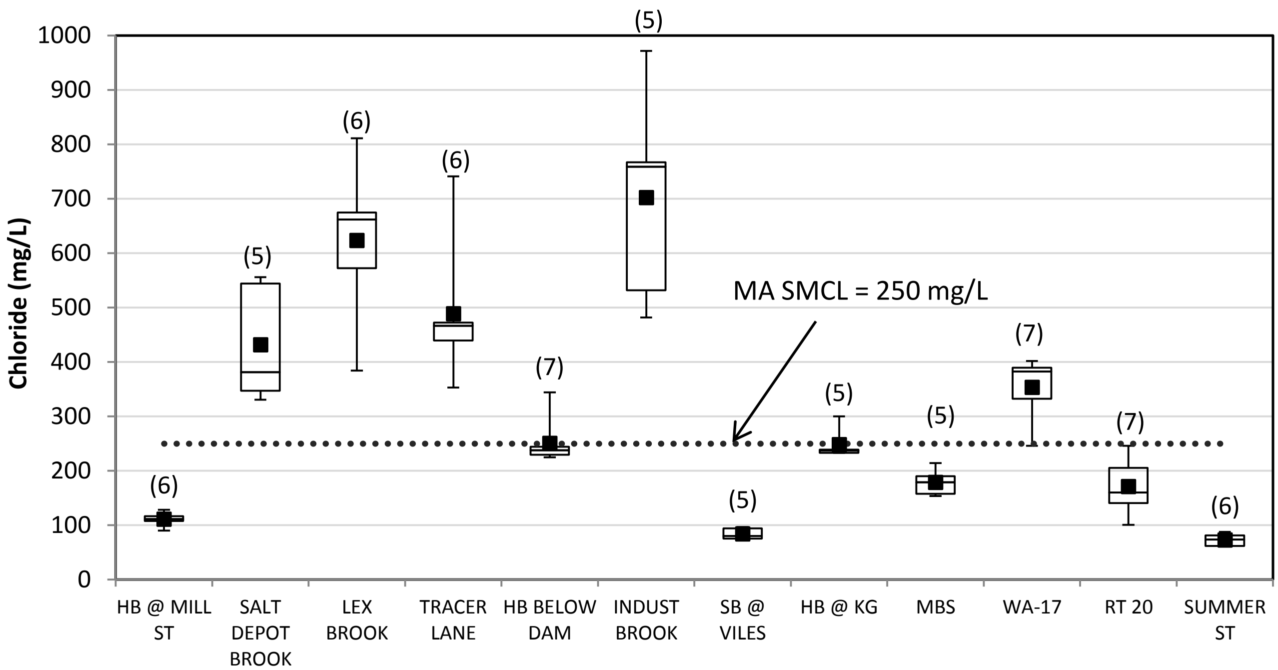


Figure 15: Primary Tributary Base Flow Chloride Concentrations, 2014

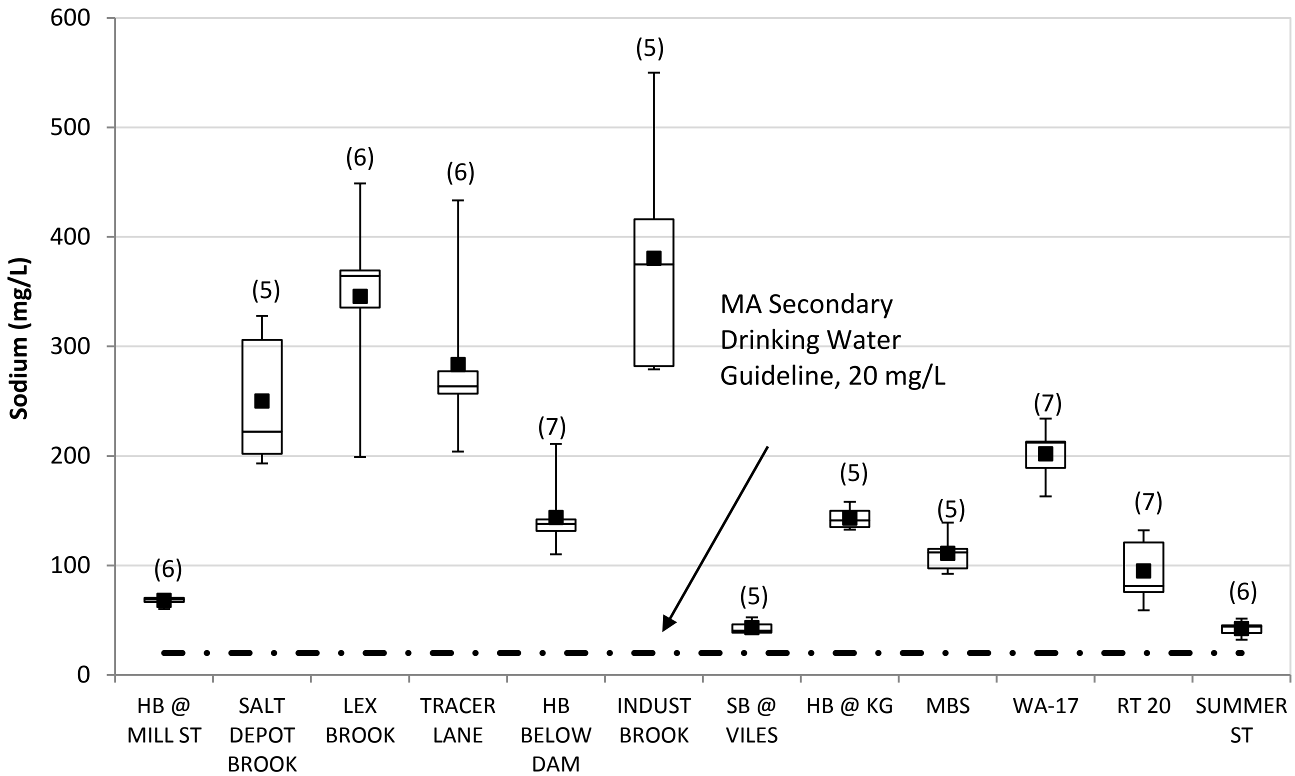
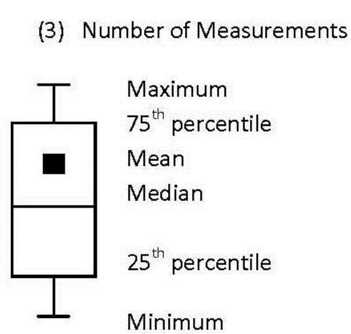


Figure 16: Primary Tributary Base-flow Sodium Concentrations, 2014



Despite the high levels of sodium and chloride impairment, Industrial Brook, Lexington Brook, Tracer Lane, Salt Depot, and WA-17 are not the only sites of concern. Median chloride concentrations at HB Below Dam and HB @ KG exceeded 230 mg/L, the concentration considered toxic to wildlife by the EPA if sustained over a four day period at least once every three years. In addition, a trend analysis reported in the CWD 2013 Source Water Quality Report found significant increasing trends ($p<0.05$) in sodium and chloride concentrations at nearly every tributary monitoring site. Figures 17 and 18 demonstrate this apparent increasing trend in sodium concentrations from 1995-2014 at Salt Depot and 1984 – 2014 at Lexington Brook.

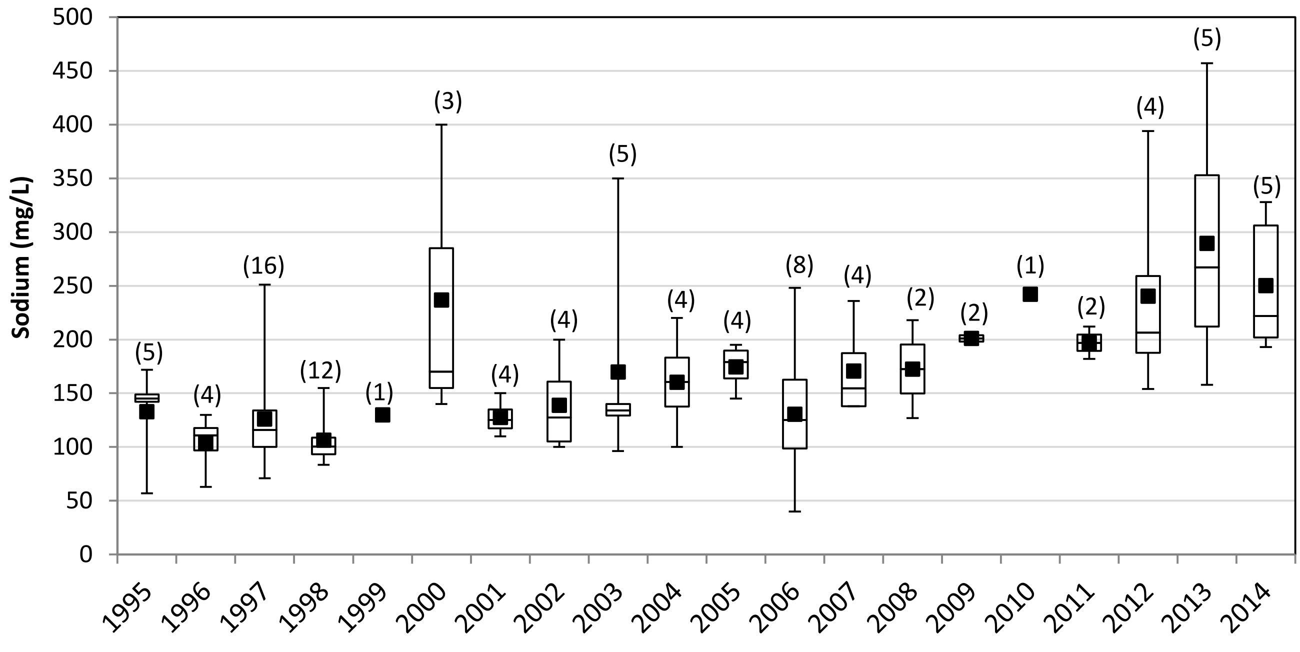


Figure 17: Sodium Concentrations in Salt Depot Brook, 1995-2014

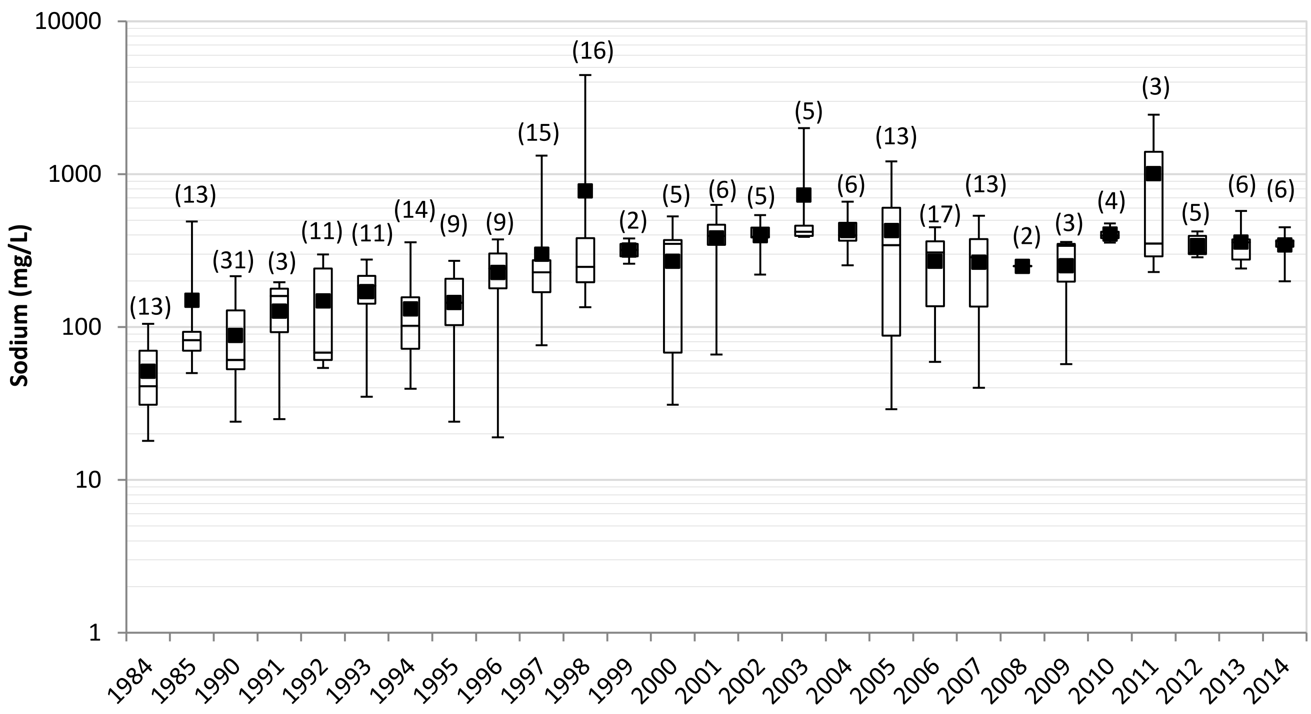


Figure 18: Sodium Concentrations in Lexington Brook, 1995-2014

Unlike many pollutants that increase in concentration due to stormflow runoff, concentrations of sodium and chloride are highest during base-flow and are diluted by the influx of water entering the waterways during storms. Figures 19-21 demonstrate the inverse relationship between discharge and specific conductance from instantaneous data collected at USGS monitoring sites for Lexington Brook, WA-17, and Summer St. This inverse relationship is not found at HB Below Dam, where water levels and pollutant concentrations are more strongly influenced by managed releases of water from the Hobbs Brook Reservoir Dam than from storm events (Figure 22).

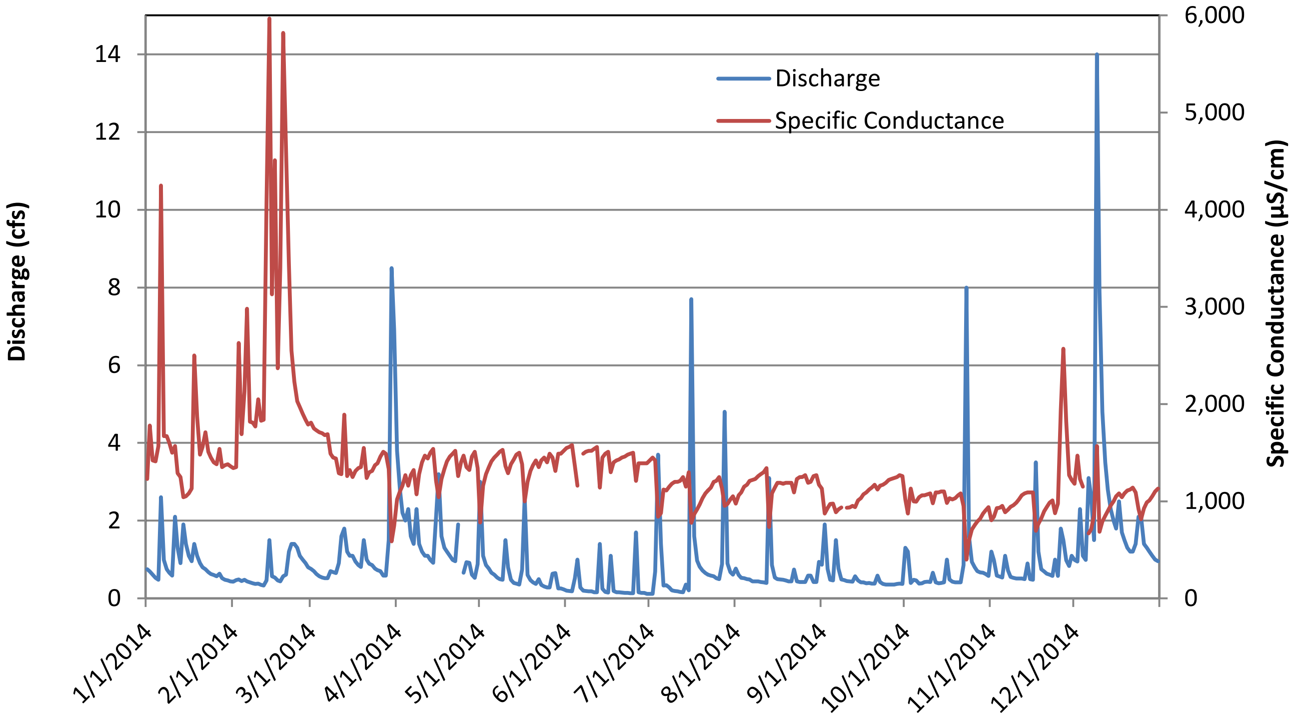


Figure 19: Lexington Brook Preliminary USGS Average Daily Discharge and Specific Conductance Data, 2014

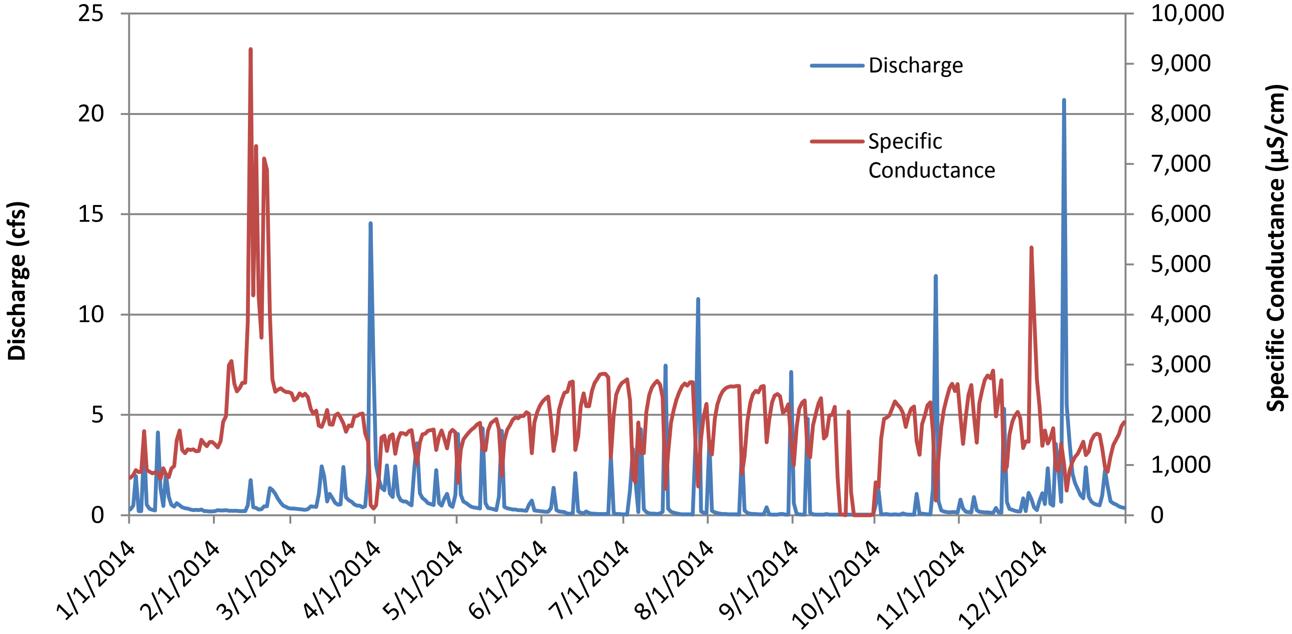


Figure 20: WA-17 Preliminary Instantaneous USGS Average Daily Discharge and Specific Conductance Data, 2014

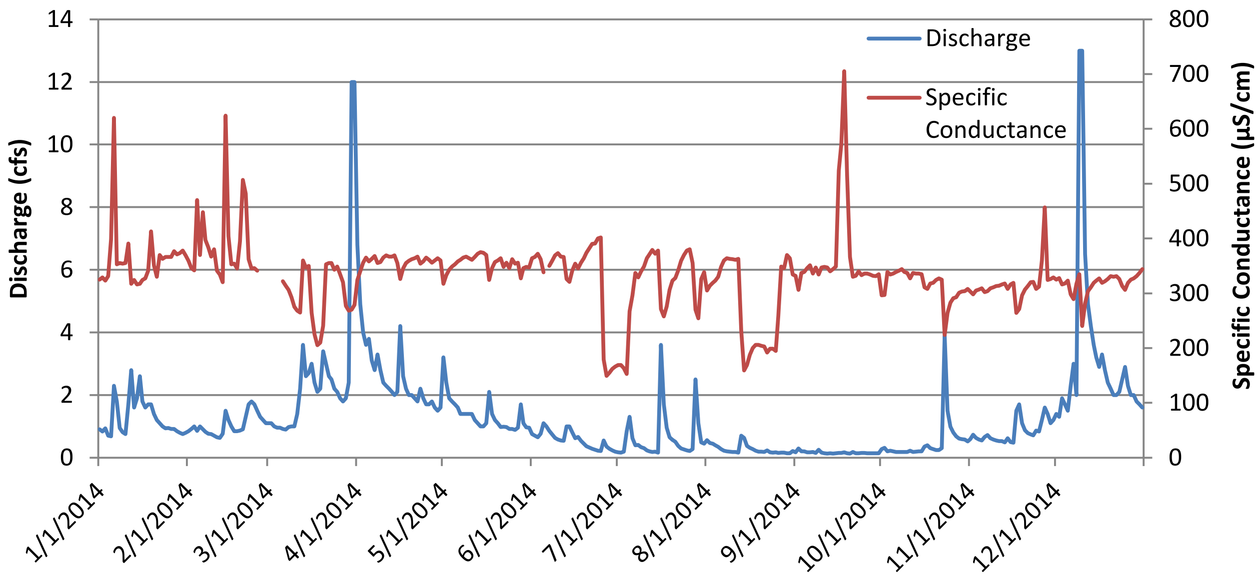


Figure 21: Summer St. Preliminary Instantaneous USGS Average Daily Discharge and Specific Conductance Data, 2014

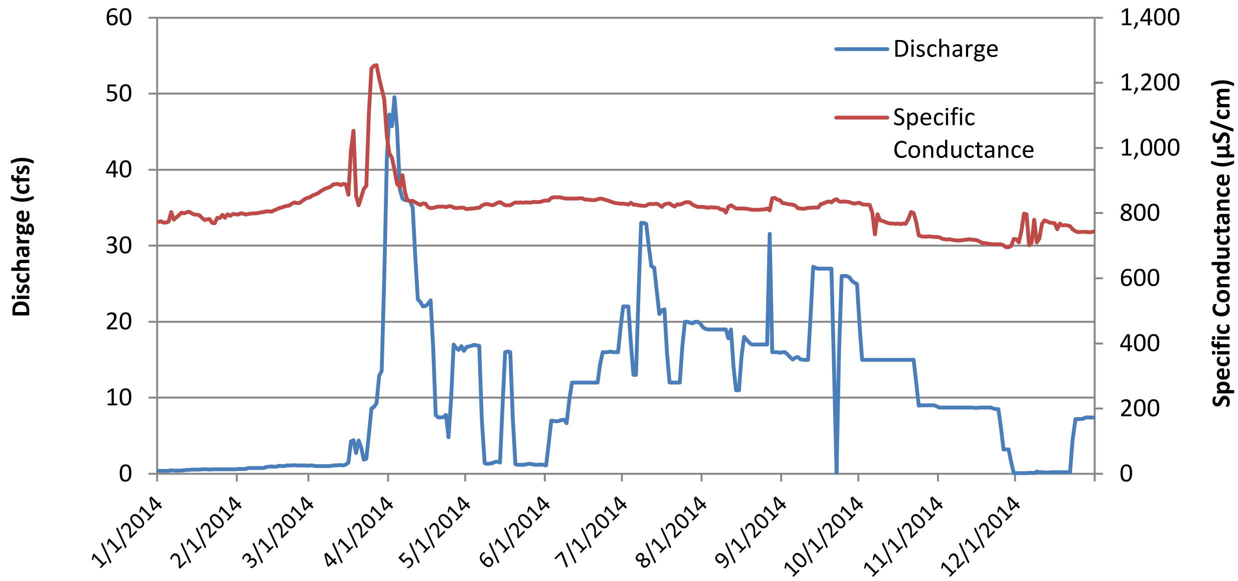


Figure 22: Hobbs Brook Below Dam Preliminary Instantaneous USGS Average Daily Discharge and Specific Conductance Data, 2014

Nutrients (Nitrate and TP)

Nutrient pollution can lead to excess algal growth and eutrophication, especially when phosphorus inputs are high. In temperate lakes and reservoirs, phosphorus is the limiting nutrient (Goldman and Horne, 1983). A limiting nutrient in an aquatic system is one that is relatively rare and often in a form that is not biologically available when compared to other nutrients (Goldman and Horne, 1983). Phytoplankton require phosphorus to photosynthesize, so their growth is often limited by the availability of soluble phosphate in the water column (Goldman and Horne, 1983). From a management perspective, limiting inputs of phosphorus into the reservoirs is a priority to prevent excessive algal growth and accelerated eutrophication. The nitrate and TP EPA nutrient criteria were established to provide targets for the maximum concentrations of nutrients a waterbody can tolerate before adverse effects are likely.

In 2014, only three sites had median base-flow TP concentrations above the EPA nutrient criteria for the watershed: HB @ Mill St., Salt Depot, and Industrial Brook (Figure 23). However, TP levels at all sites except for Lexington Brook and HB Below Dam had individual base-flow samples above the criteria limit. HB @ Mill St. had the highest median TP concentration of all sites in 2014. The high phosphorus levels at this site are likely the result of the eutrophic, wetland-type environment upstream of the gaging station. Tracer Ln and Industrial Brook, while located in more developed catchments, are also downstream of wetland systems.

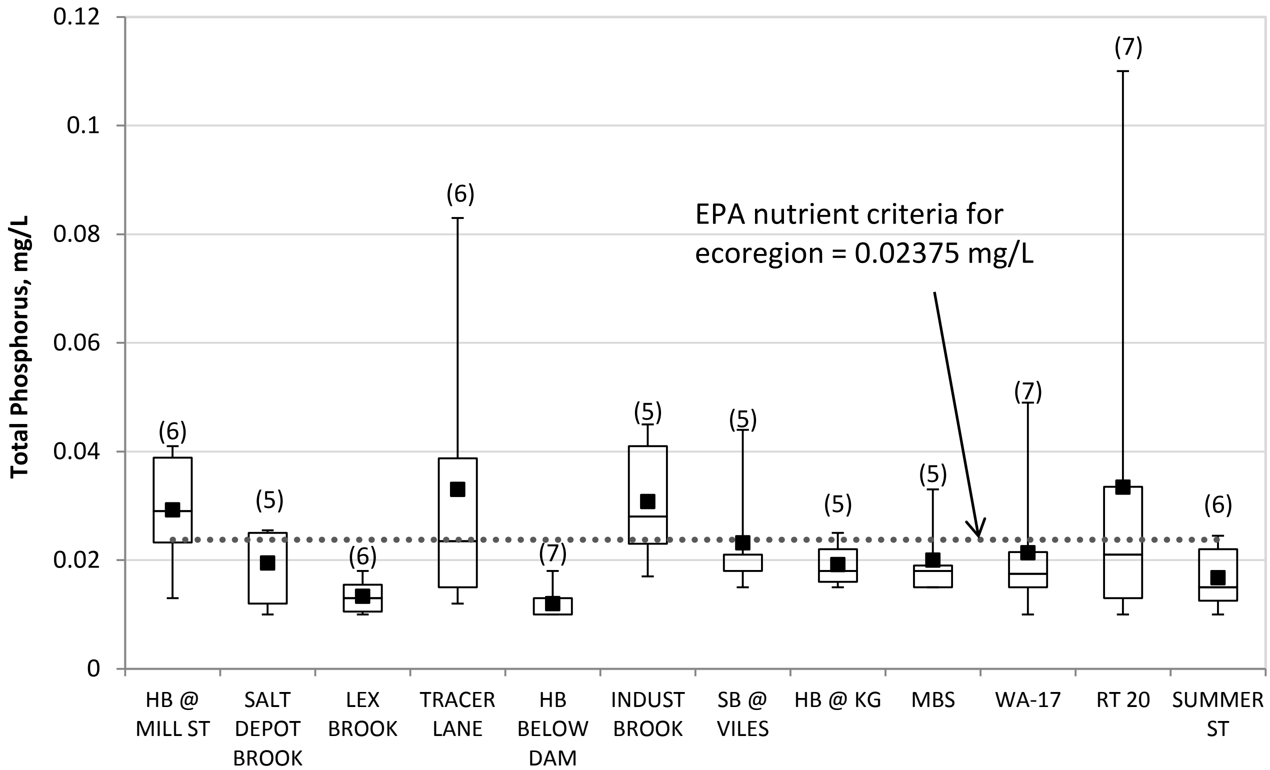


Figure 23: Primary Tributary Base-flow Total Phosphorus (TP) Concentrations

It is important to note that, unlike sodium and chloride which become diluted during storm events, TP concentrations tend to increase during storm events (Smith, 2013). Median TP concentrations from stormwater samples at Lexington Brook, Tracer Lane, WA-17, and Summer St., were in excess of the EPA nutrient criteria, though median TP base-flow levels were below the EPA threshold (see Wet Weather Tributary Monitoring section). The maximum measured concentration of total phosphorus in 2014 (0.110mg/L) occurred at Rt 20 on June 10, 2014, while all other points from that site were below 0.04 mg/L (Figure 23). The correspondingly high turbidity reading (11.5 NTU) on June 10th suggests that the phosphorus was attributable to upstream dam construction occurring at that time in Hobbs Pond. These results highlight the importance of strong stormwater regulations and management practices in the watershed.

The EPA nutrient criteria for nitrate (0.31 mg/L) is much lower than the SMCL of 10 mg/L for drinking water. All 2014 tributary samples were well below the nitrate SMCL indicating good water quality for consumptive use. However, SB @ Viles, MBS, WA-17, and Summer St. all exceeded the EPA nitrate criteria in every 2014 sampling event and every site except for HB @ KG had a median base-flow concentration above the EPA nutrient criteria level (Figure 24). Even though nitrogen is not a limiting nutrient for plant and algal growth in reservoirs, it is still important to limit nitrate pollution in the watershed to maintain and improve water quality.

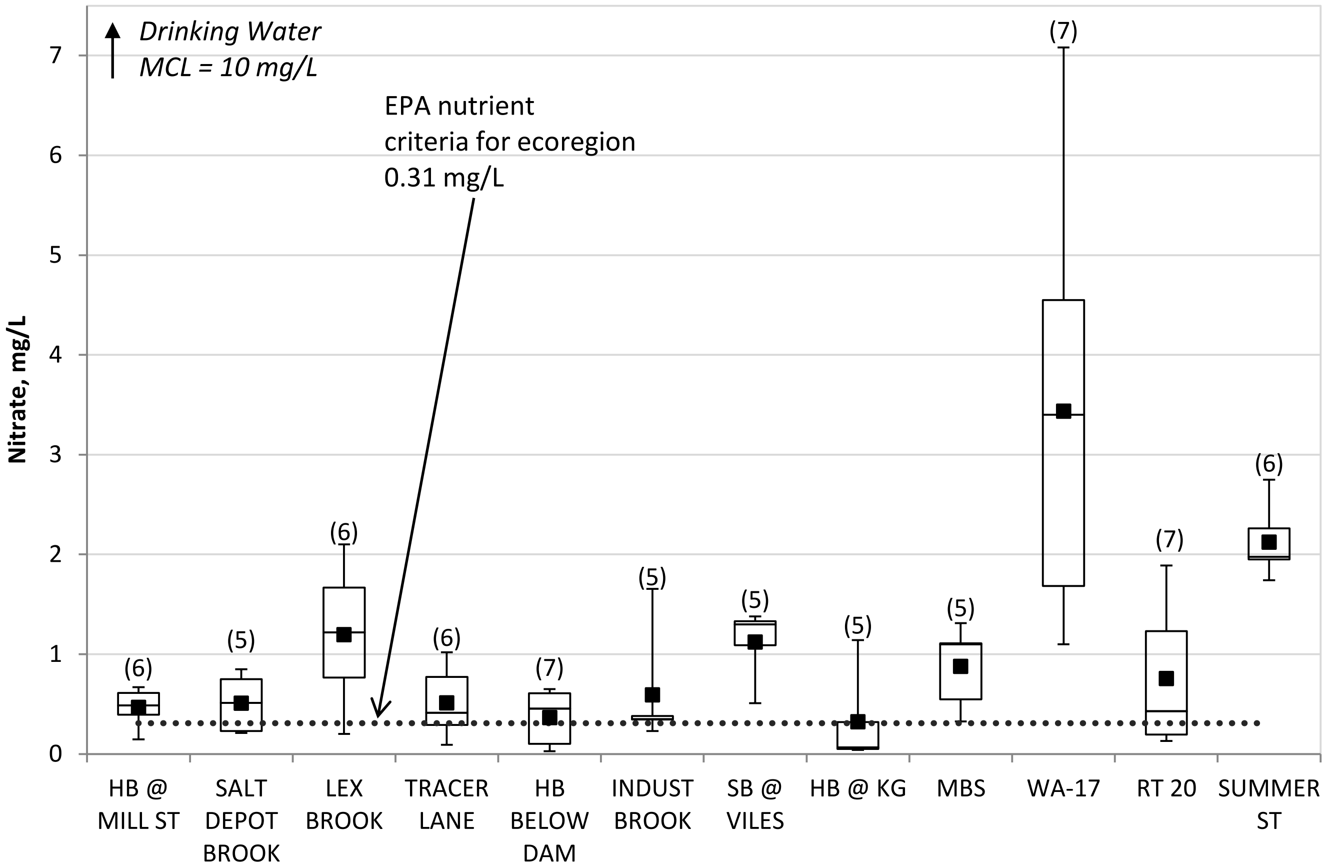


Figure 24: Primary Tributary Base-flow Nitrate Concentrations, 2014

Nitrate levels at WA – 17, the highest of any tributary in 2014, increased considerably after a 3.5 acre MassDOT stormwater retention and treatment pond in the Route 128/Route 20 rotary became operational in October, 2012 (Figure 25). The retention pond was designed to route base-flow and approximately the first inch of stormwater runoff from the entire subbasin. Possible causes of the increased base-flow nitrates measured at WA-17 at the time the pond went "online" may be from nutrient leaching from imported construction soils, and fertilizers used for the seeding and stabilizing of surrounding slopes. Further investigation is needed to determine the causes of increased nutrient concentrations as well as to alter diversion structures to capture an increased amount of the "first flush" stormflow.

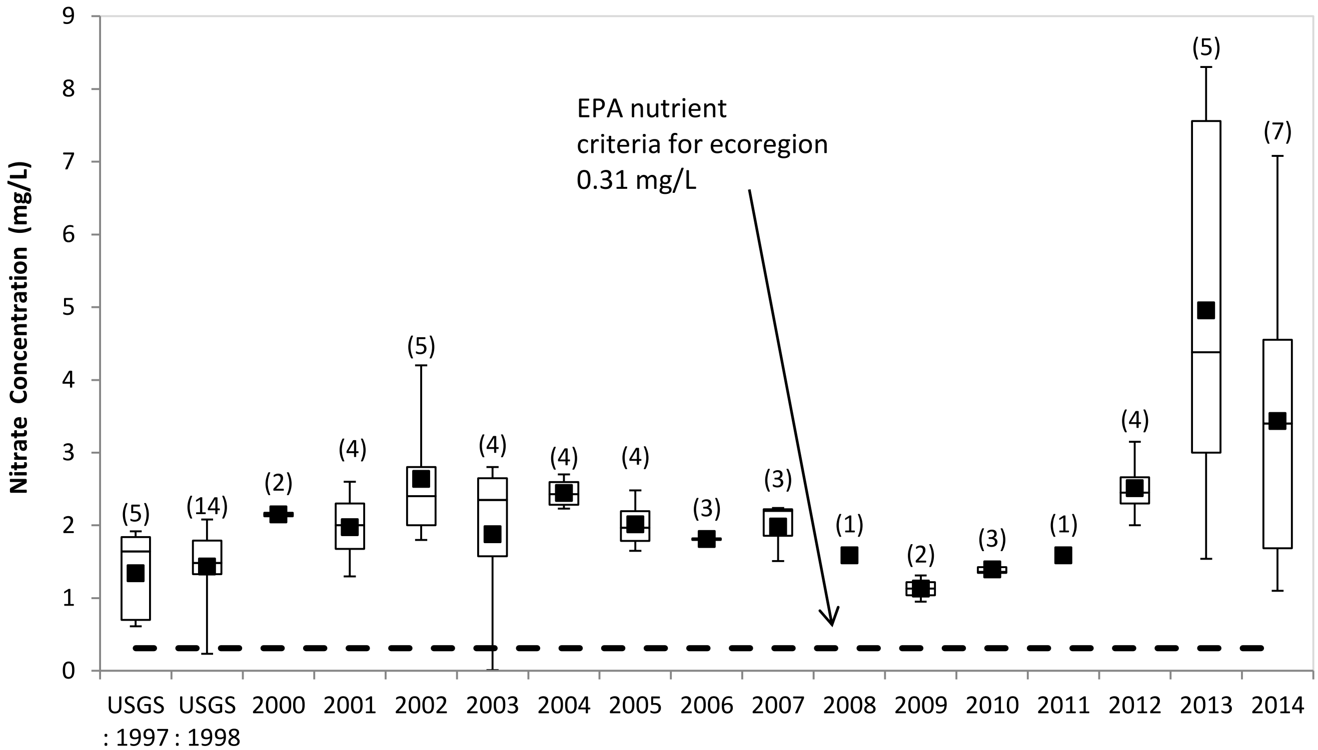
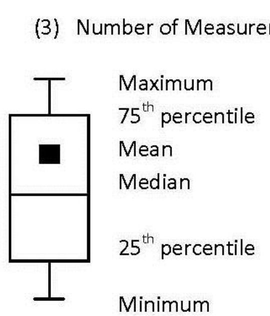


Figure 25: WA-17 Base-flow Nitrate Concentrations 1997-2014



Land use within the Summer St. catchment, which had the second highest nitrate concentration among the tributaries, differs from the other catchments in that there are no state-maintained roads, and no commercial or industrial development. The predominant land uses in the subbasin are forests, low density residential, and recreational uses (Smith, 2013). Although low impact land uses typically correspond with low concentrations of pollutants, the elevated nitrate levels at Summer St. show that even residential and recreation land uses can impact water quality. According to Smith (2013), two common land uses in the subbasin (residential and recreational) are both positively correlated with total nitrogen concentrations. The recreational land use category, which includes the Weston Golf Club that drains to Summer St., has a correlation coefficient for total nitrogen concentrations of 0.99 (Smith, 2013). Thus, the high nitrate levels at Summer St. are likely attributable to golf course and lawn fertilizer applications, as well as septic flow-through.

Nuisance Metals (Manganese and Iron)

Manganese and iron are considered nuisance metals due to their ability to cause taste, odor and discoloration problems in the water supply. Manganese and iron are soluble in their reduced form, so high concentrations can be a sign of anoxic conditions. Manganese and iron are also common elements in the local bedrock, so it is not unusual for these metals to be found in tributary waters despite abundant oxygen.

In 2014, nearly all tributaries had median concentrations of iron and manganese that exceeded the MA SMCL for drinking water (Figures 26 and 27). Tributaries regularly contained DO concentrations above the MA Standard for Class A waters, so the manganese and iron are likely from naturally occurring sources within the watershed (Figure 28).

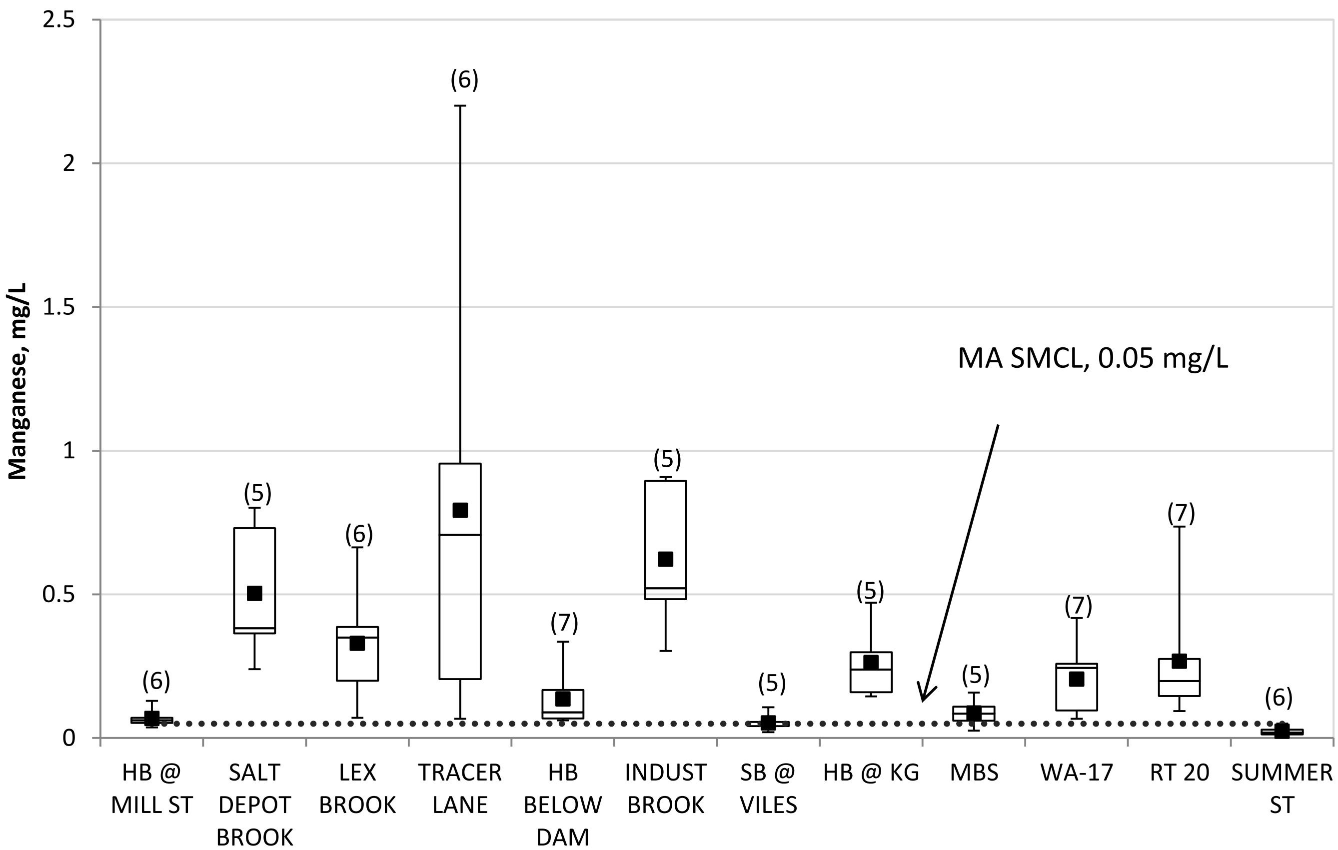


Figure 26: Primary Tributary Base-flow Manganese Concentrations, 2014

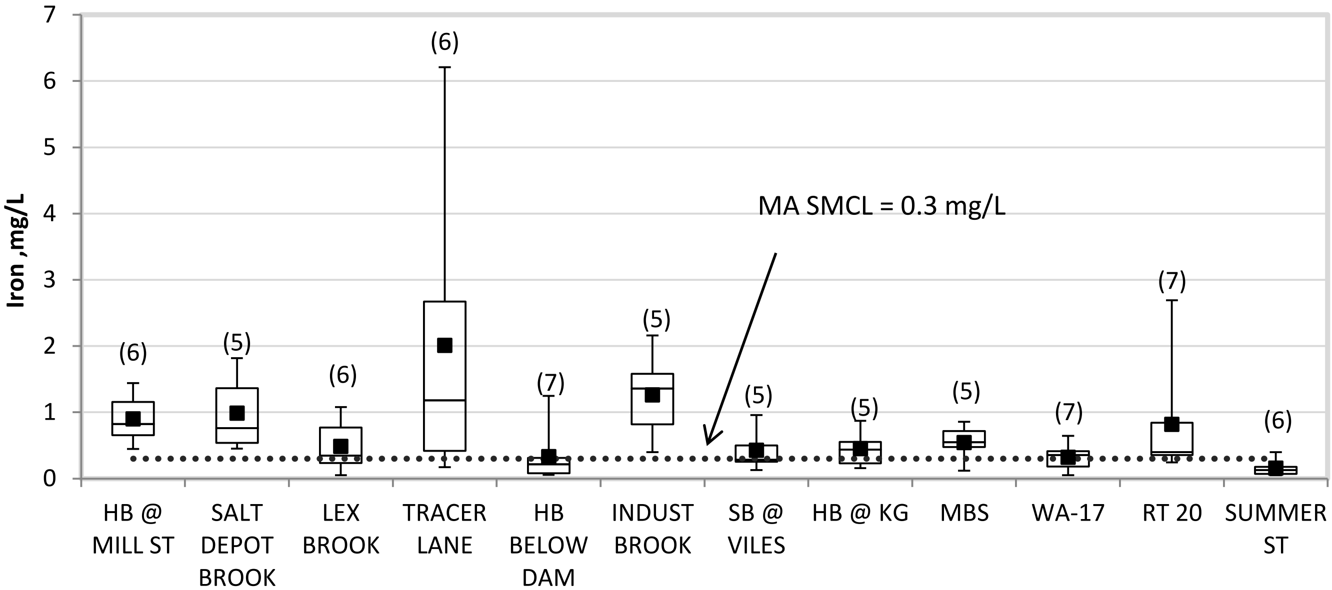


Figure 27: Primary Tributary Base-flow Iron Concentrations, 2014

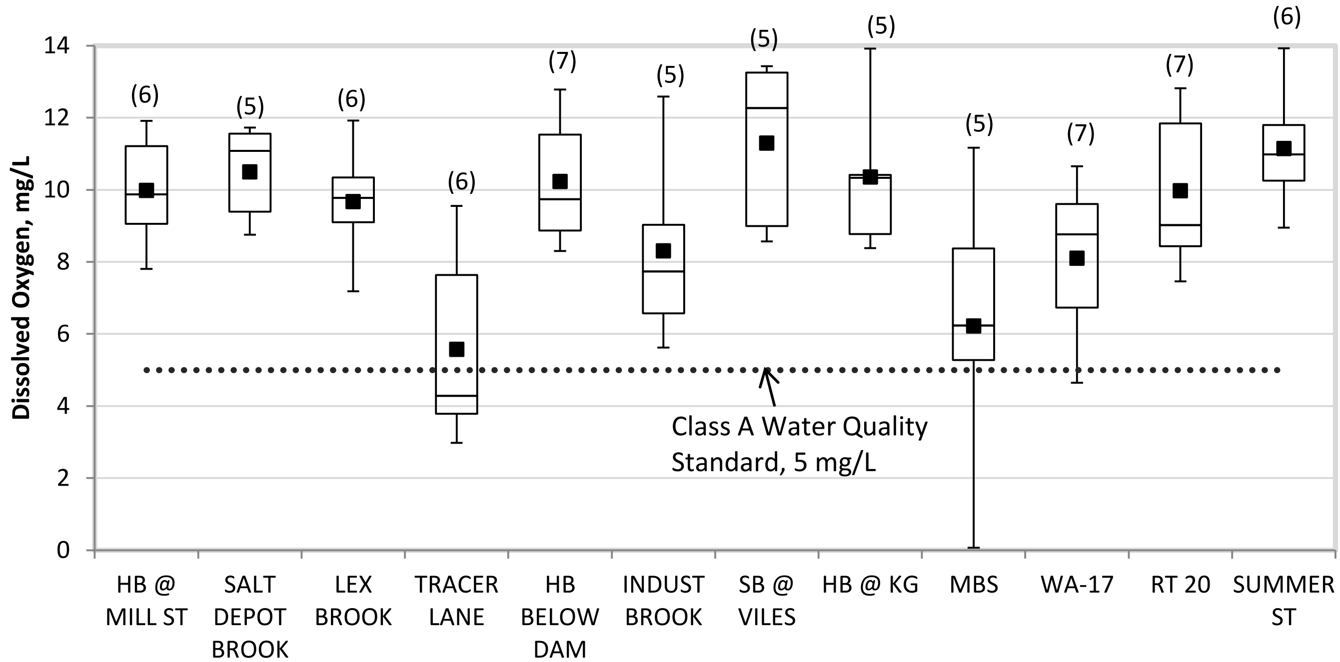


Figure 28: Primary Tributary Base-flow Dissolved Oxygen Concentrations, 2014

Tributary Wet Weather Monitoring

Stormwater runoff disproportionally impairs water bodies in developed watersheds. Impervious surfaces such as parking lots and roadways store metals, oils, and sediments from cars, aerial deposition, and other sources, which, during storms, are rapidly shunted to streams via piped drainage networks at erosive velocities. In undeveloped watersheds, trees, uncompacted soils, and vegetation capture and recharge most of the stormwater runoff. The small amount of water that flows to streams as runoff does not exacerbate erosion and is generally of high quality.

As the Cambridge source watershed is relatively developed, significant increases in constituent concentrations are observed in stream flows dominated by stormwater. CWD event monitoring measures the worst case in-stream stormwater pollutant concentrations or the “first flush” of runoff into the stream. CWD targets storm events with greater than 0.5 inches of rain expected after 72 hours of no rainfall, which makes scheduling stormwater sampling events difficult. CWD staff sampled five sites during one storm event on April 8, 2014: Industrial Brook, RT-20, Summer St., Lexington Brook, and WA-17. See Appendix G for CWD stormwater sampling results.

Several USGS continuous monitoring stations are outfitted to automatically sample storm events, eliminating scheduling conflicts. USGS stormwater automated samples are taken throughout the entire storm, mixed together, and then analyzed for a variety of chemical and nutrient parameters. The stormwater sampling data are available online by station ID number.[3] The USGS sampled eight storm events between April and December 2014 at the following sites: HB @ Mill St., Lexington Brook, Tracer Lane, WA-17, and Summer St. The stormwater sample chloride, sodium, and TP concentrations are compared to CWD base-flow samples in Figures 29 - 31.

Sodium and chloride concentrations in watershed catchments with high percentages of roadway areas (Lexington Brook, Tracer Lane, WA-17) were reduced during storm events due to dilution from runoff. Variation in sodium and chloride concentrations between dry and wet sampling efforts were minimal in less developed catchments such as HB @ Mill St. and Summer St.

[3] The USGS has complied and analyzed stormwater samples from 2005-2007 that is available here as in an interpretive report, *Water-quality conditions, and constituent loads and yields in the Cambridge drinking-water source area, Massachusetts, water years 2005–07*.

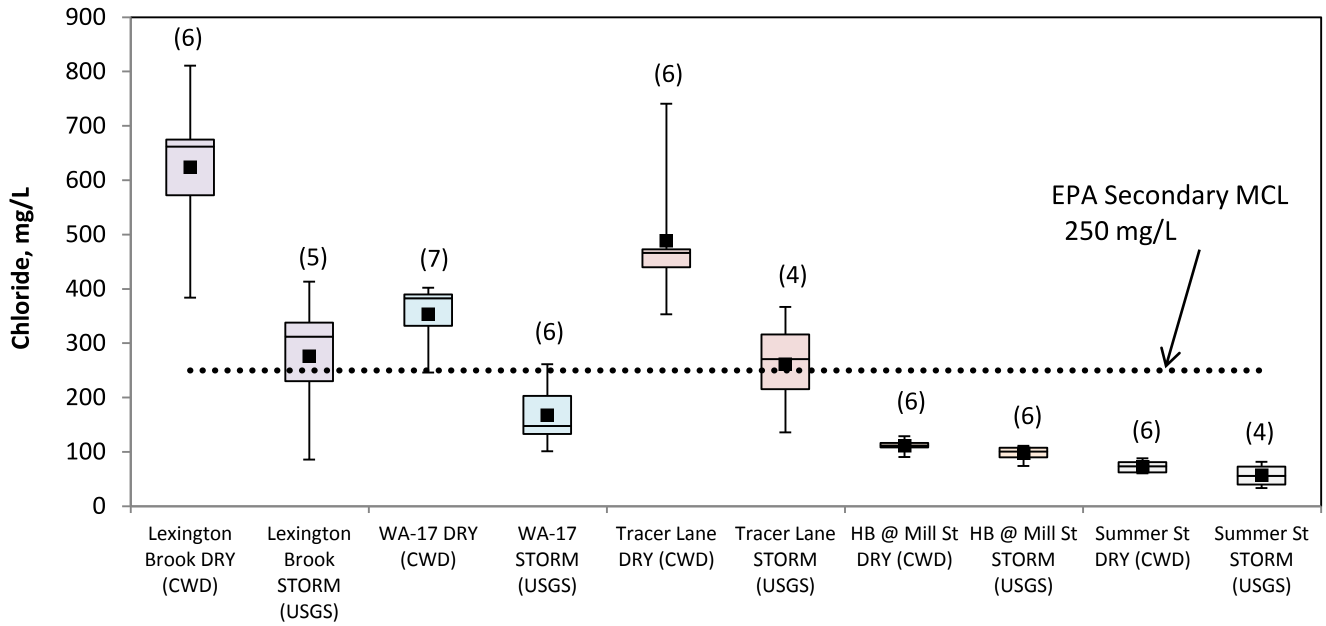


Figure 29: Comparison of Chloride Concentrations in CWD Base-flow and USGS Stormflow Data, 2014

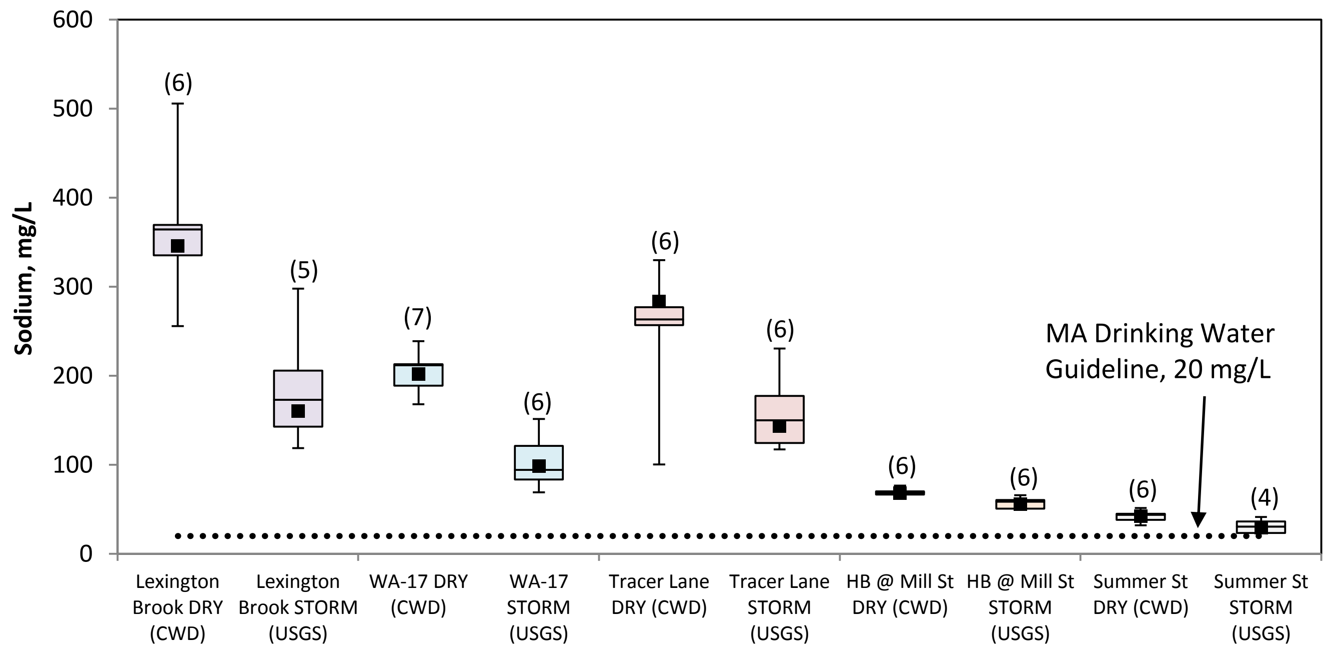


Figure 30: Comparison of Sodium Concentrations in CWD Base-flow and Preliminary USGS Stormflow Data, 2014

Total phosphorus concentrations, on the other hand, are markedly higher in stormflow samples than in base-flow at every monitoring location sampled in 2014. Common sources of TP in the watershed include the use of fertilizers, the natural weathering of rocks and soils, and septic tank leaks and failures. Phosphorus tends to stay in the particulate phase, and is thus introduced to the water supply most commonly in runoff (Smith, 2013).

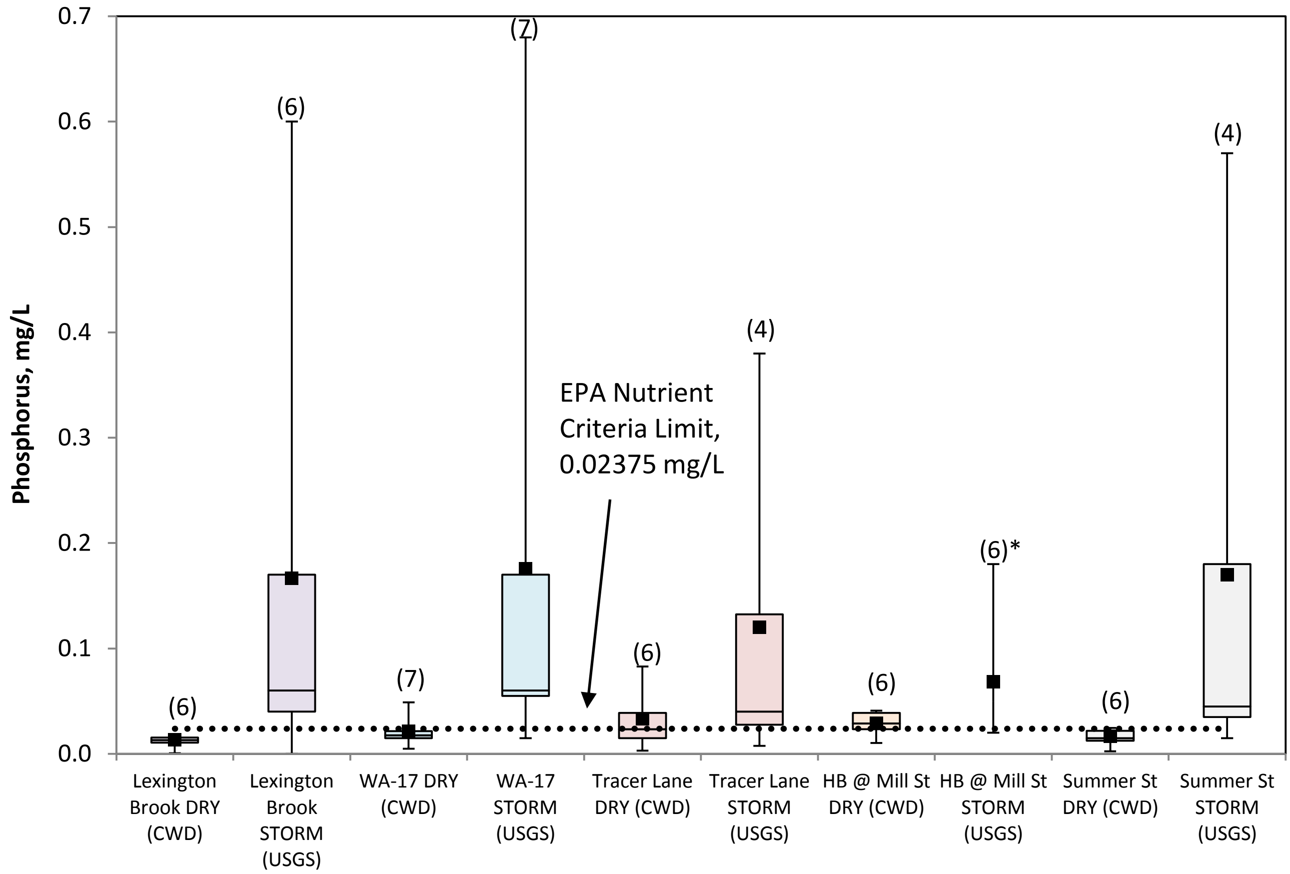


Figure 31: Comparison of Total Phosphorus Concentrations in CWD Base-flow and USGS Preliminary Stormflow Data, 2014 * For Hobbs Brook @ Mill St. storm sampling data, the median was the same as the 25^{th} and 75^{th} percentiles.

Nitrate, while not sampled by USGS during storm events in 2014, is believed to show minimal difference between base-flow and storm flow conditions. The USGS 2005-2007 report found that total nitrogen concentrations were not correlated with discharge at the tributary sites included in the study (Smith, 2013).

Load and Yields

Loads and yields of sodium, chloride, nitrate, and TP were calculated for all tributaries entering the Hobbs and Stony Brook Reservoirs. Understanding the contribution of each tributary to reservoir pollutant loads can help prioritize and target management activities within the watershed.

In 2014, the Stony Brook Reservoir received annual pollutant loads of sodium, chloride, nitrate, and TP that were four to seven times higher than Hobbs Brook. This is due to the fact that the Stony Brook Reservoir has a larger drainage area (15 mi^2, 22 mi^2 including the Hobbs drainage area) than the Hobbs Brook Reservoir (7 mi^2) and receives a greater volume of water as a result.

Water released from the Hobbs Brook Dam accounted for nearly 30 percent of the total annual volume of tributary water entering the Stony Brook Reservoir in 2014. As such, the quality of water leaving the Hobbs Brook Reservoir has implications on water quality in the Stony Brook Reservoir.

Although efforts to reduce pollutant loads typically focus on stormwater management, the majority of sodium, chloride, nitrate, and TP entering the reservoirs via tributaries did so through base-flow (Figure 32). The one exception is TP at the Hobbs Brook Reservoir, where 64 percent of the total tributary load was attributable to stormflow, and 92 percent and 70 percent of the load from the Lexington Brook and Tracer Lane tributaries, respectively, were attributable to stormflow (Figure 32 and 33). The stormflow portion of all four pollutant loads was higher at Hobbs than at Stony (Figure 32), although the Hobbs Brook Reservoir is a larger reservoir and has a greater capacity to dilute concentrated stormflow discharges. However, with more than a third of sodium, chloride, and nitrate loads and 64 percent of the TP load attributable to stormflow in the Hobbs Brook Reservoir, stormwater management is still an important watershed protection strategy.

Rt 20 was by far the largest contributor of sodium, chloride, nitrate, and TP due to its large drainage area and high volume of water transporting pollutants on a daily basis (Figure 33). However, on a per area basis, Lexington Brook, WA-17, and Tracer Lane were the largest contributors of TP, sodium, and chloride (Figure 34). WA-17 had the highest nitrate yield, which is likely due to the malfunctioning of a stormwater pond at the Rt 20/95 interchange which became active in October of 2012. Summer St. had the second highest load and yield for nitrate, likely attributable to fertilizer use at a golf course and at residences within the catchment area.

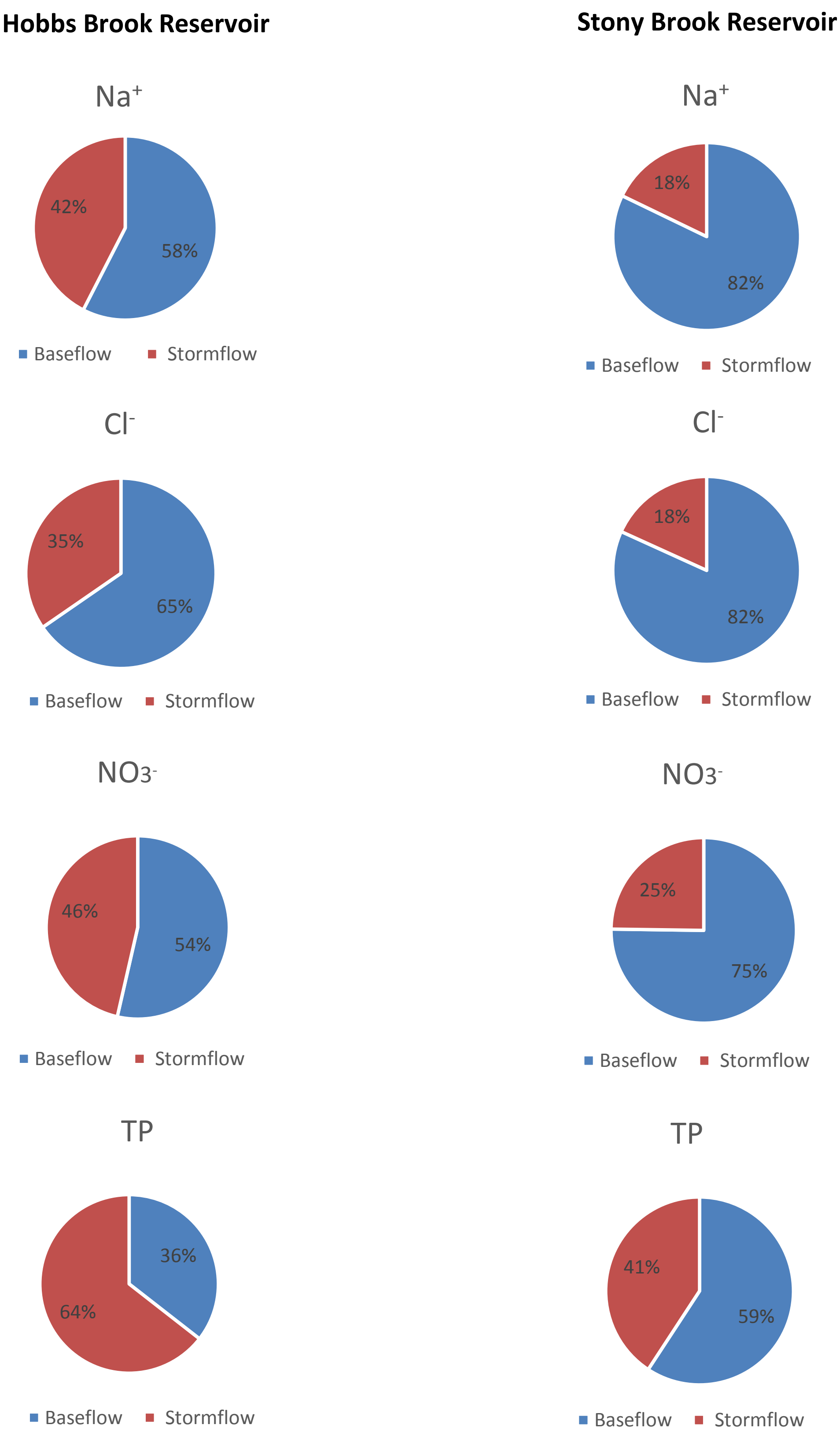


Figure 32: Base-flow and Stormflow Na^+, Cl^-, NO_3^- and TP Load Comparison at Hobbs and Stony Brook Reservoirs, 2014

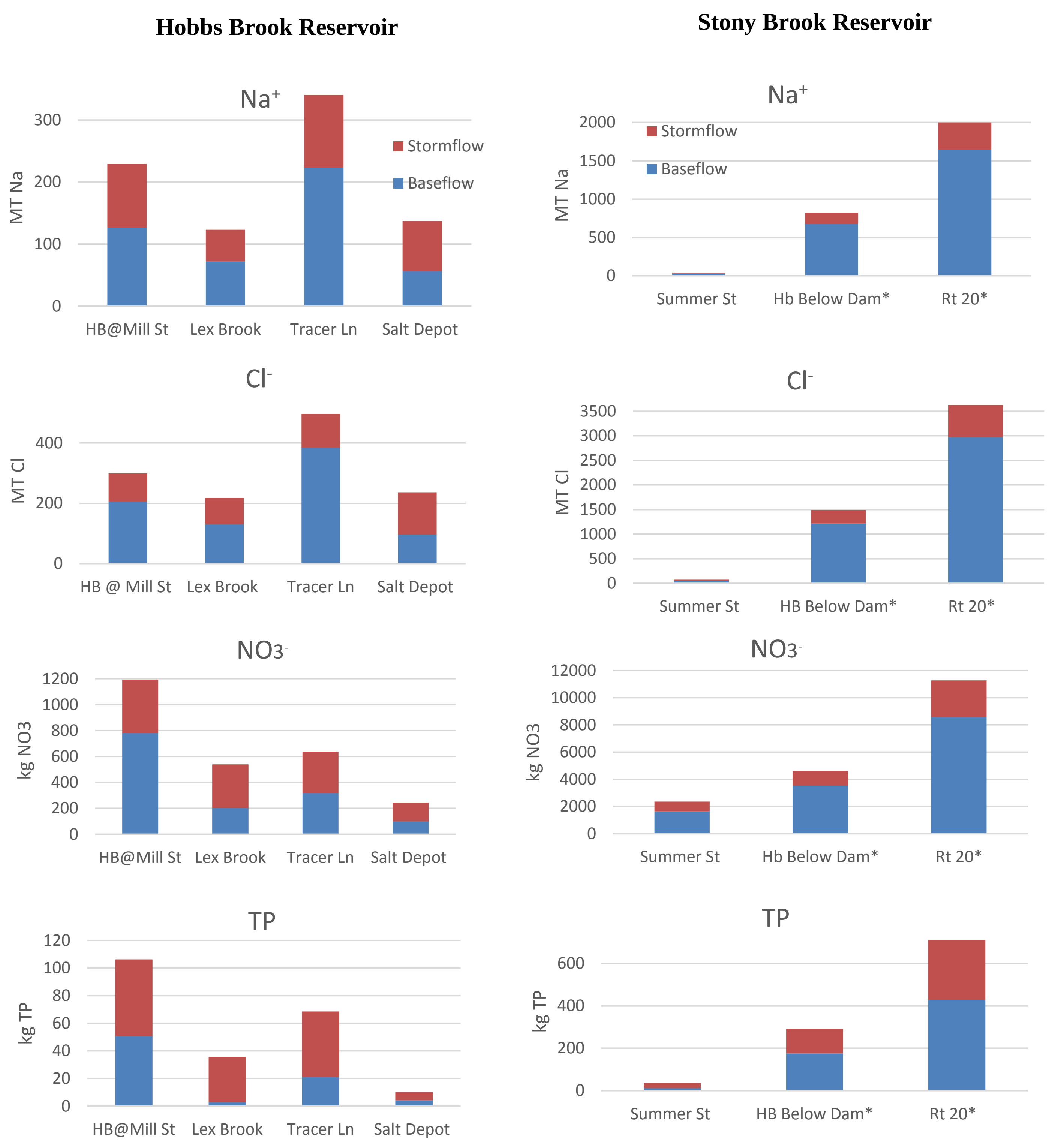


Figure 33: Comparison of Stormflow and Base-flow Na^+, Cl^-, NO_3^-, and TP Loads in Hobbs and Stony Brook Reservoir Tributaries, 2014. * "HB Below Dam" is the load from the volume of water at Rt 20 attributable to releases from the Hobbs Brook Dam. "Rt 20" is the yield attributable to water passing through the Rt 20 site excluding water released from the Hobbs Dam.

Hobbs Brook Reservoir **Stony Brook Reservoir**

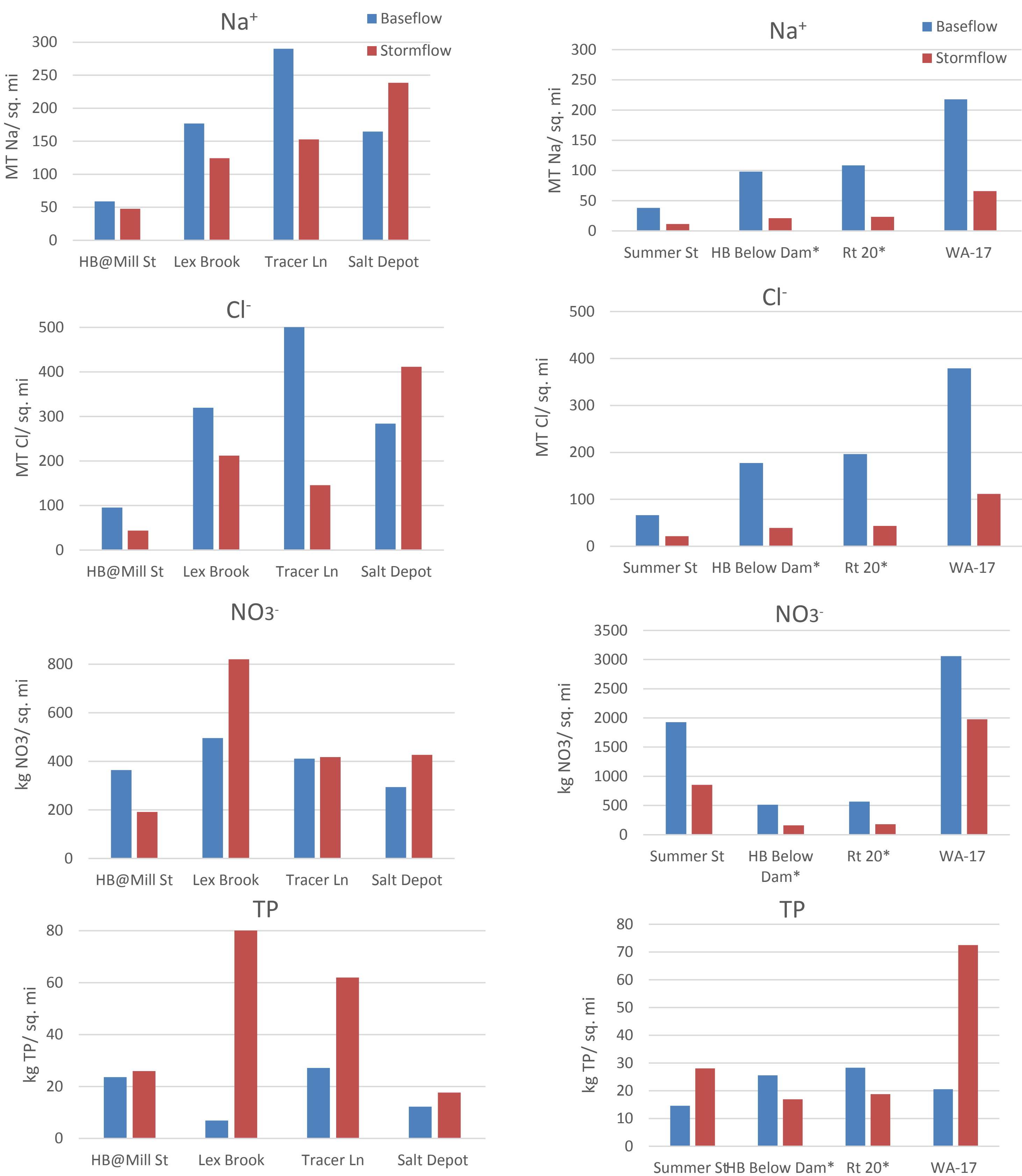


Figure 34: Comparison of Base-flow and Stormflow Na^+, Cl^-, NO_3^-, and TP Yields in Hobbs and Stony Brook Reservoir Tributaries, 2014. * "HB Below Dam" is the yield from the volume of water at Rt 20 attributable to releases from the Hobbs Brook Dam. "Rt 20" is the yield attributable to water passing through the Rt 20 site excluding water released from the Hobbs Dam.

Water Balance

Available Water

The water balance, which defines the balance between water gains (inflow components) and losses (outflow components) over a given period of time, is a useful tool for general management decisions.

The water balance determined for Hobbs Brook Reservoir during this reporting period can be considered a generalized approximation of the overall water availability. The annual outflow estimated from data obtained at the USGS monitoring station immediately downstream of Hobbs Brook in 2014 was 2.57 billion gallons (Table 8). Between 2008 and 2014, annual outflows from Hobbs Brook Reservoir ranged from 1.80 billion gallons (2012) to 4.89 billion gallons (2010), with a seven-year average of 2.92 billion gallons. The reservoir hydraulic retention time (defined as the time it would take for the reservoir to empty out if all inputs of water to the reservoir ceased) can be estimated using the total storage capacity of 2.52 billion gallons for 2010-2012 and 2.89 billion gallons for 2008-2009. The difference in storage capacity is due to the removal of spillway flash boards at the Hobbs Brook Dam in 2010. The hydraulic retention time was 12 months in 2014 and 12 months for the seven-year average.

Table 8: Hobbs Brook Reservoir Water Balance 2008-2014

Year	Hobbs Outflow (MG)**	Storage Capacity (MG)	Estimated Retention Time (months)
2008	2,465	2,885	14
2009	3,615	2,885	10
2010	4,892	2,518	6
2011	2,654	2,518	11
2012	1,806	2,518	17
2013*	2,375	2,518	13
2014*	2,565	2,518	12

*provisional USGS data, subject to revision

**total outflow = sum of average daily flows

Data records taken from the Hobbs Brook Dam precipitation gage (01104430) indicate that the Hobbs Brook and Stony Brook watersheds received an estimated 51.44 inches of rain (Table 9). This is greater than the 48.82 inch NOAA 1981-2010 Climate Normal for precipitation at the Bedford, MA station[4], but within the expected range of precipitation for the Boston-area.

Table 9: Hobbs Brook Below Dam Precipitation Gage (01104430) Total Annual Precipitation (Inches)

Year	2008	2009	2010	2011	2012	2013	2014
Total Precipitation	62.73	40.53	53.51	57.04	43.8	38.84*	51.44*

*Provisional data

Inputs to Stony Brook Reservoir are contributed mostly by its watershed during winter and spring and from the Hobbs Brook Reservoir during the summer and fall. Based on the small reservoir storage capacity

[4] http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

and large drainage area of Stony Brook, the majority of annual flows need to be diverted to the Charles River to maintain safe reservoir operating levels. Outflow from the Stony Brook Dam to the Charles River was estimated from the USGS gaging station located near the Stony Brook gatehouse. The total outflow to the Charles ranged from 2.2 billion gallons in 2012 to 10.5 billion gallons in 2010 (Table 10). Due to the reliance on MWRA during water main construction from January-May in 2014, along with greater than average precipitation, diversions to the Charles were increased relative to 2013 to maintain safe operating levels in the Stony Brook Reservoir. The high outflow in 2010 can be attributed to both the higher precipitation amount and to the March hurricane, in which very high flows were released from the Hobbs Brook Dam to sustain safe dam operating levels.

Table 10: Stony Brook Reservoir Water Balance, 2010-2014

Year	Stony to Charles (MG)**	Stony to Fresh Pond (MG)**	Total Output from Stony (MG)	Storage Capacity (MG)	Estimated Retention Time (days)
2010	10,521	3,841	14,362	418	11
2011	7,668	4,899	12,567	418	11
2012	2,178	5,256	7,435	418	22
2013*	4,222	4,098	8,320	418	18
2014*	5,463	4,317	9,780	418	15

*provisional USGS data, subject to revision

**total outflow = sum of average daily flows

Total output from Stony Brook Reservoir is the sum of water to Fresh Pond and the Charles River. The best estimate of water sent from Stony Brook through the conduit to Cambridge is based on measured flows at the Stony Brook Conduit outlet into the Fresh Pond Reservoir. Over the past five years, total annual output from Stony Brook Reservoir to Fresh Pond Reservoir ranged from 3.8 (2010) to 5.2 (2012) billion gallons. The total estimated retention time in Stony Brook Reservoir was between 11 and 22 days, indicating a high flushing rate.

Total output from Fresh Pond to the treatment plant (estimated from the total water produced by the plant) ranged from 3.6 to 4.9 billion gallons (Table 11). The seven-year average retention time is 4.11 months.

Table 11: Fresh Pond Reservoir Water Balance, 2008-2014

Year	Fresh Pond to WTP (MG)	Storage Capacity (MG)	Estimated Retention Time (months)
2008	4,878	1,507	3.72
2009	4,748	1,507	3.84
2010	4,850	1,507	3.72
2011*	4,709	1,507	3.84
2012*	4,749	1,507	3.84
2013**	3,552	1,507	5.04
2014**	3,764	1,507	4.8

*Taken from *Monthly Water Quantity and Quality Report, Decembers 2008-2012*

**Due to on-going construction projects, supplemental MWRA was used from early September-December 2013, and January-May of 2014.

Special Water Quality Investigations

The water quality monitoring program includes the investigation of specific point-source locations that contribute contaminants to the water supply. These locations are outfalls or other discharges whose sources were detected by routine or stormwater sampling and traced back upstream to their location. During this study period, continued sampling was conducted weekly at the Costco Drainage Canal, the site of a historic illicit sewage discharge into a retention basin in Waltham.

Costco Drainage Canal

Located downstream of a recently improved stormwater pond on Winter Street in Waltham, the Costco Drainage Canal site has shown extremely high bacteria concentrations that were at once from and are thought perhaps to still be from underground sewerage communication (Figure 35). Other theories identify Canada geese as the bacteria source, which frequent the upstream stormwater pond. Goose bacteria sources plus the relatively stagnant nature of the canal could explain high measured concentrations of *E. coli* bacteria.

Past chemical screening of fluoride and chlorine residual (both found in drinking water, and as such, wastewater) showed average concentrations an order of magnitude less than what would be expected in wastewater, with no direct correlations between chlorine and fluoride to bacteria concentrations. These data support the theory that the primary bacteria source is from wildlife, not sewage. Other tests such as surfactants and optical brighteners could be used to further rule out sewage sources. Bacteria results provided in Figure 35 do not yet show any clear significant trends of improvement from the recently completed pond project.

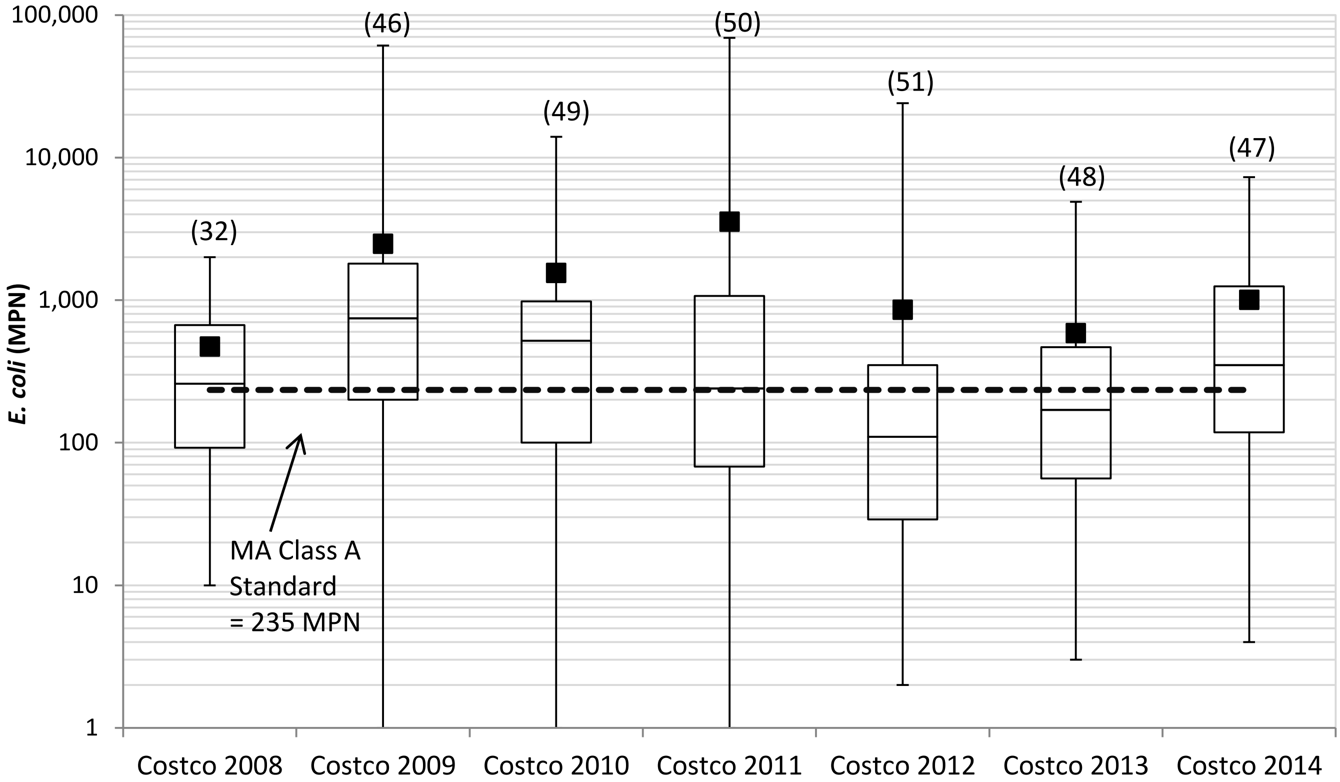


Figure 35: Costco Drainage Ditch Weekly Bacteria Results as *E. coli*, 2008-2014 (Log scale)

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Glossary

Algal bloom— The rapid proliferation of passively floating, simple plant life in and on a body of water.

Anoxic— The absence of oxygen; anaerobic.

Benthic sediments— The surface layer and some sub-surface layers of sediment in contact with the bottom zone of a water body, such as a lake or ocean.

Correlation coefficient— A statistic that can be used to measure the strength of a relation between two variables.

Discharge (hydraulics)— Rate of flow, especially fluid flow; a volume of liquid passing a point per unit of time, commonly expressed in cubic feet per second, million gallons per day, or liters per second.

Dissolved oxygen (DO) — Oxygen dissolved in water; one of the most important indicators of the condition of a water body. Dissolved oxygen is necessary for the life of fish and most other aquatic organisms.

Drainage basin— Land area drained by a river or stream; watershed.

Epilimnion— Warm, oxygen-rich, upper layer of water in a lake or other body of water, usually seasonal. *See also* Metalimnion, Hypolimnion

Eutrophic— Term applied to a body of water with a high degree of nutrient enrichment and high productivity.

Eutrophication— Process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

***Escherichia coli* (*E. coli*) bacteria**— Type of bacteria that is found in the human gastrointestinal tract. *E. coli* is commonly used as an indicator of fecal contamination in groundwater, as the result of an improper sewage connection or septic system failure.

Ground water— In the broadest sense, all subsurface water, as distinct from surface water; as more commonly used, that part of the subsurface water in the saturated zone. *See also* Surface water.

Hypolimnion— Cold, oxygen-poor, deep layer of water in a lake or other water body. *See also* Epilimnion, Metalimnion.

Hypoxic — The deprivation of oxygen compared to how much is required by the system.

Load— Material that is moved or carried by streams, reported as the weight of the material transported during a specific time period, such as kilograms per day or tons per year.

Maximum contaminant level (MCL)— Maximum permissible level of a contaminant in water that is delivered to any user of a public water system, established by a regulatory agency such as the U.S. Environmental Protection Agency. *See also* Secondary maximum contaminant level.

Mean— The arithmetic average obtained by dividing the sum of a set of quantities by the number of quantities in the set.

Median— The middle or central value in a distribution of data ranked in order of magnitude. The median also is known as the 50th percentile.

Mesotrophic— Term applied to a body of water with intermediate nutrient content and intermediate productivity.

Metalimnion— Transition zone between the warm upper layer and the cold deep layer of a lake or other water body, characterized by rapidly decreasing temperature with increasing depth. *See also* Epilimnion, Hypolimnion.

Minimum reporting limit (MRL) — The lowest measured concentration of a constituent that can be reported reliably using a given analytical method.

Monitoring station— A site on a stream, canal, lake, or reservoir used to observe systematically the chemical quality and discharge or stage of water.

Nutrient— An element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Oligotrophic— Term applied to a body of water low in nutrients and in productivity.

pH— The logarithm of the reciprocal of the hydrogen ion concentration of a solution; a measure of the acidity (pH less than 7) or alkalinity (pH greater than 7) of a solution; a pH of 7 is neutral.

Phytoplankton algae— Free-floating, mostly microscopic aquatic plants.

Phytoplankton chlorophyll-*a* — Primary light-trapping pigment in most phytoplankton algae. Concentration can be used as an indirect indicator of the abundance of phytoplankton algae in a lake or other water body.

Runoff— The part of precipitation that appears in surface streams. It is equivalent to streamflow unaffected by artificial diversions, storage, or other human works in or on the stream channel.

Secondary maximum contaminant level (SMCL) — Maximum recommended level of a contaminant in water that is delivered to any user of a public water system. These contaminants affect the esthetic quality of the water such as odor or appearance; therefore, the levels are intended as guidelines. *See also* Maximum contaminant level.

Specific conductance — A measure of the ability of a sample of water to conduct electricity.

Subbasin — Drainage basin or watershed defined by a specific monitoring station and representing the land area that contributes water to that station.

Surface water — An open body of water, such as a stream or lake.

Thermal stratification — Seasonal division of a lake or other water body into a warm upper layer and a cold deep layer that is no longer in contact with the atmosphere. In some lakes, thermal stratification can result in a loss of oxygen in the deep layer and subsequent chemical stratification.

Trihalomethane formation potential (THMFP) — Tendency of naturally occurring organic compounds in a water supply to form toxic trihalomethanes during water treatment.

Trophic state — The extent to which a body of water is enriched with plant nutrients. *See also* Eutrophic, Mesotrophic, Oligotrophic.

Trophic state index (TSI) — A numerical index indicating the degree of nutrient enrichment of a body of water.

Turbidity — The opaqueness or reduced clarity of a fluid due to the presence of suspended matter.

Water year — The continuous 12-month period, October 1 through September 30, in U.S. Geological Survey reports dealing with the surface-water supply. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1998, is referred to as the "1998" water year.

Wetlands — Lands that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Yield — The weight of material transported during any given time divided by unit drainage area, such as kilograms per day per square kilometer or tons per year per square mile.

Appendix A – Water Quality Monitoring Procedure and Schedule

Monitoring Objectives

Given the City's lack of ownership and control of most watershed lands, water quality monitoring is a necessary and effective means of identifying sources of pollution and tracking water quality changes over time. The primary goal of the Cambridge Source Water Quality Monitoring Program is to ensure that water withdrawn from Fresh Pond Reservoir for treatment is as free as possible from contaminants, thereby minimizing the costs of treatment and protecting overall water quality. Specific objectives of the program are to:

- Monitor the condition of source waters in the Cambridge drinking water supply system;
- Determine where, when, and how water quality conditions are changing over time;
- Identify actual and potential problems related to source water quality;
- Evaluate the effectiveness of programs designed to prevent or remediate water quality problems;
- Ensure that all applicable water quality goals, standards, and guidelines are being met; and
- Provide for rapid response to real-time and emerging problems.

The Cambridge Source Water Quality Monitoring Program consists of four major elements: (1) routine monitoring of reservoirs and tributary streams during base flow (dry weather) conditions, (2) event-based monitoring of streams, storm drains, and other outfalls during wet weather and special water quality investigations, (3) continuous recording of stage and selected water quality characteristics at critical sites within the drainage basin, and (4) data management, analysis, reporting, and review.

Routine Water Quality Monitoring

Under base flow (dry-weather) conditions, CWD staff members collect discrete grab samples and measure streamflow and in situ parameters (dissolved oxygen, specific conductance, temperature, oxidation-reduction potential, and pH) throughout the watershed at regular intervals during the year. Base flow sampling, conducted on days with no more than 0.10 in of rain 72 hours prior, provides a representative measurement without the influence of stormwater. Sampling is conducted at 8 reservoir-monitoring stations, and at 12 primary monitoring stations. Table 12 contains all sample dates and locations in 2014.

Routine Reservoir Monitoring

The Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs are all sampled regularly using USGS *Clean Water* sampling protocols. Each reservoir is sampled for nutrients, metals, chlorophyll-*a*, bacteria and in-situ parameters. During summer months, when the water column is thermally stratified, additional water samples at deepest hole sites are pumped from below the thermocline (the point of maximum rate of change in water temperature with depth) with a peristaltic pump through pre-cleaned Tygon tubing. Studies conducted by the USGS have shown that under most conditions, water quality data collected in depth profiles at these stations are indicative of conditions throughout the reservoirs.

Samples are analyzed at the CWD laboratory for total organic carbon, color, alkalinity, turbidity, bacteria, concentrations of major ions (sodium, calcium, chloride, and sulfate), and selected metals (aluminum, iron, and manganese) using standard approved methods. Nutrients (ammonia nitrogen, total Kjeldahl nitrogen, and TP) and chlorophyll-*a* are analyzed at contracted laboratories.

Routine Tributary Monitoring

Water entering the reservoirs is monitored at 12 monitoring stations. Monitoring stations are sampled 4 to 8 times a year. Specific conductance, pH, water temperature, and dissolved oxygen concentration are measured in situ and water samples are collected at the stream channel center in accordance with clean sampling protocols. The samples are analyzed at both CWD and contracted laboratories for the same suite of parameters as the reservoir samples except for chlorophyll-*a*.

USGS Continuous-Record Surface-Water Monitoring

Continuous (15 minute interval) monitoring is conducted at nine primary tributary monitoring stations and three reservoir monitoring stations. These stations are operated and maintained by the USGS and CWD for continuous measurement of stream and reservoir stage, discharge (eight sites only), temperature, and temperature-corrected specific conductance. Precipitation is monitored at the three reservoir stations, and wind speed and direction is measured at the Stony Brook reservoir. Late in 2001, a more elaborate water quality monitoring system was installed at Stony Brook Reservoir which measures turbidity, temperature, specific conductance and chlorophyll-*a* at three different reservoir depths (USGS unpublished data).

All continuous monitoring information is uploaded on a real-time basis to the USGS internet site, which can be accessed from the hyperlink below.

http://waterdata.usgs.gov/ma/nwis/current?type=cambrid&group_key=NONE&search_site_no_station_nm=&format=html_table

Salt Depot and Tracer Lane have continuously monitored discharge data, although this data is not published online.

Table 12: CWD Water Quality Monitoring Schedule, 2014

Primary Tributary Group 1 (5 Sites)	Sampling Dates
HB @ Mill St*	2/11
Salt Depot	3/25
Tracer Lane*	5/22
SB @ Viles	8/7
MBS	12/2

Frequency Target : 8 Events

*Sixth sample taken alongside USGS on 6/12

Primary Tributary Group 2 (5 Sites)	Sampling Dates
Lexington Brook	1/30
HB Below Dam*	3/11
WA-17*	5/13
Rt 20*	7/3
Summer St	9/25
	12/16

Frequency Target : 8 Events

*Seventh sample taken 3/25 (Below Dam) and 6/10 (WA-17 & RT-20)

Primary Tributary and Reservoir Group (4 Sites)	Sampling Dates
Industrial Brook	3/4
HB @ KG	5/6
HB Middle*	6/24
HB Upper*	7/31
	10/28

Frequency Target : 8 Events

*HB @Mid and Upper not sampled 3/4 due to ice cover

Upcountry Reservoirs Group (6 Sites)	Sampling Dates
HB @ DH	4/22
HB @ DH depth **	6/19
HB @ Intake	9/11
SB @ DH	11/13
SB @ DH depth**	
SB @ Intake	

Frequency Target : 8 Events

Fresh Pond Reservoir Group (4 Sites)	Sampling Dates
FP @ DH	4/15
FP @ DH depth **	6/3
FP @ Cove	7/1
FP @ Intake	8/5
	11/4

Frequency Target : 8 Events

Fresh Pond Reservation Group (3 Sites)	Sampling Dates
Little Fresh Pond	5/8
Blacks Nook	7/10
North Pond	11/20

Frequency Target : 4 Events

** Only during periods of thermal stratification

Event-Based Water Quality Monitoring

Stormwater Sampling

Wet weather or stormwater sampling by staff in the field can be difficult to schedule due to the unpredictable timing of precipitation events. Thus automatic sampling is a preferred method for obtaining wet weather samples when available. Due to the joint funding agreement with USGS, the city of Cambridge is in a unique position to benefit from continuous monitoring stations set up within the watershed. Stations at HB @ Mill St., Lexington Brook, Tracer Lane, WA-17 and Summer St. are equipped with automatic samplers which will collect storm water when triggered by an unusually high stream flow. As a result of this monitoring capability, the water department has scaled back our in-field storm water sampling program, preferring to rely on data provided by the gaging stations. USGS storm sample collection dates for 2014 are presented below in Table 13. The range of dates indicates the duration of the storm from which the composite sample was derived.

Table 13: USGS Wet Weather Sampling Dates, 2014

Site	USGS Site ID	Wet Weather Sampling Dates
HB @ Mill St	01104405	April 8-April 9 April 15-April 17 July 16-July 17 Nov.1-Nov.2 Nov.17-Nov.18 Dec.6-Dec.7
Lexington Brook	01104415	April 8 April 15-April 16 July 15-July 16 Nov.1-Nov. 2 Dec.5-Dec. 6
Tracer Lane	01104420	April 8-April 9 April 15-April 16 July 15-July 17 Dec. 5-Dec. 7
WA-17	01104455	April 8-April 9 April 15-April 16 July 16-July 17 Nov.17-Nov. 18 Dec. 5-Dec. 7
Summer St	01104475	April 8-April 9 April 15-April 17 July 15-July 16 Nov. 17-Nov.18

Incident-Based Sampling

CWD staff perform additional sampling on an as-needed basis to investigate problems associated emergency spills or illicit discharges within the watershed, and to monitor runoff from construction activities. These test results help guide management and enforcement activities within the watershed.

Data Management, Interpretation, Reporting, and Review

All water quality monitoring and quality-assurance data are entered into a CWD-maintained database that enables the CWD analyze, track, and report changes in water quality efficiently. Data is compared to the 1998 water year baseline study conducted by the USGS. This report is the result of the reporting portion of the water quality monitoring program.

Appendix B: Class B Waters on Fresh Pond Reservation

In this study period, all reservation ponds met Massachusetts Class B water quality standards for temperature, pH, and *E. coli* for all three sampling events (each pond was sampled three times for nine total sample events). One sampling event at Little Fresh Pond (LFP) exceeded the minimum dissolved oxygen standard. All samples at all locations exceeded the TP EPA nutrient criteria for the ecoregion (0.008 mg/L). Table 14 lists a summary of exceedances for all Class B reservation ponds in 2014.

Table 14: Summary of Exceedances for Fresh Pond Reservation Ponds (Class B Waters), 2014

Standard	Parameter	Standard	Number Sampling Events	Number Exceedances	Percent Exceedances
MA Class B Water Quality	DO	> 5 mg/L	9	1	11%
MA Class B Water Quality	Temperature	< 28.3 °C	9	0	0%
MA Class B Water Quality	pH	Between 6.5 - 8.3	9	0	0%
MA Class Single Sample	*E.Coli*	< 235 MPN	9	0	0%
EPA Nutrient Criteria for Fresh Pond Ecoregion	NO_3^-	< 0.31	9	3	33%
EPA Nutrient Criteria for Fresh Pond Ecoregion	TP	< 0.008 mg/L	9	9	100%

High phosphorus (Figure 36) and chlorophyll-*a* (Figure 37) results are consistent with expectations of moderately to highly productive ponds. TSI values are all in the mesotrophic to eutrophic range for all three ponds (Figure 38). Sodium concentrations in Little Fresh Pond are consistent with those in Fresh Pond Reservoir supporting assumptions of good groundwater communication and also the influence of Fresh Pond water being periodically diverted into Little Fresh Pond through a gated pipe for golf course irrigation in dry periods.

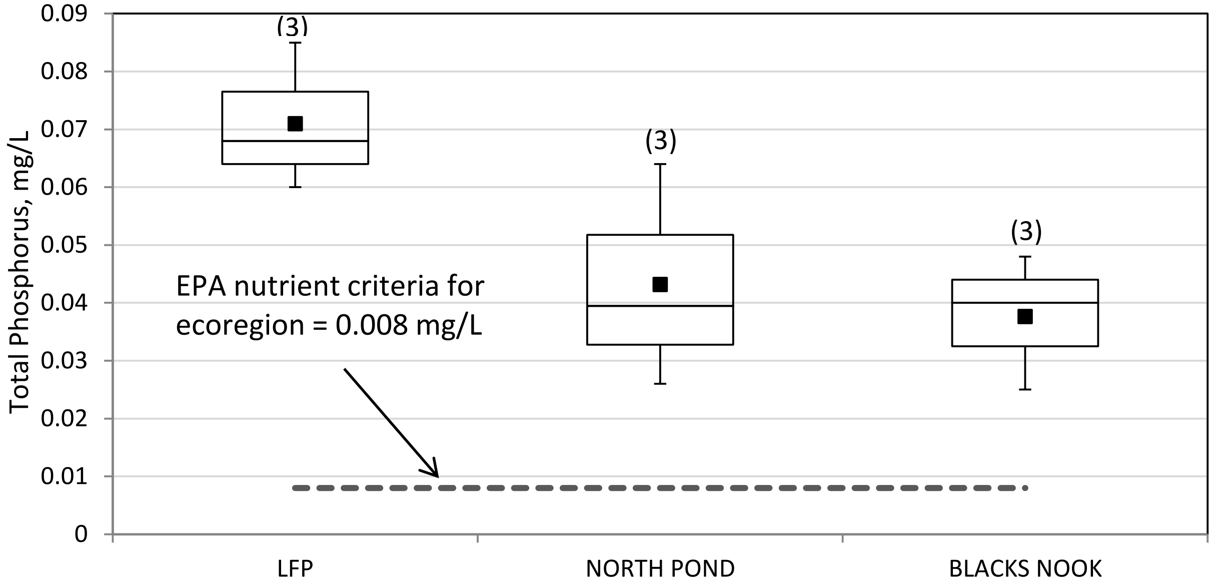


Figure 36: Fresh Pond Reservation Ponds Total Phosphorus Concentrations, 2014

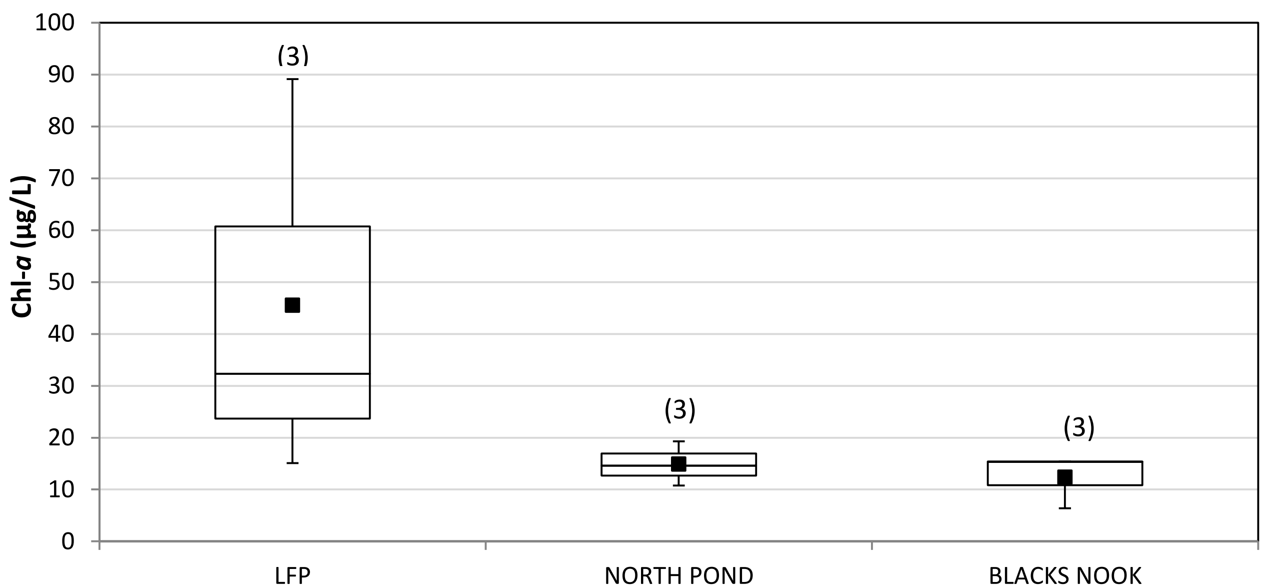


Figure 37: Fresh Pond Reservation Ponds Chl-*a* Concentrations, 2014

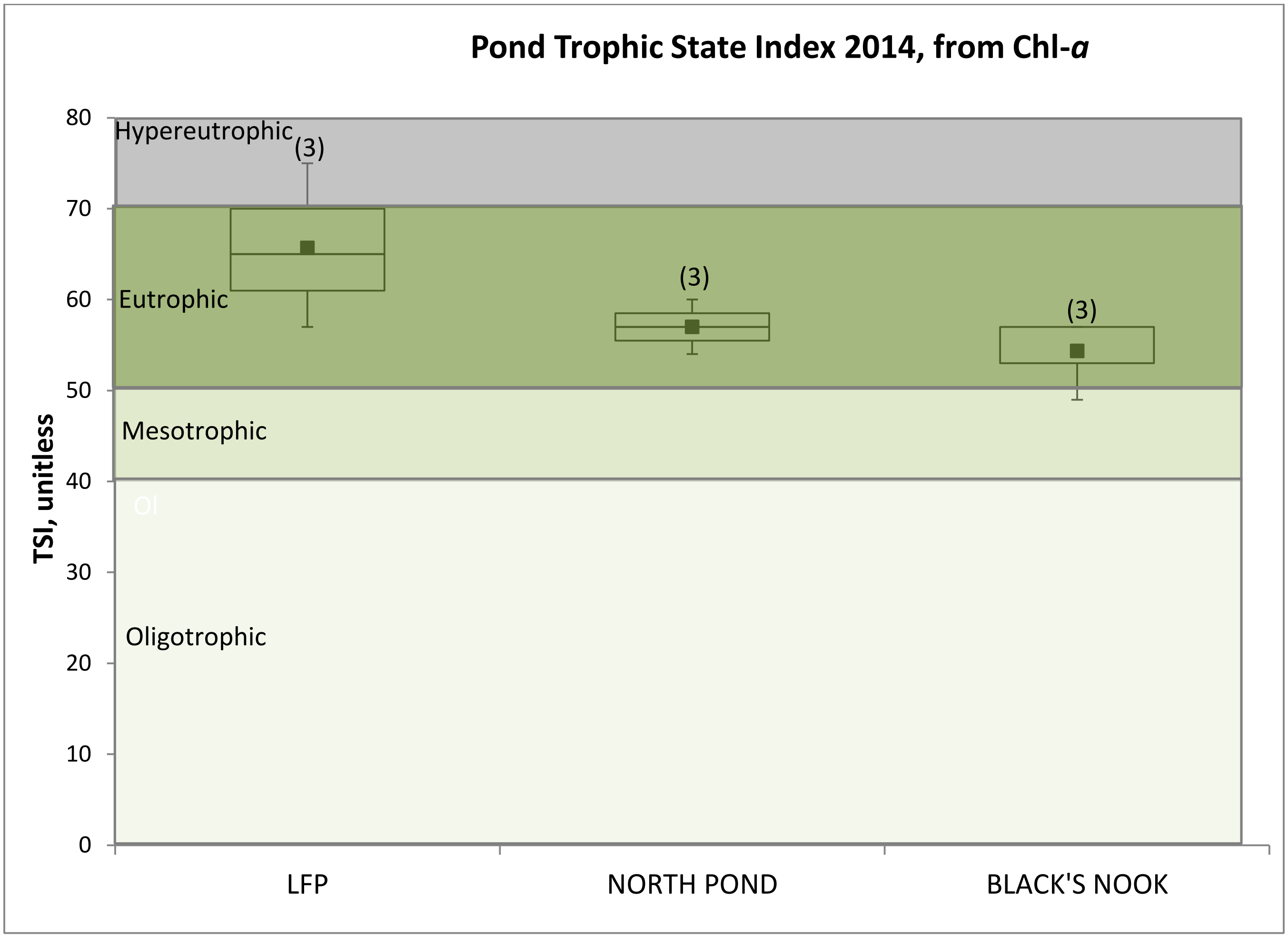
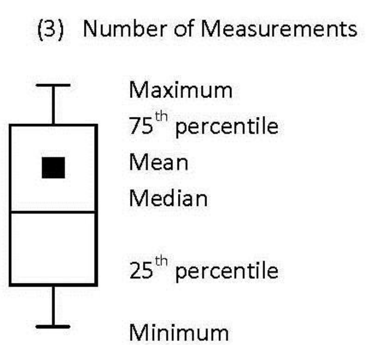


Figure 38: Fresh Pond Reservation Ponds Trophic State Index (TSI) Results from Chl-*a*, 2014



Appendix C: Quality Control Measures

USGS Side-by-Sides

CWD staff conducted sampling alongside USGS staff in June to provide a broad measure of the inherent and introduced variability in surface water samples. Variability may be introduced in results from the sample collection, processing, and analysis; from the differences in laboratory analysis techniques or handling; or from the natural variability of concentations in surface waters.

In 2014, four primary tributary sites were sampled as side-by-sides with the USGS. WA-17 and RT-20 were sampled on June 10th and HB @ Mill St. and Tracer Lane were sampled on the 12th. Grab samples were taken using the same protocols that CWD follows for routine water quality sampling. The samples were taken from the same location in the tributary at the same time.

Sampling data was collected from the USGS website and compared. The precision of the data is measured using the Relative Percent Difference (RPD) metric. RPD is calculated using the equation

$$RPD = \frac{|x_1 - x_2|}{(x_1 + x_2) * (\frac{1}{2})} * 100\%$$

Where x_1 and x_2 are the sample measurement and corresponding field duplicate. Due to the nature of measurement error and environmental sampling constraints, differences within 20 percent are considered acceptable measurements. The median, average, minimum, and maximum RPD's for all parameters are provided in Table 15. The RPD each parameter is show in in Table 16.

Table 15: Relative Percent Differences, CWD and USGS Side-by-Side Samples, 2014

Date	Station	Median	Average	Min	Max
6/10/2014	WA-17	3%	7%	0%	23%
6/10/2014	RT-20	4%	11%	0%	33%
6/12/2014	Tracer Lane	6%	17%	0%	86%
6/12/2014	HB @ Mill St	3%	13 %	0%	58%

Table 16: USGS Side-by-Side Sample Results and Percent Differences by Parameter

Site	Agency	Date	Water Temp. (°C)	SpC (µS/cm)	Total Phos. (mg/L)	Ca^{2+} (mg/L)	Cl^- (mg/L)	Lab Conductivity (umhos/cm)	Na^+ (mg/L)	lab turbidity (ntu)
HB @ Mill St	CWD	6/12/2014	15.14	458	0.034	21.8	112	447	69.2	4.41
	USGS	6/12/2014	15.10	452	0.062	18.1	113	461	57.8	3.6
%RPD			0%	1%	58%	19%	1%	3%	18%	20%
WA-17	CWD	6/10/2014	18.23	1517	0.025	75.9	402	1510	234	2.56
	USGS	6/10/2014	18.3	1480	0.026	65.9	392	1520	186	2.2
%RPD			0%	2%	4%	14%	3%	1%	23%	15%
RT-20	CWD	6/10/2014	18.59	690	0.110	30.8	186	709	112	11.5
	USGS	6/10/2014	18.8	691	0.117	24.7	188	717	91.9	16
% RPD			1%	0%	6%	22%	1%	1%	20%	33%
Tracer Lane	CWD	6/12/2014	18.33	1650	0.041	60.1	474	1640	280	6.08
	USGS	6/12/2014	17.6	1610	0.103	51.2	473	1650	225	5.70
% RPD			4%	2%	86%	16%	0%	1%	22%	6%

The largest differences were measured with TP, sodium, calcium and lab turbidity. The USGS lab and CWD lab both use ion chromatography to measure chloride concentrations. The USGS lab and CWD lab both use mass spectrometry to measure trace metals, but differences could be introduced through different sample digestion methods. High discrepancies between CWD and USGS phosphorus samples could indicate contamination from suspension of bed sediments due to multiple people walking in the stream. Future sampling efforts should ensure that samples are collected upstream of any disturbances.

Field Duplicates and Trip Blanks

Field duplicates and trip blanks provide QC checks in-house for CWD data. Field duplicates are taken at one location during most sampling events to measure the precision of CWD data. Trip blanks ensure there is no cross-contamination of the samples during sampling and processing.

The trip blank was included with the primary tributary samples taken on March 25, 2014. All analyses yielded non-detects with the exception of ammonia at 0.054 mg/L which was just above the detection limit of 0.05 mg/L, and chloride at 0.1 mg/L. Values for pH, conductivity, and turbidity were within the expected ranges for de-ionized water. This indicates that CWD sampling methods and procedures are good and prevent cross contamination of samples.

The field duplicate average RPD's broken into the various sampling types for both the CWD and Premier Labs ranged from 6-18 percent (Table 17). The overall relative percent differences were 8 percent for the tests performed by the CWD lab and 16 percent for test performed the contract lab, Premier. In general, this signifies a very high level of precision and replicability in the data obtained from watershed sampling efforts.

Table 17: Average Relative Percent Differences, 2014

All Samples		Tributaries		Reservoirs		Reservation	
Premier	CWD	Premier	CWD	Premier	CWD	Premier	CWD
16%	8%	13%	10%	18%	6%	16%	8%

Appendix D – Base-flow and Stormflow Separation Method

Separation of base-flow from total discharge was performed according to the Fixed Interval Method, whereby the lowest recorded discharge value over a fixed time interval (3 to 11 days) is used to represent base-flow over the entire interval (Sloto and Crouse, 1996). The fixed time interval (2N*) is a function of the drainage area of a catchment, and is calculated by first estimating the recession period for surface runoff following a storm event:

$N=A^{0.2}$
Where:
N=recession period, A=area of catchment (sq. mi)

2N* = the odd integer between 3 and 11 closest to twice the recession period (N*2)

In this study, all catchments had intervals of 3 days. Therefore, base-flow was calculated as the lowest discharge value in each three day period of 2014. For example, base-flow for each day between January 1 and January 3 assigned based on the minimum value recorded during the interval. The same process was repeated for the next three days, January 4 – January 6. Stormflow was calculated as the difference between total discharge and base-flow. A difference of zero between total discharge and base-flow represents dry conditions with no stormflow. Daily average discharge was used as proxy data during days where instantaneous data were missing from the record.
Annual total discharge, base-flow, and stormflow were calculated by integrating the instantaneous data for each category:

$$Q_{annual} = ((Q_2+Q_1)/2)*(t_2-t_1) + ((Q_3+Q_2)/2)*(t_3-t_2)\ldots+ ((Q_n+Q_{n-1})/2)*(t_n-t_{n-1})$$

Where

Q_{annual} = annual total discharge, base-flow, or stormflow in cubic feet per year
Q_n = instantaneous total discharge, base-flow, or stormflow in cubic feet per second
t_n = time and date of discharge measurement, in seconds elapsed since 1/1/1900[5]

Base-flow separation was performed for all sites where USGS instantaneous discharge data were available: Lexington Brook, HB @ Mill St., Salt Depot, Tracer Lane, Rt. 20, WA-17, and Summer St. Salt Depot and Tracer Lane instantaneous data were provided directly to CWD by USGS. All other data were publically available and accessible from the USGS website.

[5] The time and date of each instantaneous discharge measurement was recorded and transferred into an Excel database. Dates stored in Excel, when converted to numeric format, represent the number of days have elapsed since 1/1/1900. For example, 1/1/1900 at 00:00 = 0 days, 1/1/2014 at 12:00 = 41640.5 days. This number can be converted into the number of seconds elapsed since 1/1/1900 by multiplying by 86400, the number of seconds in a day. All time/date records from 2014 were converted into numeric format in Excel and multiplied by 86,400 to derive the number of seconds elapsed since 1/1/1900 at each time step. Having data in this format allowed for the calculation of the number of seconds elapsed between each discharge measurement (t_n-t_{n-1}).

Appendix E

Table 18: Reservoir Chlorophyll-*a*, Total Phosphorus, Secchi Depth, and Corresponding TSI Value, 2014

	Sampling Date	Chlorophyll-*a* (µg/L)	TSI	Total Phosphorus (mg/L)	TSI	Secchi Depth (m)	TSI
Hobbs Brook at Upper	5/6/2014	24.35	62	0.031	53	NS	
	6/24/2014	24.30	62	0.041	58		
	7/31/2014	17.30	59	0.041	58		
	10/28/2014	8.15	51	0.065	64		
Hobbs Brook at Middle	5/6/2014	19.4	60	0.019	47	NS	
	6/24/2014	30.95	64	0.026	51		
	7/31/2014	6.08	48	0.023	49		
	10/28/2014	18.65	59	0.058	63		
Hobbs Brook at Deep Hole	4/22/2014	2.75	41	<0.01	37	3.5	42
	6/19/2014	3.58	43	<0.01	37	4	40
	9/11/2014	5.85	48	0.011	39	NS	
	11/13/2014	2.79	41	0.01	37	3	44
Stony Brook at Deep Hole	4/22/2014	6.13	48	0.012	40	2.5	47
	6/19/2014	2.98	41	0.015	43	3	44
	9/11/2014	4.32	45	0.013	41	2.5	47
	11/13/2014	2.65	40	0.0115	39	3.00	44
Fresh Pond at Deep Hole	4/15/2014	<2	37	<0.01	37	4	40
	6/3/2014	<2	37	<0.01	37	4.5	38
	7/1/2014	2.24	39	<0.01	37	5	37
	8/5/2014	<2	37	<0.01	37	5.5	35
	11/4/2014	<2	37	<0.01	37	5	37

Note: the detection limit was used as proxy for values below detection limit
NS: Not sampled.

Table 19: CWD Base-flow Sample Results

Site	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp mV	salinity PSS	TDS (mg/L)	Air temp. (°F)	BP (mmHg)	Staff Height	Discharge (inst. cfs)	NH3 (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ca (mg/L)	Cl (mg/L)
HB @ MILL ST	2/11/2014	9:25:56	0.05	490	72.00	10.60	7	56	0.22	313.70	16.0	768.00	1.00	2.80	0.062	<0.5	0.013	19.3	118
HB @ MILL ST	3/25/2014	9:26:08	0.03	448	77.80	11.42	7	26	0.20	286.90	25.7	765.00	1.25		0.092	0.580	0.023	14.5	111
HB @ MILL ST	5/22/2014	9:17:21	12.81	414	86.60	9.15	7.26	59	0.20	265.20	58.2	760.00	1.86		0.200	0.720	0.041	18.7	107
HB @ MILL ST	6/12/2014	11:44:15	15.14	458	77.20	7.80	7	-5	0.22	293.00	66.38	764.0	1.78	>1	0.190	0.670	0.034	21.8	112
HB @ MILL ST	8/7/2014	9:11:48	16.14	515	92.10	9.02	7	92	0.25	329.40	69.4	758.00	0.70	0.42	0.120	1.000	0.039	21.9	129
HB @ MILL ST	12/2/2014	9:03:49	3.11	358	86.80	11.91	6.88	64	0.16	229.4	31.1	778.0	1.17	3.30	<0.020	0.74	0.024	14.3	90.2
SALT DEPOT	2/11/2014	9:44:59	0.07	1953	80.00	11.73	7.38	19	0.97	1250.0	18.14	768.0	0.66	0.52	<0.05	<0.5	<0.01	70.3	556
SALT DEPOT	3/25/2014	9:46:47	0.84	1222	80.70	11.56	7.32	23	0.59	782.5	27.5	765.0	0.70	0.64	0.110	<0.5	0.012	40.4	347
SALT DEPOT	5/22/2014	9:39:29	13.19	1159	83.70	8.75	7.14	3	0.58	742.2	59.9	760.0	0.64	0.46	0.160	<0.5	0.029	43.2	326
SALT DEPOT	8/7/2014	9:32:41	16.54	1842	97.00	9.39	7.09	45	0.94	1179.0	70	758.0	0.55	0.27	0.140	<0.5	0.025	65.6	544
SALT DEPOT	12/2/2014	9:27:56	3.28	1,327	81.3	11.08	6.99	94	0.65	849.3	31.5	778	0.75	0.81	0.025	<0.5	0.025	39.2	381
TRACER LANE	2/11/2014	10:24:37	0.01	2,578	25.3	3.71	6.88	96	1.30	1650.0	19.4	768	1.37	4.87	0.32	0.53	0.011	60.9	746
TRACER LANE	3/25/2014	10:22:39	0.44	1,619	59.9	8.66	7.11	70	0.80	1036.0	28.8	765	1.54	2.00	0.150	<0.5	0.015	46.6	468
TRACER LANE	5/22/2014	10:26:51	15.94	1,423	46.4	4.56	6.77	62	0.71	910.9	61.5	760	1.40	1.25	0.230	0.56	0.032	50.6	431
TRACER LANE	6/12/2014	12:57:27	18.33	1,650	42.6	4.00	6.63	77	0.83	1056.0	66.6	764	1.25		0.350	0.76	0.041	60.1	474
TRACER LANE	8/7/2014	10:08:59	19.09	1268	32.4	2.98	6.46	92	0.63	811.6	70	758	1.10		0.180	0.64	0.083	47.9	353
TRACER LANE	12/2/2014	10:05:43	3.4	1608	70.4	9.55	6.88	112	0.8	1029.0	31.5	778.0	1.61	2.60	<0.020	<0.5	0.016	36.8	463
SB@VILES	2/11/2014	10:45:52	0.18	381	91.5	13.43	7.27	88	0.17	243.7	20.8	768.0	0.86	9.40	0.071	<0.5	0.015	22	80.5
SB@VILES	3/25/2014	11:13:20	1.37	326	93.7	13.25	7.34	90	0.15	208.8	31.5	765.0	1.35	30.00	0.08	<0.5	0.021	16.8	74.3
SB@VILES	5/22/2014	10:48:12	16.00	390	91.2	8.99	7.23	84	0.18	249.8	61.0	760.0	1.22	22.00	0.13	0.760	0.044	24.7	94.6
SB@VILES	8/7/2014	10:31:26	18.08	414	91.0	8.57	7.00	143	0.20	264.8	70.0	758.0	0.62	3.70	0.09	<0.5	0.018	23	96.9
SB@VILES	12/2/2014	11:15:50	3.81	319	91.1	12.27	7.24	111	0.14	204.0	33.1	778.0	1.14	20.00	<0.020	0.620	0.018	19.8	75.6
MBS	2/11/2014	11:11:04	3.52	826	46.6	6.23	6.92	105	0.40	528.7	21.6	768.0	96.36	2.00	0.09	<0.5	0.015	27.5	214
MBS	3/25/2014	11:37:59	5.99	715	89.3	11.17	6.79	133	0.34	457.6	32.5	765.0	96.48	4.40	0.08	0.580	0.015	19.6	179
MBS	5/22/2014	11:11:46	18.98	679	57.0	5.28	6.77	109	0.33	434.5	62.4	760.0	96.46	4.60	0.19	0.780	0.018	26.3	190
MBS	8/7/2014	10:55:45	22.28	632	0.8	0.07	6.12	-27	0.30	404.6	70.0	758.0	96.40	2.80	0.13	0.620	0.033	22.7	158
MBS	12/2/2014	11:42:00	4.60	612	63.5	8.37	6.99	157	0.29	391.4	33.3	778.0	96.42	3.70	0.06	0.760	0.019	24.3	154
LEX BROOK	1/30/2014	9:32:53	0.77	2399	82.7	11.92	7.37	20	1.21	1535	18.5	772	0.65	0.18	0.23	<0.5	<0.01	54.5	679
LEX BROOK	3/11/2014	9:26:48	3.59	2252	80.2	10.39	7.36	11	1.14	1441	40.28	749	0.72	0.30	0.15	<0.5	0.02	49	675
LEX BROOK	5/13/2014	9:33:51	12.29	1840	86.7	9.34	7.34	4	0.94	1177	53.24	769	0.71	0.43	0.09	<0.5	0.014	52.9	543
LEX BROOK	7/3/2014	9:26:34	18.7		78.2	7.18	6.92	90	2.56	3047	80.06	759	0.4	0.04	0.18	<0.5	0.018	67.7	811
LEX BROOK	9/25/2014	9:02:15	12.13	2196	84.5	9.02	7.09	188	1.13	1405	53.83	761	0.26	0.03	<.05	<0.5	<0.01	56	663
LEX BROOK	12/16/2014	9:20:21	6.32	1376	82.4	10.2	7.21	49	0.68	881	43.34	765	0.82	0.70	0.08	<0.5	0.012	34.1	384
HB Below Dam	1/30/2014	10:03:26	2.78	821.6	93.2	12.78	7.61	100.00	0.4	525.8	19.76	772	0.310	0.53	0.15	<0.5	<0.01	23.1	225
HB Below Dam	3/11/2014	10:58:00	4.24	875.3	86.4	11.06	7.71	94.00	0.42	560.20	44.2	749	0.52	1.1	<0.05	<0.5	<0.01	26.4	238
HB Below Dam	3/25/2014	10:51:43	5.56	1175	65.8	8.30	7.00	111.00	0.58	752.40	30.4	765	1.00	6.7	0.120	<0.5	0.01	30	344
HB Below Dam	5/13/2014	10:02:36	15.74	843.5	97.2	9.74	7.52	111.00	0.41	539.80	54	769.0	0.34	0.94	0.054	<0.5	0.011	25.6	233
HB Below Dam	7/3/2014	9:51:58	20.82		95.9	8.44	7.23	124.00	2.43	2908.00	81.0	759	1.28	20	0.085	<0.5	0.018	25.6	239
HB Below Dam	9/25/2014	9:30:36	19.02	871.7	100.4	9.3	7.54	160	0	558	66.24	761	1.49	15	0.12	<0.5	<0.01	26.2	249
HB Below Dam	12/16/2014	9:59:11	3.56	827.7	90.2	12.00	7.49	60	0.40	529.7	35.96	765.0	0.08		0.11	<0.5	0.015	22.8	227

Table 20: CWD Base-flow Sample Results

Site	Date	Time	Color (CU)	Lab Conductivity (umhos/cm)	E-Coli (MPN)	Mn (mg/L)	NO3 (mg/L)	NO2 (mg/L)	Lab pH	Na (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Total Coliform (MPN)	Fe (mg/L)	lab turbidity (ntu)	UV254 (abs)
HB @ MILL ST	2/11/2014	9:25:56	46	479	4.1	0.071	0.39	<0.01	6.43	70.7	6.47	19	0.115	22	0.448	1.03	0.31
HB @ MILL ST	3/25/2014	9:26:08	61	421	41	0.067	0.67	<0.004	6.32	65.9	7.7	14	0.154	250	0.706	1.06	0.382
HB @ MILL ST	5/22/2014	9:17:21	130	388	91	0.056	0.63	0.004	7.05	68.7	11.1	22	0.2	>2419.6	1.23	2.57	0.726
HB @ MILL ST	6/12/2014	11:44:15	84	447	2100	0.129	0.41	0.013	7.05	69.2	7.5	30	0.129	2400	1.44	4.41	0.45
HB @ MILL ST	8/7/2014	9:11:48	100	494	580	0.038	0.722	0.02	7.07	73.7	9.6	30	0.166	>2419.6	0.947	4.65	0.554
HB @ MILL ST	12/2/2014	9:03:49	120	321	93	0.051	0.145	<0.004	6.49	60.2	14.3	13	0.259	2400	0.639	1.61	0.761
SALT DEPOT	2/11/2014	9:44:59	14	1850	14	0.802	0.23	<0.01	6.8	328	1.27	50	0.024	91	0.759	0.856	0.081
SALT DEPOT	3/25/2014	9:46:47	27	1180	1	0.364	0.75	<0.004	6.73	193	2.9	33	0.039	20	0.54	0.873	0.169
SALT DEPOT	5/22/2014	9:39:29	64	1110	35	0.376	0.7	<0.004	6.96	198	5.1	40	0.048	2400	1.23	1.67	0.361
SALT DEPOT	8/7/2014	9:32:41	48	1750	2400	0.727	0.513	0.018	7.13	306	2.6	51	0.031	>2419.6	1.82	4.2	0.241
SALT DEPOT	12/2/2014	9:27:56	52	1180	120	0.236	0.210	<0.004	6.82	222	5.3	30.5	0.079	2000	0.452	1.22	0.35
TRACER LANE	2/11/2014	10:24:37	16	2360	8.4	0.469	0.42	<0.01	6.48	438	1.51	44	0.012	150	0.586	1.42	0.104
TRACER LANE	3/25/2014	10:22:39	24	1540	46	0.119	1.02	<0.004	6.62	269	3.1	27	0.019	79	0.322	0.928	0.171
TRACER LANE	5/22/2014	10:26:51	66	1360	370	0.948	0.88	<0.004	6.85	258	5.9	46.5	0.027	>2419.6	1.65	2.64	0.425
TRACER LANE	6/12/2014	12:57:27	98	1640	340	2.2	0.091	<0.01	6.77	280	6.2	61	0.04	2400	3.01	6.08	0.519
TRACER LANE	8/7/2014	10:08:59	160	1230	280	0.958	0.378	0.02	6.77	204	7.2	47	0.023	>2419.6	6.21	14.7	0.726
TRACER LANE	12/2/2014	10:05:43	29	1440	44	0.066	0.253	<0.004	7.02	255	3.70	25.5	0.018	2400	0.166	1.13	0.226
SB@VILES	2/11/2014	10:45:52	26	360	12	0.056	1.3	<0.01	6.9	40.4	4	27.5	0.05	36	0.285	0.883	0.172
SB@VILES	3/25/2014	11:13:20	37	336	58	0.041	1.09	<0.004	6.99	38.5	5.5	21.5	0.089	160	0.501	1.14	0.235
SB@VILES	5/22/2014	10:48:12	72	379	220	0.107	1.33	0.004	7.08	52.7	7.70	28.5	0.16	>2419.6	0.96	2.56	0.408
SB@VILES	8/7/2014	10:31:26	32	396	70	0.041	1.380	0.019	7.12	46.2	5.5	26	0.011	>2419.6	0.255	0.766	0.242
SB@VILES	12/2/2014	11:15:50	54	300	91	0.02	0.51	<0.004	6.86	38.4	8.2	21	0.05	>2419.6	0.127	1.01	0.369
MBS	2/11/2014	11:11:04	32	853	4.1	0.109	1.1	0.018	6.8	139	3.92	33.5	0.036	16	0.474	0.869	0.201
MBS	3/25/2014	11:37:59	46	684	18	0.06	1.31	0.00	6.75	112	5.7	22	0.062	160	0.718	1.21	0.286
MBS	5/22/2014	11:11:46	62	675	4.1	0.085	1.11	0.01	6.92	115	6.8	28.5	0.067	1100.00	0.549	1.44	0.368
MBS	8/7/2014	10:55:45	21	608	63	0.158	0.325	0.017	6.46	92.2	8.6	34.5	0.059	>2419.6	0.856	2.96	0.461
MBS	12/2/2014	11:42:00	56	567	1	0.026	0.548	<0.004	6.88	97.4	7.8	30.5	0.053	730	0.121	1.06	0.378
LEX BROOK	1/30/2014	9:32:53	10	2110	67	0.383	2.1	0.004	6.94	371	NA	56	0.006	110	0.362	1	0.076
LEX BROOK	3/11/2014	9:26:48	17	2130	75	0.308	1.63	0.005	6.93	353	1.88	46	0.006	380	0.317	1.42	0.106
LEX BROOK	5/13/2014	9:33:51	18	1830	340	0.388	0.2	<0.004	7.06	326	2.1	51	0.015	390	1.08	1	0.126
LEX BROOK	7/3/2014	9:26:34	20		610	0.663	0.750	0.018	6.92	449	1.6	63.5	0.067	>2419.6	0.907	2	0.11
LEX BROOK	9/25/2014	9:02:15	10	2230	21	0.067	0.815	<0.004	7.22	365	1.3	40.5	0.01	>2419.6	<0.050	0.716	0.077
LEX BROOK	12/16/2014	9:20:21	13	1340	460	0.163	1.62	0.01	7.18	199	2.2	46	0.019	2400	0.202	0.805	0.111
HB Below Dam	1/30/2014	10:03:26	9	759	8.5	0.065	0.61	<0.004	7.29	126	1.96	30	<0.002	190	0.058	0.435	0.091
HB Below Dam	3/11/2014	10:58:00	10	816	0	0.061	0.65	<0.004	7.2	144	3.1	29.5	<0.002	0	0.1	0.389	0.092
HB Below Dam	3/25/2014	10:51:43	16	1160	0	0.23	0.61	<0.004	6.7	211	2.9	28.5	0.012	6.1	0.3	0.748	0.118
HB Below Dam	5/13/2014	10:02:36	17	849	12	0.089	0.456	<0.004	7.46	140	1.6	25	0.011	190	1.25	1.27	0.107
HB Below Dam	7/3/2014	9:51:58	14	846	<1	0.335	<0.05	<0.01	7.16	138	3.3	27.5	<0.002	390	0.216	0.817	0.106
HB Below Dam	9/25/2014	9:30:36	15	862	2	0.071	0.027	<0.004	7.6	137	2.8	28.5	0.005	690	0.325	1.39	0.099
HB Below Dam	12/16/2014	9:59:11	8	793	3.1	0.105	0.17	<0.004	7.29	110	2.6	26	0.003	200	0.061	0.672	0.079

Table 21: CWD Base-flow Sample Results

Site	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp mV	salinity PSS	TDS (mg/L)	Air temp. (°F)	BP (mmHg)	Staff Height	Discharge (inst. cfs)	NH3 (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ca (mg/L)	Cl (mg/L)
WA-17	1/30/2014	10:32:21	5.30	1419	83.1	10.65	7.20	97	0.71	908.6	21.56	772.0	3.11	0.27	0.077	<0.5	<0.01	50.3	352
WA-17	3/11/2014	10:20:19	7.18	1472	81.7	9.68	7.04	65	0.74	942.3	45.86	749.0	3.16	0.48	<0.05	<0.5	0.015	55.1	391
WA-17	5/13/2014	10:26:20	13.48	1439	83.4	8.76	6.96	70	0.72	920.9	53.96	769.0	3.14	0.4	0.1	<0.5	0.016	67.5	377
WA-17	6/10/2014	10:39:06	18.23	1517	78	7.32	6.86	82	0.76	971.2	71.78	761	3.08	0.18	0.18	0.66	0.025	75.9	402
WA-17	7/3/2014	10:14:41	25.27		75.8	6.14	7.08	128	2.2	2665	80.06	759	3.1	0.14	0.15	0.62	0.049	65.3	388
WA-17	9/25/2014	10:16:27	17.07	1253	48.3	4.65	6.97	110	0.62	802	62.74	761	3.07	0.095	0.15	0.71	0.018	53.1	313
WA-17	12/16/2014	10:20:06	8.94	1077	82.1	9.53	7.02	97	0.53	689.6	36.5	765	3.2	1.2	0.16	<0.50	0.018	51.4	246
RT-20	1/30/2014	10:52:32	0.96	609	88.8	12.82	7.29	49	0.28	389.8	22.1	772	5.04	12	0.18	0.60	<0.01	26.6	150
RT-20	3/11/2014	10:36:52	2.56	617.2	88.1	11.8	7.37	23	0.29	395	46.94	749	5.2	21	<0.05	<0.5	0.011	27.6	160
RT-20	5/13/2014	10:42:41	16.6	525.3	88.8	8.74	7.11	61	0	336	53.6	769	5.52	32.00	0.230	0.570	0.029	27.6	135
RT-20	6/10/2014	12:17:07	18.59	690.1	86.9	8.12	6.92	85	0.33	441.70	72.5	761	5.66	46.00	0.15	1.10	0.110	30.8	186
RT-20	7/3/2014	10:38:08	22.11		86.8	7.46	6.97	87	2.36	2833.00	80.24	759	5.34	27.00	0.100	<0.5	0.038	27.8	225
RT-20	9/25/2014	10:35:24	16.81	856.1	93.1	9.02	7.15	89	0.42	547.90	62.27	761	5.38	21.00	0.052	<0.50	0.015	26.9	246
RT-20	12/16/2014	10:33:45	3.01	420.5	87.9	11.89	7.05	100	0.19	269.10	37.4	765	5.81	56.00	0.085	0.540	0.021		101
Summer St	1/30/2014	11:14:09	2.01	353.3	99.30	13.93	7.58	113	0.16	226.1	24.08	772	0.47	0.67	0.10	0.53	<0.01	21.6	67
Summer St	3/11/2014	11:00:25	4.54	396.5	90.90	11.57	7.49	109	0.18	253.8	48.38	749	0.54	1.00	<0.05	<0.5	0.012	23.9	81.7
Summer St	5/13/2014	11:02:22	14.65	379.1	99.40	10.21	7.44	123	0.18	242.6	53.60	769	0.54	0.97	<0.05	<0.5	0.024	25.4	80.1
Summer St	7/3/2014	11:02:04	16.50		93.30	8.95	7.21	158	2.66	3165.0	79.16	759	0.28	0.15	0.06	<0.5	0.021	23	89
Summer St	9/25/2014	10:53:09	12.29	334.30	97.10	10.39	7.49	149	0.16	213.9	54.13	761	0.26		<0.05	<0.5	0.014	18.6	60.6
Summer St	12/16/2014	10:53:34	5.81	322.10	94.4	11.87	7.26	135	0.15	206.10	38	765	0.79	2.9	<0.05	0.58	0.016	17.7	60.6
INDUSTBROOK	3/4/2014	9:37:43	0.09	3286.0	52.9	7.73	7.29	13	1.7	2103.0	16.34	770	0.80	0.23	0.41	0.96	0.02	111	961
INDUSTBROOK	5/6/2014	10:33:41	13.84	2551.0	123.1	12.59	7.00	27	1.3	1632.0	58.82	758	0.82	0.27	0.20	0.58	0.02	95.1	767
INDUSTBROOK	6/24/2014	10:28:04	18.43	2548.0	60.0	5.62	6.83	15	1.3	1631.0	74.84	765	0.58	0.01	0.88	1.20	0.05	96	759
INDUSTBROOK	7/31/2014	10:18:14	19.52	1662.0	71.6	6.57	6.83	98		1063.0	74.12	765	0.76	0.165	0.22	0.65	0.04	65.60	482
INDUSTBROOK	10/28/2014	9:56:24	10.07	1811.0	80.3	9.03	6.81	74	0.9	1159.0	61.34	763	0.76	0.165	0.23	0.54	0.03	77.3	532
HB @ KG	3/4/2014	9:57:44	0.05	1094.0	94.4	13.92	7.76	64	0.5	700.3	18.68	770			0.061	0.62	0.015	41	300
HB @ KG	5/6/2014	10:53:04	11.83	843.2	95.9	10.33	7.43	95	0.4	539.6	59.54	758	1.86	18.00	0.094	<0.5	0.025	29.1	233
HB @ KG	6/24/2014	10:51:11	18.53	857.3	93.2	8.77	7.20	124	0.4	548.7	74.84	765	1.78	16.97	0.120	<0.5	0.022	26.1	239
HB @ KG	7/31/2014	10:39:15	22.33	849.1	96.3	8.38	7.15	159		543.4	75.56	765	1.89	19.64	<0.05	<0.5	0.019	27.20	238
HB @ KG	10/28/2014	10:17:07	11.04	825.6	94.3	10.41	7.31	108	0.4	528.4	61.34	763	1.51	9.00	0.140	<0.5	0.016	28.2	233

Table 22: CWD Base-flow Sample Results

Site	Date	Time	Cl (mg/L)	Color (CU)	Lab Conductivity (umhos/cm)	E-Coli (MPN)	Mn (mg/L)	NO3 (mg/L)	NO2 (mg/L)	Lab pH	Na (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Total Coliform (MPN)	Fe (mg/L)	lab turbidity (ntu)	UV254 (abs)
WA-17	1/30/2014	10:32:21	352	7	1310	0	0.067	7.08	0.007	7.08	212	0.8	70	0.022	77	0.065	1.17	0.047
WA-17	3/11/2014	10:20:19	391	10	1420	34	0.086	5	0.007	6.96	214	1.35	59.5	0.042	100	<0.050	1.7	0.054
WA-17	5/13/2014	10:26:20	377	10	1420	13	0.245	4.14	<0.004	7.02	210	3.4	57	0.022	580	0.811	1.28	0.066
WA-17	6/10/2014	10:39:06	402	20	1510	110	0.253	2.20	0.03	6.9	234	2.2	61	0.06	>2419.6	0.356	2.56	0.106
WA-17	7/3/2014	10:14:41	388	28	1440	42	0.264	1.10	0.03	7.25	198	2.6	70.5	0.096	>2419.6	0.4	3.18	0.127
WA-17	9/25/2014	10:16:27	313	19	1280	19	0.402	1.14	0.02	7.15	176	2.4	70	0.105	>2419.6	0.391	2.04	0.113
WA-17	12/16/2014	10:20:06	246	11	1050	130	0.105	3.4	<0.004	7.08	163	1.9	67.5	0.071	2400	0.297	1.98	0.069
RT-20	1/30/2014	10:52:32	150	28	572	7.5	0.201	1.98	0.006	6.99	75.7	3.18	36	0.022	180	0.363	0.933	0.178
RT-20	3/11/2014	10:36:52	160	27	580	36	0.172	1.5	0.004	7.12	81.2	3.85	29	0.016	90	0.355	0.96	0.169
RT-20	5/13/2014	10:42:41	135	53	543	79	0.221	0.15	<0.004	7.22	75.2	5.9	31	0.122	2400	0.796	2.42	0.305
RT-20	6/10/2014	12:17:07	186	53	709	1400	0.736	0.430	0.01	7.05	112	4.7	29	0.71	>2419.6	2.69	11.5	0.221
RT-20	7/3/2014	10:38:08	225	23	802	200	0.329	0.240	<0.01	7.16	130	3.6	28	0.142	>2419.6	0.889	1.46	0.141
RT-20	9/25/2014	10:35:24	246	11	873	77	0.12	0.130	<0.004	7.3	132	2.8	31	0.107	>2419.6	0.243	0.915	0.097
RT-20	12/16/2014	10:33:45	101	41	414	31	0.094	0.96	0.004	7.01	58.9	6.2	22.5	0.097	2400	0.401	1.02	0.273
Summer St	1/30/2014	11:14:09	67	9	344	17	0.009	2.75	0.005	7.5	36.8	2.37	33	0.009	93	0.139	0.271	0.076
Summer St	3/11/2014	11:00:25	81.7	11	386	290	0.019	2.35	<0.004	7.36	43	2.64	32	0.02	290	0.189	0.621	0.079
Summer St	5/13/2014	11:02:22	80.1	16	400	54	0.05	1.74	<0.004	7.63	45.2	3.1	31	0.066	1700	0.4	1.57	0.103
Summer St	7/3/2014	11:02:04	89	7	396	130	0.03	2.000	<0.01	7.3	50.4	1.6	30.5	0.04	1700	0.102	0.743	0.045
Summer St	9/25/2014	10:53:09	60.6	5	334	66	0.01	1.950	<0.004	7.65	45	1.6	37	0.038	1400	<0.050	0.587	0.042
Summer St	12/16/2014	10:53:34	60.6	16	321	14	0.019	1.95	0.004	7.3	32	3.6	26	0.046	2000	0.059	0.542	0.117
INDUSTBROOK	3/4/2014	9:37:43	961	21	3110	12	0.857	1.66	0.009	6.63	531	0.9	57.5	0.027	870	1.34	3.1	0.089
INDUSTBROOK	5/6/2014	10:33:41	767	24	2550	78	0.521	0.23	0.008	7.01	416	1.7	55	0.036	1400	0.821	2.88	0.125
INDUSTBROOK	6/24/2014	10:28:04	759	31	2520	130	0.908	0.350	0.045	6.98	375	2.1	67	0.187	>2419.6	2.16	4.7	0.147
INDUSTBROOK	7/31/2014	10:18:14	482	37	1650	120	0.303	0.380	0.020	7.23	279	2.6	63.0	0.209	>2419.6	1.58	4.10	0.178
INDUSTBROOK	10/28/2014	9:56:24	532	20	1650	60	0.483	0.346	0.009	6.87	282	2.2	75.0	0.009	>2419.6	0.398	1.63	0.129
HB @ KG	3/4/2014	9:57:44	300	13	1080	14	0.471	1.14	0.005	6.97	158	1.39	32	0.028	140	0.436	1.11	0.081
HB @ KG	5/6/2014	10:53:04	233	27	868	24	0.238	0.32	<0.004	7.29	150	3.2	26.5	0.438	550	0.874	4.12	0.122
HB @ KG	6/24/2014	10:51:11	239	21	842	41	0.298	0.051	<0.01	7.21	135	3.5	27	0.061	>2419.6	0.554	1.27	0.129
HB @ KG	7/31/2014	10:39:15	238	17	844	120	0.151	0.040	0.004	7.42	140	3.50	29.0	0.02	>2419.6	0.23	0.65	0.122
HB @ KG	10/28/2014	10:17:07	233	16	760	20	0.160	0.066	<0.004	7.26	141	2.90	28.5	0.006	>2419.6	0.156	0.89	0.115

Table 19: Sample Results cont.

Site	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp mV	Depth (feet)	Salinity (PSS)	TDS (mg/L)	Air temp. (°F)	BP (mmHg)	Water level (above Cambridge Vertical Datum)
Little Fresh Pond	5/8/2014	9:22:55 AM	16.06	498.7	102.2	10.14	7.69	92	0.32	0.24	319.2	60	766	15.85
Little Fresh Pond	7/10/2014	9:25:00 AM	26.07	573	72.2	5.91	7.21		S	0.28		72.68	769	15.68
Little Fresh Pond	11/20/2014	9:05:05 AM	3.59	517.3	95.8	12.66	8.09	29	S	0.24	331	36.14	759	16.31
North Pond	5/8/2014	10:13:22 AM	16.74	255.3	91.8	8.98	7.44	145	0.32	0.12	163.4	63	766	N/A
North Pond	7/10/2014	9:50:00 AM	26.26	225	67	5.4	7.41		S	0.11		73	769	N/A
North Pond	11/20/2014	9:23:12 AM	3.33	242.9	59.5	7.92	7.49	79	S	0.11	155.4	38.48	759	N/A
Black's Nook	5/8/2014	11:08:24 AM	16.29	148.8	105.8	10.46	7.76	113	0.36	0.07	95.2	63.5	766	N/A
Black's Nook	7/10/2014	10:05:00 AM	25.11	134	51.5	4.31	7.54		S	0.07		73	769	N/A
Black's Nook	11/20/2014	9:46:16 AM	2.32	155.9	78.8	10.79	7.51	126	0.03	0.07	99.8	39.56	759	N/A

Site	Date	Time	NH3 Ammonia (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chlorophyll (mg/m3)	Ca (mg/L)	Cl (mg/L)	Color (CU)	Lab Conductivity (umhos/cm)	Mn (mg/L)	NO3 (mg/L)	NO2 (mg/L)
Little Fresh Pond	5/8/2014	9:22:55 AM	0.14	0.85	0.085	32.3	30	117	44	480	0.162	0.934	<0.004
Little Fresh Pond	7/10/2014	9:25:00 AM	0.11	0.9	0.068	15.1	34.3	128	70	565	0.395		
Little Fresh Pond	11/20/2014	9:05:05 AM	0.17	1	0.061	102	32.3	116	51	456	0.131	0.054	<0.004
North Pond	5/8/2014	10:13:22 AM	0.1	0.74	0.026	14.6	35.6	17.6	56	257	0.083	1.47	<0.004
North Pond	7/10/2014	9:50:00 AM	0.092	0.61	0.039	9.84	29.6	17.1	66	229	0.1		
North Pond	11/20/2014	9:23:12 AM	0.096	0.86	0.064	19.3	32.2	18.8	64	235	0.112	0.015	<0.004
Black's Nook	5/8/2014	11:08:24 AM	0.094	0.66	0.038	17.1	17	15.1	26	151	0.068	0.659	<0.004
Black's Nook	7/10/2014	10:05:00 AM	0.055	<0.5	0.048	6.36	15.4	13.3	28	141	0.05		
Black's Nook	11/20/2014	9:46:16 AM	0.098	<0.5	0.025	15.4	118.00	16.4	21	152	0.044	0.034	<0.004

Site	Date	Time	Lab pH	Na (mg/L)	TOC (mg/L	Alkalinity (mg/L CaCO3)	Al (mg/L)	E-coli (MPN)	Total coliform (MPN)	Fe (mg/L)	lab turbidity (ntu)	UV254 (abs)
Little Fresh Pond	5/8/2014	9:22:55 AM	7.92	66.7	4.3	52	0.061	<1	18	0.631	5.76	0.13
Little Fresh Pond	7/10/2014	9:25:00 AM	7.32	76	4.8	67	0.067	100	>2419.6	1.18	9.22	0.176
Little Fresh Pond	11/20/2014	9:05:05 AM	7.59	72.1	5.5	58	0.024	2	1300	0.4	5.25	0.159
North Pond	5/8/2014	10:13:22 AM	7.69	11.9	9.3	106	0.004	17	290	1.47	6.68	0.28
North Pond	7/10/2014	9:50:00 AM	7.93	12	10.2	90	<0.002	7.5	2000	1.64	6.15	0.367
North Pond	11/20/2014	9:23:12 AM	7.4	12.6	9.5	58	0.028	28	>2419.6	1.65	6.12	0.324
Black's Nook	5/8/2014	11:08:24 AM	7.93	9.35	5.8	49	0.016	1	89	0.55	2.26	0.127
Black's Nook	7/10/2014	10:05:00 AM	7.49	8.38	6.2	48	0.109	50	>2419.6	0.534	2.58	0.164
Black's Nook	11/20/2014	9:46:16 AM	7.24	475	4.9	92	0.05	28	1300	0.302	1.57	0.127

Table 19: Sample Results cont.

Site ID	Date	Time	Water Temp. (°C)	SpC (µS/cm)	DO (%Sat)	DO (mg/L)	pH	Orp (mV)	Depth (m)	Depth (feet)	Salinity	TDS mg/L	Air Temp. (°F)	BP (mmHg)	Water level (Cam. Datum)	Water Depth (m)	Secchi depth (m)
HB @ DH	4/22/2014	10:56	11.57	837.8	107.5	11.58	7.42	154	0.32	1.06	0.41	536.2	65.84	754	181.77	8.3	3.5
HB @ DH	6/19/2014	11:32	23.76	857.7	105.4	8.89	7.73	154	0.32	1.08	0.42	548.9	76.46	760	182.03	8.45	4
HB @ DH	9/11/2014	11:10	23.53	865.6	97.4	8.27	7.54	175	0.06	0.19	0.42	554	69.6	761	177.59	6.48	
HB @ DH	11/13/2014	9:39	8.94	848.5	87.9	10.19	7.69	88	0.54	1.78	0.41	543	42.8	763	174.84	6.19	3
SB @ DH	4/22/2014	9:37	12.85	599.9	105.7	11.07	7.70	77	0.32	1.05	0.29	383.9	60.8	754	77.8	7.63	2.5
SB @ DH	6/19/2014	9:55	22.59	605.5	91.5	7.90	7.26	142	0.29	0.96	0.29	387.5	71.24	760	79.78	8.91	3
SB @ DH	9/11/2014	9:22	23.34	780.7	94.6	8.05	7.26	205	0.08	0.28	0.38	499.6	68.54	761	77.83	7.09	2.5
SB @ DH	11/13/2014	10:42	9.78	657.3	88.4	10.05	7.32	143	0.37	1.22	0.32	420.7	44.06	763	78.27	8.27	3
FP @ DH	4/15/2014	9:21	9.81	582.2	105.7	11.92	7.74	124	0.3	0.99	0.28	372.6		757	15.68		4
FP @ DH	6/3/2014	9:39	19.46	597.4	102.9	9.44	7.78	115	0.32	1.06	0.29	382.3	70.7	760	15.89	14.6	4.5
FP @ DH	7/1/2014	9:13	24.32		101.1	8.41	7.6	227	0.29	0.96	0.45	592.1	77.72	758	15.82	14.71	5
FP @ DH	8/5/2014	9:27	25.28	650.6	98.1	8.07	7.68	107	0.33	1.08	0.31	416.4	75.74	762	15.92	14.77	5.5
FP @ DH	11/4/2014	11:14	12.68	709.7	91.1	9.7	7.71	100	0.26	0.86	0.34	454.2	57.2	764	15.94	15.09	5

Table 19: Sample Results cont.

Site ID	Date	Time	NH3 (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chlorophyll (mg/m3)	lab number	Ca (mg/L)	Cl^- (mg/L)	Color (CU)	Lab Conductivity (umhos/cm)
HB @ DH	4/22/2014	10:56	0.077	<0.5	0.01	<2	2014-1683	22.5	239	13	804
HB @ DH	6/19/2014	11:32	0.13	<0.5	<0.01	3.58	2014-2597	25.2	243	12	843
HB @ DH	9/11/2014	11:10	<0.05	<0.5	0.011	5.85	2014-3871	24.6	237	13	860
HB @ DH	11/13/2014	9:39	<0.05	0.5	0.01	2.79	2014-4787	24.7	241	9	788
SB @ DH	4/22/2014	9:37	<0.05	<0.5	0.012	6.13	2014-1681	22.5	160	29	549
SB @ DH	6/19/2014	9:55	0.19	<0.5	0.015	2.98	2014-2594	26.6	157	32	595
SB @ DH	9/11/2014	9:22	<0.05	<0.5	0.013	4.32	2014-3868	25.2	214	20	756
SB @ DH	11/13/2014	10:42	<0.05	0.5	0.01	2.42	2014-4788	24.7	170	23	620
FP @ DH	4/15/2014	9:21	0.092	<0.5	<0.01	<2	2014-1552	23.3	145	12	581
FP @ DH	6/3/2014	9:39	0.014	<0.5	<0.01	<2	2014-2325	25.2	149	10	575
FP @ DH	7/1/2014	9:13	0.18	<0.5	<0.01	2.24	2014-2795	27.8	153	14	605
FP @ DH	8/5/2014	9:27	0.051	<0.5	<0.01	<2	2014-3321	25	166	11	657
FP @ DH	11/4/2014	11:14	0.079	<0.50	<0.01	<2.00	2014-4638	27.6	188	8	648

Table 19: Sample Results Cont.

Site ID	Date	Time	Mn (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Lab pH	Na^+ (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Fe (mg/L)	LabTurbidity (NTU)	UV254 (abs)
HB @ DH	4/22/2014	10:56	0.039	0.55	<0.004	7.3	128	3	25	0.005	<0.050	0.709	0.101
HB @ DH	6/19/2014	11:32	0.015	<0.05	<0.01	7.69	137	3.8	24.5	0.002	0.151	0.634	0.1
HB @ DH	9/11/2014	11:10	0.058	0.014	<0.004	7.77	126	3	27.5	0.004	0.258	1.05	0.096
HB @ DH	11/13/2014	9:39	0.02	0.059	<0.004	7.46	132	2.6	25	0.006	0.238	0.883	0.082
SB @ DH	4/22/2014	9:37	0.069	0.86	<0.004	7.14	82.8	4.3	25.5	0.023	0.073	1.35	0.186
SB @ DH	6/19/2014	9:55	0.23	0.47	<0.01	7.26	87.9		32	0.016	0.333	0.886	0.212
SB @ DH	9/11/2014	9:22	0.149	0.152	<0.004	7.53	110	5.7	30.5	0.003	0.111	1.41	0.116

Table 19: Sample Results Cont.

Site ID	Date	Time	Mn (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Lab pH	Na^+ (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Fe (mg/L)	LabTurbidity (NTU)	UV254 (abs)
SB @ DH	11/13/2014	10:42	0.02	0.217	<0.004	7.3	132	4.2	30	0.006	0.238	0.737	0.163
FP @ DH	4/15/2014	9:21	0.021			7.39	85	3.19	33	0.017	0.056	0.473	0.096
FP @ DH	6/3/2014	9:39	0.013	0.985	0.004	7.5	84.5	3.3	33.5	0.021	<0.050	0.525	0.098
FP @ DH	7/1/2014	9:13	0.028	0.47	<0.01	7.5	91	3.3	34	0.021	0.077	0.523	0.12
FP @ DH	8/5/2014	9:27	0.032	0.312	0.005	7.64	90.8	3.3	34	0.014	<0.050	0.401	0.103
FP @ DH	11/4/2014	11:14	0.035			7.5	114	2.8	32.5	0.016	<0.050	0.57	0.082

Table 19: Sample Results Cont.

Site ID	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp (mV)	Depth (feet)	Salinity (PSS)	TDS (mg/L)	Air temp. (°F)	BP (mmHg)
HB @ UPPER	5/6/2014	9:32:52	13.47	623.6	99.5	10.33	7.55	65	0.81	0.3	399.1	56.3	758
HB @ UPPER	6/24/2014	9:23:26	22.47	723.0	72.7	6.33	6.96	167	0.93	0.4	462.7	70.16	765
HB @ UPPER	7/31/2014	9:20:35	24.27	695.2	87.3	7.33	7.02	180	1.61		444.9	69.62	765
HB @ UPPER	10/28/2014	8:59:06	10.49	672.0	70.8	7.91	7.04	70	0.31	0.3	430.1	63.3	763
HB @ MIDDLE	5/6/2014	10:07:54	14.00	813.4	101.9	10.45	7.50	87	0.46	0.4	520.6	57.56	758
HB @ MIDDLE	6/24/2014	9:58:48	22.15	880.8	96.1	8.41	7.15	138	0.95	0.43	563.7	72.14	765
HB @ MIDDLE	7/31/2014	9:52:23	24.37	829.2	85.5	7.16	7.07	160	1.87		530.7	73.58	765
HB @ MIDDLE	10/28/2014	9:39:01	11.41	700.2	68.7	7.51	6.94	114	0.48	0.34	448.1	63.3	763

Table 19: Sample Results Cont.

Site ID	Date	Time	NH3 Ammonia (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chlorophyll (mg/m3)	lab number	Ca (mg/L)	Cl^- (mg/L)	Color (CU)	Lab Conductivity (umhos/cm)	*E. coli* (MPN)	Total Coliform (MPN)
HB @ UPPER	5/6/2014	9:32:52	0.11	0.69	0.03	22.20	2014-1896	19.00	176.00	84.00	614.00	1.00	330
HB @ UPPER	6/24/2014	9:23:26	0.12	1.90	0.04	24.30	2014-2679	21.90	194	84	712	8.5	>2419.6
HB @ UPPER	7/31/2014	9:20:35	<0.05	0.60	0.04	17.30	2014-3243	23.00	188	66	689	690	>2419.6
HB @ UPPER	10/28/2014	8:59:06	0.2	0.98	0.07	8.15	2014-4539	28.60	197	150	616	210	>2419.6
HB @ MIDDLE	5/6/2014	10:07:54	0.12	0.83	0.02	19.40	2014-1898	22.8	228	50	816	3	130
HB @ MIDDLE	6/24/2014	9:58:48	0.13	0.61	0.03	31.10	2014-2680	26.9	248	50	872	3.1	1200
HB @ MIDDLE	7/31/2014	9:52:23	0.13	<0.05	0.02	6.08	2014-3244	27.1	240	50	821	28	>2419.6
HB @ MIDDLE	10/28/2014	9:39:01	0.13	0.85	0.06	16.70	2014-4540	22.8	191	84	649	1200	>2419.6

Table 19: Sample Results Cont.

Site ID	Date	Time	Mn (mg/L)	NO_3^- (mg/L)	NO_2^- (mg/L)	Lab pH	Na^+ (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Fe (mg/L)	Lab Turbidity	UV254 (abs)
HB @ UPPER	5/6/2014	9:32:52	0.074	0.44	<0.004	7.12	108	7.2	19	0.186	0.735	2.9	0.424
HB @ UPPER	6/24/2014	9:23:26	0.125	<0.05	<0.01	6.82	108	8	28	0.065	1.38	2.70	0.459
HB @ UPPER	7/31/2014	9:20:35	0.093	0.02	0.004	7.3	127	7	25	0.106	1.2	3.02	0.368
HB @ UPPER	10/28/2014	8:59:06	0.256	0.175	0.019	6.83	115	14	22	0.469	1.67	7.01	0.791
HB @ MIDDLE	5/6/2014	10:07:54	0.098	0.23	<0.004	7.17	132	5.1	20.5	0.046	0.654	1.63	0.281
HB @ MIDDLE	6/24/2014	9:58:48	0.157	<0.05	<0.01	6.96	136	6.7	28.5	0.047	0.731	2.01	0.334
HB @ MIDDLE	7/31/2014	9:52:23	0.09	0.05	0.004	7.33	142	6.3	30	0.026	0.981	2.01	0.313
HB @ MIDDLE	10/28/2014	9:39:01	0.198	2.72	<0.004	6.85	106	7	21	0.223	1.23	6.2	0.407

Table 19: Sample Results Cont.

SITE ID	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp (mV)	Depth (m)	Depth (feet)	Salinity (PSS)	TDS mg/L	Air temp. (°F)	BP (mm Hg)	Water level	Water Depth (m)	Secchi depth (m)	*E. coli* (MPN)	Total Coliform (MPN)	lab number
HB @ INTAKE	4/22/2014	11:21	11.55	838.6	106.7	11.50	7.34	137	0.39	1.29	0.41	536.7	67.28	754	181.77	7.05	3.5	3.1	32	2014-1714
HB @ INTAKE	4/22/2014	11:22	11.09	838.2	107.9	11.75	7.40	139	0.92	3.04	0.41	536.4	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	4/22/2014	11:23	10.96	837.9	107.8	11.77	7.43	142	2.97	9.75	0.41	536.2	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	4/22/2014	11:24	10.82	838.6	105.9	11.61	7.44	146	4.95	16.24	0.41	536.7	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	4/22/2014	11:34	10.56	842.5	92.4	10.18	7.16	82	6.44	21.16	0.41	539.2	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	4/22/2014	11:29	10.41	850.2	12.1	1.33	7.06	77	6.93	22.76	0.41	544.1	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	4/22/2014	11:30	10.31	733.6	10.2	1.14	6.94	10	7.05	23.13	0.36	469.5	67.28	754	181.77	7.05	3.5			
HB @ INTAKE	6/19/2014	12:14	24.10	858.8	106.4	8.92	7.74	177	0.27	0.91	0.42	549.6	77.36	760	182.03	7.21	4	4.1	310	2014-2592
HB @ INTAKE	6/19/2014	12:15	24.03	858.7	106.9	8.97	7.82	177	1	3.29	0.42	549.6	77.36	760	182.03	7.21	4			
HB @ INTAKE	6/19/2014	12:17	22.55	853.1	107.2	9.25	7.99	177	2.96	9.72	0.41	546	77.36	760	182.03	7.21	4			
HB @ INTAKE	6/19/2014	12:21	16.78	850.8	59.4	5.75	7.11	209	5.01	16.44	0.42	544.5	77.36	760	182.03	7.21	4			
HB @ INTAKE	6/19/2014	12:27	13.12	850.3	3.9	0.41	6.72	98	7.06	23.18	0.42	544.2	77.36	760	182.03	7.21	4			
HB @ INTAKE	6/19/2014	12:27	12.94	848.6	7.0	0.73	6.65	6	7.21	23.68	0.41	543.1	77.36	760	182.03	7.21	4			
HB @ INTAKE	9/11/2014	11:38	23.61	865.9	97.5	8.26	7.55	149	0.01	0.05	0.42	554.1	70.16	761	177.59	5.61	3.5	8.6	920	2014-3865
HB @ INTAKE	9/11/2014	11:39	23.58	865.6	96.9	8.21	7.56	159	1.15	3.78	0.42	554	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:40	23.52	865.7	96.7	8.21	7.53	165	2.08	6.82	0.42	554	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:42	23.44	865.5	92.4	7.85	7.40	175	3.08	10.12	0.42	553.9	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:43	23.36	866.1	88.5	7.53	7.30	182	3.96	12.99	0.42	554.3	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:45	22.25	872.6	49.4	4.29	6.85	194	5.19	17.04	0.42	558.4	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:47	22.53	869.9	35.1	3.03	6.92	53	5.11	16.78	0.42	556.7	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	9/11/2014	11:48	20.76	887.1	46.9	4.20	6.80	51	5.61	18.41	0.43	567.7	70.16	761	177.59	5.61	3.5			
HB @ INTAKE	11/13/2014	9:54	8.89	847.4	88.7	10.30	7.35	134	0.33	1.10	0.41	542.3	42.8	763	174.84	4.97	4	0	1100	2014-4785

Table 19: Sample Results Cont.

SITE ID	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp (mV)	Depth (m)	Depth (feet)	Salinity (PSS)	TDS mg/L	Air temp. (°F)	BP (mm Hg)	Water level	Water Depth (m)	Secchi depth (m)	*E. coli* (MPN)	Total Coliform (MPN)	lab number
HB @ INTAKE	11/13/2014	9:55	8.82	847.5	87.9	10.21	7.36	142	1.08	3.55	0.41	542.4	42.8	763	174.84	4.97	4			
HB @ INTAKE	11/13/2014	9:56	8.81	847.5	87.5	10.18	7.36	145	2.18	7.17	0.41	542.4	42.8	763	174.84	4.97	4			
HB @ INTAKE	11/13/2014	9:58	8.78	847.2	87.7	10.21	7.37	133	4.87	15.98	0.41	542.2	42.8	763	174.84	4.97	4			
HB @ INTAKE	11/13/2014	10:00	8.93	728.7	19.7	2.29	6.87	82	4.97	16.33	0.35	466.3	42.8	763	174.84	4.97	4			
SB @ INTAKE	4/22/2014	10:04	12.69	594.1	106.1	11.15	7.16	141	0.28	0.92	0.29	380.2	61.52	754	77.8	6.68	2	2	99	2014-1713
SB @ INTAKE	4/22/2014	10:05	12.34	591.6	105.5	11.18	7.20	144	1.00	3.28	0.28	378.6	61.52	754	77.8	6.68	2			
SB @ INTAKE	4/22/2014	10:09	11.12	590.6	98.1	10.69	7.14	156	3.03	9.96	0.28	377.9	61.52	754	77.8	6.68	2			
SB @ INTAKE	4/22/2014	10:12	10.40	590.7	91.9	10.18	7.08	162	5.03	16.53	0.28	378	61.52	754	77.8	6.68	2			
SB @ INTAKE	4/22/2014	10:12	9.81	605	89.1	10.01	7.06	164	5.99	19.65	0.29	387.2	61.52	754	77.8	6.68	2			
SB @ INTAKE	4/22/2014	10:13	9.52	619.5	86.7	9.80	7.03	166	6.68	21.93	0.3	396.5	61.52	754	77.8	6.68	2			
SB @ INTAKE	6/19/2014	10:42	22.96	602.1	95.2	8.16	7.13	143	0.30	1.00	0.29	385.3	73.04	760	79.78	7.23	3	14	580	2014-2591
SB @ INTAKE	6/19/2014	10:43	22.93	602.7	95.2	8.16	7.15	149	1.08	3.56	0.29	385.7	73.04	760	79.78	7.23	3			
SB @ INTAKE	6/19/2014	10:45	22.09	605.4	90.3	7.87	7.11	161	3.06	10.05	0.29	387.4	73.04	760	79.78	7.23	3			
SB @ INTAKE	6/19/2014	10:50	20.00	597.2	73.6	6.68	6.94	178	5.02	16.48	0.29	382.2	73.04	760	79.78	7.23	3			
SB @ INTAKE	6/19/2014	10:52	18.44	632.2	62.4	5.84	6.84	186	7.00	22.98	0.3	404.6	73.04	760	79.78	7.23	3			
SB @ INTAKE	6/19/2014	10:52	18.12	635.4	62.0	5.84	6.83	186	7.23	23.75	0.31	406.6	73.04	760	79.78	7.23	3			
SB @ INTAKE	9/11/2014	10:01	23.44	780.7	95.4	8.11	7.26	190	0.17	0.56	0.38	499.6	69.26	761	77.83	6.91	NS	7.5	550	2014-3864
SB @ INTAKE	9/11/2014	10:03	23.44	780.7	95.2	8.09	7.24	193	1.11	3.66	0.38	499.6	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:04	23.41	780.2	95	8.08	7.22	196	2.03	6.68	0.38	499.3	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:06	23.40	780	94.1	8.01	7.20	199	3.16	10.38	0.38	499.2	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:07	23.40	780	93.7	7.97	7.19	201	4.16	13.66	0.38	499.2	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:08	23.37	779.7	93.4	7.95	7.19	203	5.14	16.89	0.38	499	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:11	23.25	779.5	89	7.59	7.14	207	6.34	20.8	0.38	498.9	69.26	761	77.83	6.91	NS			
SB @ INTAKE	9/11/2014	10:15	22.45	790.3	32.7	2.83	7.09	-169	6.91	22.69	0.38	505.8	69.26	761	77.83	6.91	NS			
SB @ INTAKE	11/13/2014	10:58	9.82	657.6	84.5	9.60	7.31	136	0.15	0.49	0.32	420.8	44.06	763	78.27	7.12	3	2	35	2014-4784
SB @ INTAKE	11/13/2014	10:59	9.78	657.4	88.7	10.08	7.27	150	2.13	6.99	0.32	420.7	44.06	763	78.27	7.12	3			

Table 19: Sample Results Cont.

SITE ID	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp (mV)	Depth (m)	Depth (feet)	Salinity (PSS)	TDS mg/L	Air temp. (°F)	BP (mm Hg)	Water level	Water Depth (m)	Secchi depth (m)	*E. coli* (MPN)	Total Coliform (MPN)	lab number
SB @ INTAKE	11/13/2014	11:00	9.75	657.4	91.4	10.40	7.25	159	4.09	13.41	0.32	420.7	44.06	763	78.27	7.12	3			
SB @ INTAKE	11/13/2014	11:01	9.50	655.6	91.3	10.45	7.21	167	6.03	19.79	0.32	419.6	44.06	763	78.27	7.12	3			
SB @ INTAKE	11/13/2014	11:03	9.27	649.9	86.9	10.00	7.14	178	7.12	23.37	0.31	415.9	44.06	763	78.27	7.12	3			
FP @ INTAKE	6/3/2014	10:43	20.07	596.9	103.4	9.37	7.50	96	0.28	0.92	0.3	382.0	72.32	760	15.88	9.96	4.5	22	53	2014-2328
FP @ INTAKE	7/1/2014	10:26	24.81		101.5	8.37	7.47	111	0.34	1.12	0.5	586.7	81.68	758	15.82	9.62	4.5	26	310	2014-2797
FP @ INTAKE	8/5/2014	10:26	25.66	646.3	101.9	8.32	7.55	175	0.34	1.11	0.3	413.6	78.44	762	15.92	9.47	5.5	38	220	2014-3323
FP @ INTAKE	11/4/2014	12:21	12.83	709.5	91.7	9.72	7.56	138	0.09	0.29	0.3	454.1	60.44	764	15.94	9.22	5	26	220	2014-4639

Tributary Boxplots by Parameter

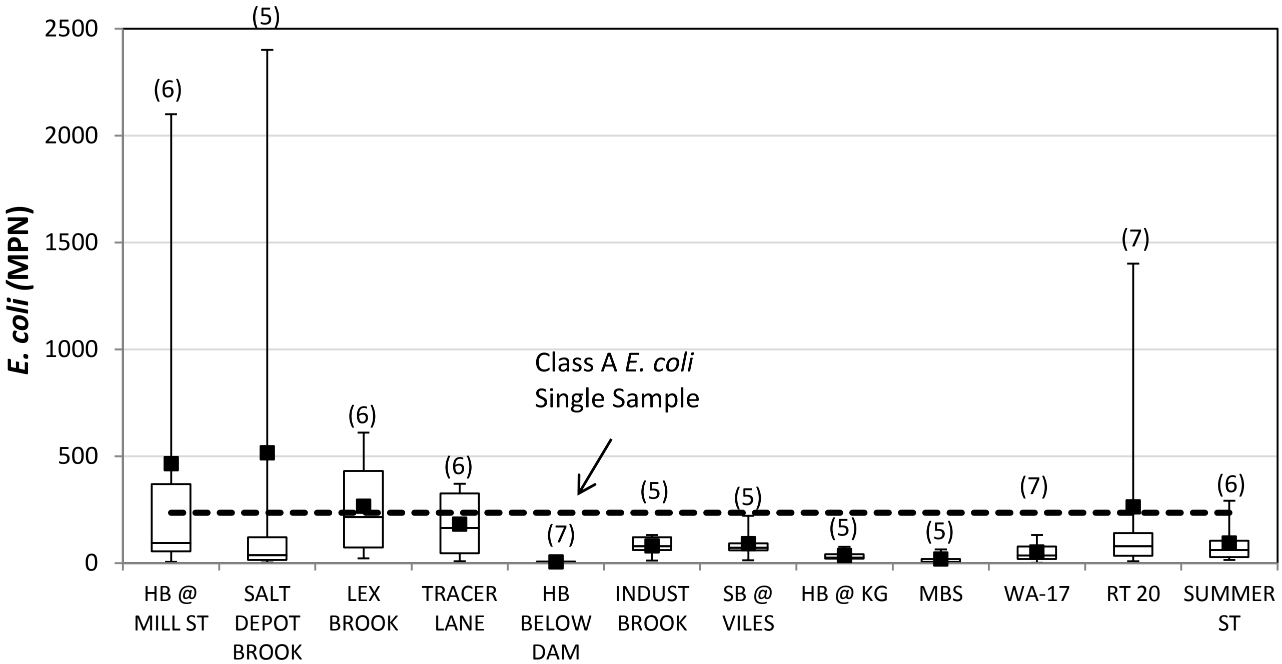


Figure 39a: Primary Tributary Base-flow *E. coli* Concentrations, 2014

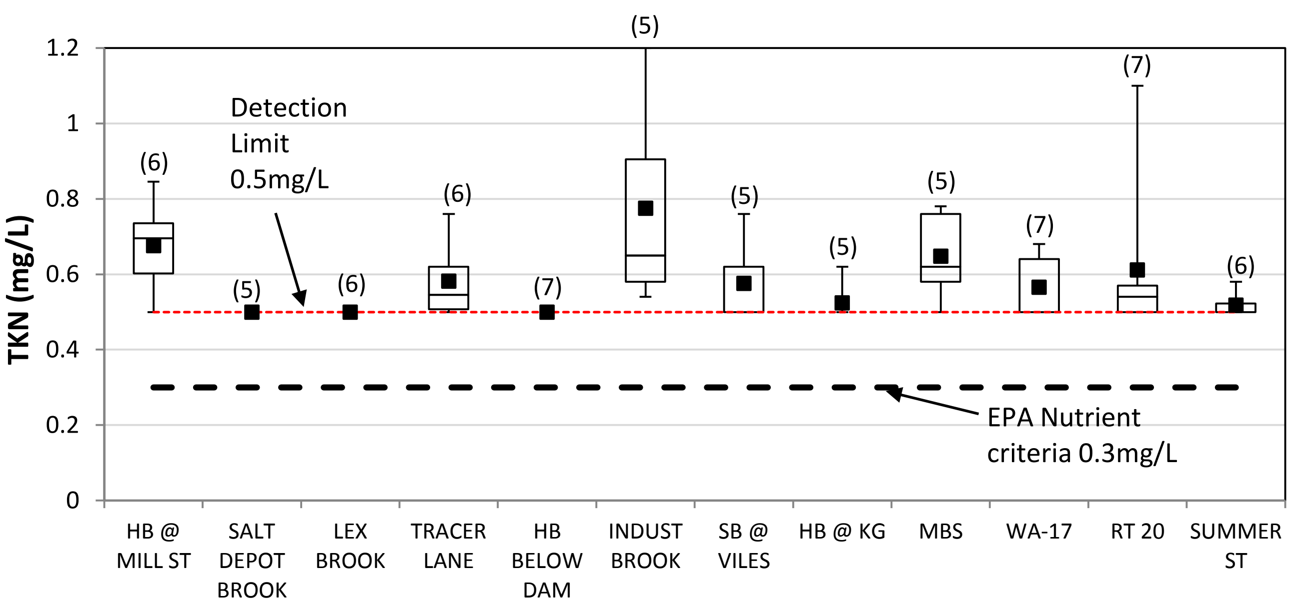


Figure 39b: Primary Tributary Base-flow Total Kjehdahl Nitrogen (TKN) Concentrations, 2014

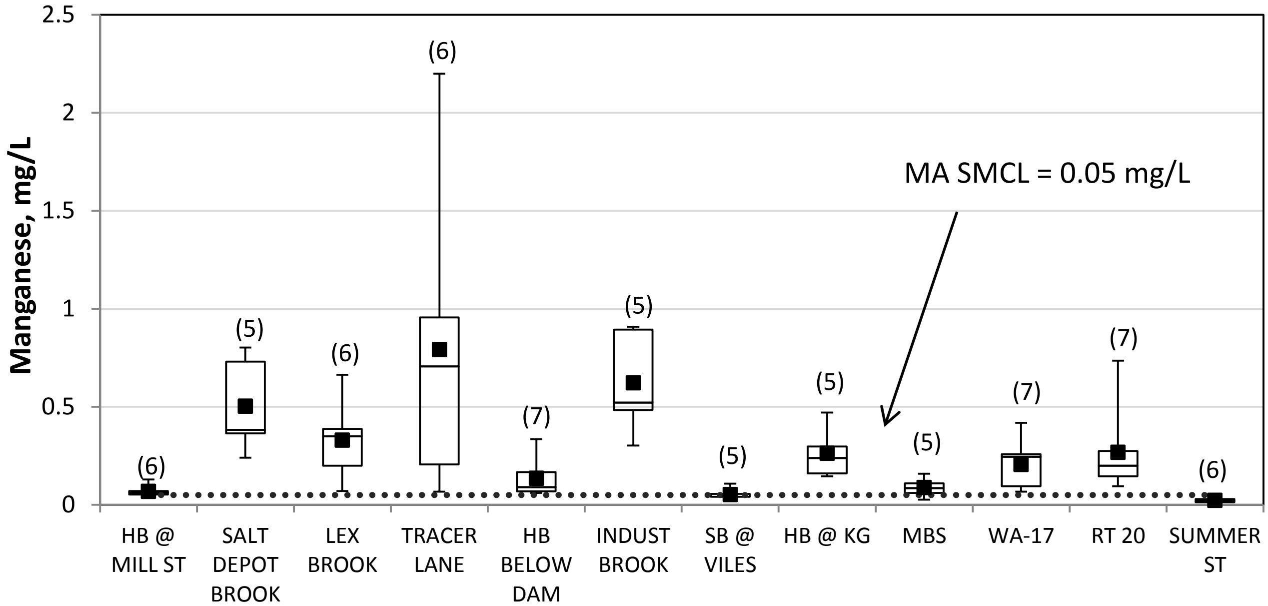


Figure 39c: Primary Tributary Base-flow Manganese Concentrations

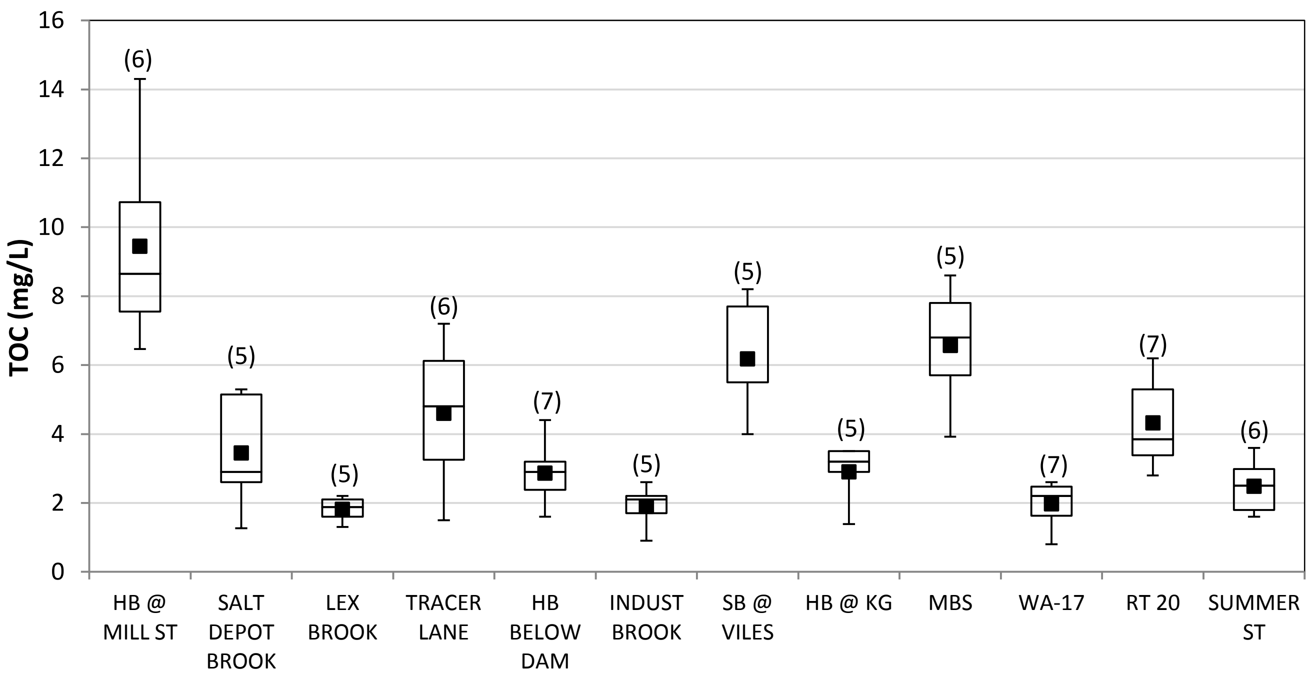


Figure 39d: Primary Tributary Base-flow Total Organic Carbon Concentrations, 2014

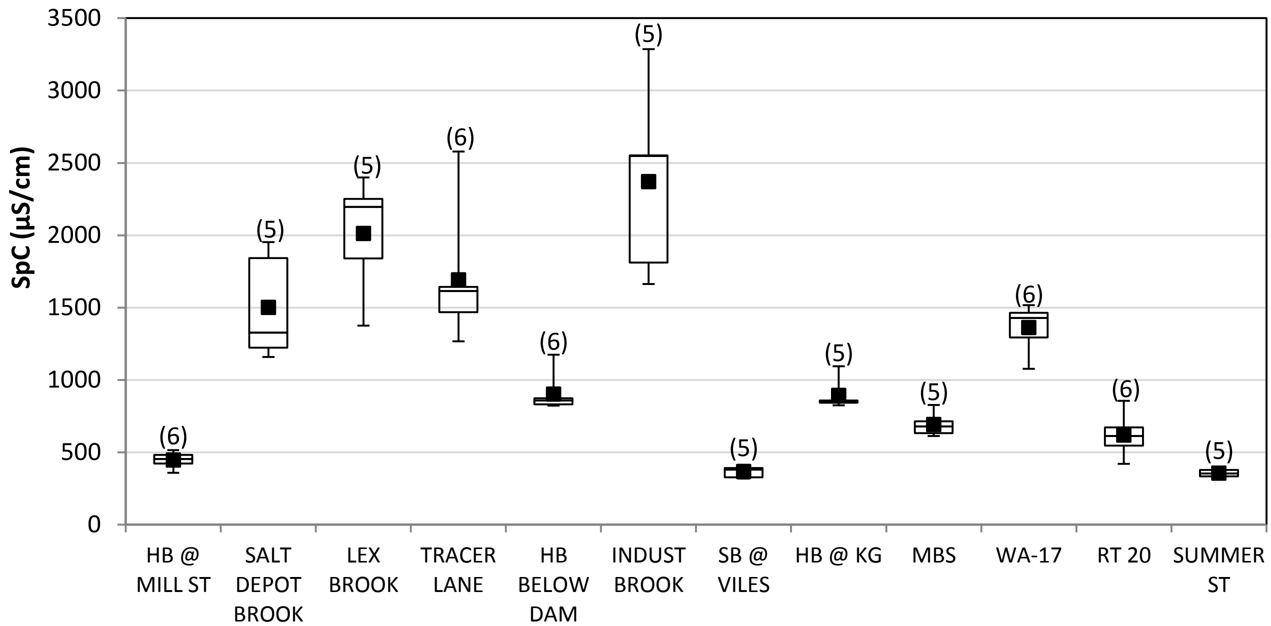


Figure 39e: Primary Tributary Base-flow Specific Conductance (SpC) Concentrations, 2014

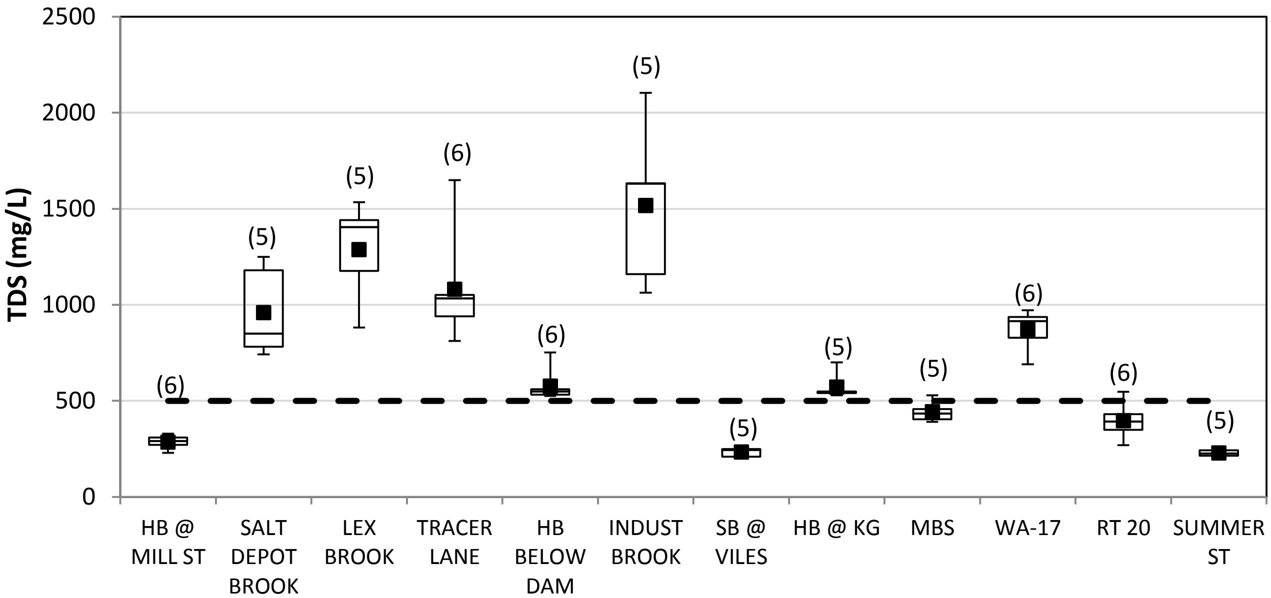


Figure 39f: Primary Tributary Base-flow Total Dissolved Solids Concentrations, 2014

Appendix F – Tributary Catchment Land Cover

Table 24: USGS Stations and Corresponding CWD Site Names

CWD Site Name	MBS	HB @ KG	SB @ KG	INDUST BROOK	HB BELOW DAM	Rt 20	SUMMER ST	TRACER LANE	LEX BROOK	SALT DEPOT BROOK	HB @ MILL ST
USGS Site ID	01104453	01104440	01104390	01104433	01104430	01104460	01104475	01104420	01104415	01104410	01104405

Table 23: 2005 MassGIS Land Use Classification, Percent by Area per USGS Subbasin

	Sampling Station ID													
2005 MA Land Use	**01104405**	**01104410**	**01104415**	**01104420**	**01104430**	**01104433**	**01104370**	**01104440**	**01104453**	**01104455**	**01104460**	**01104475**	**01104480**	**Watershed Total**
Forest	56.58	50.35	27.05	27.2	32.68	12.13	47.1	49.2	42.3	39.77	23.17	45.07	38.66	43.26
Low Density Residential	7.23	0.14	6.94	7.33	2.59	0.06	18.08	18.75	21.31	0.04	9.41	20.6	19.21	13.86
Forested Wetland	20.79	10.5	0.28	11.16	2.62	8.09	11.49	5.11	9.42	0.92	2.47	3.01	1.13	9.33
Water	0.29			0.13	29.33	0.26	3.78	1.47	0.43	0.17	8.48	1.27	16.31	6.49
Commercial		8.29	3.4	9.26	8.19	35.77	0.82	5.01	1.21	7.92	15.98		1.58	3.32
Cropland	3.17		0.97	0.27	0.05		4.89	1.25	1.21			1.87		2.74
Non-Forested Wetland	1.95	7.26	1.27	1.71	0.84	0.63	3.71	3.41	3.46		4.61	0.63	0.4	2.73
Medium Density Residential			24.46	10.48	9.52		0.33		2.84	6.62	0.15	0.29	0.32	2.69
Very Low Density Residential	3.13	0.01		0.14	0.73		3.89	1.22	3.69	0.25		3.38	0.45	2.66
Transportation		0.1	16.12	6.61	5.89	10.82	0.54	0.04		10.6	4.12		6.27	2.24
Industrial		5.41		5.98	4.92	32.03	0.11	5.7		17.19	3.17	0.04		2.16
Urban Public/Institutional	1.55	4.56	2.24	1.7	0.67	0.21	1.03	1.73	4.58	0.06	1.54	1.38	7.09	1.69
High Density Residential			15.48	16.27	0.07					6.78			7.26	1.24
Pasture	1.58	1.36			0.17		1.27	1.16	1.64			4.23		1.11
Multi-Family Residential			0.09	0.22	0.02		1.22	3.21	0.45	0.48	7.82			0.88
Open Land	1.09	3.68	0.47	1.55	0.37		0.8	0.92	0.87		4.1	0.37	0.56	0.84
Golf Course									1.16			16.75		0.71
Participation Recreation	1.17	0.82	1.22		0		0.49	1.82	2.25			0.61	0.14	0.69
Powerline/Utility	0.08	7.51			1.34		0.13		0.68	7.45	1.86			0.6
Cemetery	0.72								2.17					0.27
Mining									0.36	0.15	12.33		0.32	0.23
Brushland/Successional	0.3						0.02					0.48		0.06
Orchard	0.15						0.07							0.05
Spectator Recreation	0.05						0.08						0.3	0.05
Junkyard										1.61	0.6			0.04
Waste Disposal	0.18						0.06							0.04
Transitional							0.03		0		0.19			0.02
Water-Based Recreation							0.05							0.02

Appendix G– Cambridge Water Department Wet Weather Sampling

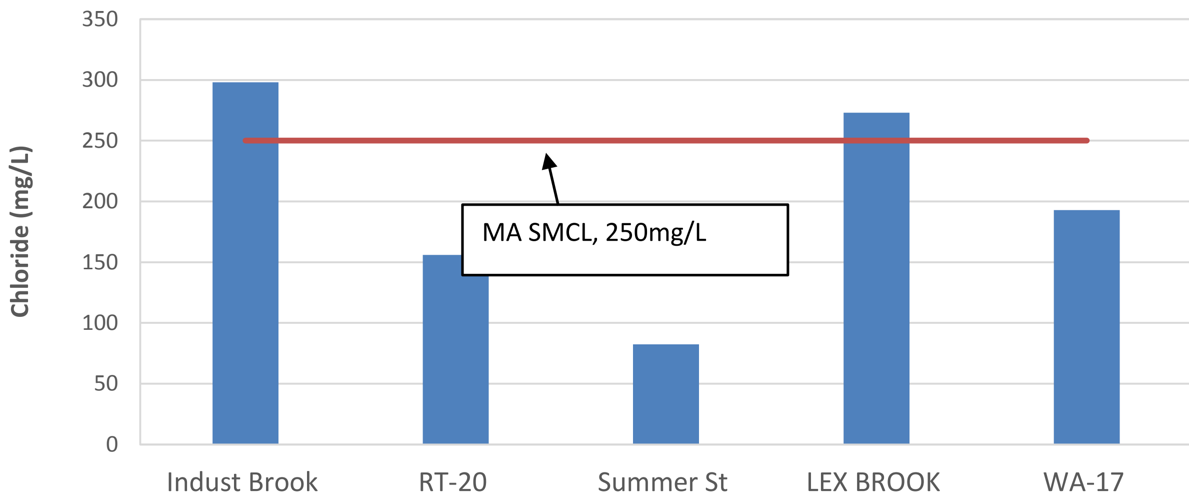


Figure 40a: CWD Storm Sampling Chloride Concentrations, 4/8/2014
Summer St. result averaged with field duplicate

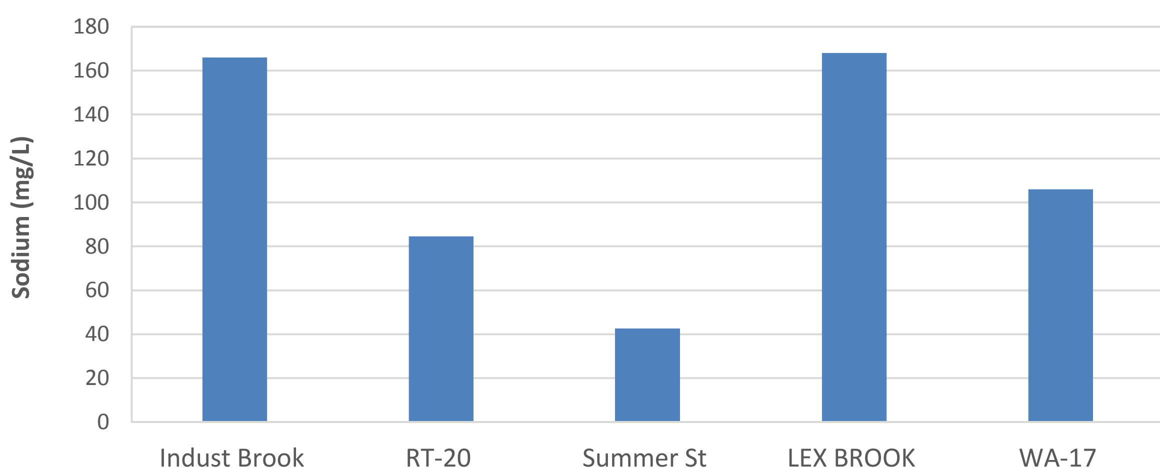


Figure 40b: CWD Storm Sampling Sodium Concentrations, 4/8/2014
Summer St. result averaged with field duplicate

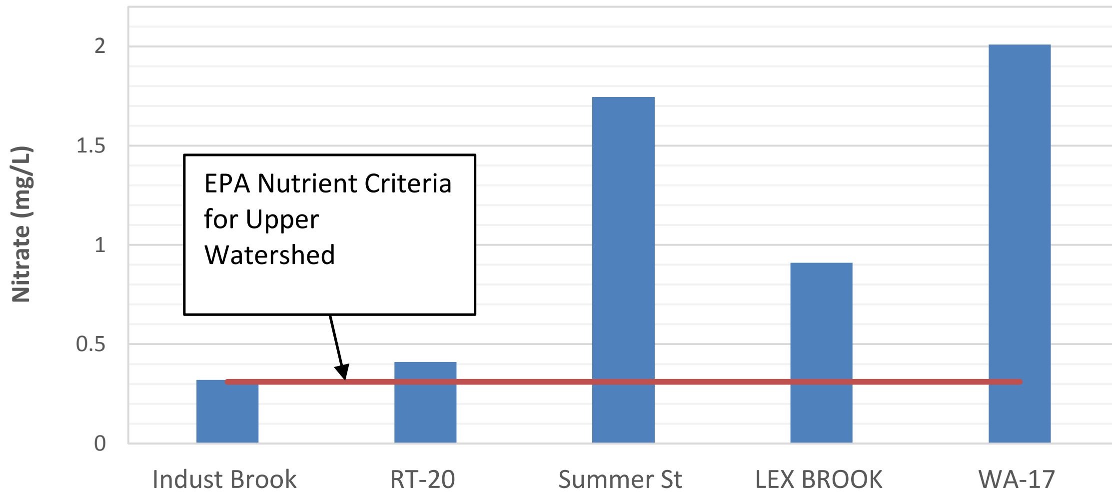


Figure 40c: CWD Storm Sampling Nitrate Concentrations, 4/8/2014
Summer St. result averaged with field duplicate

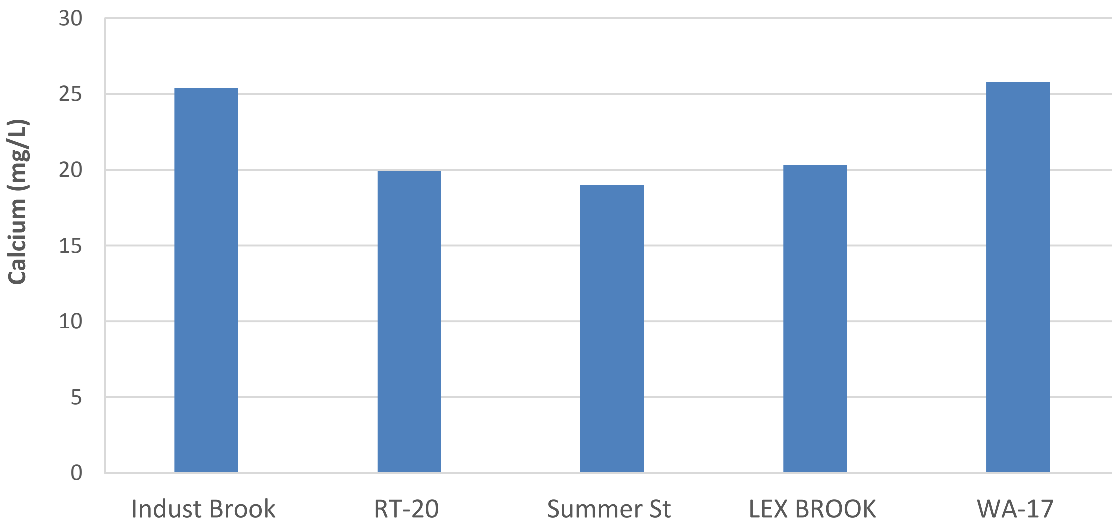


Figure 40d: CWD Storm Sampling Calcium Concentrations, 4/8/2014
Summer St. result averaged with field duplicate

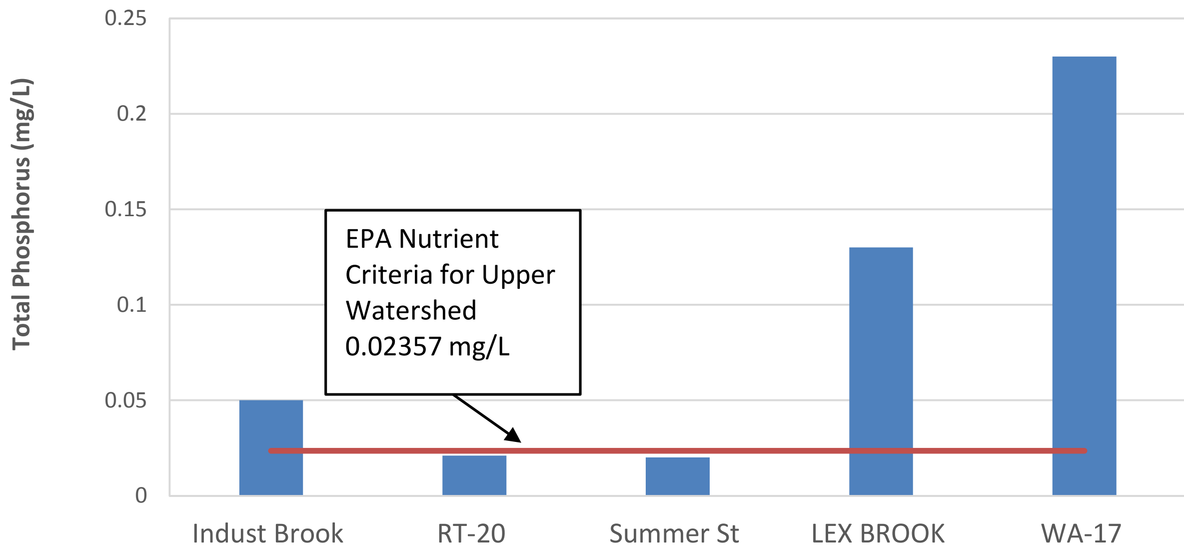


Figure 40e: CWD Storm Sampling Phosphorus Concentrations, 4/8/2014
Summer St. result averaged with field duplicate

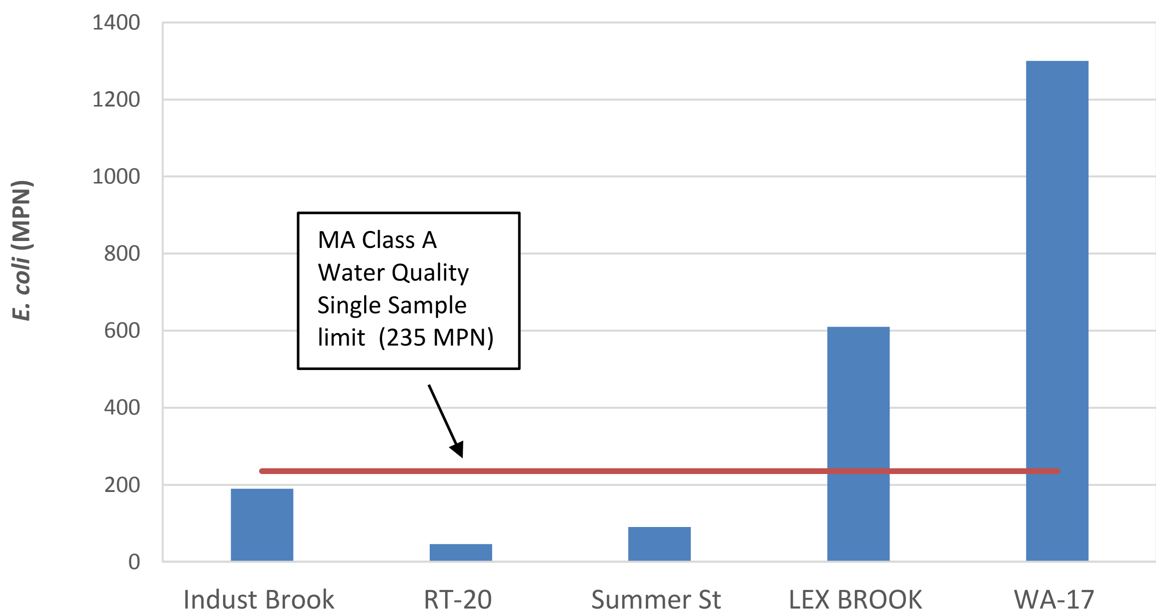


Figure 40f: CWD Storm Sampling *E.coli* Concentrations, 4/8/2014
Summer St. result averaged with field duplicate