City of Cambridge Water Department
2013 Source Water Quality Report

June, 2014

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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
TOC	Total organic carbon
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 2013 sampling results are compared to Federal and Massachusetts ambient and drinking water quality standards, as well as with past data primarily from 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 and is compared to historic results. 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.

Source water quality in 2013 was mostly consistent with results and expectations set from previous years of sampling. Water quality in the reservoir system was generally lower in the Hobbs Brook Reservoir, and improved as it flowed through the system via Stony Brook Reservoir in Weston/Waltham to Fresh Pond in Cambridge. The highest chloride concentrations were measured in Hobbs Brook Reservoir, which is strongly influenced by runoff from deicing salt-treated impervious surfaces, most notably Route 2 and Interstate 95. Water quality at the intake to the treatment plant in Fresh Pond was high throughout the study period. Analytical results of samples collected in Fresh Pond yielded consistently low concentrations of nutrients and selected total metals, with sodium and chloride having the highest relative concentrations of constituents sampled.

The Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs generally met Massachusetts Class A Surface Water Quality Standards. Under periods of reservoir thermal stratification, lower depth dissolved oxygen consistently fell below the 5 mg/L threshold in all three reservoirs. Hobbs Brook and Stony Brook Reservoir weekly samples met bacteria standards in 100% of samples, and exceeded the chloride drinking water standards in 2% of weekly samples. All three reservoirs exhibited thermal and chemical stratification in late-summer depth profiles, despite artificial mixing by air hoses in Stony Brook Reservoir and Fresh Pond. Stratification produced anoxic or hypoxic conditions in the deepest parts of all three reservoirs which resulted in the release of phosphorus, iron and manganese from reservoir bed sediments. Trophic state indices (TSI) indicated that Hobbs Brook and Stony Brook reservoir were mostly intermediate in productivity with the potential to support algal blooms; whereas Fresh Pond TSI values ranged from oligotrophic to mesotrophic classifications, indicating clear, oxygenated water with potential anoxia in the hypolimnion during summer stratification. These results are similar to results from the 2012 and 2008-2011 reporting periods.

In general, tributary water quality in dry weather for all contributing streams is good and meets Class A standards. Chloride concentrations, sodium concentrations, and specific conductance levels are the highest at Salt Depot Brook, Lexington Brook, Industrial Brook, and WA-17 and show increasing, statistically significant trends at most monitoring locations. All sites met the 10 mg/L SMCL for nitrate but exceeded the 0.30 mg/L nutrient criteria at least once, indicating anthropogenic impacts to source water bodies. All tributaries met single-sample water quality standards for *E. coli* except for the Salt Depot Brook monitoring station, which exceeded the MA Class A standard in more than half of the 2013 samples.

In this study period, the Cambridge watershed received 39 inches of rain, as measured at the Hobbs Brook Dam USGS precipitation gage. This is less 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 usage 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 2013 was 13 months. The average retention time of Stony Brook Reservoir was approximately 22 days, with total annual diversion to the Charles River of roughly 4.2 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 2013, 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 2012 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% 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 2013. The report uses water quality data from the CWD 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 evaluate the efficacy of management initiatives and re-prioritize their efforts if necessary.

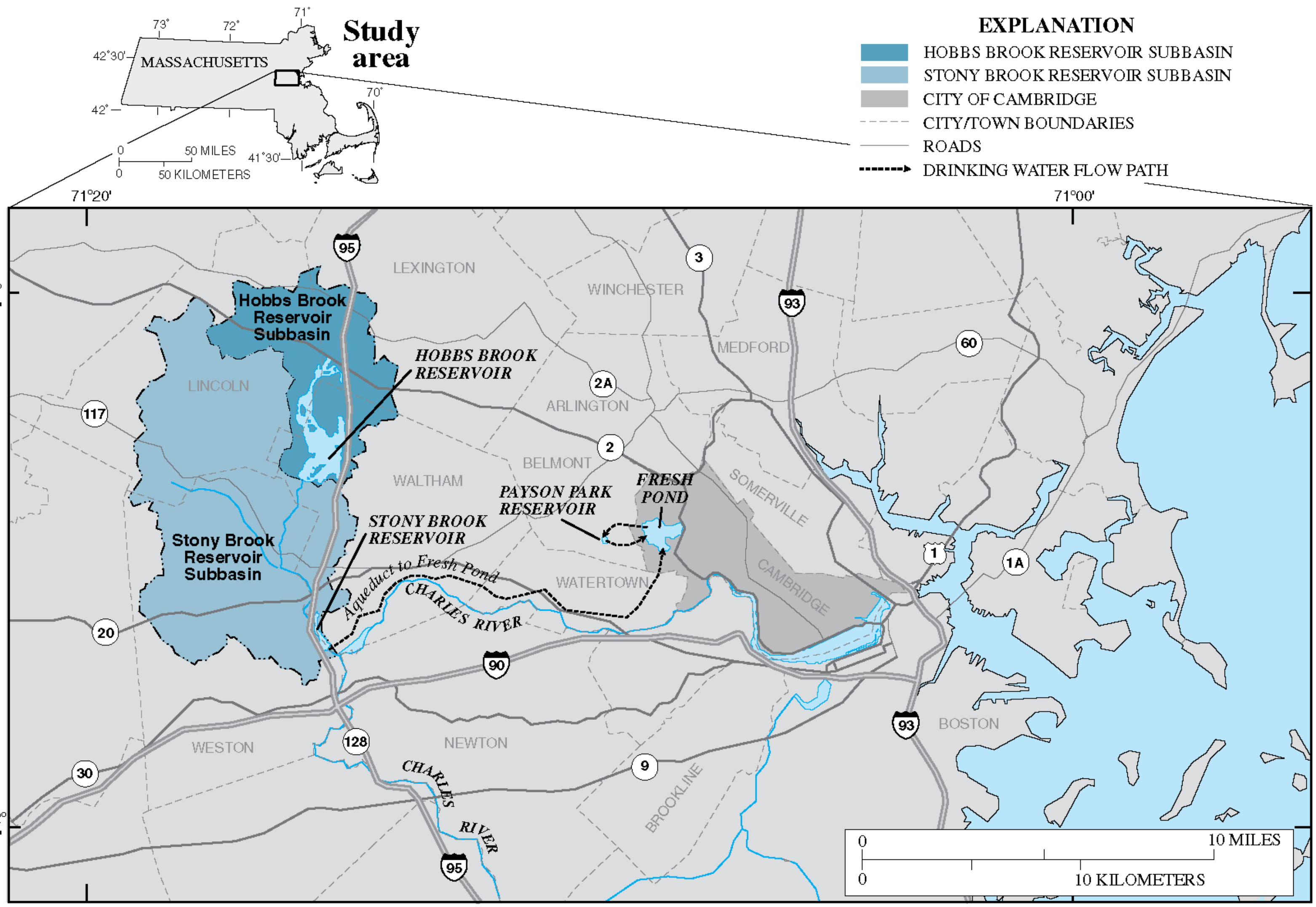


Figure 1: Cambridge Water Supply Source Area

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 2013 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 early September and continued through the end of the 2013 reporting period.

Methodology

Monitoring Procedure and Schedule

Water samples are taken from all sampling sites using *Clean Water* techniques (Wilde and others, 1999). For a more detailed discussion on the methods and process overview of the water quality monitoring program, please refer to Appendix A. All primary tributary and reservoir monitoring locations were sampled by CWD staff five times during the 2013 calendar year; the Fresh Pond Reservation monitoring locations were sampled four times; and four primary tributary locations were sampled a sixth time alongside USGS field staff to conduct side-by-side comparisons. These replicate samples provide a measure of the total variability introduced through sample collection and processing, through laboratory handling and analysis, and through the natural variability of concentrations in natural water bodies. USGS staff sampled nine primary tributary sites six times under baseflow conditions during the 2013 calendar year and sampled five of those sites an additional eight times during stormflow conditions.

Watershed staff conducted nine depth profiles at the Fresh Pond Reservoir "Deep Hole" site throughout the summer and fall months to measure temperature and dissolved oxygen concentrations. The profiles were used to monitor thermal and chemical stratification within the Reservoir to better inform the operation of the aeration system (see the *Reservoir Water Quality* section for more information).

Monitoring Equipment

CWD measures *in situ* parameters, such as temperature, dissolved oxygen (DO), specific conductivity, pH, and oxidation reduction potential (ORP), using a calibrated Measurement Specialties (formerly Eureka Environmental) 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 Parameters and Standards

CWD monitors source water quality to assess general stream 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.

E. coli – 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).

Phosphorus – 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) phosphorus 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 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.

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 and manganese 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 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) can 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.

The following sections describe the results of the water quality analyses conducted for all sampling locations in 2013 and provide a comparison to the water quality monitoring conducted from the 2012 and 2008-2011 reports. Average measurements and highlighted results are provided in the following sections. A complete summary of sampling results is provided at the end of this report.

Reservoir Water Quality

The Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs are monitored for water quality on a regular basis. Hobbs Brook Reservoir has four monitoring sites, two of which are sampled from the shoreline (HB@UPPER & HB@MIDDLE), and the other two (HB@DH and HB@INTAKE), sampled by boat at fixed mooring locations. Stony Brook Reservoir has two sampling sites sampled by boat (SB@DH, and SB@INTAKE), and Fresh Pond Reservoir has three sites (FP@COVE, FP@DH, FP@INTAKE) all sampled by boat (Figure 2).

Surface samples of chlorophyll-*a*, nutrients, bacteria, and selected metals are taken at the each reservoir's deep hole buoy (deepest point of the reservoir) along with Secchi depth measurements. During periods of thermal stratification, additional samples are taken from the bottom layer (hypolimnion) of the reservoir. Depth profiles of dissolved oxygen, temperature, pH, and specific conductance are taken at both "deep hole" (the location of the deepest point in the reservoirs) sites and buoys close to the gatehouse or intake structures. In addition to *in situ* parameter measurements, surface *E. coli* bacteria samples are taken at "intake" buoys.

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 up, 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. Nuisance metals and plant/algae nutrients normally bound to sediments can be released into the hypolimnion in the absence of an oxygenated environment, which 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 have been included on the reservoir depth profiles to illustrate chemical stratification development in the warmer months.

All three reservoirs exhibited slightly supersaturated dissolved oxygen conditions (greater than 100%) in the surface layer during some spring and summer months: April 18th, May 7th, and June 4th at Fresh Pond, and April 16th and July 18th at Stony Brook and Hobbs Brook Reservoirs. This, plus increased pH can be indicative of algal photosynthesis in the reservoirs.

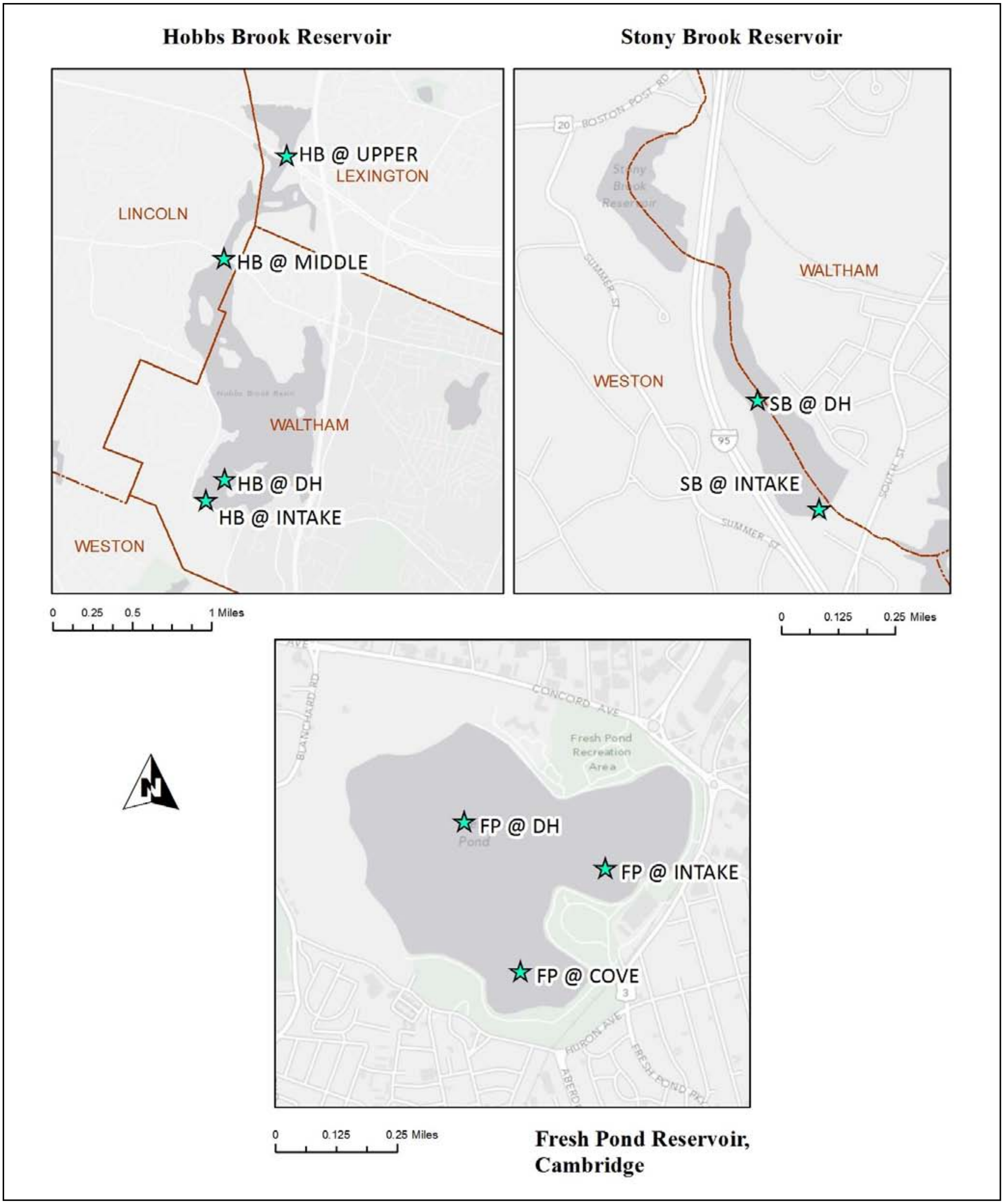


Figure 2: Reservoir Sampling Locations

Hobbs Brook Reservoir

The Hobbs Brook Reservoir is divided into three basins by State Route 2, Trapelo Road, and Winter Street. All sampling locations were sampled five times during this reporting period (HB@UPPER, HB@MIDDLE, HB@DH, and HB@INTAKE). Generally, the water column at the deep hole buoy in Hobbs Brook Reservoir 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.

All surface samples taken from HB@DH met MA Class A standards[1] for DO (> 5mg/L), pH (6.5 – 8.3), and *E. coli* (<235 MPN, taken from HB@INTAKE). One surface sample exceeded the temperature maximum (28.3°C) in the top meter of the water column on 7/18. Grab samples taken from HB@UPPER met Class A standards for DO, temperature, *E. coli*, pH; all samples met the EPA secondary drinking water standard for manganese (0.5 mg/L). Four samples exceeded the NO_3 and TP nutrient criteria for the ecoregion, and all samples exceeded the EPA secondary drinking water standards for iron (0.3 mg/L).

Grab samples taken from HB@MIDDLE met Class A standards for DO, temperature, pH, and *E. coli*; as well as the EPA SMCL for Manganese in all samples. Five out of six samples exceeded the NO_3 and TP nutrient criteria for the ecoregion, and all samples exceeded the iron SMCL.

2013 depth profiles exhibit the expected behavior of thermal stratification during the warmer months (in the July and August profiles, Figure 3), and complete mixing conditions all other measured times. Winter profiles were not collected in 2013, 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 16th and July 18th 2013 sampling events, DO readings measured greater than 100% at depths less than 5 meters at the Hobbs Brook Reservoir. 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 7.8 to 8.2 in the super-saturated layers. The photosynthesis process removes dissolved carbon dioxide from the water column and reduces carbonic acid, thus increasing the pH of the water.

[1] http://www.mass.gov/dep/service/regulations/314cmr04.pdf

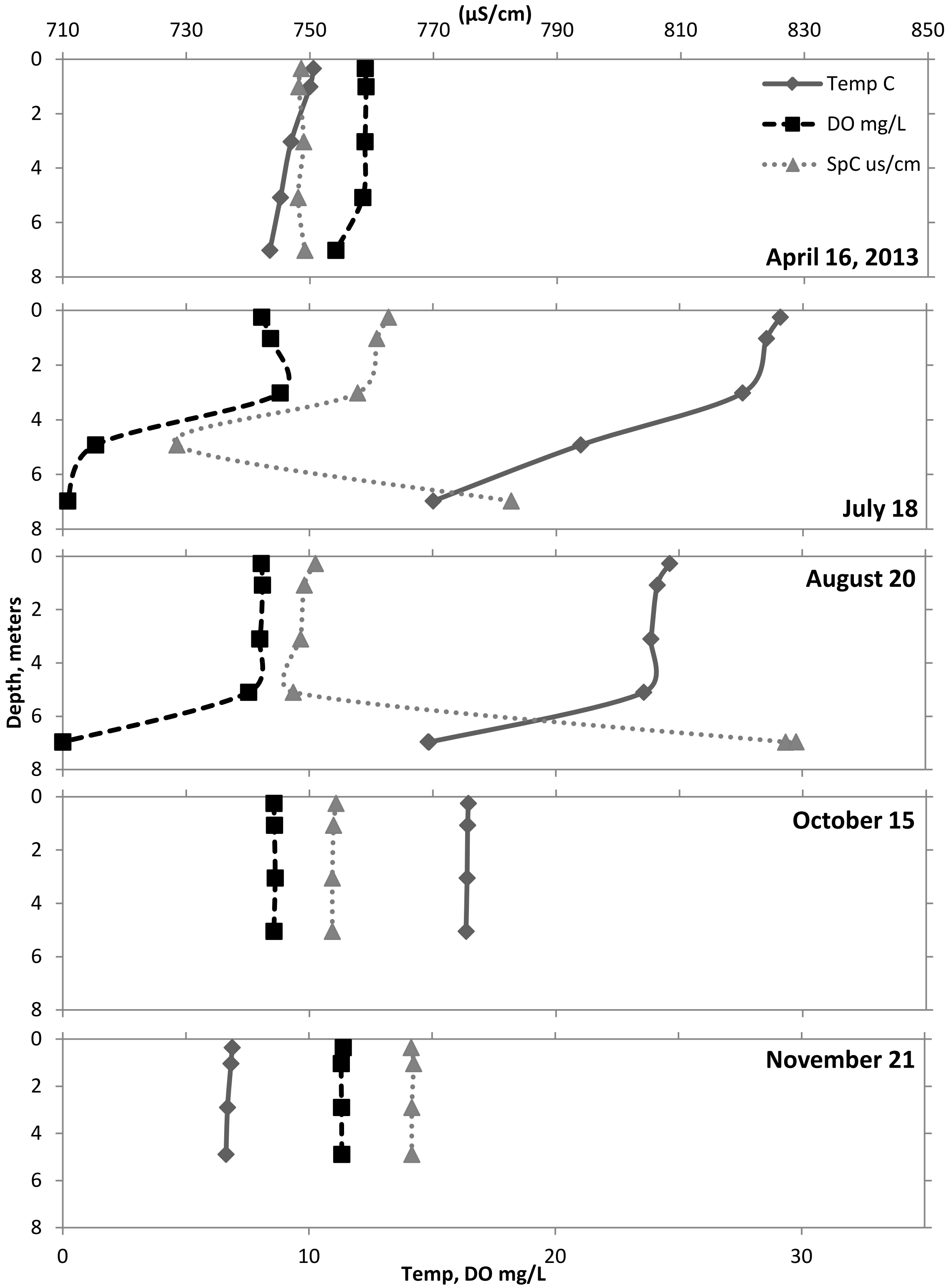


Figure 3: Hobbs Brook @ Deep Hole Depth Profiles, April – November 2013

Anoxic conditions are both a stressor to fish and other aquatic fauna and an opportunity for nuisance metals, such as iron (Fe) and manganese (Mn), to be reduced and released from benthic sediments into the water column. These released metals are mixed into the water supply during spring and autumn turnovers. In finished (treated) drinking water, the EPA recommends a limit of 0.05 mg/L Mn, and 0.3 mg/L Fe. Although stratified reservoir bottom waters can periodically exceed federal secondary (aesthetic) standards, finished water consistently meets them.

During this study period, iron and manganese concentrations in the Hobbs Brook Reservoir differed significantly from surface to bottom during periods of thermal stratification (Figure 4). The median manganese bottom concentration was about 200 times higher than the median surface manganese concentration at Hobbs Brook Reservoir, as a result of stratification during the summer with anoxic conditions forming in the hypolimnion (bottom layer). Whereas most surface samples meet the SMCLs for iron and manganese, all bottom samples substantially exceeded the recommended limits.

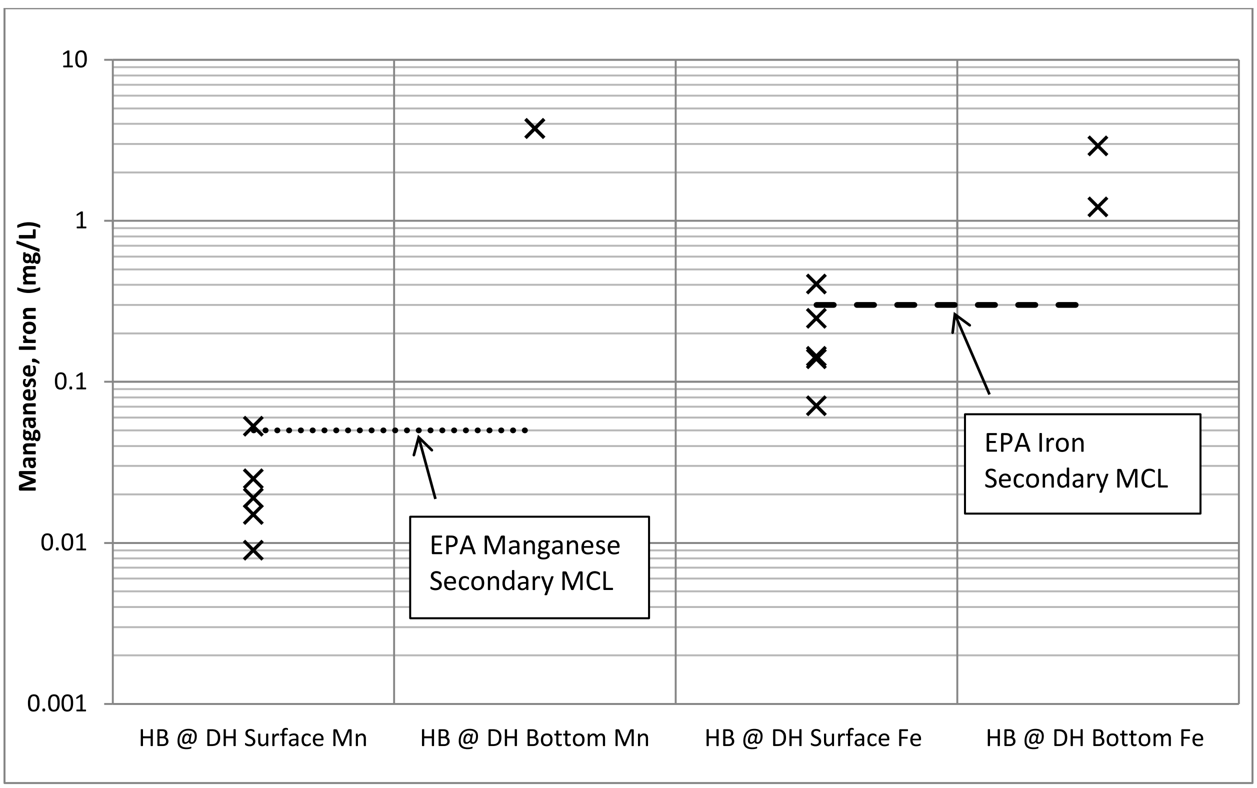


Figure 4: Hobbs Brook Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Nuisance Metal Concentrations (mg/L) During Periods of Thermal Stratification (Logarithmic Scale)

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 five times in 2013. The aeration system was operated continuously from the end of July until mid-October. These aeration lines are designed to aid mixing throughout the reservoir and to help avoid thermal stratification and anoxic conditions from forming in the hypolimnion. Contractors perform regular maintenance on the aeration compressor, and detailed maintenance on the underwater diffuser lines is scheduled for summer, 2014.

Surface samples taken from the Stony Brook Reservoir met Class A water quality standards for pH, DO, and *E. coli* (SB@INTAKE only). One surface sample taken at SB@DH exceeded the temperature maximum in the first meter of water on 7/18. As with Hobbs Brook Reservoir, Stony Brook exhibited thermal stratification in the warmer months despite the use of the aeration system. However, when comparing profiles at SB@DH (Figure 5) before (7/18) and during (8/20) the use of the aeration system, there is less variability between surface and bottom temperatures and dissolved oxygen concentrations, and no observed bottom anoxic conditions, which supports the effectiveness of reservoir aeration.

DO values greater than 100% in the first meter of water during the April and July sampling events indicate high productivity in the reservoir at depths less than 1 meter. The pH range of 7.6-8.2 for these measurements support this theory. Slight chemical stratification is evident in the April, July, and August profiles. The reservoir starts to exhibit thermal stratification in the April and July profiles, but the effects appear attenuated in the August profile, with a running aeration system

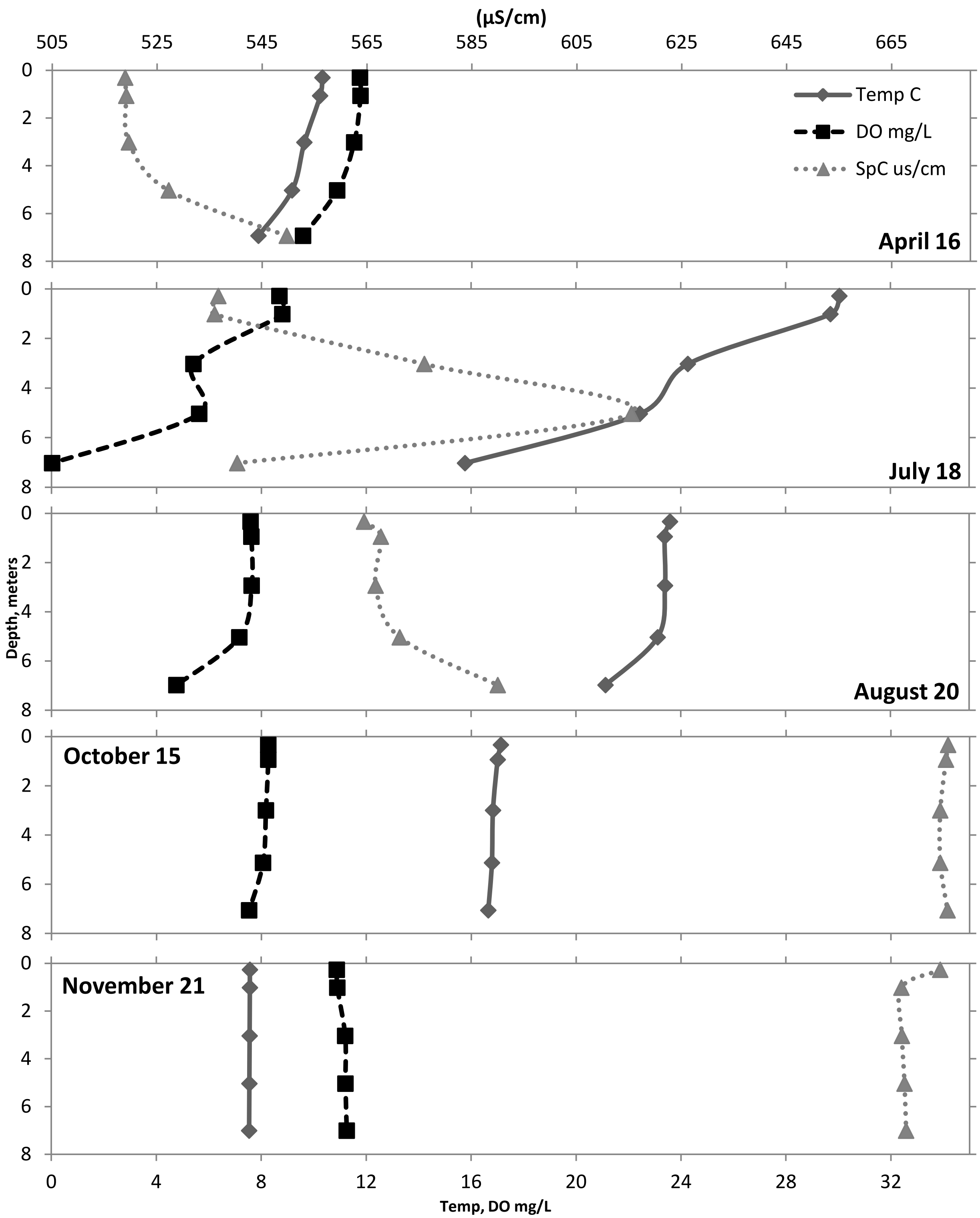


Figure 5: Stony Brook @ Deep Hole Depth Profiles, April – October 2013

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 6. 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 likely because of the 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 2013 than in Stony Brook Reservoir. This may be a result of decreased stratification from the successful aeration of the Stony Brook Reservoir during the summer and fall months. Stony Brook iron and manganese concentrations differed by 6 and 29 times respectively from surface to bottom during periods of thermal stratification.

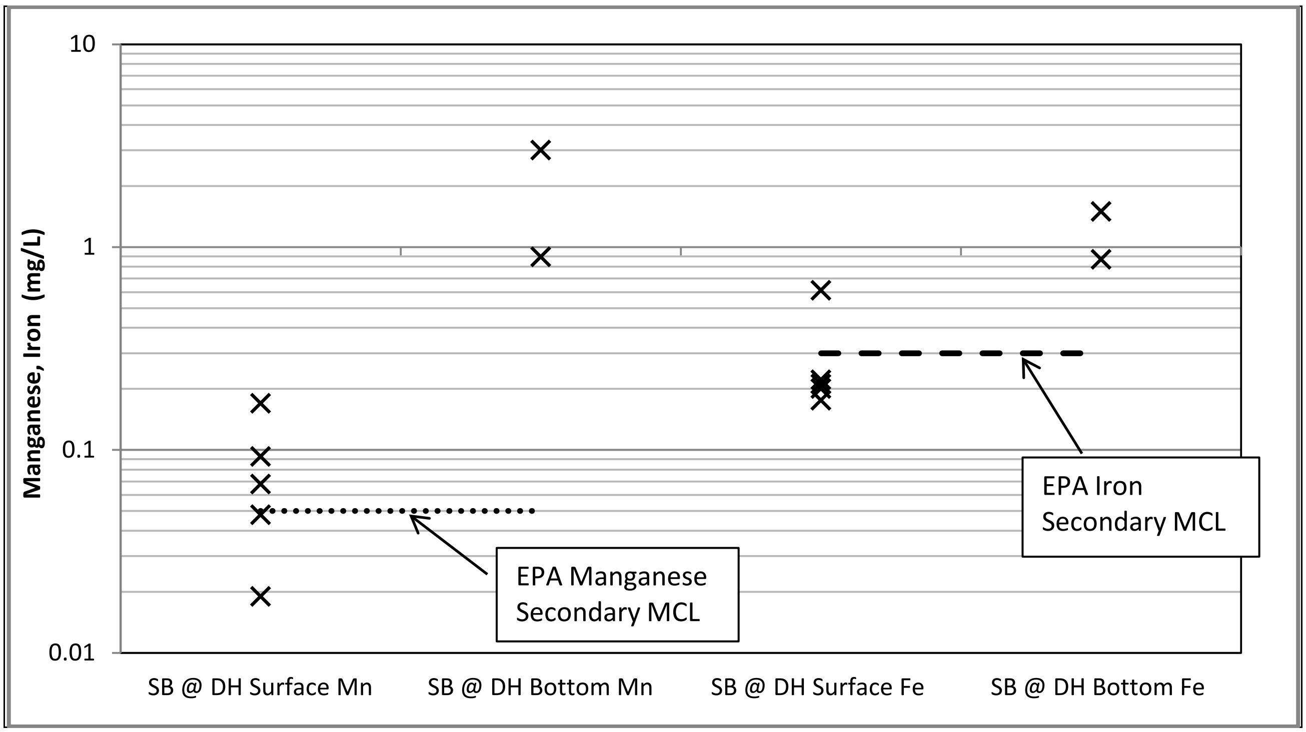


Figure 6: Stony Brook Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Nuisance Metal Concentrations (mg/L) During Periods of Thermal Stratification (Logarithmic Scale)

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 metals 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 system in the Stony Brook Reservoir, an aeration system operates continuously (overnight) throughout spring until the autumn turnover to help avoid anoxic conditions in the reservoir.

Water-column sampling was conducted with samples taken at Fresh Pond five times during this reporting period; an additional five water-column profiles were taken throughout the spring into the fall 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. Observed decreased effectiveness over time of the aeration system could be due to the shortened running-time of the system, and potential clogs in line perforations. Originally designed to be operated non-stop, the aeration system is operated overnight to reduce energy costs at the treatment plant. Even with reduced effectiveness, 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 is scheduled for summer, 2014.

All surface samples taken from Fresh Pond met Class A water quality standards for DO, temperature, pH, and *E. coli* (taken from FP@INTAKE). In 2013, Fresh Pond was thermally stratified from April to September, Figures 7-8. In addition to thermal stratification, DO measurements greater than 100% on April 18th, May 7th, and June 4th indicate algal photosynthesis in the upper layer of the Reservoir. The corresponding pH levels around 7.8 support this theory.

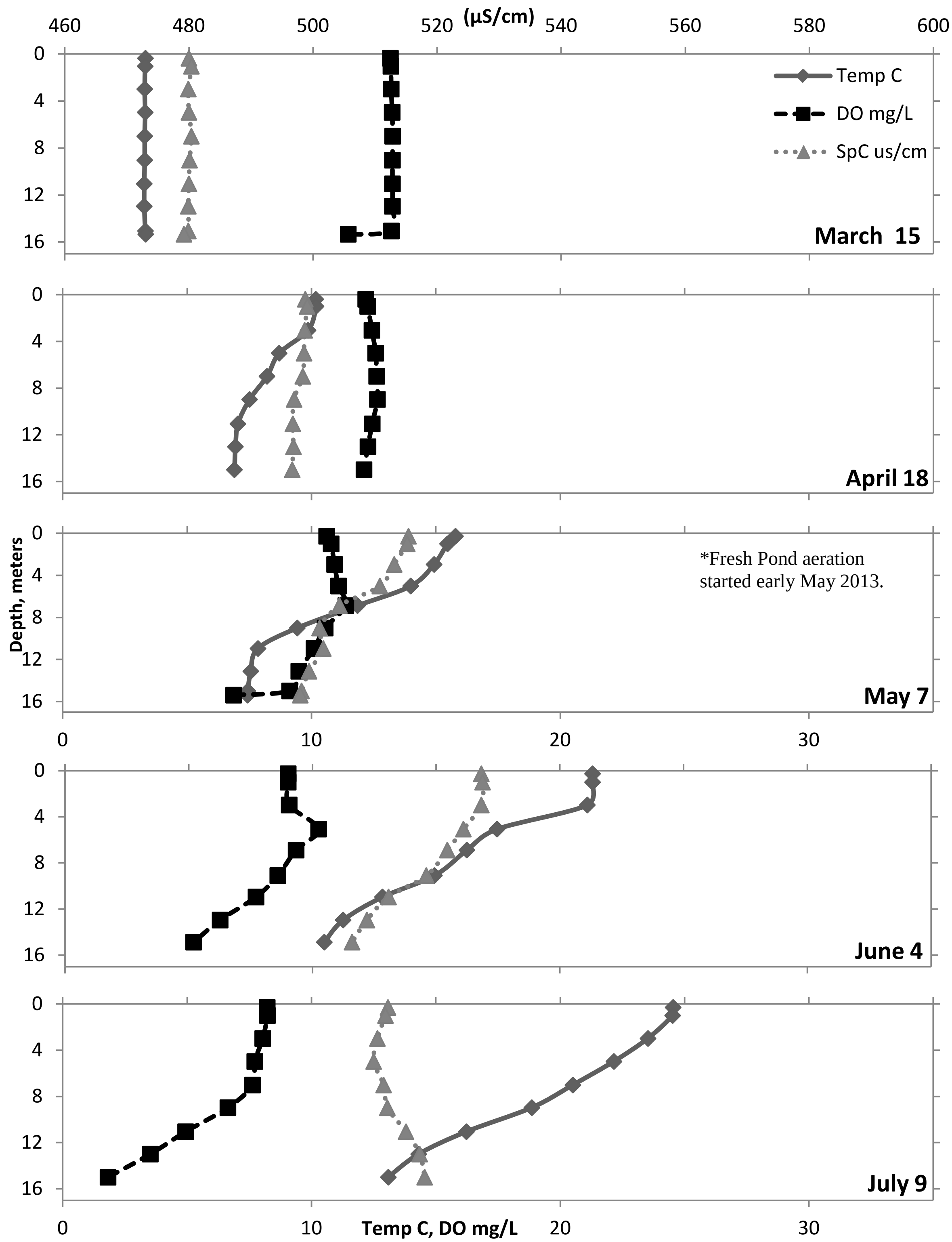


Figure 7: FP@DH Profile March – November, 2013

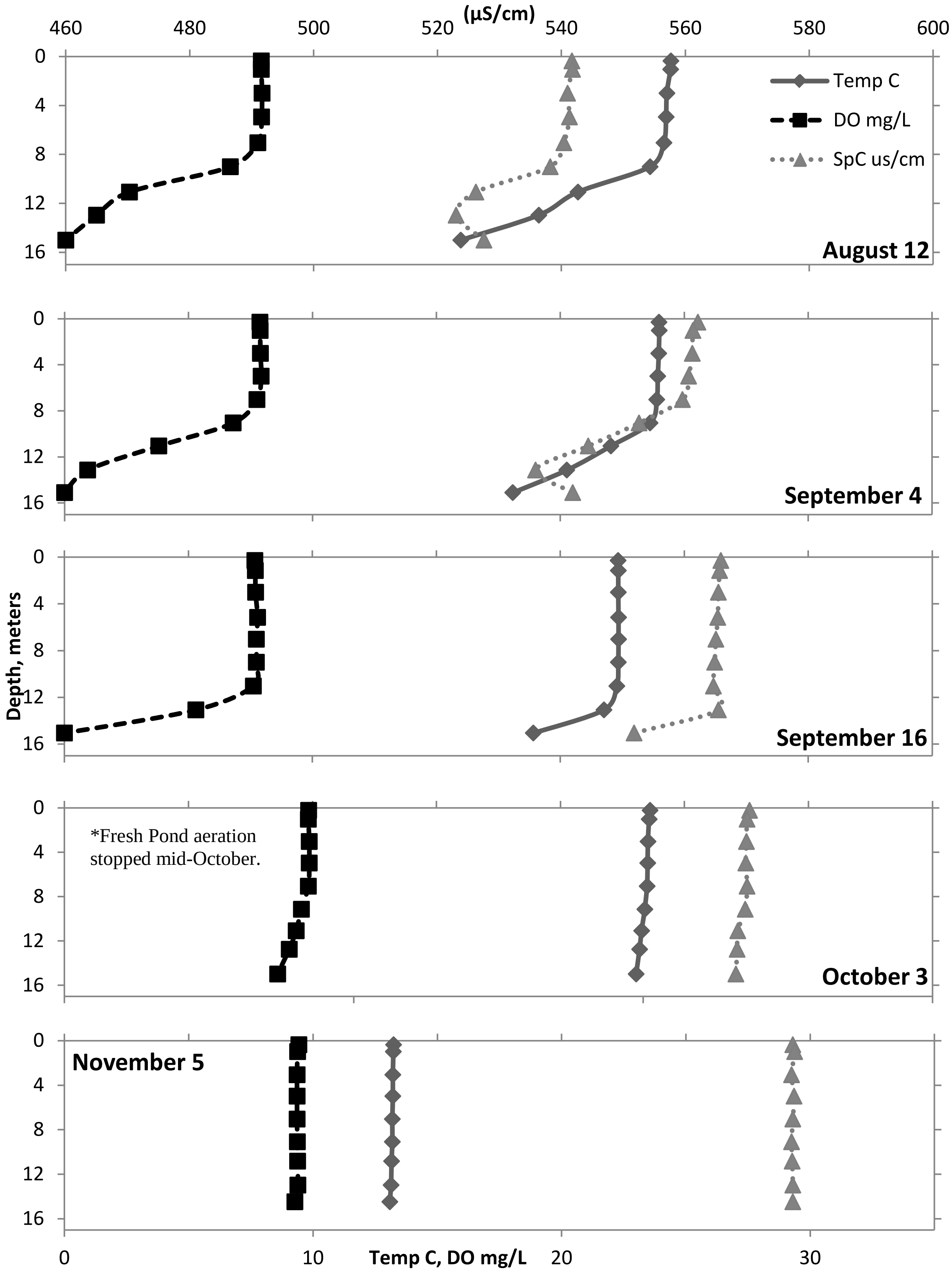

(µS/cm)
460
480
500
520
540
560
580
600
Temp C
DO mg/L
SpC us/cm
August 12
September 4
September 16
October 3
November 5
*Fresh Pond aeration
stopped mid-October.
Depth, meters
0
4
8
12
16
0
10
Temp C, DO mg/L
20
30

Figure 8: FP@DH Profile March – November, 2013, Cont.

Similar to past years, the aeration system provided enough oxygen in the hypolimnion to avoid reducing iron from the sediments (Figure 8). 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. Iron concentrations did not show differences in the surface and bottom samples, likely because manganese is a stronger reducing agent than iron and is released from sediments more easily.

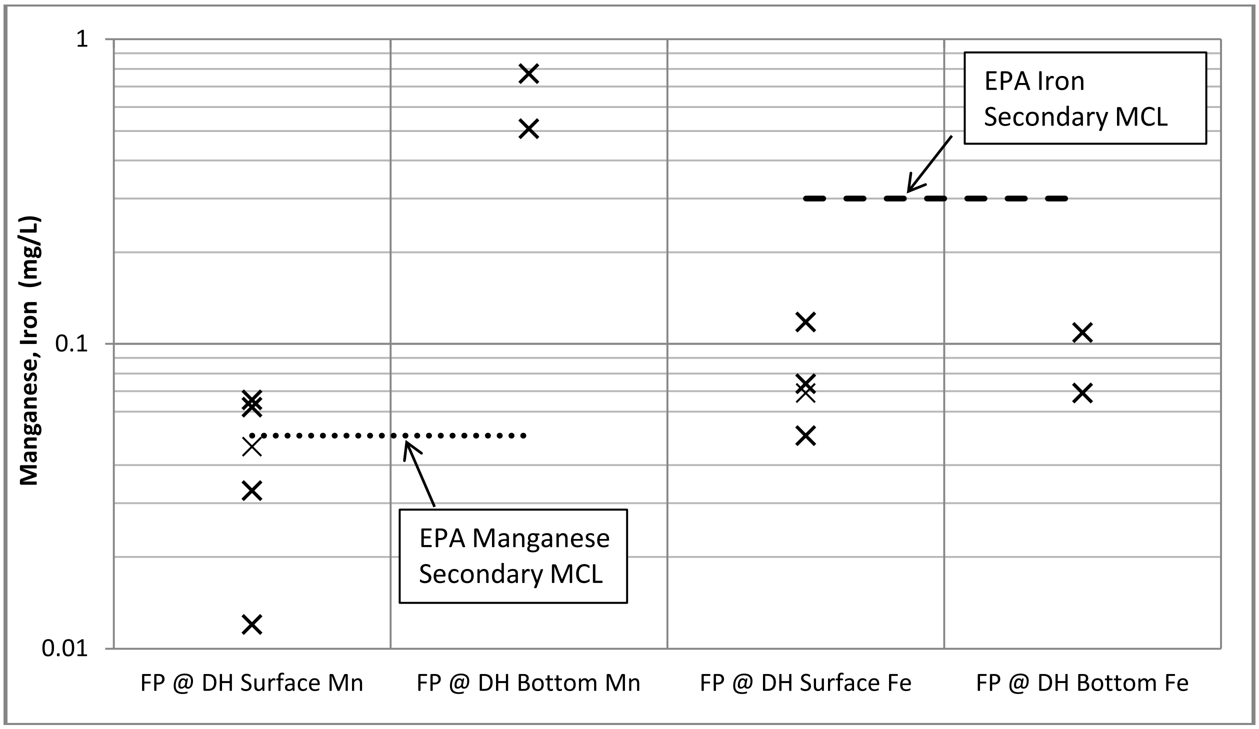


Figure 9: Fresh Pond Reservoir Epilimnion (Surface) vs. Hypolimnion (Bottom) Nuisance Metal Concentrations (mg/L) During Periods of Thermal Stratification (Logarithmic Scale)

Reservoir Trophic State

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. 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.

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

The TSI of a water body can be estimated using chlorophyll-*a* concentrations, phosphorus concentrations, or measured secchi depths. As TSI is an estimator of algal biomass weight in the reservoir, chlorophyll-*a* concentrations are the best parameter to use to calculate TSI. Chlorophyll-*a* is directly affected by nutrients in the water column and therefore provides a good indicator of overall water quality.

For the 2013 TSI estimations, the index was calculated from chlorophyll-*a* concentrations collected during the growing season, when available. When chlorophyll-*a* concentrations were below the limit of detection, secchi depth and total phosphorus were used as a surrogate to calculate reservoir TSI. The chlorophyll-*a* concentrations, total phosphorus concentrations, secchi depths, and corresponding TSI values are provided in Table 3. A box plot of the reservoir TSI values and trophic state categories is provided in Figure 10. Sampling events with field duplicates were averaged to help provide a more accurate representation of the true value of the parameter in the reservoirs.

Table 2: Reservoir Chlorophyll-*a*, Total Phosphorus, Secchi Depth, and Corresponding TSI Value, 2013

	Sampling Date	Chlorophyll-*a* (µg/L)	TSI	Total Phosphorus (µg/L)	TSI	Secchi Depth (m)	TSI
Hobbs Brook at Upper	3/12/2013	7.65	**51**	22	**49**	NS	
	6/25/2013	10.3*	**53**	23.5	**50**		
	8/6/2013	13.8	**56**	52	**61**		
	9/26/2013	35.2	**66**	53	**61**		
	11/26/2013	20.8	**60**	60	**63**		
Hobbs Brook at Middle	3/12/2013	3.53	**43**	17	**45**	NS	
	6/25/2013	29.4	**64**	24	**50**		
	8/6/2013	6.45	**49**	28.5	**52**		
	9/26/2013	28.8	**64**	54	**62**		
	11/26/2013	13.1	**56**	47	**60**		
Hobbs Brook	4/16/2013	7.82	**51**	16	**44**	2	**50**
	7/18/2013	<2		64	**64**	5	**37**
	8/20/2013	<2		12	**40**	5	**37**
	10/15/2013	2.6**	**40**	16.5*	**45**	3.5	**42**
	11/21/2013	2.12	**38**	15	**43**	4	**40**
Stony Brook	4/16/2013	8.29	**51**	10	**37**	2.5	**47**
	7/18/2013	3.11	**42**	ND		4	**40**
	8/20/2013	3.37	**43**	20	**47**	2.5	**47**
	10/15/2013	<2		16	**44**	3.5	**42**
	11/21/2013	2.15**	**38**	12.5*	**39**	3.5	**42**
Fresh Pond	4/18/2013	4.7	**46**	<0.01		3	**44**
	7/9/2013	<2		<0.01		3.5	**42**
	8/15/2013	<2		10	**37**	3.8	**41**
	9/4/2013						**40**
	9/16/2013						**40**
	10/3/2013	<2		<0.01		5	**37**
	11/5/2013	<2		<0.01		6.5	**33**

*Average value of sample and field duplicate.
** Field duplicate lower than detection limit.
NS: Not sampled.
ND: Not detected.

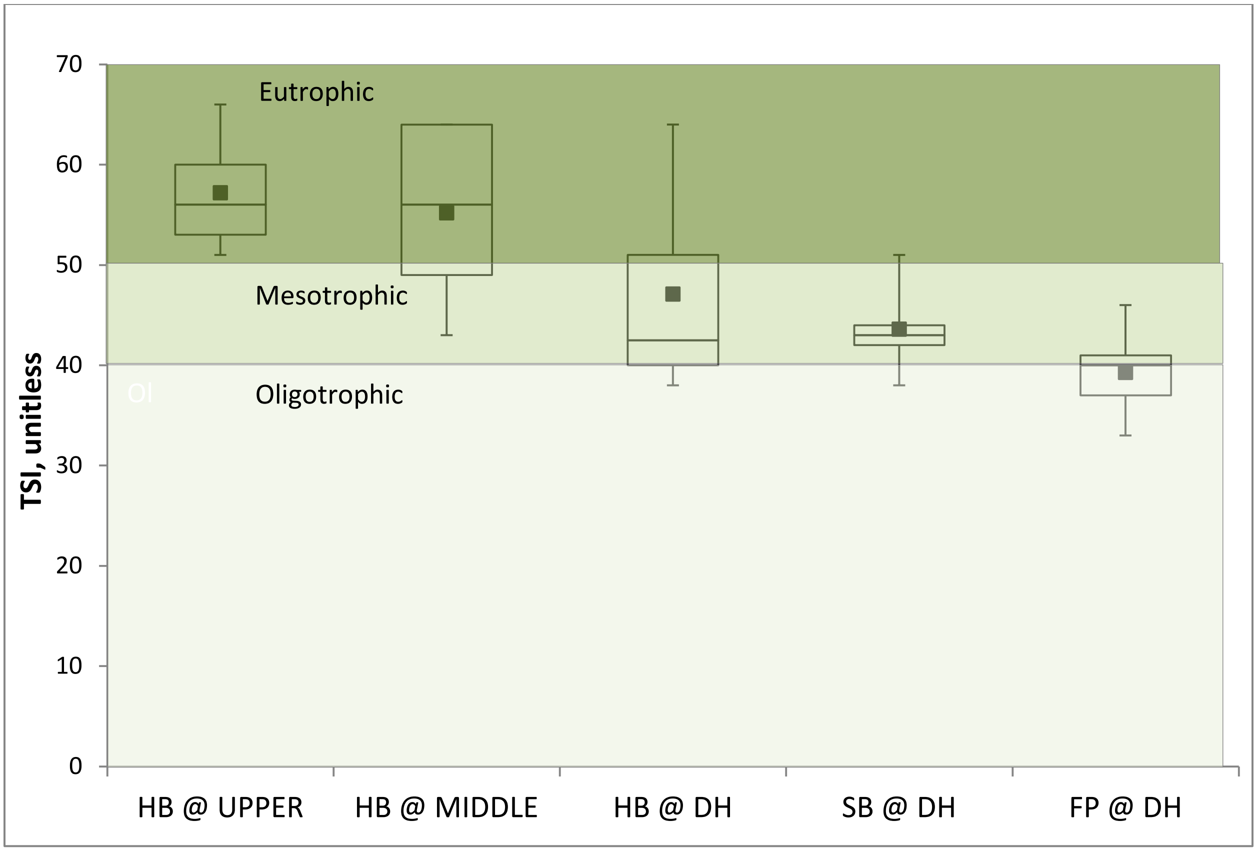
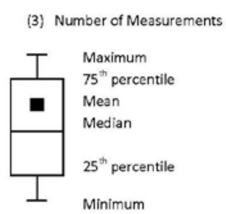


Figure 10: Reservoir Trophic State Index, from Chlorophyll-*a* and Total Phosphorus Concentrations, 2013



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. 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 10, median TSI values for the Hobbs Brook, Stony Brook, and Fresh Pond Reservoirs during 2013 were 42.5, 43, and 40, respectively. These values are barely above oligotrophy (<40 TSI), indicating good water quality within the reservoirs. The majority of values measured at the Hobbs Brook and Stony Brook were in the mesotrophic zone (40 – 50); whereas Fresh Pond TSI values indicate a range from oligotrophy to mesotrophy. The TSI values are similar to results from previous years and exhibit the expected decrease from Hobbs Brook to Fresh Pond Reservoir.

Reliance on particulate settling, however, does not address the growing concern over soluble ions, such as sodium and chloride. Commonly used in the watershed for deicing materials, these ions have shown increasing concentrations over the years in the Cambridge watershed. Fresh water dilution continues to maintain drinking water standards, but controlled use of deicing substances in the watershed is crucial to maintaining a viable drinking water source.

Weekly Reservoir Samples

To further aid water treatment decisions, reservoir samples are collected weekly by Watershed Division staff and analyzed by the Water Department laboratory staff. The weekly monitoring events capture seasonal and climatic water quality variability and can be used to track chemical concentration changes over time. Samples are analyzed primarily for *E. coli* bacteria, select metals, TOC, and specific conductance.

At Hobbs Brook Dam, surface grab samples are collected inside the gatehouse, or when the reservoir is frozen over, from the dam outlet. At Stony Brook Dam, samples are pulled from flushed spigots that draw water from the reservoir at three different depths, roughly corresponding to gate invert elevations.

In 2013, 100% of the weekly samples from the Hobbs and Stony Brook Reservoirs met Massachusetts Class A water quality standards for bacteria (*E. coli* <235 MPN). Distributions of bacteria results for 2013, along with the results from the 2012 and 2008-2011 reporting periods, are illustrated in Figure 11. 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 – 100 range.

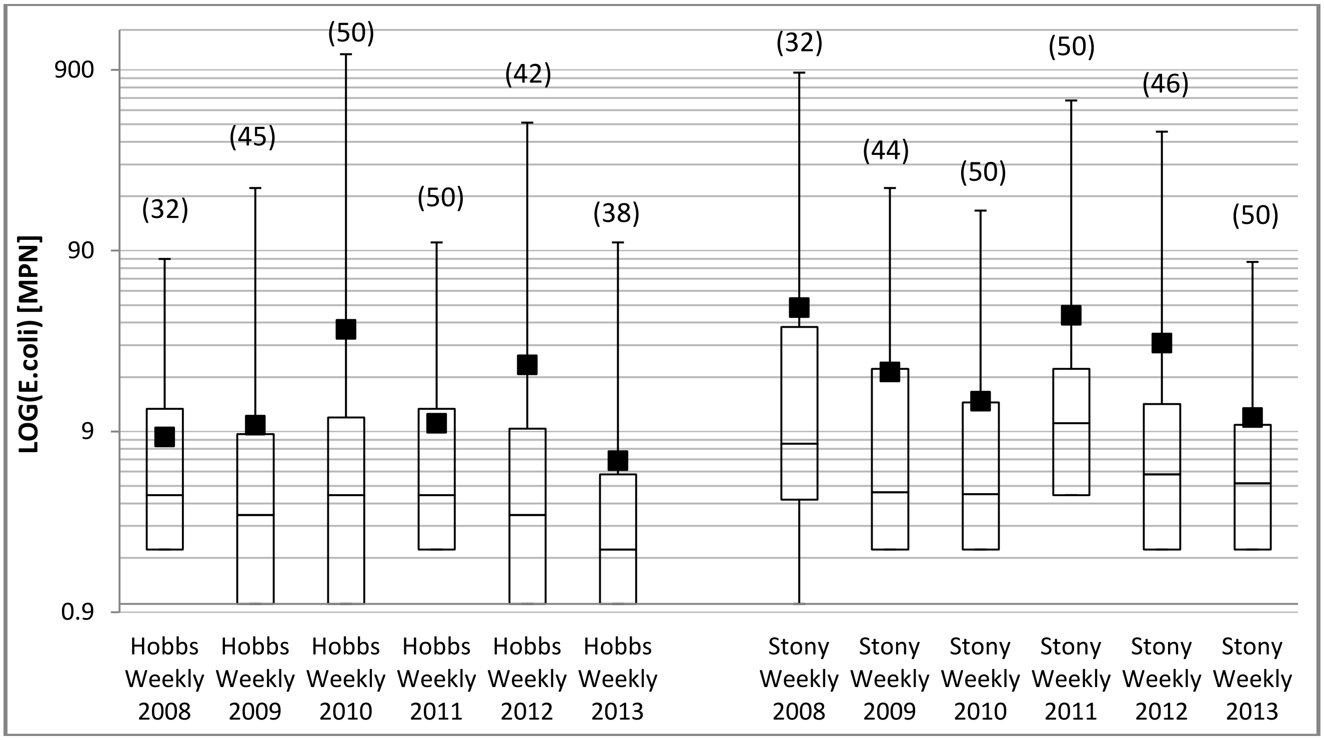


Figure 11: Weekly Bacteria Monitoring (Log (*E. coli*)), [MPN], Hobbs and Stony Brook Reservoirs, 2008-2013

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. In an effort to track changes over time, sodium and chloride are also analyzed in weekly grab samples. 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. As a surface water supply, freshwater dilution is currently the only way to reduce deicing salts to acceptable concentrations.

Median chloride concentrations in the Hobbs Brook Reservoir are below, but close to State and Federal drinking water and ambient toxicity standards (Figure 12). 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. No chloride standard exceedances were observed in weekly samples collected at Stony Brook Reservoir between 2008 and 2013. 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.

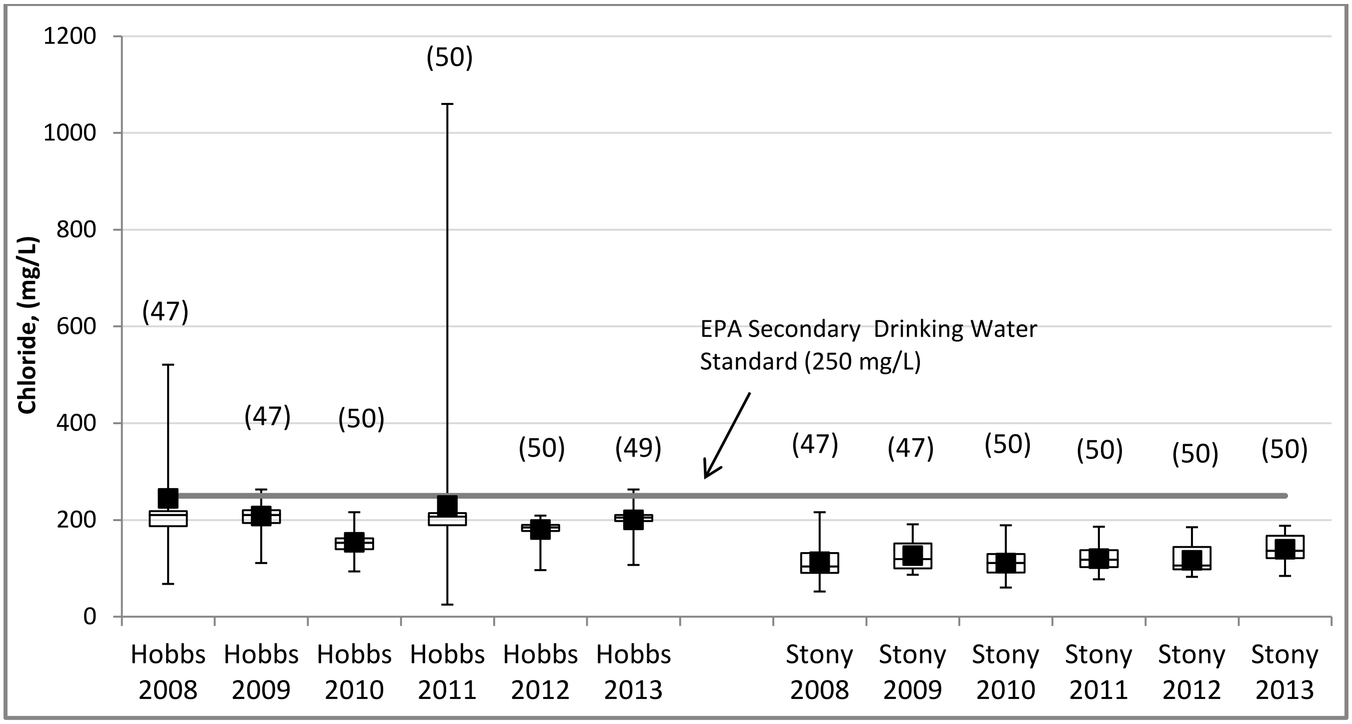
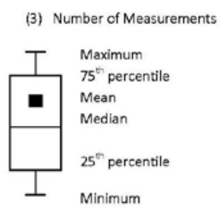


Figure 12: Weekly Chloride Monitoring [mg/L], Hobbs and Stony Brook Reservoirs



Review of the total organic carbon results from 2008 - 2013 (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 small increase in medians from the past three years at the Hobbs Brook Reservoir may indicate a slow increase in TOC concentrations, but the trend is so slight and the record too short to determine a significant trend.

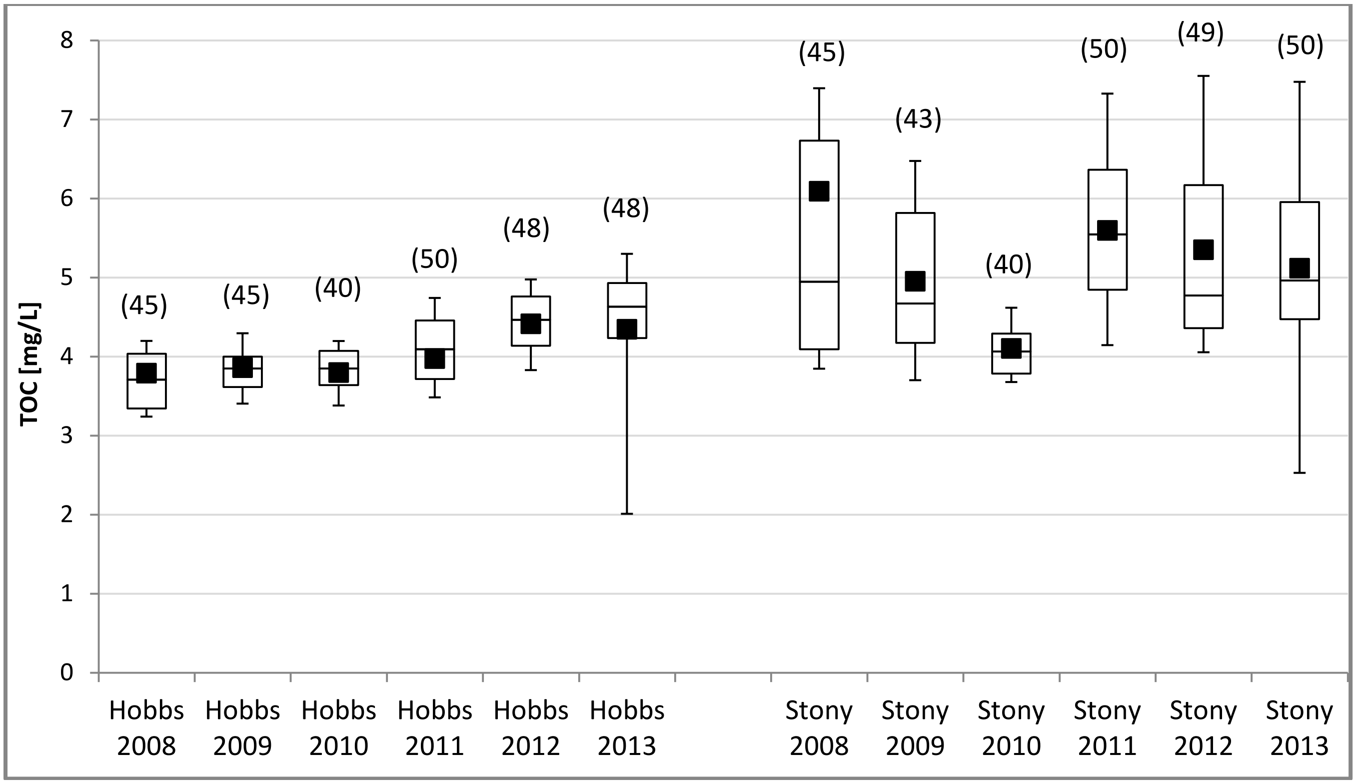
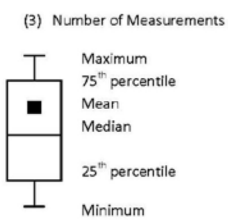


Figure 13: 2008 - 2013 Upcountry Reservoir Total Organic Carbon, [mg/L]



Tributary Water Quality

All 12 primary tributary sampling sites (Figure 14) were sampled at least five times during 2013. Stony Brook at Viles Street, Stony Brook at Route 20, Lexington Brook, and Hobbs Brook at Mill Street were sampled an additional time alongside USGS staff as a broad quality control (QC) measure to gauge the inherent variability in surface water samples.

Water samples for chemical analysis were collected at stream and reservoir sampling stations using *Clean Water* protocols (Wilde and others, 1999) for all aspects of sample collection, preservation, and transport. Samples were physically collected from the streams by the centroid dip technique (Edwards and Glysson, 1999). In addition to CWD water quality measurements, the nine primary tributary sites with USGS monitoring stations are equipped to continuously monitor stream stage, temperature, and specific conductance as part of a joint-funding agreement (JFA) between the CWD and USGS.

Through the tributary monitoring program, sources of sewage-related bacteria, sodium, chloride, nitrate, total phosphorus, and manganese (among other parameters) entering Hobbs Brook and Stony Brook Reservoirs are continuously 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. For water quality samples with continuous streamflow measurements, load estimates were normalized to subbasin areas to calculate instantaneous yields (Appendix B).

Discharge data was collected through various methods. The nine primary tributary sites with USGS continuous monitoring stations measure stage at 15 minute intervals and use a USGS calibrated relation to estimate discharge. The Industrial Brook is no longer a continuous monitoring station; instead, discharge was estimated by CWD staff for all 2013 sampling events using a USGS published stage-discharge relationship. Stream discharge was similarly estimated at Tracer Lane for all 2013 sampling events relating observed stage heights to an updated stage-discharge relationship developed from discrete USGS discharge measurements. Discharge was manually measured using an acoustic Doppler velocimeter (Rantz and others, 1982) for two Hobbs Brook at Kendal Green sampling events and estimated for the three other sampling events using a CWD-developed rating curve.

Characteristics of each subbasin in terms of percent areal coverage of 21 land use/land cover categories, minimum, maximum, and mean, slope, and surficial geology are provided in the 2001 USGS report (Waldron and Bent, 2001). Subbasin updates using 2005 MassGIS (Massachusetts office of Geographic Information) 37 land use/land cover categories are provided in Table 3.

The following discussion highlights the results of tributary monitoring from north (upstream) to south (downstream) along with statistically significant results from historical trending analysis. Quality control measures and analysis are provided in the *Quality Control* Section. A discussion of the statistical methods used is provided in Appendix C.

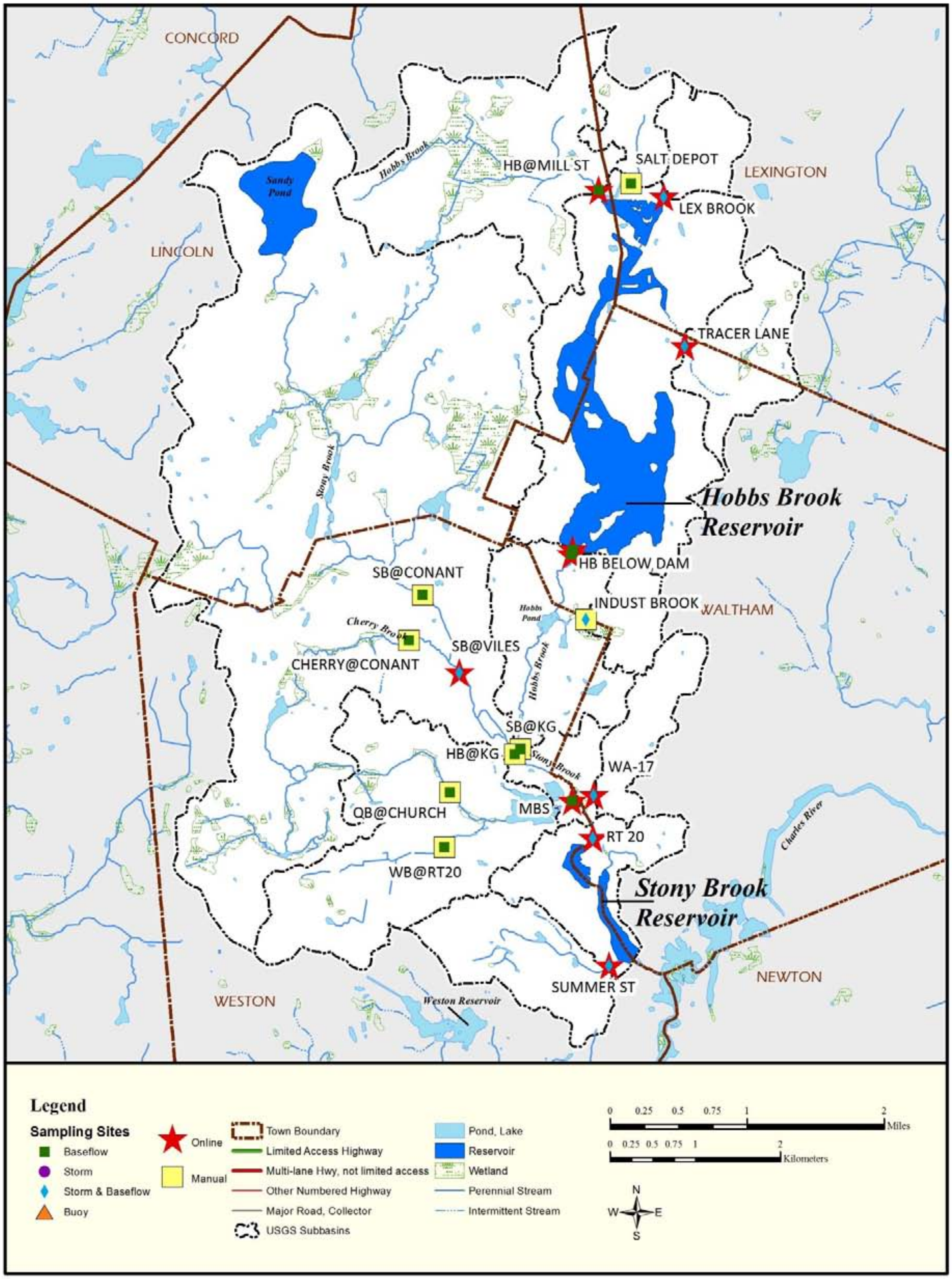


Figure 14: Tributary Monitoring Station Locations within the Watershed

Table 3: 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

Hobbs Brook at Mill Street (01104405)

Hobbs Brook is one of three tributaries that convey water to the upper basin of Hobbs Brook Reservoir. The subbasin defined by USGS station 01104405 (Hobbs Brook at Mill Street, near Lincoln, MA), at 2.15 mi^2, is the largest of the three. The subbasin is comprised of a large proportion of wetland and forested cover (~77% by area) relative to the other upper basin tributaries (Table 3). The USGS reestablished this site at the end of 2011 as a continuously monitored stream. Flow estimates, stream temperature and specific conductance are available online in real-time.

During the 2013 study period, “HB@MILL ST” was sampled six times under baseflow conditions. No wet weather samples were collected. For each sample, water quality met Class A standards for temperature (< 28.3°C), dissolved oxygen (> 5mg/L), and pH (between 6.5 – 8.3). No samples exceeded single sample *E. coli* thresholds of 235 MPN (most probable number).

Chloride, sodium, nitrate, total phosphorus, and total organic carbon (TOC) concentration medians, along with the specific conductance median value, were higher in 2013 than those found in the 2012 reporting period. The *E. coli* count and total Kjeldahl nitrogen (TKN) concentration median were lower in 2013 than in 2012; and the manganese median concentration was similar in 2013 to the 2012 median.

Nutrient pollution continues to be a concern throughout tributaries in the watershed. The EPA established nutrient criteria to provide guidance on preventing many risks associated with excess nutrients in water bodies, including eutrophication and the risk of disinfection byproducts formation in the water treatment process. All but one nitrate concentration from the 2013 sampling events was below the 0.31 mg/L EPA nutrient criteria for this ecoregion; four out of six total phosphorus sampling results were above the 0.02375 mg/L EPA nutrient criteria.

The increase in chloride, sodium, and specific conductance median levels in 2013 supports the significant increasing trends monitored in salt-related parameters (Table 6, found at the end of this Section). All three show significant increasing trends ($p = 0.00$) from the 1990s to 2013 when analyzed using the Spearman’s Rho method of trend analysis (Appendix C). The increase in sodium and chloride concentrations could be attributed to local effects from continual build-up and soil/groundwater migration of road salt in Route 2 shoulder areas; however, baseflow chloride and sodium concentrations in HB@MILL ST continue to be much lower than other monitored tributaries (Figures 23 and 24).

Salt Depot Brook (01104410)

“SALT DEPOT” has an estimated 0.34 mi^2 drainage area and drains directly into the upper basin of the Hobbs Brook Reservoir. The station was named for the nearby MassDOT road salt storage facility that previously stored deicing salt uncovered on bare ground. Over the years, salt leached into the surrounding soils and groundwater, thereby creating a hyper-saline groundwater plume that was studied and mapped in 1985.

The site was monitored five times during baseflow conditions in 2013. No stormwater samples were collected. For this site, water quality met Class A standards for temperature (< 28.3°C), dissolved oxygen (> 5mg/L), and pH (between 6.5 – 8.3). Three sampling events exceeded the single sample *E. coli* threshold (235 MPN) with measurements ranging from 340 to >2419.6 MPN. Relatively high bacteria concentrations could be explained by the upstream wetland that contributes to this sampling station. Wetland habitats typically provide for an abundance of wildlife/bacteria sources.

SALT DEPOT's high specific conductance, sodium and chloride results may be attributed to the continuous movement of the hyper-saline groundwater plume from the MassDOT (Massachusetts Department of Transportation) salt storage facility. A boxplot of sodium concentrations from 1995-2013 is provided in Figure 15. The statistical analysis of specific conductance, sodium, and chloride from 1995-2013 data (1997 for chloride) all yielded significant increasing trends over time ($p = 0.00$, all). This upward trend is likely the combined result of increased deicing salt applications as well as the migrating hyper-saline groundwater plume.

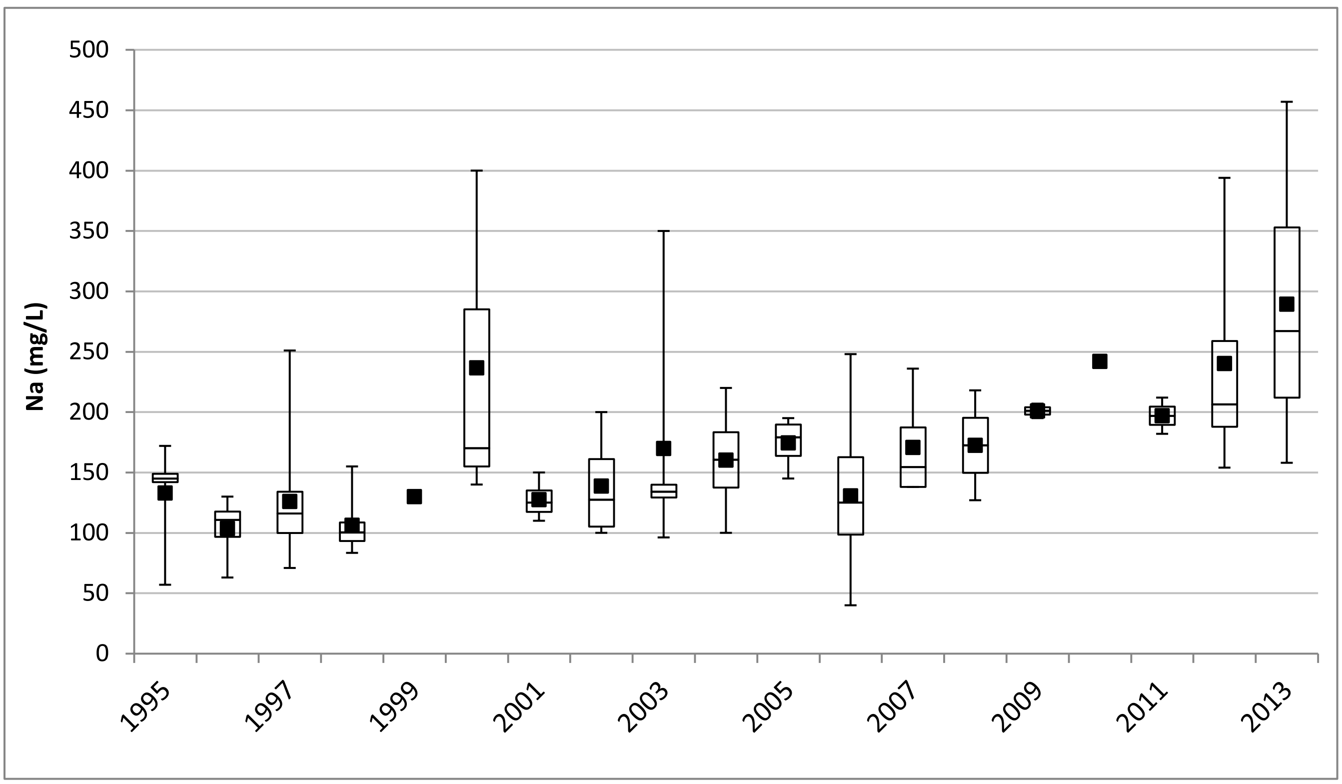
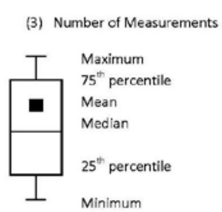


Figure 15: Box plot of Long-Term (1995-2013) Sodium Concentrations [mg/L], Salt Depot Brook



Nitrate concentrations at Salt Depot Brook are relatively low compared to other tributaries in the watershed (Figure 30); however, all but one nitrate sample taken by CWD staff in 2013 exceeded the nitrate EPA nutrient criteria for the ecoregion.

In the 2001 USGS baseline report, relatively high dissolved iron and orthophosphate concentrations were measured at the site. Salt Depot Brook continues to yield high concentrations of iron, although Tracer Lane surpassed Salt Depot Brook in both median concentration and range (Figure 29) in 2013. The high baseflow total phosphorus measurements have been correlated to the percentage of floodplain alluvium in the Salt Depot Brook subbasin (Table 3), which is more than five times that of any other subbasin in the source area; however, the total phosphorus levels in Salt Depot Brook during 2013 were not nearly the highest in the watershed (Figure 31). Two out of the five samples taken by CWD staff in 2013 exceeded the total phosphorus EPA nutrient criteria for the region. The median 2013 total phosphorus value was similar to that in 2012 (0.02 mg/L).

Lexington Brook (01104415)

With a drainage area of 0.41 mi^2, the Lexington Brook monitoring station drains the second largest area to the Cambridge reservoir's upper basin. Lexington Brook is dominated by residential land uses (Table 3), and receives many direct, untreated stormwater discharges from the adjacent highway. Some of those direct discharges have been or are planning on being rerouted by MassDOT as part of the upcoming Route 128 resurfacing/Route 2 bridge reconstruction project.

Lexington Brook is equipped with a USGS-maintained automated monitoring station that continuously records temperature, stage, and specific conductance. In 2013, CWD staff sampled Lexington Brook six times under baseflow conditions. For all 2013 CWD sampling events, temperature, dissolved oxygen, and pH did not exceed MA Class A surface water quality standards. One sampling event on July 16th exceeded the single sample *E. coli* threshold (235 MPN).

All 2013 samples exceeded the EPA nutrient criteria for nitrate. Lexington Brook continues to yield high nitrate concentrations in relation to the other tributaries (Figure 30). Only two samples exceeded the EPA nutrient criteria for total phosphorus. A statistically significant decreasing trend ($p = 0.00$) in baseflow TP and TKN ($p = 0.05$) was detected in data collected from 1995-2013 (Table 6), but may be heavily influenced by the high amount of non-detects.

This site continues to exhibit the highest median specific conductance, sodium, and chloride concentrations in the entire source water area (Figures 23-25), and these values are also significantly higher than those found in the 1998 USGS study (Figure 16). Mann-Kendall trend analysis indicated significant increasing trends in specific conductance, sodium, and chloride levels in Lexington Brook in baseflow data spanning from the early 1990's to 2013. Lexington Brook has historically yielded the highest concentrations for road-salt related parameters; however, Salt Depot Brook could surpass Lexington Brook if the hyper-saline groundwater plume migrates and dominates baseflow contributions.

The high concentrations of salt-related parameters are likely attributed to the high percentage of roadway coverage in the subbasin (more than 16%, Table 3). Contributing drainage area includes a major highway interchange connecting State routes 2A and 128 and the MassDOT salt storage facility (Figure 14). State highways cover twice as much area in this subbasin as any other and are in close proximity to the sampling station, the tributary, and the reservoir. Inclusion of this station in a water-quality monitoring program is essential because of the apparent continued rising trend in sodium concentrations (Figures 16 and 17) and probable contributions of urban and highway runoff contaminants to the water supply.

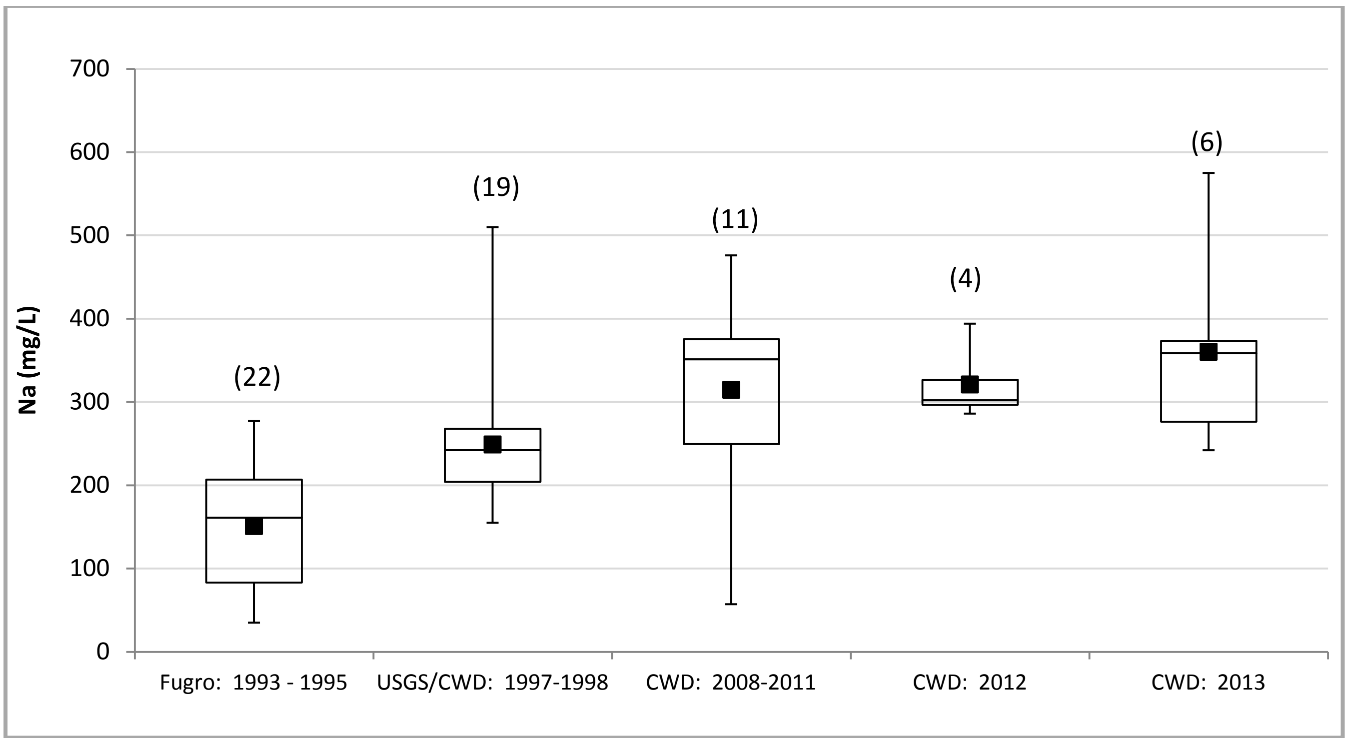


Figure 16: Periodic Sodium Comparison, Lexington Brook, [mg/L]

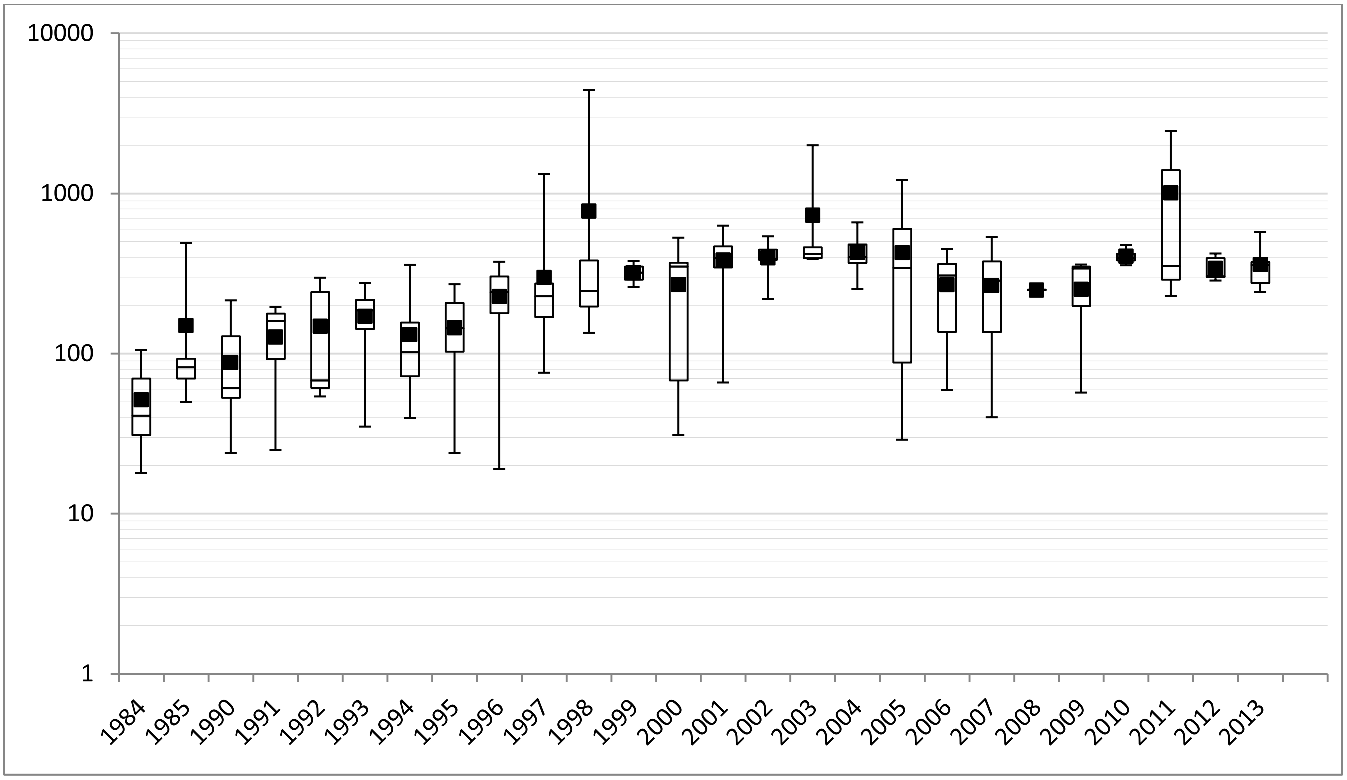


Figure 17: Long-Term Lexington Brook Sodium Trend – All Weather

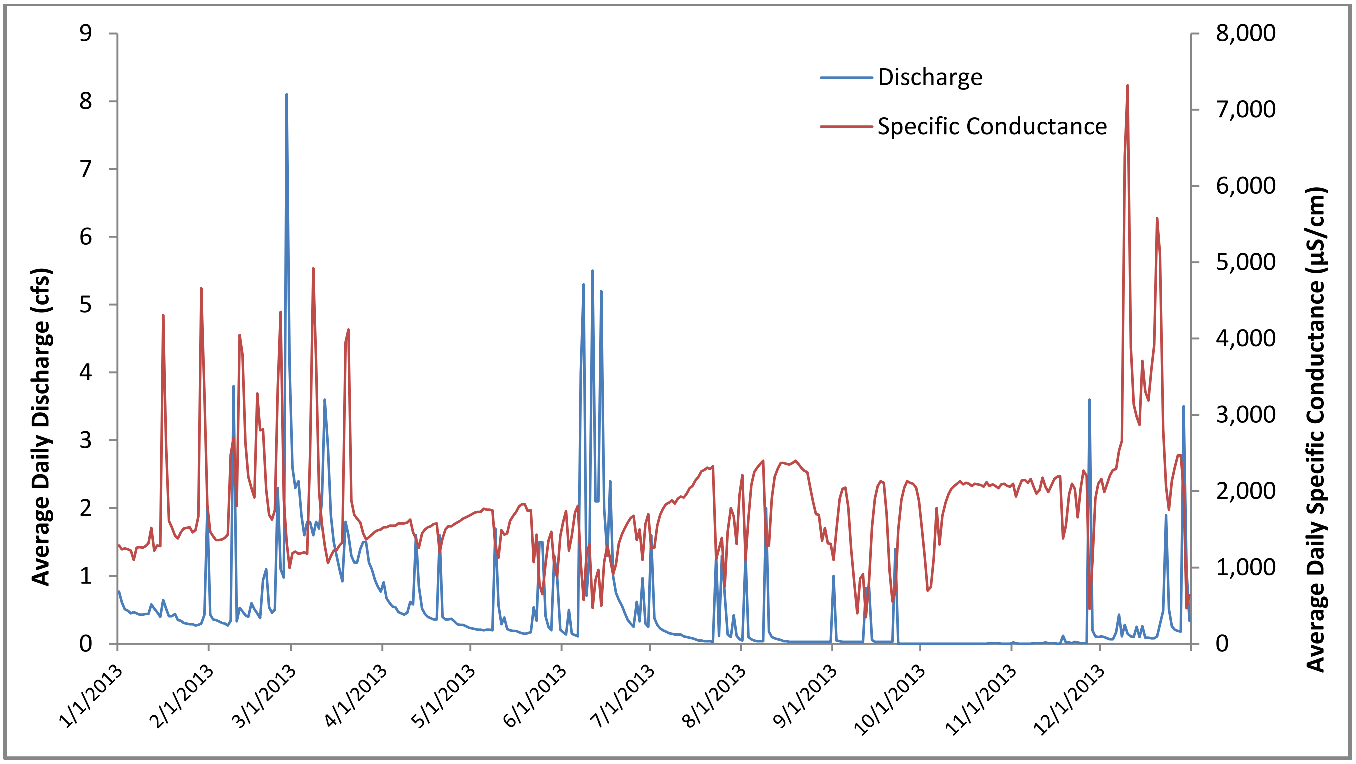


Figure 18: Preliminary Instantaneous USGS Data for Lexington Brook – Average Daily Discharge and Specific Conductance, 2013

The above figure (Figure 18) illustrates published automated stream flow and specific conductance (indicator of sodium and chloride concentrations in the water) records for 2013. During non-winter months when no deicing chemicals are used, the graph depicts an inverse relationship between flow and specific conductance. This phenomenon is the result of storm water dilution of high salinity in-stream groundwater flows. Conversely, in the winter months, the relationship between specific conductance and streamflow is proportional, and large conductance spikes follow melt events or runoff-generating mixed precipitation. On an annual basis, preliminary data analysis by CWD, USGS and UMass Amherst show that the majority of salt contributions to Hobbs Brook Reservoir via LEX BROOK are from high salinity groundwater (base) flows rather than from runoff generating events.

Due to the watershed's developed nature, this site is also monitored during wet weather to better characterize runoff-generated water quality (See *Wet Weather Monitoring Section* for sampling results and discussion). USGS included this site when studying storm flows and their impacts on the water supply from 2005 - 2007. The publication can be found online on the USGS website (http://pubs.usgs.gov/sir/2013/5039/).

Tracer Lane (01104420)

The "TRACER LANE" tributary enters the middle basin of Hobbs Brook Reservoir and receives runoff from State Routes 2, 128, an adjacent commercial parking lot, and a mix of wetland, residential and commercial areas (Table 3). The USGS reestablished Tracer Lane as a continuously-monitored station for temperature and specific conductance on January 31, 2012.

CWD staff sampled the Tracer Lane site five times in 2013. All samples met Class A standard for temperature, pH, and *E. coli*. One DO reading was less than the 5 mg/L limit. No wet-weather samples were collected during this monitoring period. Five out of the six samples exceeded the both EPA nutrient criteria for nitrate and total phosphorus. Sodium, chloride, specific conductance, and pH levels all show significant increasing trends ($p = 0.00$ for all) over time (Table 6).

Compared to other sites, this site had the second highest baseflow phosphorus concentrations (Figure 31), as well as relatively manganese and high total organic carbon concentrations (Figures 28 and 32).

Hobbs Brook Below Dam (01104430)

This sampling station is located at the discharge outlet of the Hobbs Brook Dam on Winter Street in Waltham. In addition to taking open-water samples in the reservoir, sampling at the outlet provides further information on water quality released into the stream channel for which subsequent constituent loads and yields can be calculated (Appendix B).

HB BELOW DAM met Massachusetts Class A water quality standards for bacteria, temperature, pH, and dissolved oxygen for all 2013 sampling events. In addition, total phosphorus measurements at the site were consistently lower than the EPA nutrient criteria; but nitrate concentrations were consistently higher. All but one sample exceeded the nitrate EPA nutrient criteria (Figures 30 and 31).

Results from trending analysis show sodium, chloride, and specific conductance increasing ($p = 0.00$, all); whereas color, fecal coliform, and total phosphorus levels are decreasing ($p = 0.04, 0.00, 0.00$, respectively). Because of dilution and settling throughout the reservoir, concentrations of most constituents were relatively low compared to other subbasins throughout the system.

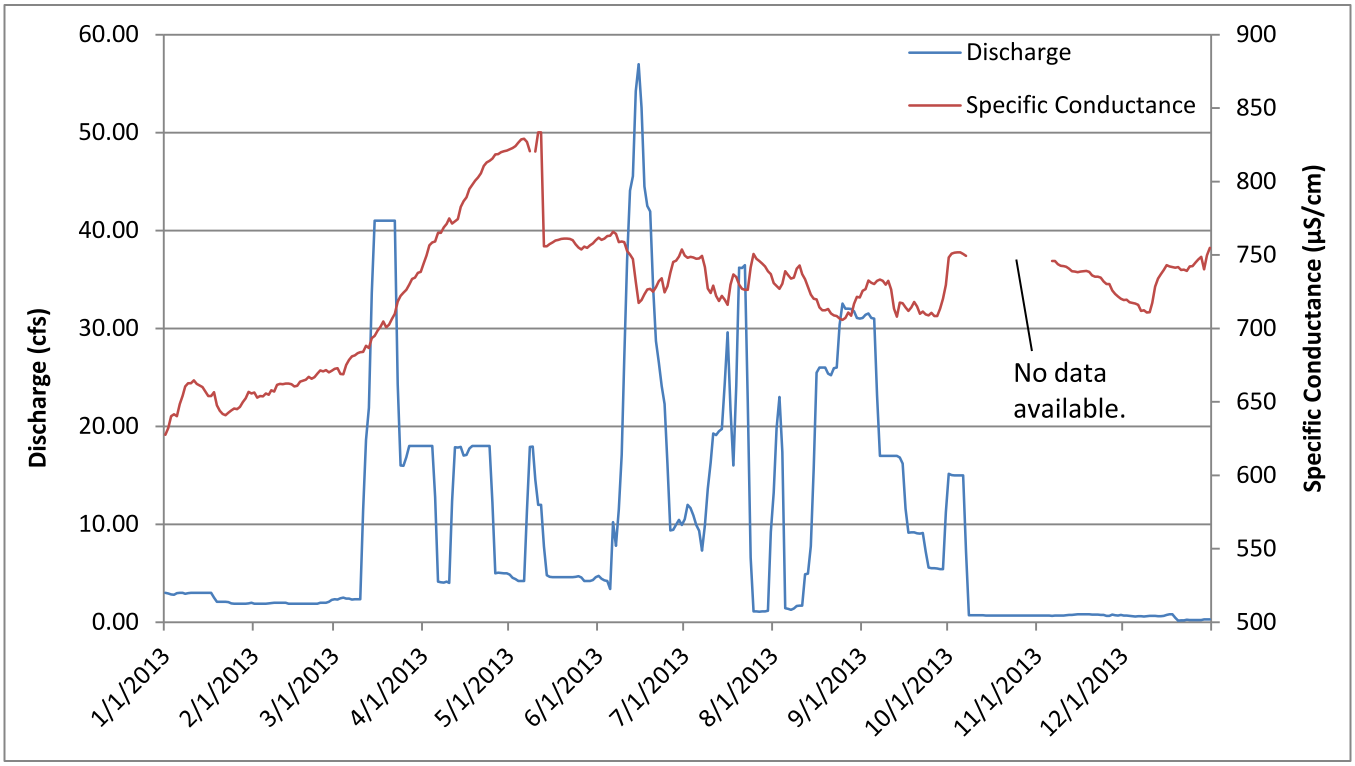


Figure 19: Preliminary Instantaneous USGS Data for HB BELOW DAM – Average Daily Discharge and Specific Conductance, 2013

Figure 19 illustrates managed flows from the reservoir and its specific conductance throughout the year. The flow fluctuates as floodwater passed over the spillway and as the gates were either opened or shut. Hobbs Brook gatehouse is typically shut for the duration of the winter and spring when precipitation from the Stony Brook subbasin adequately supplies Cambridge demand. Specific conductance rises in the spring months, which reflects the delayed effect of winter road salt applications. Under normal usage, specific conductance levels drop during the summer when the primary water supply is shifted from the Stony Brook to the Hobbs Brook Reservoir and the storage water is drained and replaced with summer rain water. Usage did not shift to the Hobbs Brook Reservoir in 2013 due to the construction projects and therefore specific conductance did not drop significantly.

Industrial Brook (01104433)

This small tributary enters Hobbs Brook approximately 0.5 mile downstream from the dam (Figure 14) at Lexington Street in Weston. The subbasin drains a small forested wetland and has the greatest densities of commercial and industrial land use of any subbasin. Sixty five percent of the subbasin by area is covered by impervious surfaces including Route 128, municipal roads, parking lots, and rooftops.

During 2013 dry weather sampling, temperature, pH, and *E. coli* met state standards. One sample barely exceeded the Massachusetts Class A DO minimum with a concentration of 4.94 mg/L. All samples exceeded the EPA nutrient criteria for nitrate, and all but one sample exceeded the EPA nutrient criteria for total phosphorus.

Industrial Brook yielded relatively high chloride, sodium, specific conductance, and total phosphorus concentrations when compared to the other tributaries (Figures 23-25, 31). Statistical analysis yielded significant increasing trends for chloride, sodium, and specific conductance ($p = 0.00$, all; Table 6).

Due to its developed nature, this site is also monitored during wet weather (See *Wet Weather Monitoring* Section for sampling results and discussion). USGS included this site in the report on storm flows and their impacts on the water supply (http://pubs.usgs.gov/sir/2013/5039/).

Hobbs Brook at Kendal Green (01104440)

The Hobbs Brook at Kendal Green (HB@KG) monitoring station is the furthest downstream sampling site on Hobbs Brook before its confluence with Stony Brook (Figure 14), and therefore is representative of the entire Hobbs Brook subbasin flows. The station affords useful comparisons with monitoring data collected at the adjacent Stony Brook station.

This site met Class A water quality standards for *E. coli*, pH, temperature, and dissolved oxygen for all samples taken during 2013. All but one of the samples exceeded the EPA Nutrient criteria of 0.31 mg/L nitrate for the ecoregion; no samples exceeded the phosphorus EPA nutrient criteria of 0.02375 mg/L. Statistical analysis yielded significant increasing trends for sodium, specific conductance, chloride ($p = 0.00$), and pH ($p = 0.04$; Table 6).

Stony Brook at Viles Street (01104370)

The Stony Brook at Viles Street (SB@VILES) station was established in 2009 as an automated monitoring station for temperature, specific conductance, and discharge. This site is located approximately ¾ of a mile upstream of the previously used Stony Brook at Kendal Green site (Figure 14) and is not affected by backwater from the Hobbs Brook confluence. A staff gage and access remains for the Kendal Green site for future monitoring.

Water quality data from SB@VILES integrates and represents conditions for a subbasin that comprises more than half of the total Cambridge source-water area. The Stony Brook subbasin contains significantly less commercial and industrial land and a larger amount of wetlands and low-density residential land use on septic systems (Table 3) than the Hobbs Brook subbasin. In general, sodium, chloride and specific conductance measurements on the Stony Brookare significantly less than those observed in the more developed Hobbs Brook subbasin, which has considerably more salt-treated impervious surfaces (Figures 23-25).

During this period, SB@VILES was sampled six times, all taken in dry weather. As Stony Brook is a state-designated cold water fish resource, temperature standards are lower to accommodate temperature-sensitive fluvial fish. Preliminary USGS temperature data at this site indicates that daily maximum 7-day temperatures exceeded the 20°C temperature standard six times during 2013, during the summer months. CWD water supply management has no influence on this station's temperature and state regulations allow exceedances when "naturally occurring".

CWD dry weather sampling indicated that SB@VILES met MA Class A water quality standards for temperature (< 20°C at time of sample), pH, and dissolved oxygen (greater than 6 mg/L for a cold water resource) in all 2013 sampling events. One sample exceeded the Class A *E. coli* standard on May 2nd. All samples were above the 0.31 mg/L EPA nutrient criteria for nitrate, and four samples exceeded the 0.02375 mg/L EPA nutrient criteria for total phosphorus. Statistical analysis indicated significant increasing trends in sodium, chloride, specific conductance, and pH for the site (p=0.00 for all; Table 6), as expected from the increasing trends indicated in the upstream tributaries.

WA-17 (01104455)

This USGS operated real-time station discharges through a small wetland to Stony Brook approximately 0.4 miles upstream from Stony Brook Reservoir. In addition to flow, temperature, and specific conductance, this site is equipped with a real-time turbidimeter and is calibrated to estimate chloride concentrations from conductivity data (Smith, 2013). The subbasin is mostly developed and drains significant amounts of State and municipal roads along with commercial and industrial lands, most notably the old Polaroid facility currently under redevelopment. A large percentage of the lower subbasin is paved and the tributary is routed through pipes and culverts draining Route 128 and the Route 128/Route 20 rotary.

WA-17 met Massachusetts Class A water quality standards for temperature, pH, and *E. coli* for all 2013 samples during baseflow conditions. All baseflow chloride samples exceeded the federal chronic aquatic toxicity standard (250 mg/L). All baseflow samples exceeded the EPA Nutrient criteria of 0.31 mg/L nitrate for the ecoregion; three out of five exceeded the phosphorus EPA nutrient criteria of 0.02375 mg/L. Nitrate concentrations measured at WA-17 have markedly increased in 2013 (Figure 20).

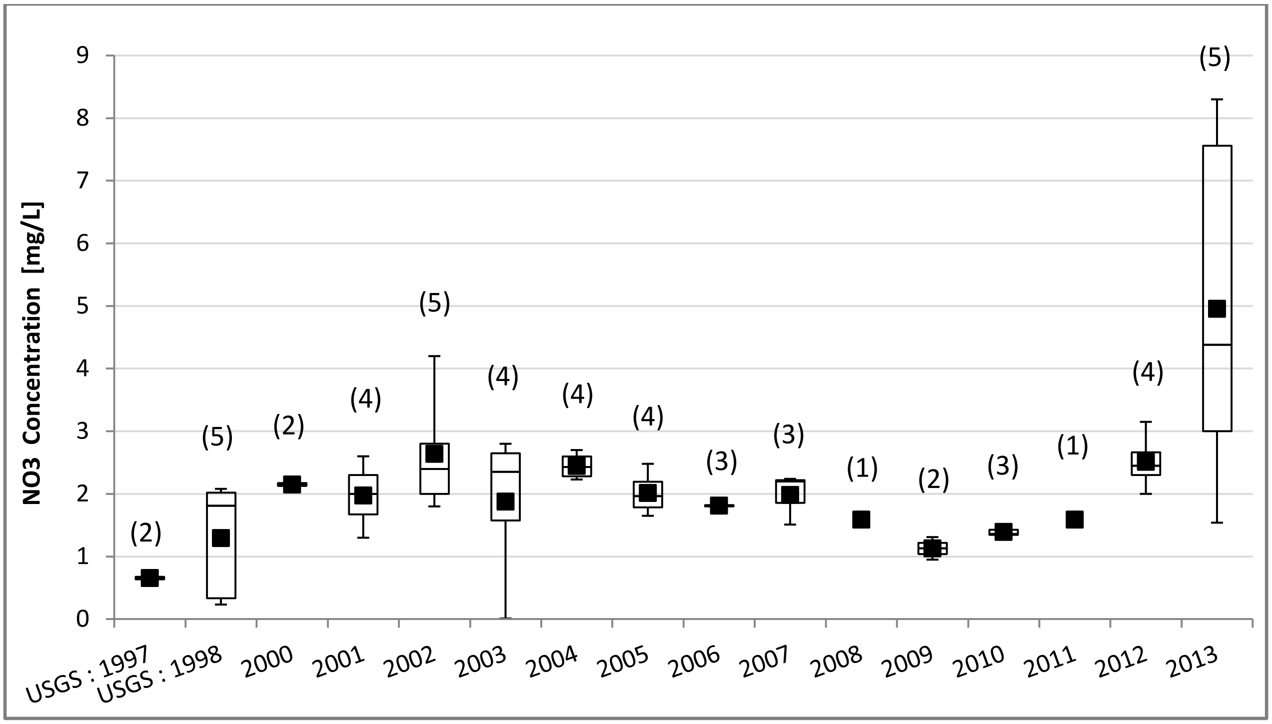
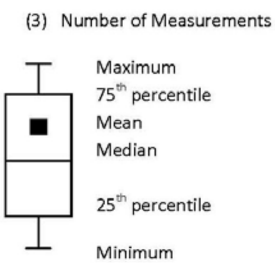


Figure 20: Long-term Baseflow Nitrate Concentrations [mg/L]



MassDOT recently constructed a 3.5 acre stormwater retention and treatment pond in the Route 128/Route 20 rotary, which was connected to the interstate drainage network in October, 2012. The retention pond was designed to route baseflow and approximately the first inch of stormwater runoff from the entire subbasin. Due to design issues, the pond is only capturing baseflow and stormflows are bypassing the treatment mechanism. Possible causes of the increased baseflow 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 fix diversion structures to capture "first flush" stormflows as originally intended.

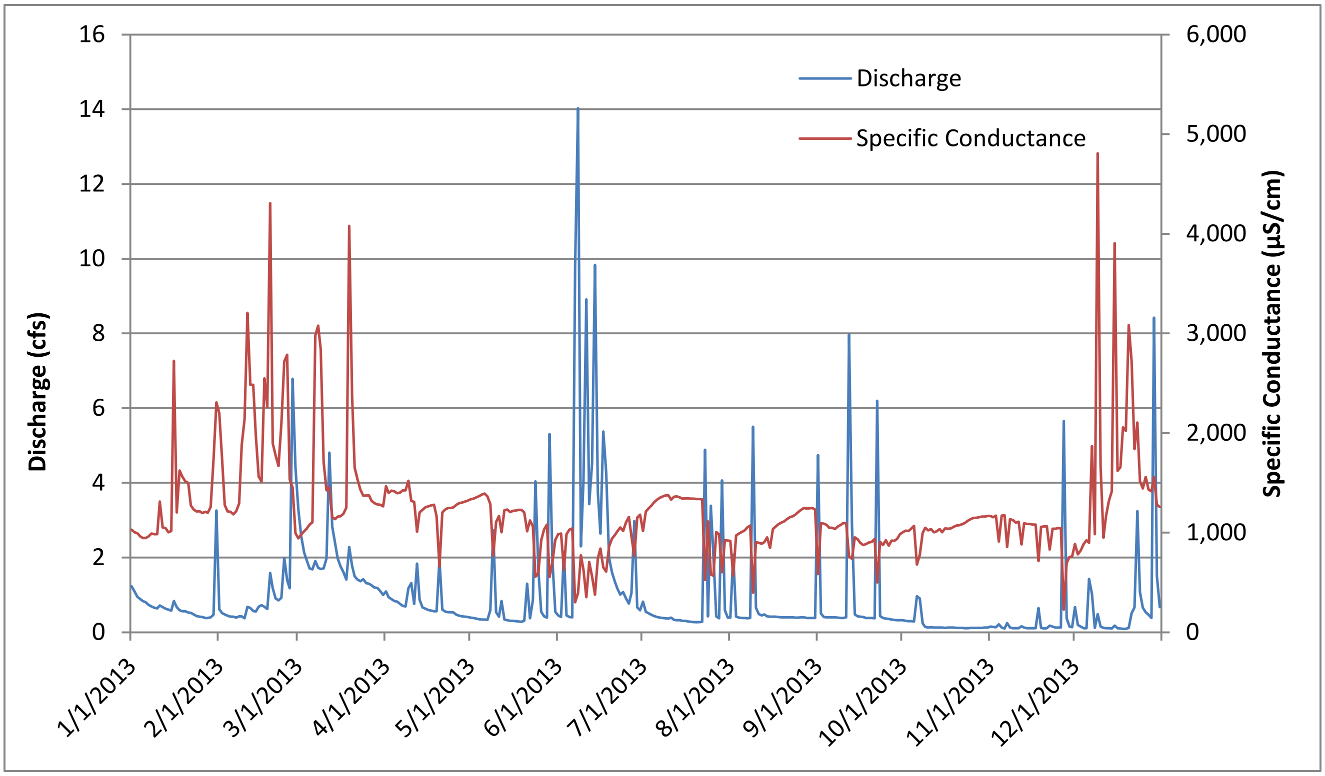


Figure 21: Preliminary Instantaneous USGS Data for WA - 17 – Average Daily Discharge and Specific Conductance, 2013

As described earlier for Lexington Brook, data for the WA-17 tributary shows dramatic changes in specific conductance directly related to sodium and chloride concentrations from changes in discharge and season (Figure 21). During warmer months, the graph depicts an inverse relationship between flow and specific conductance. Conversely, in the winter months under icing conditions, the relationship between specific conductance and flow is proportional, and salt-laden runoff generates large conductance spikes.

Mass Broken Stone (01104453)

The "MBS" station was added in 2000 to the CWD source water quality monitoring program as a recommendation from the Water Year 1998 USGS baseline assessment. This site's relatively large drainage area (2.23 mi^2) consists primarily of forested and residential land use and was the former location of an active rock quarry. The quarry has since been closed and redeveloped into a LEED (Leadership in Energy and Environmental Design) Core and Shell Platinum office complex that has no stormwater discharges to the tributary; instead stormwater is pre-treated and routed to quarry ponds. As part of the redevelopment, the stream channel was relocated and restored, and owners agreed to establish a USGS-maintained real-time flow, temperature and conductivity monitoring station at the culverted tributary inlet from an approximately 36-acre shallow, highly productive pond.

The MBS station was sampled five times with one field duplicate taken during the 2013 reporting period. All baseflow samples for temperature, pH, and *E. coli* met Massachusetts Class A water quality standards. Two samples did not meet standards for dissolved oxygen, taken on August 1st and September 19th. The exceedances are most likely due to oxygen demand from microbial activity breaking down organic matter in the shallow, slow moving upstream pond. All 2013 samples exceeded the EPA nutrient criteria for nitrate and three samples exceeded the EPA nutrient criteria for total phosphorus.

The inclusion of the site within the continuous monitoring network is currently under review. Backflow issues at the site prevent accurate flow measurements. The accurate measurement of stream stage is difficult at the site due to downstream vegetation build-up and high beaver activity at the weir, both which change the stage-discharge relationship. The ever-changing relationship adds inaccuracy to the continuous flow measurements recorded by the USGS, which are estimated in real-time using a USGS-developed stage-discharge rating curve.

Stony Brook at Route 20 (01104460)

This station integrates both Stony and Hobbs Brook and represents water quality from the majority (93%) of the watershed before entering the Stony Brook reservoir. A USGS-maintained monitoring station measures flow, temperature and specific conductance in real-time.

Baseflow sampling was conducted at this station six times in 2013 under baseflow conditions. CWD staff conducted sampling alongside USGS staff at this site for laboratory accuracy analysis on December 10th. All baseflow samples met Massachusetts Class A water quality standards. All samples exceeded the EPA nutrient criteria for nitrate except one on August 17th; and only one sample on July 16th exceeded the total phosphorus EPA nutrient criteria.

According to USGS approved and provisional data at this site, similar to SB@VILES, daily maximum temperatures can and do exceed 20°C for periods of 7 days or greater during summer months (temperatures exceed the maximum consistently starting late June to early September). Significant increasing trends were found for road-deicing materials (sodium, chloride, and specific conductance, p=0.00 all, Table 6) and for pH levels (p=0.03).

Summer Street (01104475)

The Summer Street monitoring station is located just west of Route 128 in Weston before the stream is culverted under the highway. This stream discharges directly into the Stony Brook reservoir close to the intake structure. Land use in the subbasin differs from the others 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 the Weston Golf Club.

The Summer Street location was sampled five times in 2013 during baseflow conditions. All samples met Massachusetts Class A water quality standards for temperature, dissolved oxygen, pH, and *E. coli*. Two samples exceeded the EPA nutrient criteria for total phosphorus; all samples exceeded the EPA nutrient criteria for nitrate (Figures 30-31). Of all monitored tributaries, this site continues to have relatively low concentrations of all parameters, except for nitrate, highlighted in Figures 23-32. High nitrate concentrations and yields are most likely from golf course and lawn fertilizer applications, as well as septic flow-through.

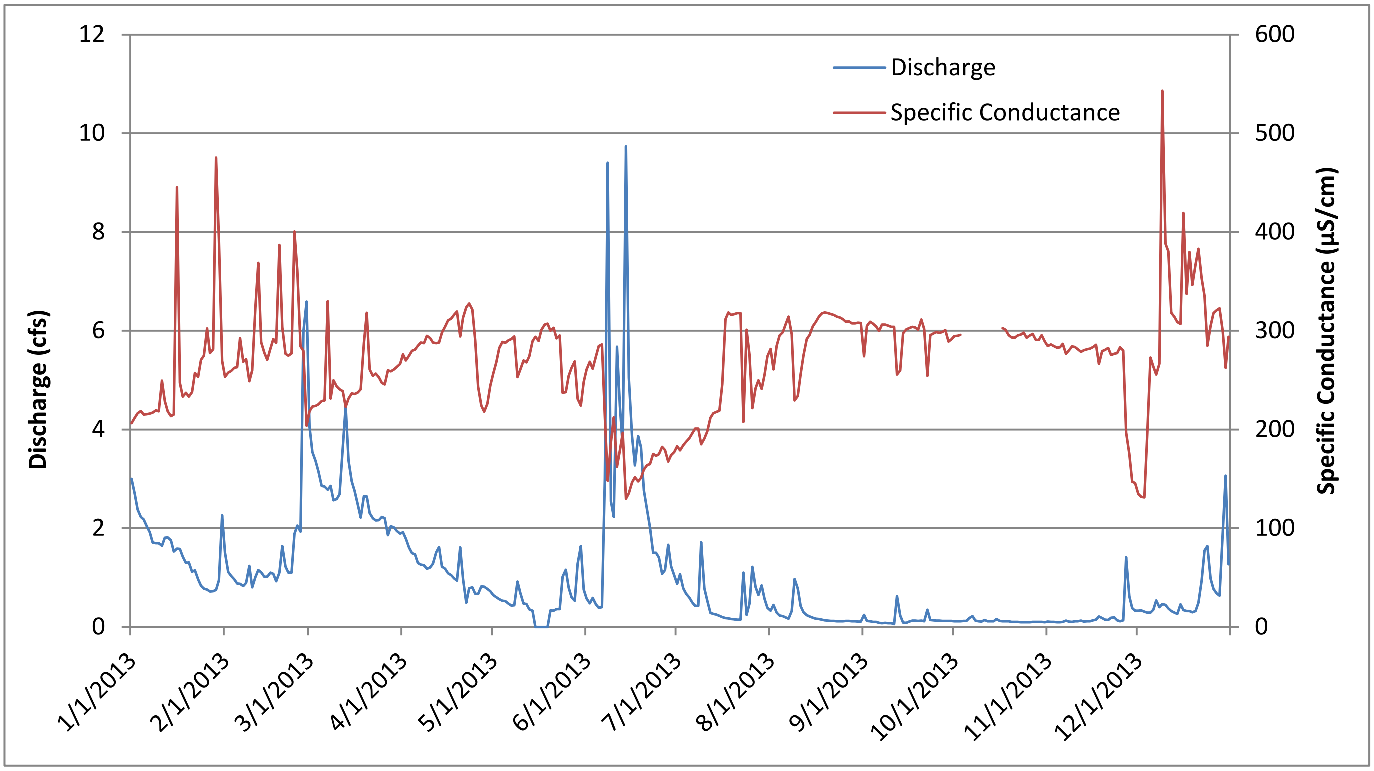


Figure 22: Preliminary Instantaneous USGS Data for Summer Street – Average Daily Discharge and Specific Conductance, 2013

Figure 22 shows a tight range of conductance values and inverse relationship between flow and conductance in most runoff generating events, indicating the lack of significant deicing chemical influences on stream chemistry.

Tributary Water Quality Summary

Overall, the water quality samples taken by CWD staff in 2013 were consistent with expectations established from previous sampling data. Chloride concentrations, sodium concentrations, and specific conductance levels are the highest at Salt Depot Brook, Lexington Brook, Industrial Brook, and WA-17 (Figures 23-25) and appear to be increasing at most monitoring locations (Table 6). Almost half of all samples taken in Cambridge watershed tributaries (41%, Table 4) exceeded the MA SMCL for chloride; and Salt Depot Brook, Lexington Brook, Industrial Brook, and WA-17 all exceeded the chloride SMCL in every 2013 sampling event. Lexington Brook, Industrial Brook, and WA-17 all have the highest areal percentages of transportation corridors in their corresponding drainage basins (Table 3), which is consistent with the high correlation found between mean chloride concentrations and roadway coverage in Cambridge basins in the 2005-2007 USGS report (Smith, 2013).

The nitrate and total phosphorus EPA nutrient criteria for the ecoregion were established to provide guidelines for the maximum nutrient concentrations allowable in a waterbody to limit nutrient pollution effects. Nutrient pollution can lead to excess algal growth and eutrophication. The recommended nitrate maximum concentration for the watershed is much lower than the SMCL of 10 mg/L for drinking water. All 2013 tributary samples were below the 10 mg/L SMCL for nitrate indicating good water quality for consumptive use; but every site exceeded the 0.30 mg/L nutrient criteria at least once, indicating the need to control nutrient pollution in the watershed to prevent adverse effects on the ecosystems within the tributaries and reservoirs. Lexington Brook, Industrial Brook, SB @Viles, MBS, WA-17, and Summer Street all exceeded the nitrate nutrient criteria in every 2013 sampling event (Figure 30).

All tributaries generally met water quality standards for *E. coli* (Figure 27), except for Salt Depot Brook, which exceeded the MA Class A standard in more than half of the 2013 samples. Two samples were 5 and 10 times the 235 MPN limit. The following table lists a summary of exceedances for all tributaries in 2013.

Table 4: Exceedances Summary for Cambridge Watershed Tributaries, 2013

Standard	Parameter	Standard	Number Sampling Events	Number Exceedances	Percent Exceedances
MA Class A Water Quality	DO	> 5 mg/L	52	5	8%
MA Class A Water Quality	DO- Cold Water Fisheries	> 6 mg/L	12	0	0%
MA Class A Water Quality	Temperature	< 28.3 °C	52	0	0%
MA Class A Water Quality	Temperature- Cold Water Fisheries	< 20.0 °C	12	2	17%
MA Class A Water Quality	pH	Between 6.5 - 8.3	64	1	2%
MA Class A Single Sample	*E. coli*	< 235 MPN	64	5	8%
MA Secondary Drinking Water Standards	Cl	< 250 mg/L	64	26	41%
MA Secondary Drinking Water Standards	Mn	< 0.05 mg/L	64	16	25%
MA Secondary Drinking Water Standards	Fe	< 0.3 mg/L	64	47	73%
EPA Nutrient Criteria for Upper Watershed	NO3	< 0.31 mg/L	64	58	91%
EPA Nutrient Criteria for Upper Watershed	TP	< 0.02357 mg/L	64	29	45%

Primary Tributary Boxplots

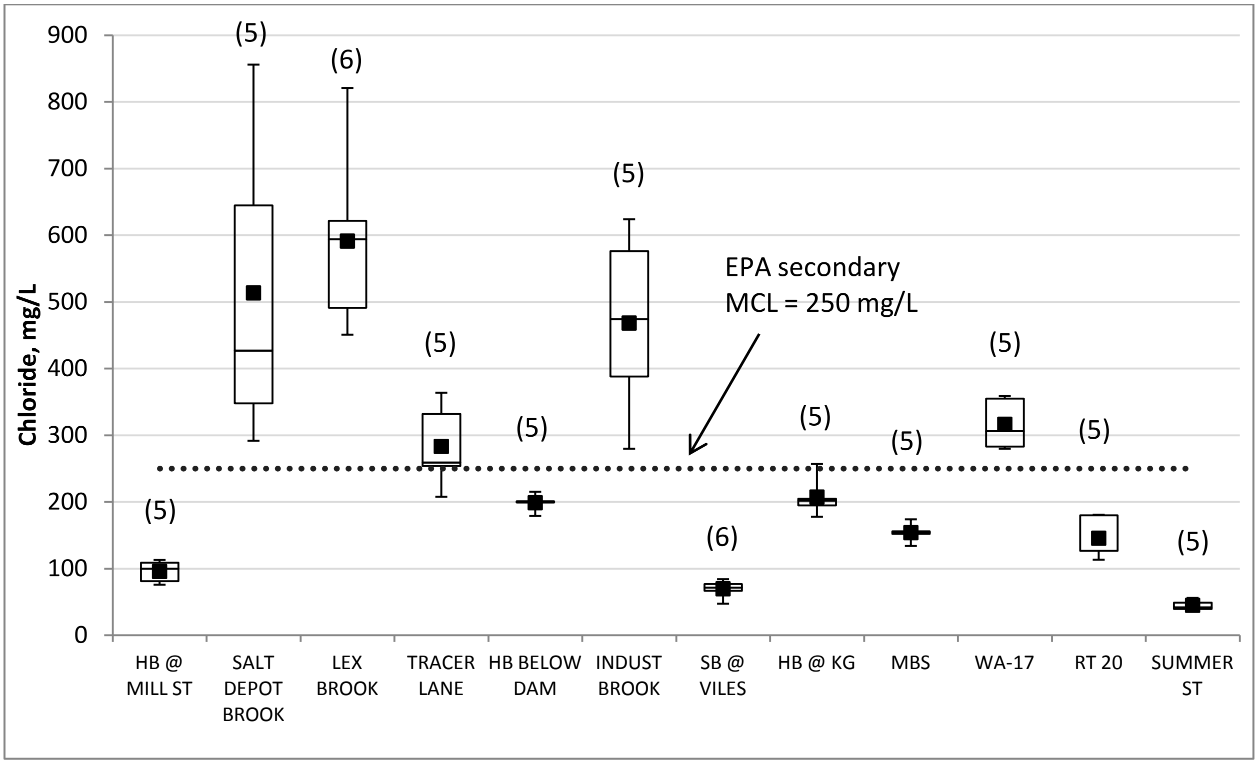


Figure 23: Primary Tributary Base flow Chloride [mg/L] Concentrations, 2013

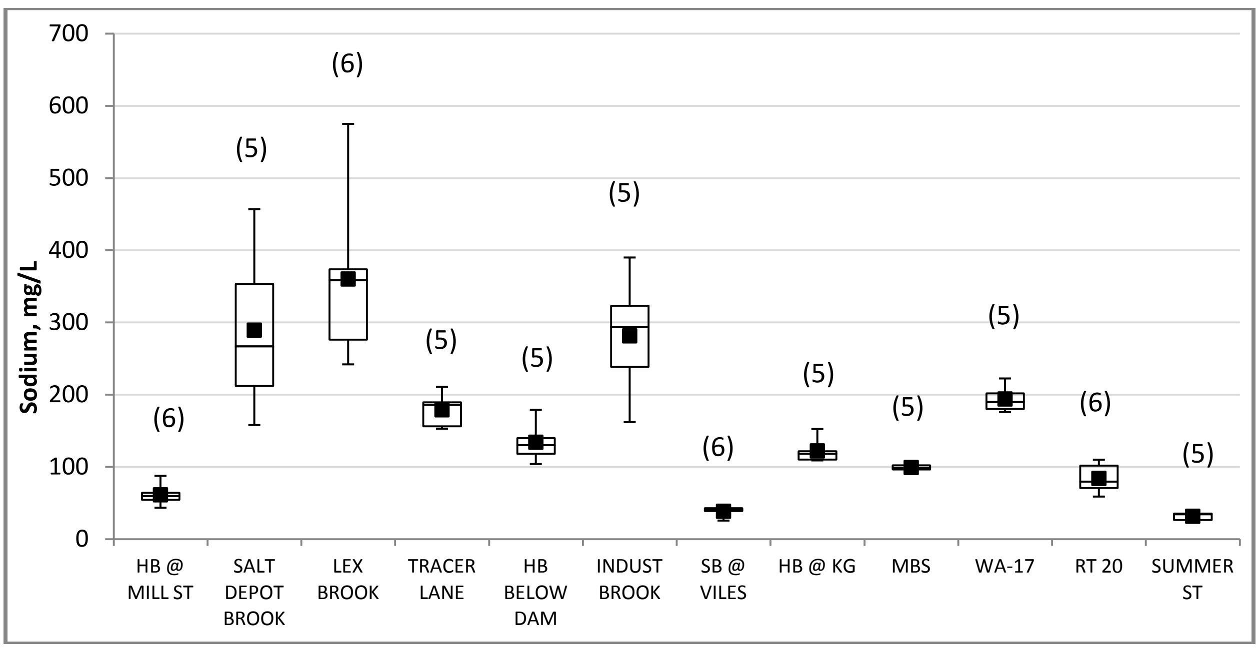


Figure 24: Primary Tributary Base flow Sodium Concentrations [mg/L], 2013

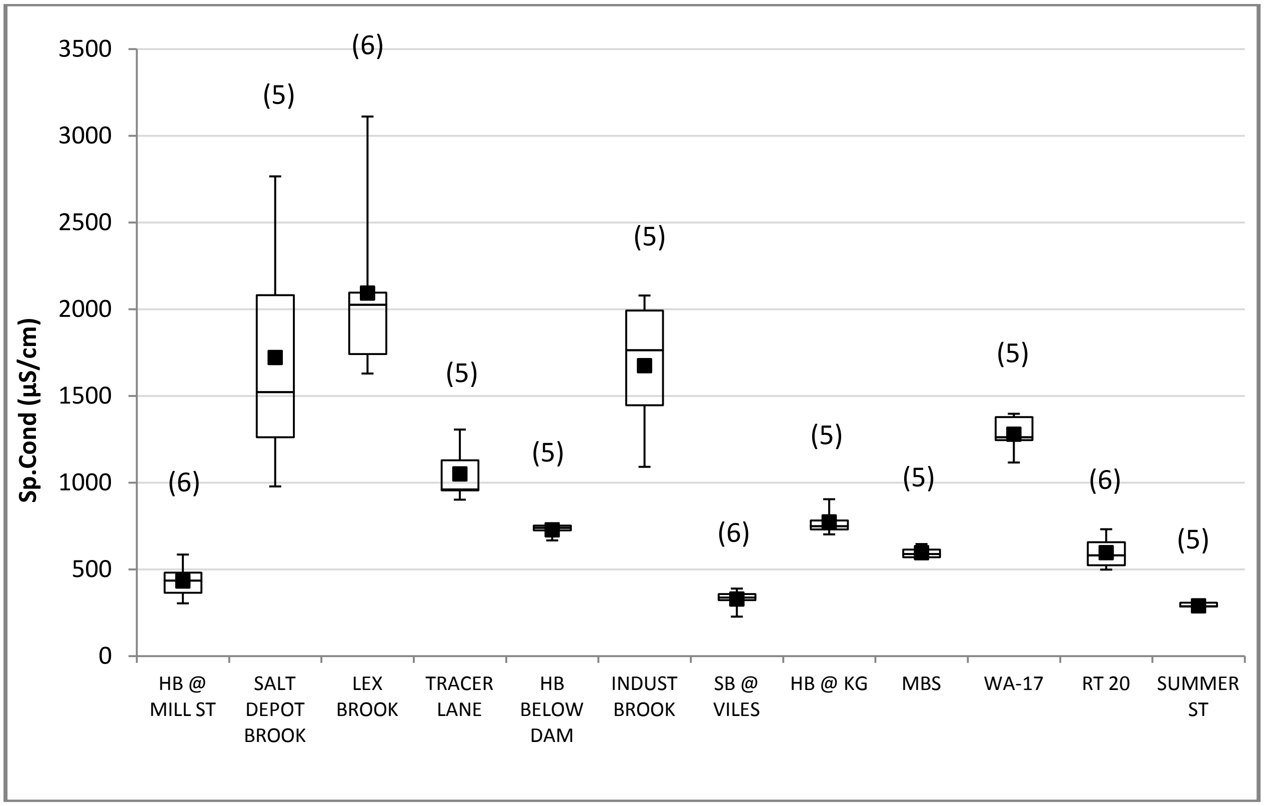
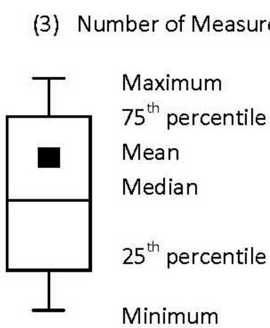


Figure 25: Primary Tributary Base flow Specific Conductance (SpC), [µS/cm], 2013



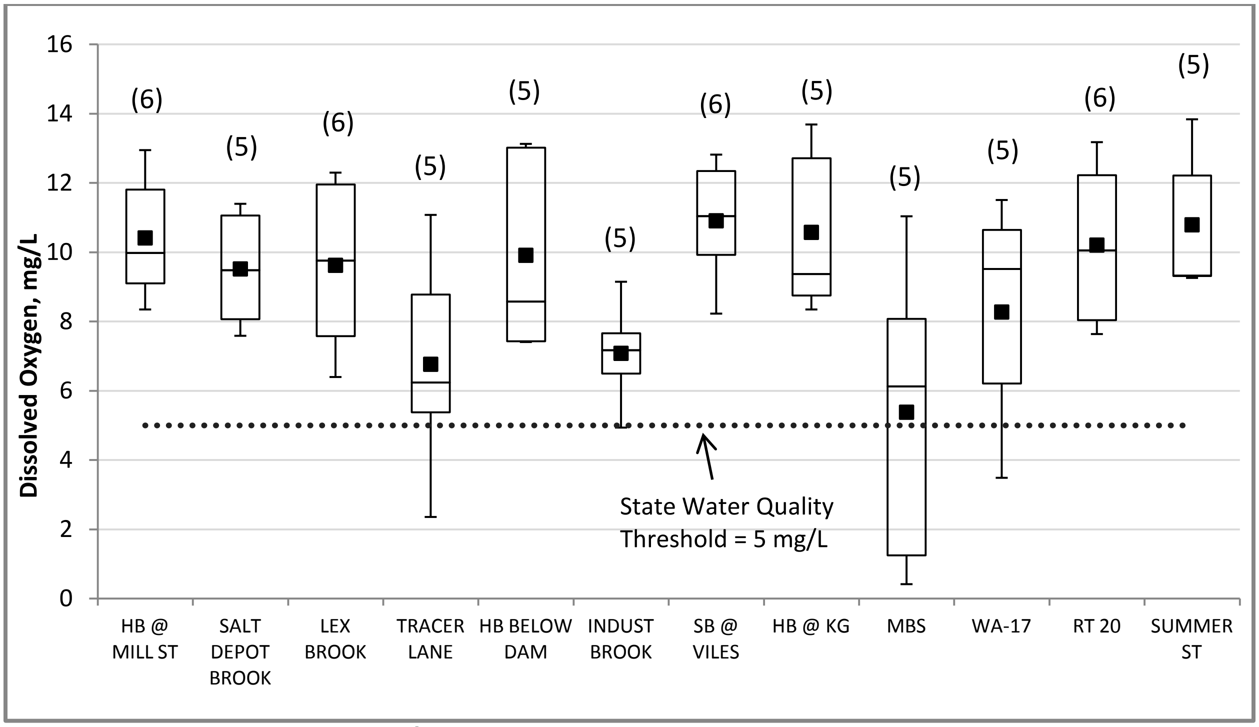


Figure 26: Primary Tributary Base flow Dissolved Oxygen Concentrations, [mg/L], 2013

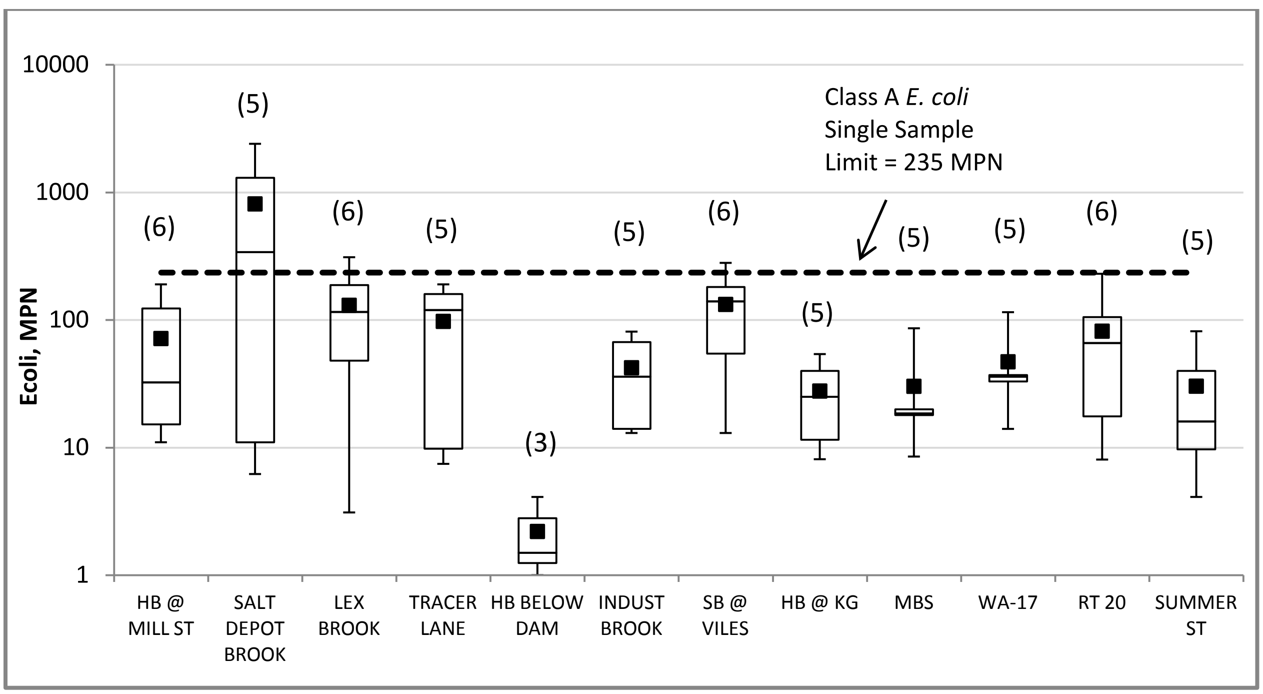


Figure 27: Primary Tributary Base flow, E. coli [MPN], 2013 (Logarithmic Scale)

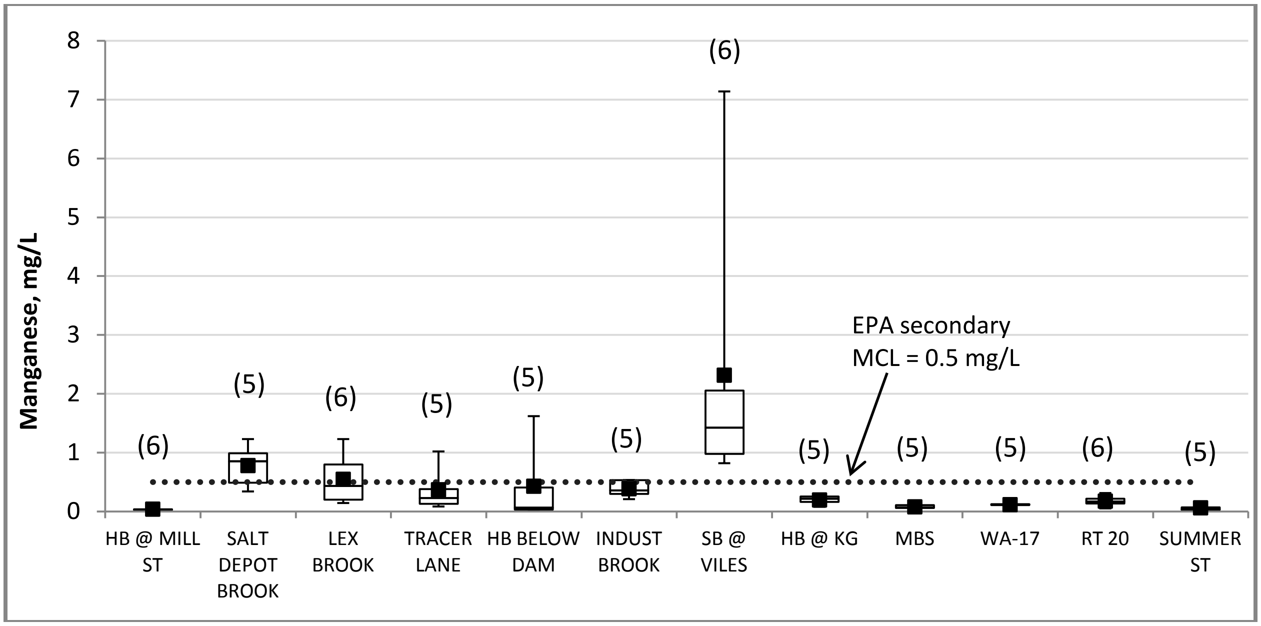


Figure 28: Primary Tributary Base flow Manganese Concentrations, [mg/L], 2013

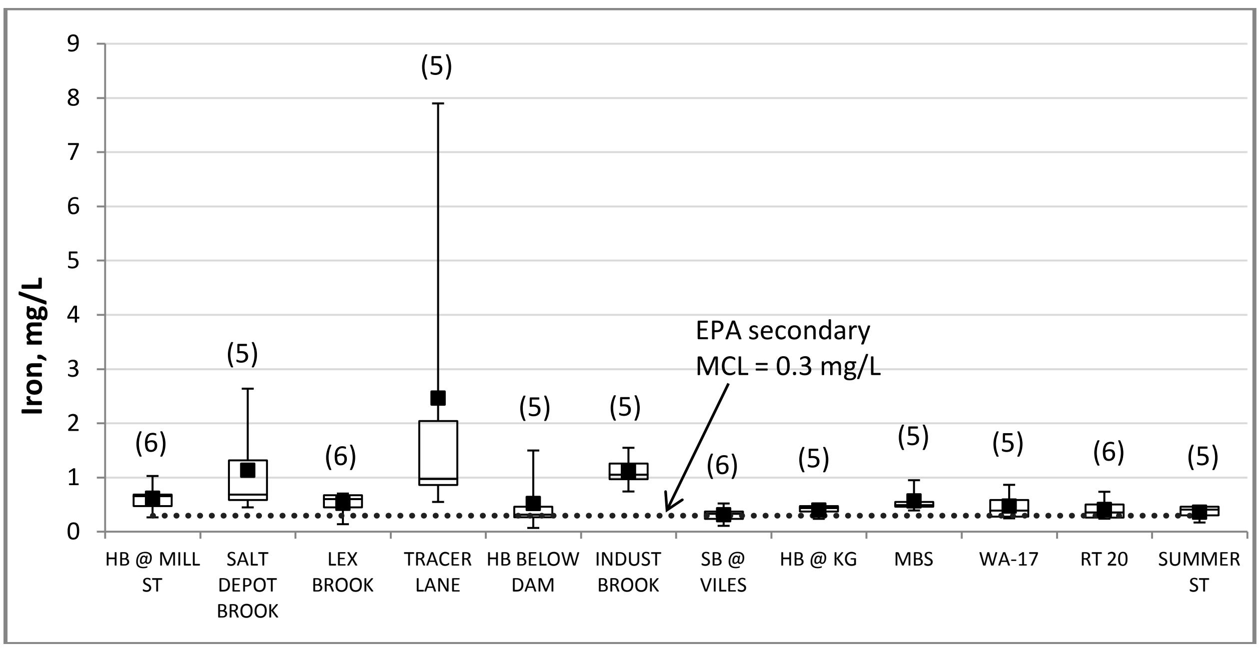
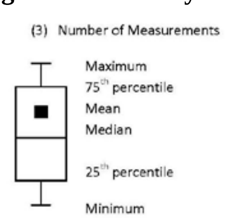


Figure 29: Primary Tributary Base flow Iron Concentrations, [mg/L], 2013



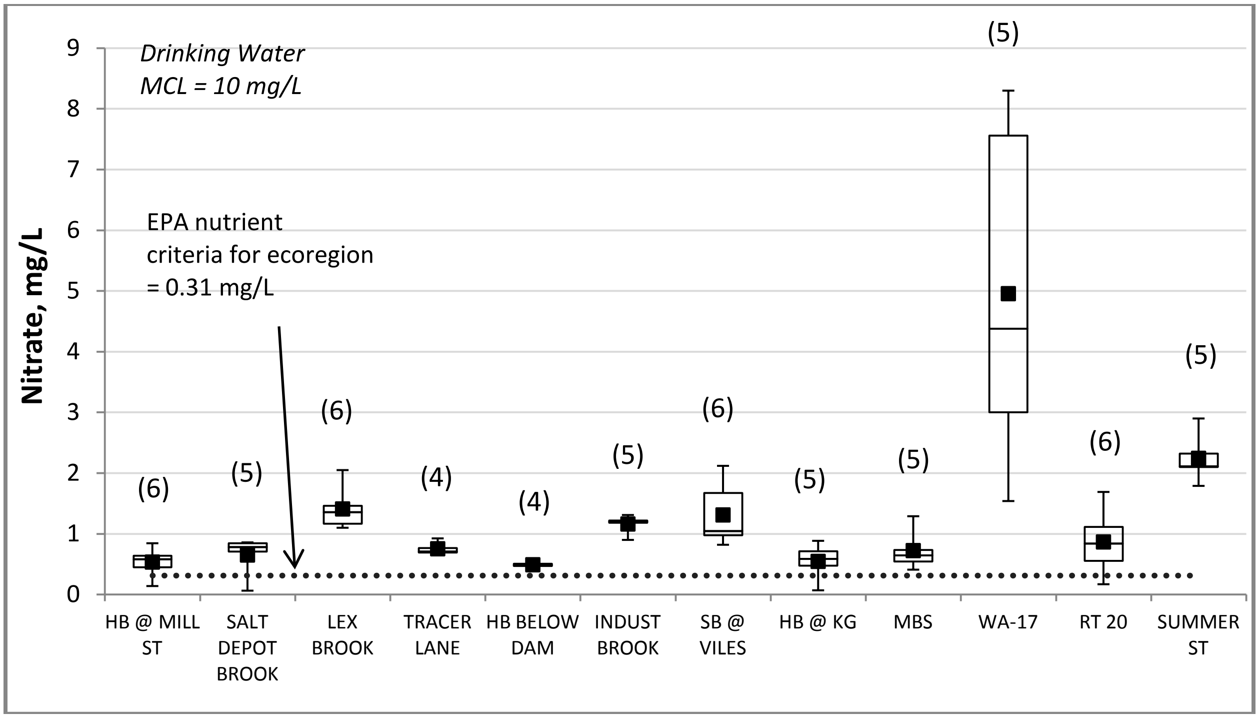


Figure 30: Primary Tributary Base flow Nitrate Concentrations, [mg/L], 2013

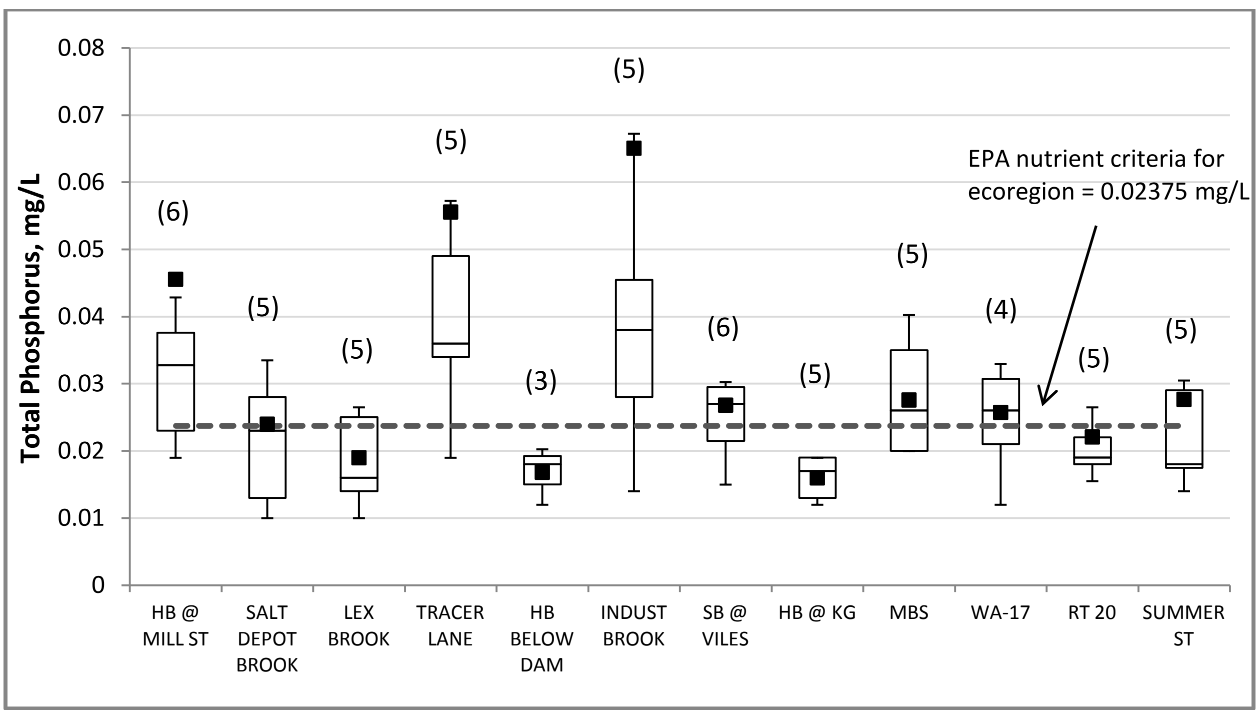


Figure 31: Primary Tributary Base flow Total Phosphorus (TP) Concentrations, [mg/L], 2013

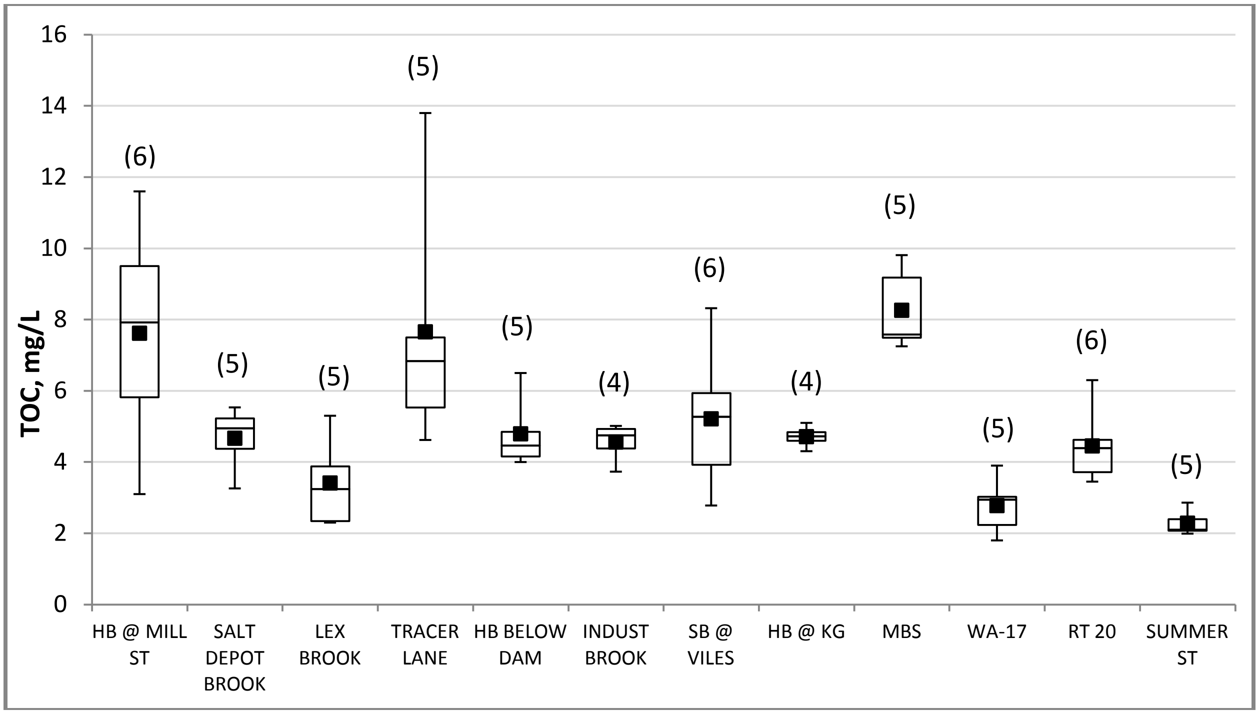


Figure 32: Primary Tributary Base flow Total Organic Carbon (TOC) Concentrations, [mg/L], 2013

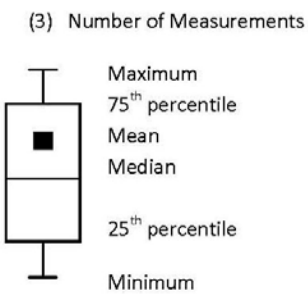


Table 5: Primary Tributary Base flow Median Concentrations, 2013

	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	105	**427**	**594**	**259**	200	**474**	72	202	154	**306**	154	42
DO	9.98	9.48	9.76	6.24	8.58	7.17	11.04	9.37	6.13	9.52	10.06	9.33
E. coli	33	**340**	116	120	2	36	140	25	19	36	66	16
Mn	0.03	**0.85**	0.43	0.23	0.07	0.36	**1.42**	0.22	0.07	0.12	0.17	0.04
Na	60	267	359	186	130	294	40	118	98	190	79	34
NO3	**0.58**	**0.78**	**1.36**	**0.71**	**0.49**	**1.20**	**1.05**	**0.59**	**0.65**	**4.38**	**0.84**	**2.11**
SpC	436	1522	2027	961	741	1764	338	749	590	1262	582	287
TKN	0.71	ND	1.01	0.61	ND	0.58	ND	ND	0.58	ND	ND	ND
TOC	7.9	5.0	3.2	6.8	4.5	4.8	5.3	4.7	7.6	2.9	4.4	2.1
TP	**0.033**	0.023	0.016	**0.036**	0.018	**0.038**	**0.027**	0.017	**0.026**	**0.026**	0.019	0.018

ND: Not Detected
BOLD: Exceeds Massachusetts Water Quality Standard or Criteria

Table 6: Primary Tributary Trend Results from *Spearman's Rho* Analysis, 2013

	HB @ Mill St		Salt Depot		Lex Brook		Tracer Lane		HB Below		Industrial		SB @ Viles		HB @ KG		MBS***		WA - 17		RT 20		Summer St	
	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p	RT	p
Cl	0.59	0.00	0.59	0.00	0.18	0.10	0.50	0.00	0.56	0.00	0.25	0.05	0.57	0.00	0.65	0.00	0.02	0.93	0.29	0.01	0.51	0.00	0.22	0.10
Na	0.52	0.00	0.66	0.00	0.73	0.00	0.68	0.00	0.82	0.00	0.58	0.00	0.55	0.00	0.79	0.00	0.52	0.00	0.19	0.15	0.69	0.00	0.33	0.01
SpC	0.34	0.00	0.52	0.00	0.39	0.00	0.64	0.00	0.60	0.00	0.54	0.00	0.35	0.00	0.71	0.00	0.11	0.52	0.30	0.01	0.53	0.00	0.47	0.00
NO3/NO2	0.26	0.07	0.12	0.42	0.03	0.81	0.02	0.92	-0.23	0.12	-0.03	0.84	0.26	0.05	0.00	0.98	-0.68	0.00	0.17	0.24	0.19	0.19	0.46	0.00
TKN	-0.14	0.29	0.00	0.98	-0.24	0.05	0.14	0.34	-0.20	0.15	0.03	0.83	-0.05	0.72	-0.05	0.76	0.03	0.91	0.00	0.98	-0.53	0.00	-0.17	0.23
NH3	0.20	0.19	-0.06	0.72	-0.02	0.86	0.13	0.33	0.10	0.46	0.20	0.15	0.06	0.67	-0.05	0.76	-0.14	0.53	-0.03	0.81	0.11	0.50	-0.16	0.30
Color	0.31	0.02	-0.05	0.77	-0.27	0.03	-0.07	0.64	-0.27	0.04	-0.18	0.18	-0.14	0.34	-0.32	0.01	0.09	0.64	0.04	0.80	-0.17	0.18	-0.22	0.13
Turb*	0.60	0.00	-0.03	0.87	0.35	0.02	0.20	0.20	0.42	0.00	0.13	0.36	0.10	0.53	0.20	0.17	-0.37	0.08	-0.29	0.05	0.20	0.13	0.18	0.25
pH	0.18	0.09	0.46	0.00	0.20	0.06	-0.64	0.00	0.01	0.94	-0.03	0.76	0.37	0.00	0.21	0.04	-0.21	0.22	0.40	0.00	0.22	0.03	0.40	0.00
Mn	-0.42	0.00	0.43	0.00	0.55	0.00	0.08	0.52	0.17	0.10	0.11	0.38	-0.45	0.00	-0.02	0.89	-0.34	0.07	-0.56	0.00	-0.20	0.10	-0.37	0.01
Fecal**	-0.27	0.06	-0.15	0.36	-0.15	0.30	-0.18	0.30	-0.73	0.00	-0.06	0.68	0.07	0.63	-0.21	0.19	-0.58	0.06	0.08	0.71	-0.18	0.25	-0.41	0.01
TP	0.13	0.33	0.00	0.98	-0.32	0.00	0.03	0.79	-0.74	0.00	-0.04	0.70	0.15	0.20	-0.29	3.00	-0.17	0.37	-0.34	0.00	-0.09	0.48	-0.24	0.04
Al	-0.30	0.05	-0.15	0.40	-0.29	0.07	-0.18	0.28	-0.23	0.15	0.28	0.07	-0.06	0.70	-0.29	0.08	0.03	0.90	0.04	0.83	-0.25	0.13	-0.06	0.73

*Not sampled for most of 2012 and all of 2013.

**Not sampled after 2009.

*** Shorter chloride and specific conductance record, possible explanation for lack of significant trends detected.

Significant to $p < 0.15$

Significant to $p < 0.05$

Secondary Tributary Analysis

No samples were taken from secondary tributary locations in 2013; instead, past data from the calendar years 2000 to 2011 were compared to data collected from primary tributary stations to determine whether the secondary sites should be monitored and what an appropriate monitoring frequency would be. Two statistical analyses were performed on water quality monitoring results from the secondary monitoring sites in accordance with methods outlined in the USGS *Statistical Methods in Water Resources* Manual (Helsel, 2002).

Primary-Secondary Site Comparison Procedure

The first analysis preformed on the data was a *Matched-Pair Sign Test* on the corresponding primary and secondary tributary sites to determine whether there were significant differences between the data collected from the two sites. The secondary sites analyzed were Cherry Brook at Conant Road (Cherry @ Conant), Stony Brook at Conant Road (SB @ Conant), Quarry Brook at Church Street (QB @ Church), and Weston Brook at Route 20 (WB @ RT20). The corresponding primary sites analyzed were Stony Brook at Viles Street (SB @ Viles) and Mass Broken Stone (MBS). Cherry Brook and Stony Brook @ Conant both flow into Stony Brook @ Viles; Quarry Brook and Weston Brook both flow into MBS (Figure 14).

To conduct the analysis, data was compiled for both sites for the calendar years 2000-2011. The data was then filtered into datasets for the following suite of parameters: chloride, sodium, specific conductance, calcium, nitrate, total Kjeldahl nitrogen, color, turbidity, pH, manganese, fecal coliform, total phosphorus, and aluminum. To account for variability in sampling frequency during the study period, mean concentration values were calculated at each station for every year to create similarly sized datasets. No sampling data was available for the secondary tributaries in 2010.

To perform the matched-pair sign test, the differences between the mean yearly concentration for each parameter at the primary and secondary sites were calculated. The number of positive differences was counted, and this number was compared to the exact-test result of the binomial distribution (calculated using the online program available at: http://vassarstats.net/binomial01.html). Data below the detection limit was set to half of the detection limit value to limit positive skew from censored data. While this is not the most robust method, this is an easy way to keep censored values in the analysis and to minimize errors associated with eliminating censored values from the dataset. The p-value for significance was taken using the number of positive differences using a two-sided test. P-values less than 0.05 were considered significant.

Trend Analysis Procedure

A trend analysis was performed on a suite of parameters measured within the secondary tributaries to detect significant trends over the 11-year record of water quality data. A non-parametric approach was used for the trend analysis due to the relatively small sample sizes for all parameters and the non-normality of the sample sets used. The Mann-Kendall test was used as outlined in the *USGS Statistical*

Methods Manual (Helsel, 2002. *Chapters 8 and 12*). The parameters were tested for trends with discharge volumes as well as with time; when a significant trend with discharge was assessed, the effect of this trend was removed from the analysis using a LOWESS smooth line.

Primary-Secondary Analysis Results

In general, the secondary tributary sites do not differ significantly from corresponding primary tributary locations and are not significantly changing over time. Major differences observed were within salt-related parameters, which are suspected to be the result of the differences in roadway miles draining to the sites (Table 3). Significant trends were generally observed with salt-related parameters and discharge measurements; these trends tended to be decreasing with increasing discharge (dilution effects). The lack of significant time trends may be attributed to the relatively short dataset available for the secondary sites. A complete list of results is provided in Appendix C.

From the information gathered, it is suggested that the recommended secondary tributary monitoring schedule be reduced from four times a year to once a year. The additional secondary tributary sites do not add significant data to that collected from the primary tributary monitoring sites, and can be reduced to alleviate scheduling constraints in the primary tributary monitoring schedule.

Wet Weather Monitoring

Stormwater runoff disproportionally impairs water bodies in more 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 more difficult. Several USGS continuous monitoring stations have been outfitted to automatically sample storm events, eliminating scheduling conflicts. 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*.

The recently published USGS interpretive report explains wet weather versus dry weather constituent contributions to the water supply and will help focus Watershed Division stormwater management programs. USGS has conducted comprehensive stormwater studies where instead of taking one-time samples on the rising limb of the hydrograph (stream flows begin increasing from stormwater runoff contributions), automated samples are taken throughout the entire storm, mixed together, then analyzed for chemical concentrations. The stormwater sampling data are available online by station ID number.

Due to scheduling conflicts, CWD staff did not take stormwater samples in 2013. The USGS automatic samplers took eight stormflow samples from HB@MILLST, LEX BROOK, TRACER LANE, WA-17, and SUMMER ST. The stormwater sample chloride and total phosphorus concentrations are compared to baseflow samples in Figures 33 and 34. The stormwater sampling results include both winter and non-winter storms.

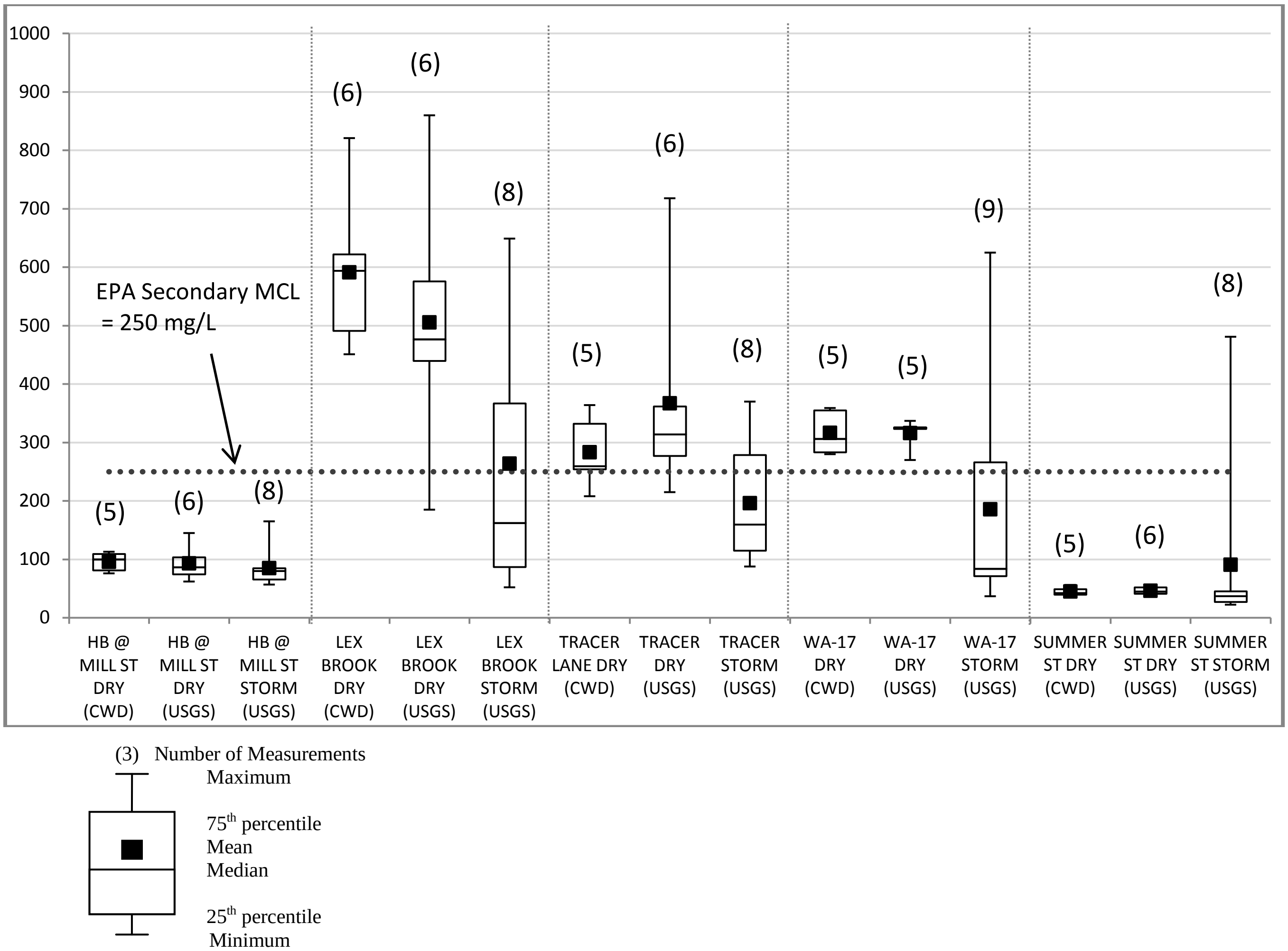


Figure 33: Chloride Baseflow-Stormflow Concentration Comparison for CWD and Preliminary USGS Data, [mg/L], 2013

The chloride concentrations in Cambridge watershed tributaries vary seasonally and spatially. Chloride concentrations measured at HB @ Mill St are similar in both dry weather and wet weather sampling events; whereas Lexington Brook, Tracer Lane, WA-17 and Summer St yield considerable variation from dry weather to wet weather (Figure 33). Runoff dilutes chloride concentrations in Lexington Brook and Tracer Lane and alternately increases chloride in Summer St, most likely due to road salt runoff.

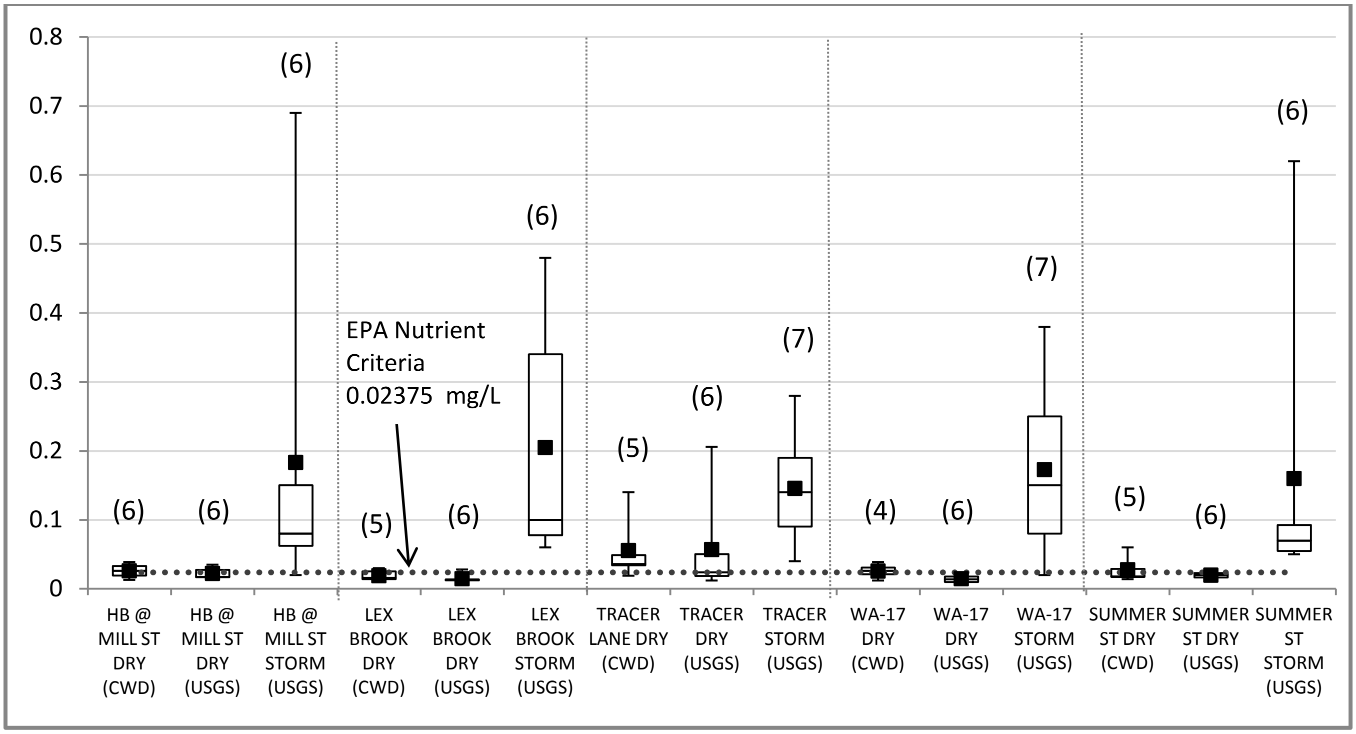
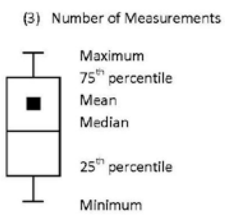


Figure 34: Total Phosphorus Baseflow-Stormflow Concentration Comparison for CWD and Preliminary USGS Data, [mg/L], 2013



Total phosphorus concentrations are markedly higher in stormflow samples than baseflow in every monitoring location sampled during storms in 2013. Common sources of total phosphorus 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).

Class B Waters on Fresh Pond Reservation

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, and North Pond (Figure 35). 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 to be Class B water bodies, as the ponds support primary contact recreation and are not considered to be part of the drinking water supply.

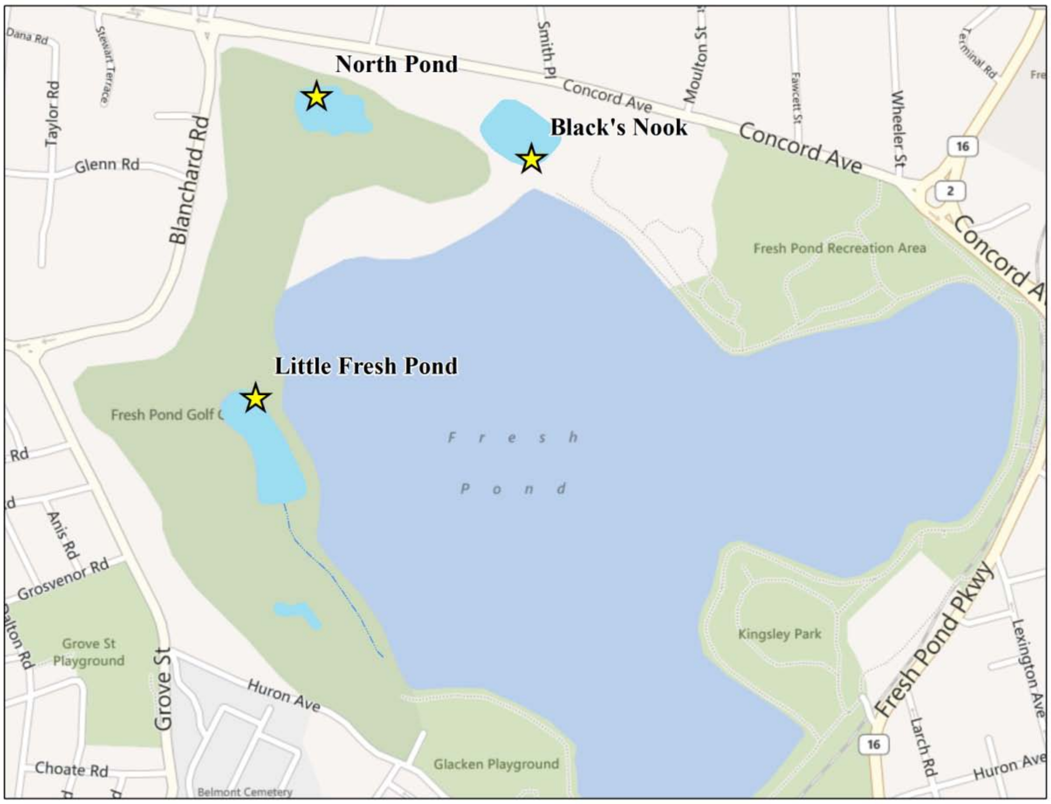


Figure 35: Fresh Pond Reservation Sampling Locations

During this period, reservation ponds were sampled four 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 any of the reservoirs in the drinking water supply in that they are significantly smaller, shallower, and more productive. Average pond depth is approximately 6 feet.

In this study period, all reservation ponds met Massachusetts Class B water quality standards for temperature, pH, and *E. coli* for all four sampling events. One sampling event at Little Fresh Pond exceeded the minimum dissolved oxygen standard, two sampling events exceeded the DO minimum at North Pond, and three out of the four sampling events exceeded the DO minimum at Black's Nook. All samples at all locations exceeded the total phosphorus EPA nutrient criteria for the ecoregion (0.008 mg/L). The following table lists a summary of exceedances for all tributaries in 2013.

Table 7 : Exceedances Summary for Class B Waters on Fresh Pond Reservation, 2013

Standard	Parameter	Standard	Number of Sampling Events	Number of Exceedances	Percent Exceedances
MA Class B Water Quality	DO	> 5 mg/L	12	3	25%
MA Class B Water Quality	Temperature	< 28.3 °C	12	0	0%
MA Class B Water Quality	pH	Between 6.5 - 8.3	12	0	0%
MA Class Single Sample	*E. coli*	< 235 MPN	12	1	8%
EPA Nutrient Criteria for Fresh Pond Ecoregion	NO3	< 0.31	12	6	50%
EPA Nutrient Criteria for Fresh Pond Ecoregion	TP	< 0.008 mg/L	12	12	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 37). 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.

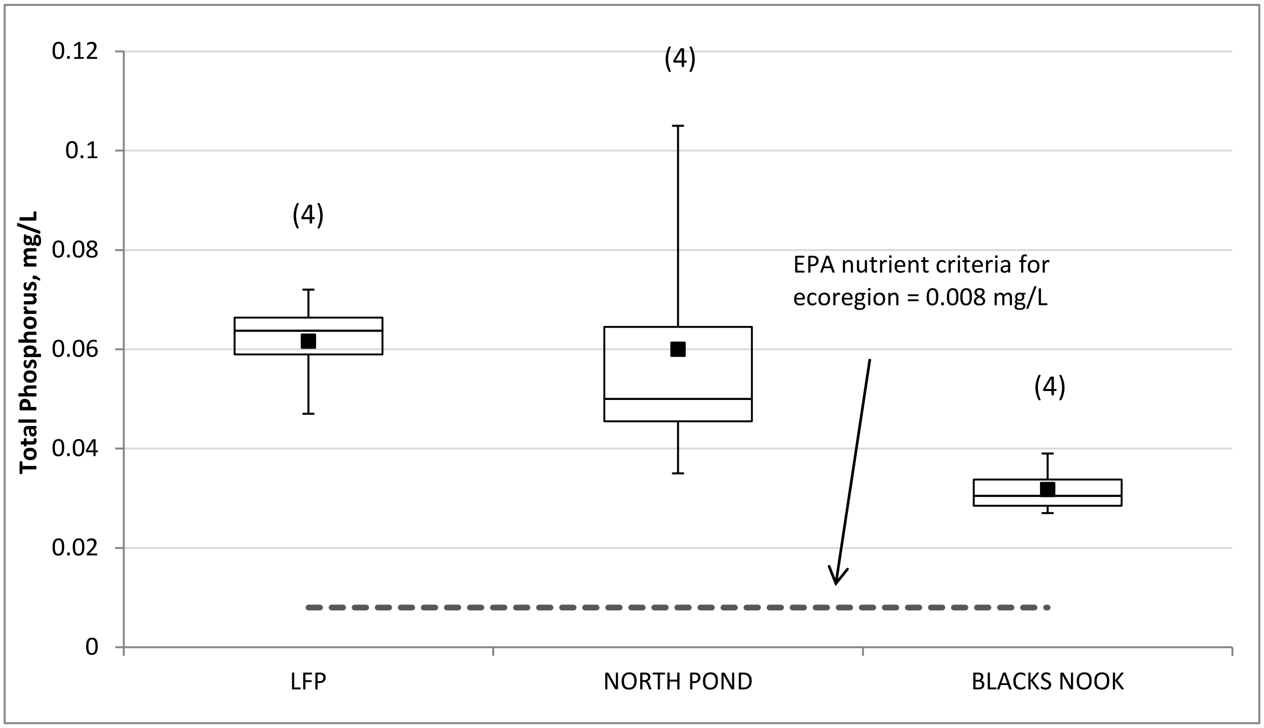
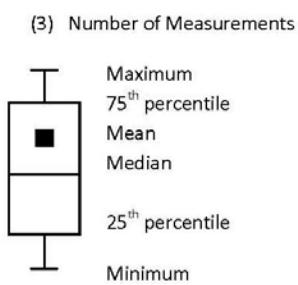


Figure 36: Fresh Pond Reservation Dry Weather Total Phosphorus [mg/L], 2013



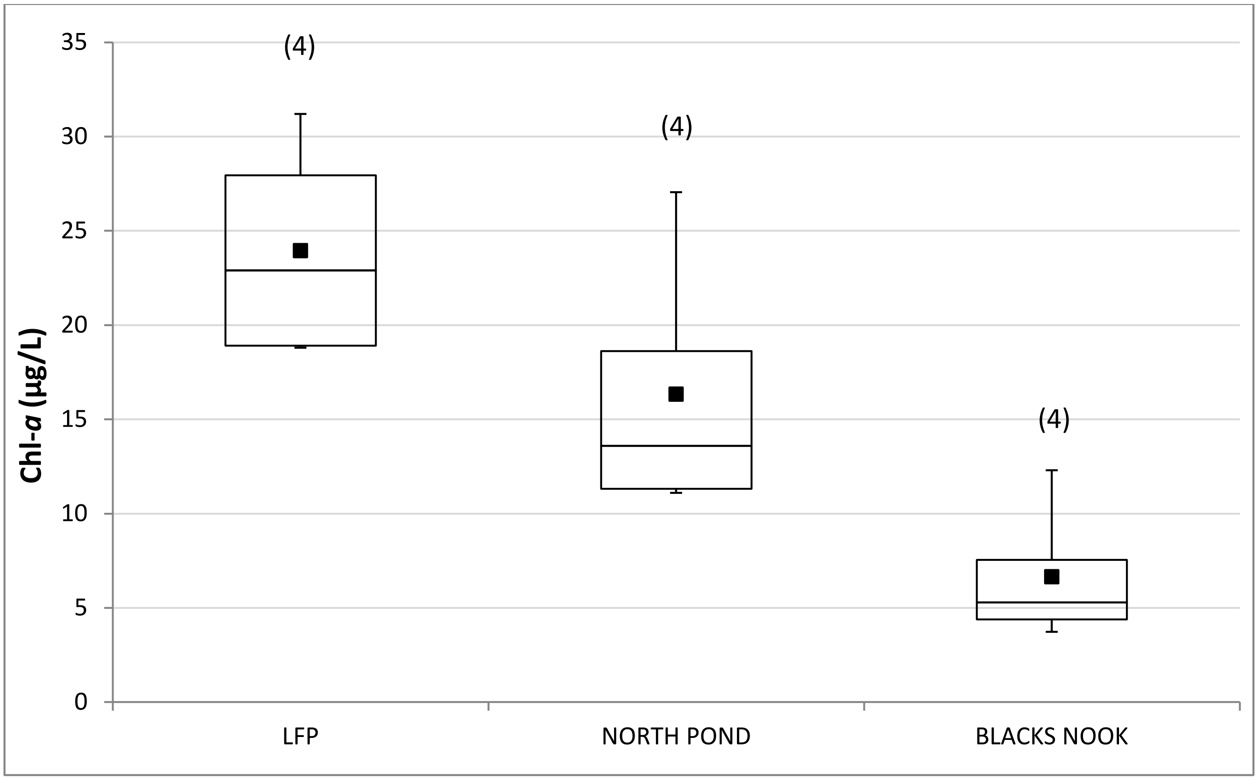
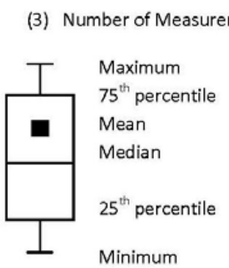


Figure 37: Fresh Pond Reservation Dry-Weather Chlorophyll-a [mg/m3], 2013



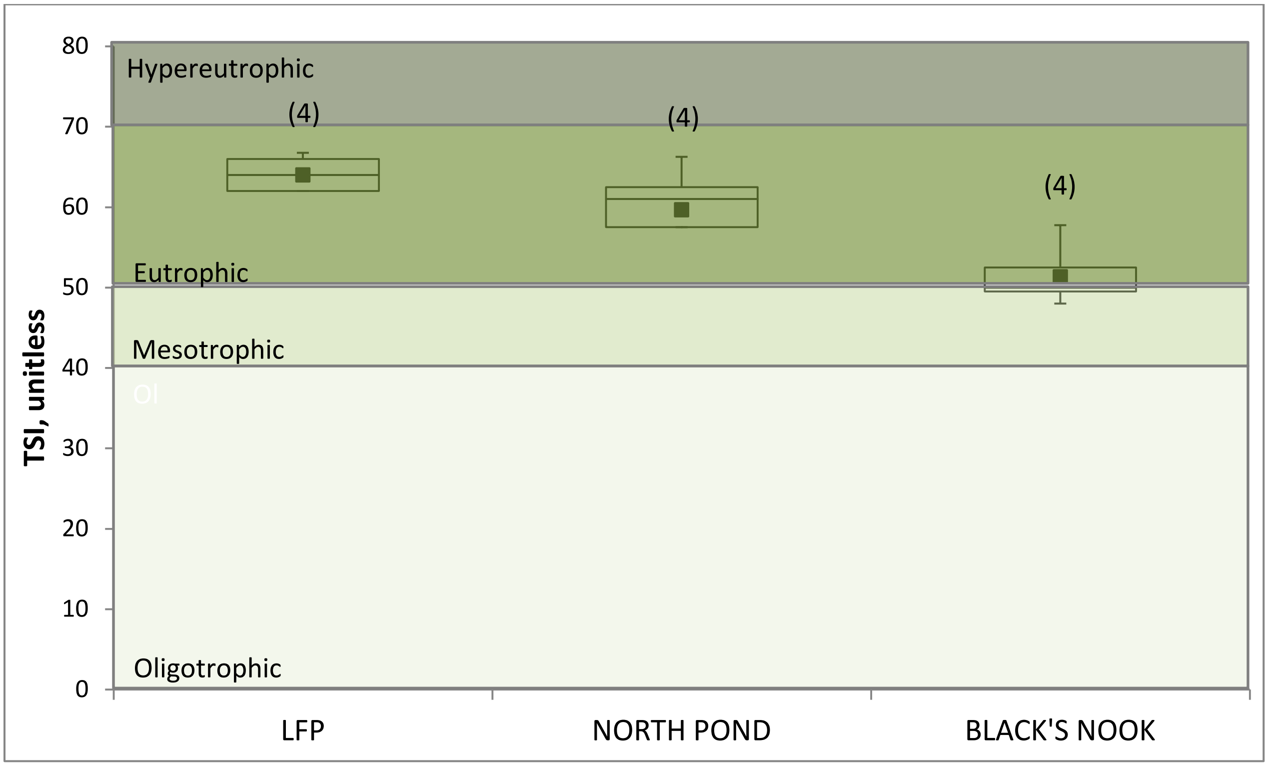


Figure 38: Fresh Pond Reservation Class B Waters Trophic State Index (TSI) from Chlorophyll-*a*, 2013

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 38). 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 39 do not yet show any clear significant trends of improvement from the recently completed pond project.

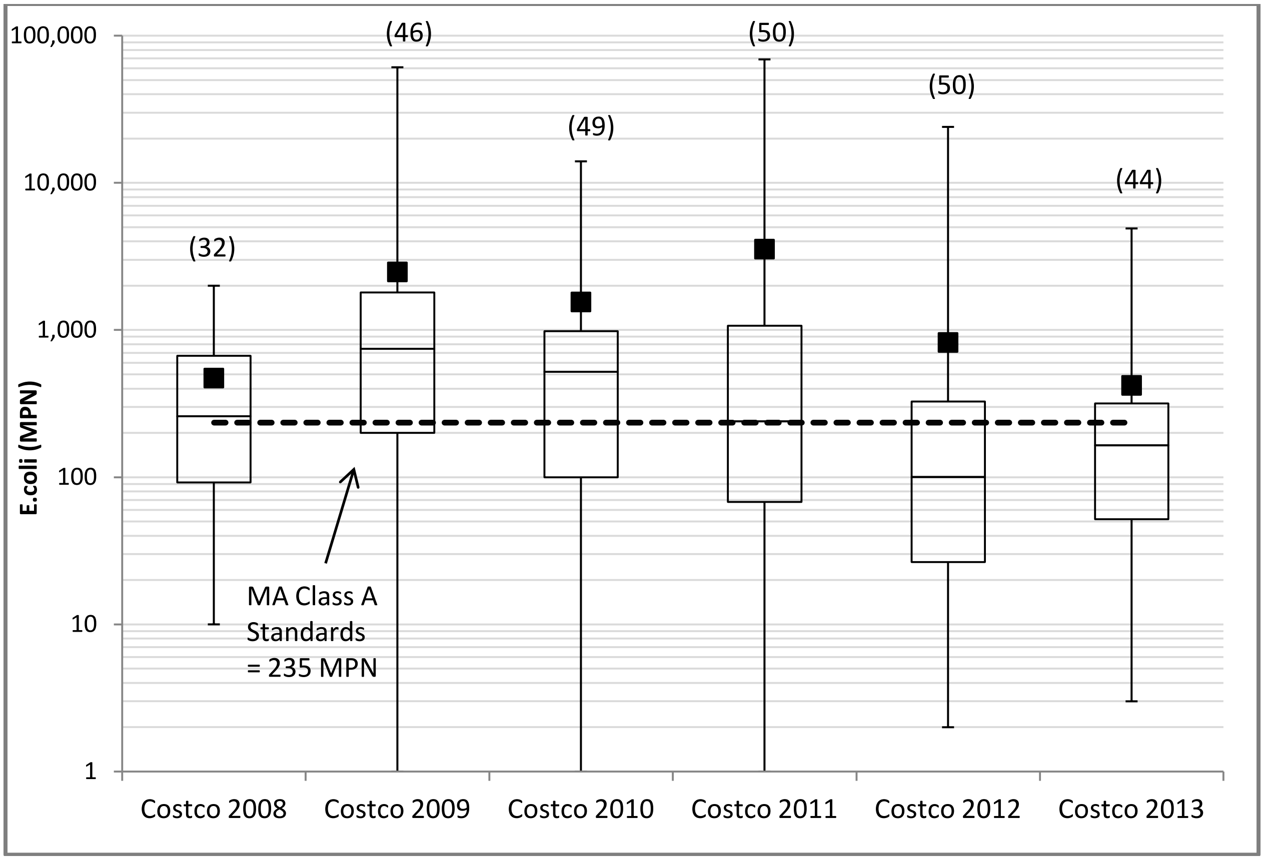


Figure 39: Weekly *E. coli* Results, Costco Drainage Ditch, Logarithmic Scale

Quality Control Measures

USGS Side-by-Sides

CWD staff conducted sampling alongside USGS staff in December to provide a broad measure of the inherent and introduced variability in surface water samples. Varibility 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.

Four primary tributary sites were sampled on two separate days: SB @ Viles ST and SB @ RT 20 on Tuesday, 12/10, and HB @ Mill St and LEX BROOK on Thursday, 12/12. 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% are considered acceptable measurements. The median, average, minimum, and maximum RPD's are provided in Table 8 (A) for each sampling site and broken into the individual parameters (B).

Table 8: Average RPD's, CWD and USGS Analysis Results Comparison

Grouped by Sampling Date and Station

Date	Station	Median	Average	Min	Max
12/12/2013	MILL ST	11%	35%	0%	192%
12/12/2013	LEX B	10%	23%	0%	162%
12/10/2013	VILES	11%	29%	1%	176%
12/10/2013	RT 20	13%	22%	2%	67%

Grouped by Sampling Parameter

SpC (µS/cm)	1%	**Ca (mg/L)**	4%	**NO2 as N (mg/L)**	102%	**Al (mg/L)**	15%
pH	5%	**Cl (mg/L)***	3%	**Na (mg/L)**	7%	**Fe (mg/L)**	39%
NH3 as N (mg/L)	84%	**Mn (mg/L)**	7%	**TOC (mg/L)**	74%	**Lab Turbidity (ntu)**	18%
Total Phos. As P (mg/L)	13%	**NO3 as N (mg/L)**	39%	**Alkalinity (mg/L CaCO3)**	6%	**UV254 (abs)**	5%

*Only two chloride measurements available due to equipment failure.

The largest differences were measured with NH_3, NO_2, NO_3, and TOC. The disparity between NO_2 and NO_3 measurements may be attributed to the different analysis techniques used by USGS and CWD. The USGS lab uses colorimetry to measure the concentration of nitrite whereas the CWD lab uses ion chromatography (IC). 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 may introduce differences in different sample digestion methods. Another round of side-by-side sampling is recommended to verify the results obtained from the December samples.

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 Upper Reservoir samples taken on April 16, 2013. All analyses yielded non-detects and were within the expected ranges from de-ionized water for pH, conductivity, and turbidity. 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 5-8% (Table 9). The overall RPD for the CWD lab was 4%, and was 8% from Premier Labs. In general, this indicates a very high level of precision and replicability in the data obtained from watershed sampling efforts. This indicates that the precision of CWD and Premier Laboratory equipment is very good.

Table 9: Average Relative Percent Differences, 2013

Overall		Tributaries		Reservoirs		Reservation	
Premier	CWD	Premier	CWD	Premier	CWD	Premier	CWD
8%	4%	7%	5%	8%	3%	8%	6%

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 2013 was 2.38 billion gallons (Table 10). Between 2008 and 2013, annual outflows from Hobbs Brook Reservoir ranged from 1.85 billion gallons (2012) to 4.89 billion gallons (2010), with a six- year average of 2.98 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 boards at the Hobbs Brook Dam in 2010. The hydraulic retention time was 13 months in 2013 and 12 months for the six-year average.

Table 10: Hobbs Brook Reservoir Water Balance

Year	Hobbs Outflow (MG)	Storage Capacity (MG)	Estimated Retention Time (months)
2008	2465	2885	14
2009	3615	2885	10
2010	4892	2518	6
2011	2654	2518	11
2012*	1850	2518	16
2013*	2375	2518	13

*provisional USGS data, subject to revision

total outflow = sum of avg. 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 39 inches of rain (Table 11). This is less than the 48.82 inch NOAA 1981-2010 Climate Normal for precipitation at the Bedford, MA station[2], but within the expected range of precipitation for the Boston- area. During a normal usage year, the lower precipitation amount would be offset by smaller released from Stony Brook Reservoir to the Charles River; however, since CWD supply was supplemented with MWRA water for a portion of the year, releases to the Charles River increased in 2013 as compared to 2012 (Table 10). 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.

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

Table 11: HB Below Dam (01104430) Precipitation Gage Annual Totals [in]

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

*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. Outflow from the Cambridge source water area 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 12). Based on the small reservoir storage capacity 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. Due to the reliance on MWRA during water main construction starting in September, diversions to the Charles were increased to maintain safe operating levels in the Stony Brook Reservoir.

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. Charles River flows from Stony Brook are measured at a downstream USGS gaging station. Over the past six years, total output from Stony Brook Reservoir to the Fresh Pond ranged from 2.5 (2010) to 7.7 (2008) billion gallons. The total estimated retention time in Stony Brook Reservoir was between 11 and 26 days, indicating a high flushing rate.

Table 12: Stony Brook Reservoir Water Balance

Year	Stony to Charles (MG)	Stony to Fresh Pond (MG)	Total Output from Stony (MG)	Storage Capacity (MG)	Estimated Retention Time (days)
2008	7729	7730	15459	418	11
2009	6672	6672	13344	418	11
2010	10521	2483	13004	418	11
2011	7668	3167	10834	418	15
2012*	2178	3398	5576	418	26
2013*	4222	2649	6871	418	22

*provisional USGS data, subject to revision

total outflow = sum of avg. daily flows

Total estimated output from Fresh Pond to the treatment plant (estimated from the total water produced by the plant) ranged from 4.71 to 4.88 billion gallons (Table 13). The six-year average retention time is 4.02 months.

Table 13: Fresh Pond Reservoir Water Balance

Year	Fresh Pond to WTP (MG)	Storage Capacity (MG)	Estimated Retention Time (months)
2008	4878	1507	3.72
2009	4748	1507	3.84
2010	4850	1507	3.72
2011*	4709	1507	3.84
2012*	4749	1507	3.84
2013*	3544**	1507	5.16

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

**Due to on-going construction projects, supplemental MWRA was used from early September through December.

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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 and 4 secondary tributary-monitoring stations. The distinction between primary and secondary monitoring stations is based on the location of sampling station in relation to the watershed system, which dictates the frequency of sampling, as well as the number and type of analyses performed on the samples.

Reservoir Sampling Process Overview

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 volatile organic compounds, 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 total phosphorus) and chlorophyll-a are analyzed at contracted laboratories.

Routine Tributary Monitoring Process Overview

Water entering the reservoirs is monitored at 12 primary and 4 secondary tributary monitoring stations. Primary monitoring stations are sampled 4 - 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*.

The four secondary stream monitoring stations are monitored 1 - 2 times a year, usually during base flow conditions. These stations are located higher up in the drainage basin on smaller tributaries that feed into larger tributaries that have primary monitoring stations. The secondary stations are sampled for the same constituents as the primary stations to provide indicators of potential changes in water quality or of base flow conditions.

Event-Based Water Quality Monitoring

Stormwater Sampling

CWD staff members conduct storm event sampling at primary stream monitoring stations, Fresh Pond Reservation, and at major pipes and other discharge locations. The goal of the storm event sampling is to collect samples of the first flush of runoff from storms producing 0.5 inches or more of rain after a period of at least 3 days of dry weather.

Storm water samples are analyzed for color, *E. coli* bacteria, alkalinity, total suspended solids, and concentrations of major ions, nutrients, and selected metals. Stormwater sample results are compared to baseline levels from routine, dry-weather monitoring in order to assess the effects of storms on introducing sediment and associated constituent loads to the reservoir.

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

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.

Table 14: Water Quality Monitoring Schedule, 2013

Primary Tributary Group 1 (5 Sites)	Sampling Dates
HB @ Mill St*	3/5
Salt Depot	5/2
Tracer Lane	8/1
SB @ Viles*	9/19
MBS	10/29

Frequency Target : 8 Events

*Sixth sample taken alongside USGS on 12/10 and 12/12.

Primary Tributary Group 2 (5 Sites)	Sampling Dates
LexBrook*	1/24
HB Below Dam	3/26
WA-17	7/16
Rt 20*	8/27
Summer St	10/22

Frequency Target : 8 Events

Primary Tributary and Reservoir Group (4 Sites)	Sampling Dates
Indust Brook	3/12
HB @ KG	6/25
HB Middle	8/6
HB Upper	9/26
	11/26

Frequency Target : 8 Events

Upcountry Reservoirs Group (6 Sites)	Sampling Dates
HB @ Dh	4/16
HB @ DH _ m**	7/18
HB @ Intake	8/20
SB @ DH	10/15
SB @ DH _ m**	11/21
SB @ Intake	

Frequency Target : 8 Events

Fresh Pond Reservoir Group (4 Sites)	Sampling Dates
FP @ DH	4/18
FP @ DH_m**	7/9
FP @ COVE	8/15
FP @ INTAKE	10/3
	11/5

Frequency Target : 8 Events

Fresh Pond Reservation Group (3 Sites)	Sampling Dates
LFP	4/4
BLACKS NOOK	6/27
NORTH POND	9/5
	10/31

Frequency Target : 4 Events

** Only during periods of thermal stratification

Appendix B – Water Quality Monitoring Results Average Instantaneous Yields

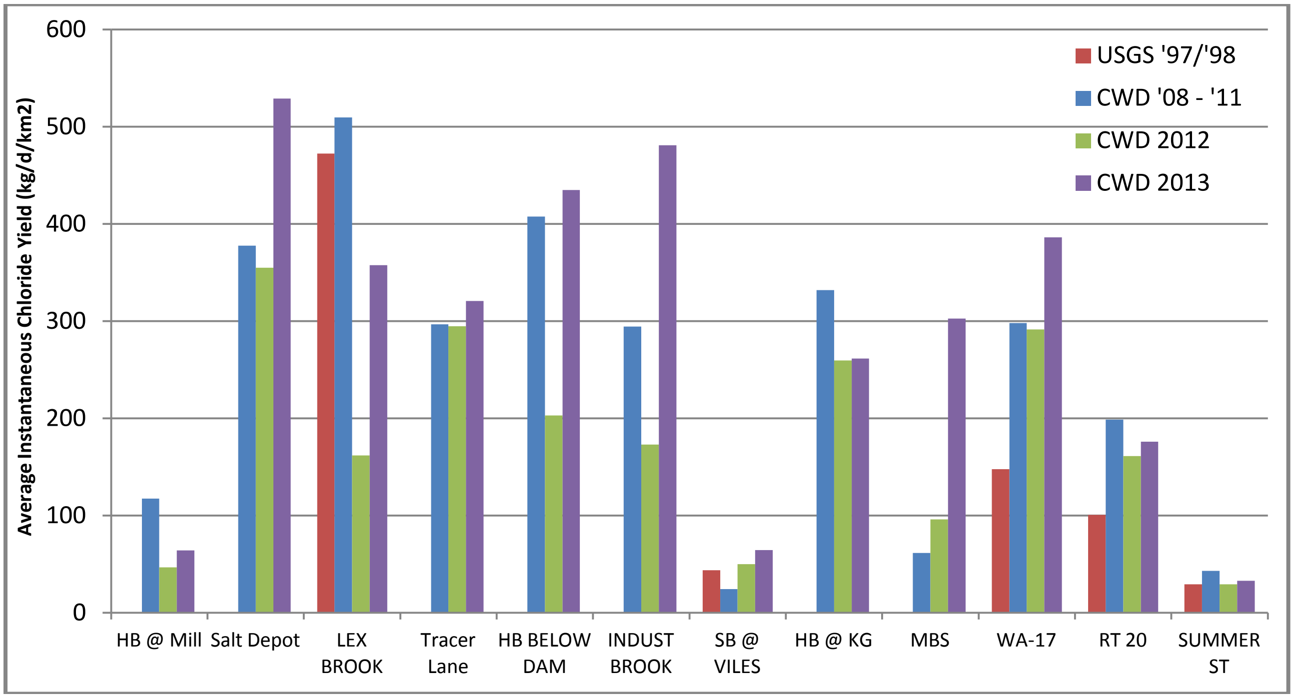

Figure 40: Primary Tributary Base flow Chloride Average Instantaneous Yields [kg/d/m2], 2013

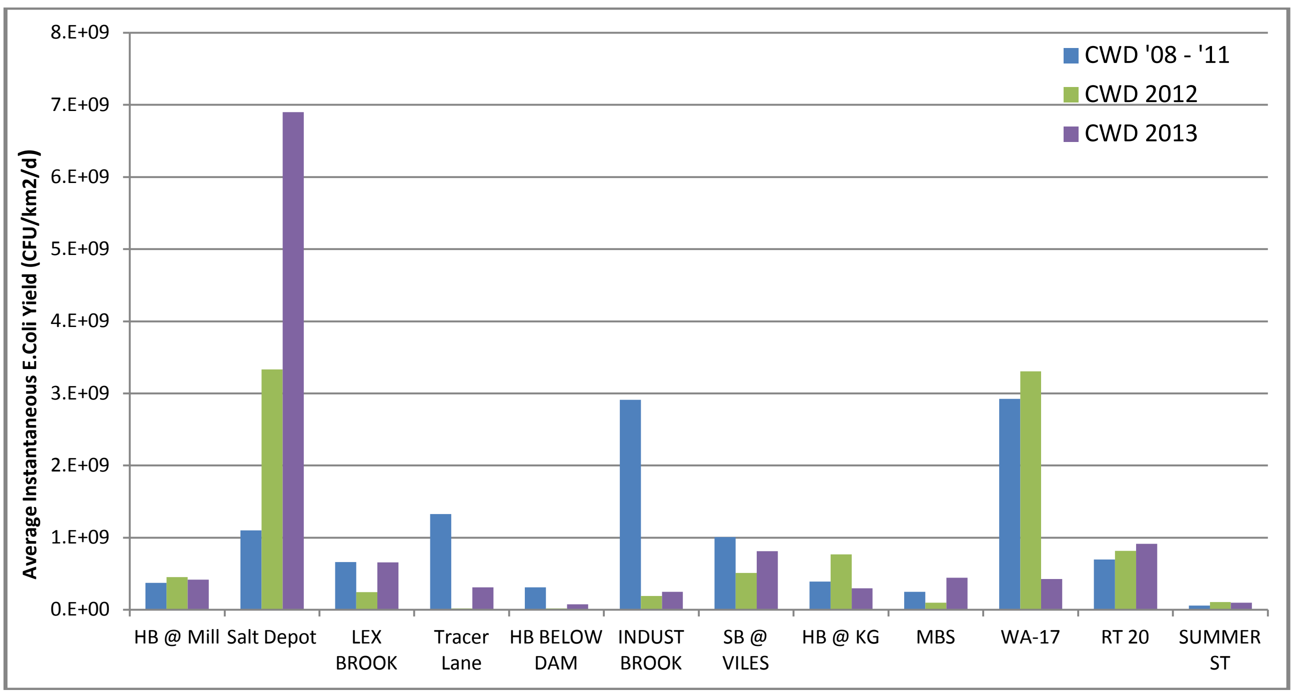

Figure 41: Primary Tributary Base flow *E. coli* Average Instantaneous Yields [CFU/km2/d], 2013

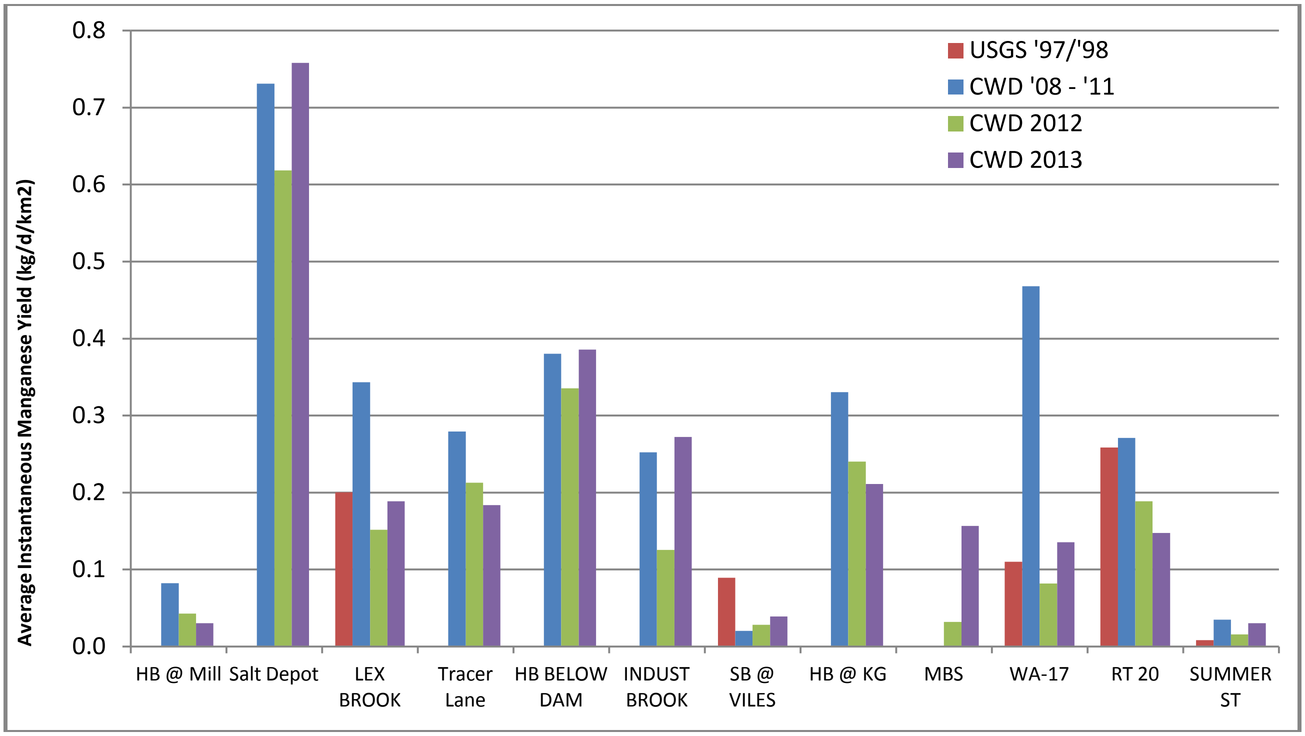

Figure 42: Primary Tributary Base flow Manganese Average Instantaneous Yields [kg/d/m^2], 2013

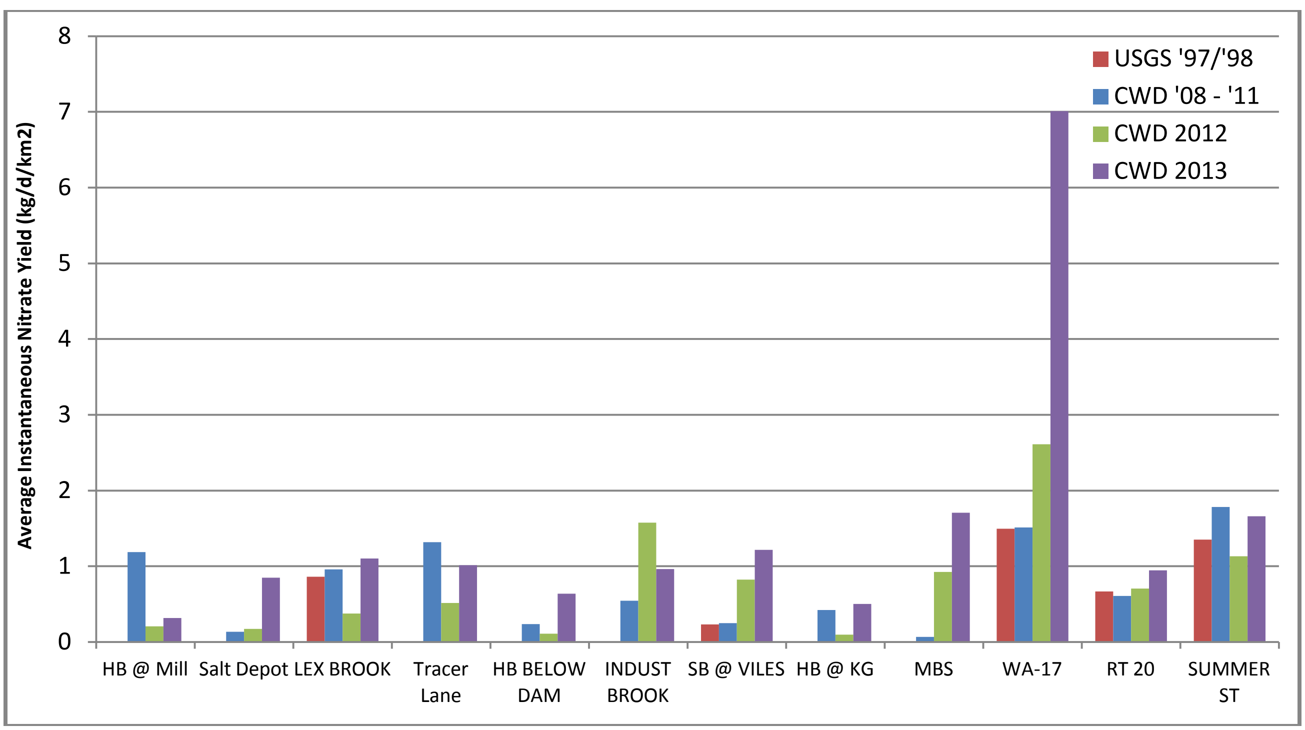

Figure 43: Primary Tributary Base flow Nitrate Median Instantaneous Yields [kg/d/m^2], 2013

Appendix C – Statistical Trend Analysis Method and Results

Statistical analysis was performed on time series data for each tributary site to determine the significance of trends in the concentrations of key parameters, using current and historic data sets compiled from CWD and various consultants. A variation of the Mann-Kendall test (as outlined in the USGS Statistical Methods Manual, Chapters 8 and 12) was used to test the significance of the trends. In this variation, the Pearson's r correlation coefficient was calculated from the ranks of the date-concentration data sets. Pearson's r on ranks was used as an alternative to Kendall's tau, which was unwieldy to compute using Excel for large data sets. The non-parametric approach was used instead of linear regression because normality of residuals is a requirement for hypothesis testing.

Trends were tested by calculating the Pearson's r correlation coefficient on the ranks of the data sets (also known as Spearman's rho). The ranks were calculated using excel in order of increasing time; the null hypothesis (no trend) was rejected when rho was significantly different from 0, as determined using the t-test. Spearman's rho was calculated using the equation

$$rho = \frac{\sum_{i=1}^{n}(Rx_i Ry_i) - n(\frac{n+1}{2})^2}{n(n^2-1)/12}$$

Where Rx_i is the rank of the dates and Ry_i is the rank of the concentrations. Since (n+1)/2 is the mean rank of both x and y, rho will be close to 0 when there is no trend in the ranks. To remove the effects that discharge may have on the parameters, the residuals from a LOWESS (Locally Weighted Scatterplot Smooth) of the concentrations was used to eliminate the effect. The LOWESS curve was calculated using the Excel add-on. P values were calculated using the TDIST excel function. A p-value < 0.05 was considered a significant trend and the null hypothesis (no trend) was rejected. P-values between 0.05 and 0.15 were considered weakly significant trends, and all others were considered to not be able to reject the null hypothesis (no trend). The direction of the trend (increase or decrease) was determined by the sign of the Pearson's r coefficient on ranks. The results of the primary trend analysis are provided throughout the report. The results from the secondary tributary analysis are provided in the following tables (Tables 14 - 21).

Table 15: SB @ Viles / SB @ Conant Matched-Pair Sign Test Results

*CWD 2000-2011 Baseflow SB @ Viles/ SB @ Conant Tributary Comparison**

Parameter	n	Z+	p	Conclusion
Cl	11	-3.02	0.00	*SB @ Viles tends to have higher Cl concentrations.*
Na	11	-3.02	0.00	*SB @ Viles tends to have higher Na concentrations.*
NO3	11	-0.60	0.55	*No evidence of difference between stations.*
TKN	11	-2.41	0.01	*SB @ Viles tends to have higher TKN concentrations*
NH3	7	1.51	0.13	*Not enough evidence of difference between stations.*
SpC	11	-2.41	0.01	*SpC concentrations in SB @ Viles tend to be higher than in SB @ Conant*
Color	9	0.67	0.51	*No evidence of difference between stations.*
Turb**	11	-1.21	0.23	*No evidence of difference between stations.*
pH	11	-1.21	0.23	*No evidence of difference between stations.*
Mn	11	-2.41	0.01	*SB @ Viles tends to have higher Mn concentrations.*
Fecal	7	0.00	1.00	*No evidence of difference between stations.*
TP	9	-1.33	0.18	*Not enough evidence of difference between stations.*
Al	11	0.00	1.00	*No evidence of difference between stations.*

*Exact-test computation for p-value (for all parameters) using binomial distribution calculator from http://vassarstats.net/binomial01.html.

** Supplemented data with lab turbidity.

TEXT	P-value significant, α = 0.05.
TEXT	P-Value significant, α = 0.10.

Table 16: SB @ Viles/ Cherry Brook Matched-Pair Sign Test Results

*CWD 2000-2011 Baseflow SB@ Viles/Cherry Brook Tributary Comparison**

Parameter	n	Z+	p	Conclusion
Cl	11	2.41	0.01	*Cherry Brook tends to have higher concentration than SB @ Viles.*
Na	11	1.21	0.23	*No evidence of difference between both sites.*
NO3	11	-1.81	0.07	*Weakly significant, NO3 concentrations tend to be higher at SB @ Viles.*
TKN	11	-1.81	0.07	*Weakly significant, TKN concentrations tend to be higher at SB @ Viles.*
NH3	7	0.00	1.00	*No evidence of difference between two stations.*
SpC	11	2.41	0.01	*SpC concentrations in Cherry Brook tend to be higher than in SB @ Viles.*
Color	9	1.33	0.18	*No evidence of difference between stations.*
Turb**	11	-1.81	0.07	*Weakly significant, SB @ Viles tends to have higher turbidity.*
pH	11	-0.60	0.55	*No evidence of difference between stations.*
Mn	11	-2.41	0.01	*Mn concentrations tend to be higher in SB @ Viles.*
Fecal	9	-2.00	0.04	*SB @ Viles tends to have higher fecal counts than Cherry Brook.*
TP	9	0.67	0.51	*No evidence of difference between stations.*
Al	10	0.00	1.00	*No evidence of difference between stations.*

*Exact-test computation for p-value (for all parameters) using binomial distribution calculator from http://vassarstats.net/binomial01.html.

** Supplemented data with lab turbidity.

TEXT P-value significant, α = 0.05.

TEXT P-Value significant, α = 0.10.

Table 17: MBS/Quarry Brook Matched-Pair Sign Test Results

*CWD 2000-2011 Baseflow MBS/Quarry Brook Comparison**

Parameter	n	Z+	p	Conclusion
Cl	11	-3.02	0.00	*MBS tends to have higher Cl concentrations than Quarry Brook.*
Na	10	-2.85	0.00	*MBS tends to have higher Na concentrations than Quarry Brook.*
NO3	11	0.00	1.00	*No evidence of difference between stations.*
TKN	11	0.00	1.00	*No evidence of difference between stations.*
NH3**	7	-0.76	0.45	*No evidence of difference between stations.*
SpC	11	-3.02	0.00	*MBS tends to have higher conductance than Quarry Brook.*
Color	9	1.33	0.18	*No evidence of difference between stations.*
Turb***	10	0.32	0.75	*No evidence of difference between stations.*
pH	11	-1.81	0.07	*MBS tends to have a higher pH than Quarry Brook.*
Mn	10	-0.32	0.75	*No evidence of difference between stations.*
Fecal	8	0.35	0.73	*No evidence of difference between stations.*
TP	10	1.58	0.11	*No evidence of difference between stations.*
Al	9	2.67	0.00	*Quarry Brook tends to have higher Al concentrations.*

*Exact-test computation for p-value (for all parameters) using binomial distribution calculator from http://vassarstats.net/binomial01.html.

**Very limited record of data for Quarry Brook @ Church St.

*** Supplemented data with lab turbidity.

TEXT	P-value significant, α = 0.05.
TEXT	P-Value significant, α = 0.10.

Table 18: MBS/Weston Brook Matched-Pair Sign Test Results

*CWD 2000-2011 Baseflow MBS/Weston Brook Comparison**

Parameter	n	Z+	p	Conclusion
Cl	11	3.02	0.00	*Weston Brook tends to have higher Cl concentrations than MBS.*
Na	10	2.85	0.00	*Weston Brook tends to have higher Na concentrations than MBS.*
NO3	11	2.41	0.01	*Weston Brook tends to have higher NO3 concentrations than MBS.*
TKN	11	-0.60	1.00	*No evidence of difference between stations.*
NH3	8	0.35	0.73	*No evidence of difference between stations.*
SpC	11	2.41	0.01	*Weston Brook tends to have higher conductance than MBS.*
Color	10	-0.32	0.75	*No evidence of difference between stations.*
Turb**	11	1.81	0.02	*Weston Brook tends to have higher turbidity than MBS.*
pH	11	-0.60	0.34	*No evidence of difference between stations.*
Mn	10	-0.95	0.34	*No evidence of difference between stations.*
Fecal	8	1.77	0.07	*Weakly significant, Weston Brook tends to have higher F.Coli counts.*
TP	8	-1.77	0.07	*Weakly significant, MBS tends to have higher TP concentrations.*
Al	9	0.67	0.51	*No evidence of difference between stations.*

*Exact-test computation for p-value (for all parameters) using binomial distribution calculator from http://vassarstats.net/binomial01.html.

** Supplemented data with lab turbidity.

TEXT (shaded)	P-value significant, α = 0.05.
TEXT	P-Value significant, α = 0.10.

Table 19 : SB @ Conant St Trend Test Results

	Time		*Discharge*		*Time (no Q)*		
Parameter	**τ**	**p**	**τ**	**p**	**τ**	**p**	**Trend Assessment**
Cl	0.12	0.63	-0.72	0.01	-0.22	0.47	*No trend with time. Decrease with Q.*
Na	0.18	0.45	-0.53	0.060	-0.06	0.92	*No trend with time. Decrease with Q.*
NO3/NO2	0.12	0.63	-0.11	0.76	-	-	*No trend.*
TKN	0.35	0.13	-0.13	0.65	-	-	*Weak increase with time. No trend with Q.*
NH3	0.02	1.00	-0.11	0.81	-	-	*No trend.*
SpC	0.01	1.00	-0.64	0.00	0.28	0.11	*Weak increase with time. Decrease with Q.*
Color	0.44	0.12	-0.20	0.72	-	-	*Weak increase with time. No trend with Q.*
Turb	-0.26	0.25	-0.34	0.10	0.22	0.30	*No trend with time. Weak decrease with Q.*
pH	0.35	0.07	0.64	0.00	0.24	0.17	*No trend with time. Significant decrease with Q.*
Mn	-0.17	0.49	-0.44	0.12	-0.44	0.12	*Weak decrease with time and Q.*
Fecal	0.33	0.47	-0.73	0.06	0.20	0.72	*No trend with time. Significant decrease with Q.*
TP	0.07	0.70	0.15	0.58	-	-	*No trend.*
Al	0.06	0.84	0.06	0.92	-	-	*No trend.*

Table 20 : Cherry Brook @ Conant St Trend Test Results

	Time		*Discharge*		*Time (no Q)*		
Parameter	**τ**	**p**	**τ**	**p**	**τ**	**p**	**Trend Assessment**
Cl	0.32	0.14	-0.08	0.76	-	-	*No trend.*
Na	0.21	0.50	-0.19	0.392	-	-	*No trend.*
NO3/NO2	0.13	0.58	-0.01	1.00	-	-	*No trend.*
TKN	0.50	0.03	0.02	1.00	-	-	*Increase with time. No discharge trend.*
NH3	0.27	0.26	-0.04	0.94	-	-	*No trend.*
SpC	0.19	0.35	-0.39	0.05	0.30	0.14	*No trend with time. Decrease with Q.*
Color	0.44	0.25	0.07	0.86	-	-	*No trend.*
Turb	-0.73	0.00	-0.29	0.28	-	-	*Significant decrease with time. No trend with Q.*
pH	0.45	0.06	0.13	0.64	-	-	*Weak increase with time. No trend with Q.*
Mn	-0.36	0.18	-0.38	0.15	-0.20	0.47	*No trend with time. Weak decrease with Q.*
Fecal	-0.60	0.14	-0.07	1.00	-	-	*Weak decrease with time. No trend with Q.*
TP	-0.38	0.12	-0.44	0.07	-0.09	0.76	*No trend with time. Decrease with Q.*
Al	0.15	0.54	0.27	0.24	-	-	*No trend.*

Table 21: Quarry Brook @ Church St Trend Test Results

	Time		*Discharge*		*Time (no Q)*		
Parameter	**τ**	**p**	**τ**	**p**	**τ**	**p**	**Trend Assessment**
Cl	-0.05	0.76	-0.29	0.39	-	-	*No trend.*
Na	0.05	0.88	-0.36	0.23	-	-	*No trend.*
NO3/NO2	0.20	0.44	0.07	0.90	-	-	*No trend.*
TKN	0.16	0.44	-0.39	0.18	-	-	*No trend.*
NH3	0.09	0.75	0.29	0.40	-	-	*No trend.*
SpC	0.09	0.73	-0.39	0.18	-	-	*No trend.*
Color	0.07	0.90	0.00	0.82	-	-	*No trend.*
Turb	-0.28	0.36	-0.33	0.47	-	-	*No trend.*
pH	0.29	0.22	0.14	0.69	-	-	*No trend.*
Mn	0.18	0.39	-0.57	0.06	0.00	0.90	*No time trend. Weakly significant trend with Q.*
Fecal	0.24	0.56	-0.60	0.14	-	-	*No trend.*
TP	0.26	0.20	-0.28	0.36	-	-	*No trend.*
Al	0.07	0.81	-0.18	0.63	-	-	*No trend.*

Table 22 : Weston Brook @ RT 20 Trend Test Results

	Time		*Discharge*		*Time (no Q)*		
Parameter	**τ**	**p**	**τ**	**p**	**τ**	**p**	**Trend Assessment**
Cl	-0.10	0.58	-0.48	0.03	-0.26	0.25	*No trend with time. Decrease with Q.*
Na	-0.04	0.90	-0.44	0.05	-0.06	0.81	*No trend with time. Decrease with Q.*
NO3/NO2	-0.05	0.83	0.18	0.43	-	-	*No trend.*
TKN	0.00	0.94	0.25	0.30	-	-	*No trend.*
NH3	0.00	0.94	0.22	0.41	-	-	*No trend.*
SpC	-0.14	0.51	-0.64	0.00	-0.18	0.43	*No trend with time. Significant decrease with Q.*
Color	0.42	0.09	0.42	0.11	0.09	0.76	*No trend.*
Turb	-0.40	0.07	-0.15	0.54	-	-	*Weakly significant decrease with time.*
pH	0.19	0.38	0.17	0.46	-	-	*No trend.*
Mn	0.03	0.85	-0.12	0.63	-	-	*No trend.*
Fecal	0.11	0.75	0.00	1.00	-	-	*No trend.*
TP	0.15	0.38	-0.21	0.31	-	-	*No trend.*
Al	-0.02	1.00	0.40	0.10	0.00	0.95	*No trend with time. Weakly significant trend with Q.*

Appendix D – Sample Analysis Results

Table 23: Sample Results

Site	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Sat)	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)
HB @ MILL ST	3/5/2013	9:17:59	1.45	305	86.4	12.13	6.69	90	0.1	195.1	36.14	761.00	1.32	6.60	<0.02	<0.5	0.032
HB @ MILL ST	5/2/2013	9:20:39	10.02	353	94.7	10.86	7.50	30	0.2	226.1	61.16	773.00	0.90	1.70	<0.02	<0.5	0.033
HB @ MILL ST	8/1/2013	9:10:02	17.52	405	87.2	8.35	7.25	91	0.2	259	74.66	762.00	0.74	0.75	<0.02	<0.5	0.039
HB @ MILL ST	9/19/2013	9:19:20	11.13	466	82.3	9.10	7.66	93	0.2	298.4	58.46	765.00	0.42	0.06	0.11	<0.5	0.02
HB @ MILL ST	10/29/2013	9:34:17	3.38	486	67.3	9.10	7.52	86	0.2	311.2	35.96	772.00	0.46	0.09	0.11	<0.5	0.019
HB @ MILL ST	12/12/2013	11:21:24	0.27	586	88.5	12.95	7.62	29	0.3	375.2	22.40	768.00	0.80	1.10	0.05	0.710	0.013
SALT DEPOT	3/5/2013	9:40:24	3.31	979	85.6	11.40	6.95	47	0.5	626.6	37.40	761.00	0.80	1.02	0.05	<0.5	0.028
SALT DEPOT	5/2/2013	9:36:58	11.06	1262	99.1	11.06	7.44	10	0.6	807.9	62.96	773.00	0.56	0.29	<0.02	<0.5	0.046
SALT DEPOT	8/1/2013	9:30:25	18.08	1522	85.5	8.07	7.05	-3	0.8	974	76.10	762.00	0.56	0.29	0.14	<0.5	0.024
SALT DEPOT	9/19/2013	9:37:45	11.74	2082	87.4	9.48	7.51	-17	1.1	1332	60.44	765.00	0.45	0.19	0.10	<0.5	0.013
SALT DEPOT	10/29/2013	9:52:20	2.94	2767	56.0	7.59	7.22	62	1.4	1771	37.58	772.00	0.60	0.37	0.07	<0.5	0.01
LEX BROOK	1/24/2013	9:24:37	0.39	1670	85.1	12.30	7.56	12	0.8	1069	6.08	764.00	0.70	0.22	<0.02	0.620	0.016
LEX BROOK	3/26/2013	9:45:36	5.47	1630	98.6	12.24	7.25	23	0.8	1043	39.38	752.00	0.82	1.40	<0.02	<0.5	<0.01
LEX BROOK	7/16/2013	9:03:51	18.70	2098	78.2	7.30	7.04	150	1.1	1343	82.22	765.00	0.54	0.09	0.17	<0.5	0.03
LEX BROOK	8/27/2013	9:15:47	17.31	1959	88.4	8.40	7.09	154	1.0	1254	72.14	757.00	0.33	0.03	0.12	<0.5	0.014
LEX BROOK	10/22/2013	9:26:35	10.76	2095	58.2	6.40	7.03	120	1.1	1341	52.16	758.00	0.44	0.04	<0.05	<0.5	0.025
LEX BROOK	12/12/2013	10:57:46	2.08	3112	80.5	11.11	7.60	-4	1.6	1992	22.46	768.00	0.58	0.10	0.07	1.400	0.01
TRACER LANE	3/5/2013	10:12:36	1.70	1129	79.6	11.08	7.09	57	0.6	722.8	37.94	761.00	1.65	2.90	<0.02	<0.5	0.012
TRACER LANE	5/2/2013	10:09:10	13.32	1307	58.9	6.24	6.94	49	0.7	836.9	64.94	773.00	1.08	0.33	<0.02	<0.5	0.034
TRACER LANE	8/1/2013	10:55:54	20.99	961	26.5	2.36	6.53	34	0.5	615.3	77.90	762.00	1.06	0.30	0.05	0.610	0.14
TRACER LANE	9/19/2013	10:07:33	13.19	903	51.1	5.38	7.03	29	0.4	577.7	65.66	765.00	0.94	0.16	0.14	<0.5	0.049
TRACER LANE	10/29/2013	10:19:30	4.22	956	66.5	8.78	7.16	48	0.5	612	38.12	772.00	0.96	0.18	<0.05	<0.5	0.036
HB BELOW DAM	1/24/2013	9:51:41	2.93	668	97.0	13.13	7.73	64	0.3	427.4	7.70	764.00	1.04	2.00	<0.02	<0.5	0.012
HB BELOW DAM	3/26/2013	10:16:02	4.25	726	101.3	13.02	7.84	101	0.4	464.8	39.56	752.00	1.54	16.00	<0.02	<0.5	<0.01
HB BELOW DAM	7/16/2013	9:34:43	19.82	741	81.1	7.43	6.99	2	0.4	473.9	83.66	765.00	1.76	28.00	0.13	<0.5	0.018
HB BELOW DAM	8/27/2013	9:46:39	23.51	754	87.8	7.41	7.30	123	0.4	482.4	74.12	757.00	1.85	33.00	0.19	<0.5	<0.01
HB BELOW DAM	10/22/2013	10:00:33	15.18	755	85.9	8.58	7.53	95	0.4	483.3	56.48	758.00	0.78	0.50	0.09	<0.5	0.021
INDUST BROOK	3/12/2013	9:24:01	6.84	2080	75.3	9.15	6.88	44	1.1	1331	47.84	763.00	1.04	0.98	0.14	<0.5	0.028
INDUST BROOK	6/25/2013	10:19:16	19.72	1993	79.0	7.17	6.84	50	1.0	1275	82.94	759.00	0.80	0.23	0.17	0.510	0.014
INDUST BROOK	8/6/2013	10:19:29	17.23	1764	79.7	7.66	6.92	69	0.9	1129	71.78	764.00	0.74	0.14	0.04	<0.5	0.2
INDUST BROOK	9/26/2013	10:52:15	15.28	1448	65.0	6.50	7.07	39	0.7	926.8	60.62	762.00	0.72	0.11	0.20	0.600	0.046
INDUST BROOK	11/26/2013	10:11:06	0.42	1092	33.9	4.94	7.21	21	0.5	698.9	35.06	769.00	0.66	0.05	0.24	<0.5	0.038
SB @ VILES	3/5/2013	10:39:31	2.28	228	93.4	12.82	7.13	80	0.1	146.1	38.48	761.00	1.70	46.00	<0.02	<0.5	0.02
SB @ VILES	5/2/2013	11:04:59	13.33	328	99.4	10.57	7.19	85	0.2	209.6	69.08	773.00	0.88	8.30	<0.02	<0.5	0.03
SB @ VILES	8/1/2013	10:04:49	19.15	321	88.8	8.23	7.05	102	0.2	205.7	76.28	762.00	0.73	6.40	<0.02	<0.5	0.042
SB @ VILES	9/19/2013	10:34:40	12.40	362	90.4	9.71	7.42	59	0.2	231.7	67.10	765.00	0.48	2.00	0.09	<0.5	0.015
SB @ VILES	10/29/2013	10:45:47	5.54	390	90.0	11.51	7.45	84	0.2	249.6	40.10	772.00	0.45	1.80	<0.05	<0.5	0.026
SB @ VILES	12/10/2013	12:59:15	2.27	349	92.1	12.62	7.15	115	0.2	223.4	32.90	759.00	0.79	7.30	0.16	<0.5	0.028
HB @ KG	3/12/2013	8:58:08	4.03	905	97.0	12.72	7.46	68	0.4	579.3	46.40	763.00	1.99	22.38	<0.02	<0.5	0.021
HB @ KG	6/25/2013	10:34:22	20.99	749	94.0	8.35	7.23	122	0.4	479.5	83.12	759.00	1.94	20.80	<0.02	<0.5	0.012
HB @ KG	8/6/2013	10:36:10	18.31	703	92.7	8.75	7.25	125	0.3	449.6	72.86	764.00	0.96	1.69	<0.02	<0.5	0.019
HB @ KG	9/26/2013	11:11:06	15.97	732	94.8	9.37	7.52	110	0.4	468.2	60.26	762.00	1.30	5.50	0.14	<0.5	0.017
HB @ KG	11/26/2013	10:31:41	0.73	783	94.7	13.69	7.52	101	0.4	501.3	35.60	769.00	0.90	1.60	0.09	<0.5	0.014
MBS	3/5/2013	11:03:27	3.84	570	83.9	11.04	6.82	105	0.3	364.6	39.20	761.00	96.75	9.40	<0.02	<0.5	0.026
MBS	5/2/2013	10:33:33	17.21	615	82.7	8.08	7.00	113	0.3	393.7	66.38	773.00	96.34	3.80	<0.02	<0.5	0.037
MBS	8/1/2013	10:27:14	22.96	563	4.9	0.42	6.30	-20	0.3	360.4	78.62	762.00	96.40	2.80	<0.02	<0.5	0.035
MBS	9/19/2013	10:59:50	16.13	590	12.6	1.25	6.64	124	0.3	377.3	68.54	765.00	96.58	6.80	0.12	<0.5	0.02
MBS	10/29/2013	11:12:07	7.61	647	50.6	6.13	7.04	113	0.3	413.9	42.08	772.00	96.23	0.01	0.11	0.580	0.019
WA-17	1/24/2013	10:12:16	2.53	1262	84.3	11.51	7.35	102	0.6	808.1	7.88	764.00	3.19	0.61	0.03	<0.5	0.012
WA-17	3/26/2013	10:38:59	8.01	1378	91.3	10.65	7.11	78	0.7	882.3	39.56	752.00	3.24	1.30	0.21	<0.5	<0.01
WA-17	7/16/2013	9:55:18	24.21	1398	113.2	9.52	7.29	143	0.7	895.2	84.92	765.00	3.80	0.38	0.18	<0.50	0.028
WA-17	8/27/2013	10:06:52	22.79	1246	72.7	6.21	7.35	134	0.6	797.9	74.66	757.00	3.18	0.32	0.26	<0.50	0.039
WA-17	10/22/2013	10:23:54	14.31	1117	34.3	3.49	7.28	88	0.6	714.9	59.18	758.00	3.08	0.44	0.10	<0.5	0.024
RT 20	1/24/2013	10:33:01	0.46	499	91.0	13.18	7.32	31	0.2	319.6	10.04	764.00	5.15	18.00	0.04	<0.5	0.016
RT 20	3/26/2013	10:58:09	4.93	507	97.2	12.29	7.37	60	0.2	324.5	39.56	752.00	5.90	63.00	<0.02	<0.5	<0.01
RT 20	7/16/2013	10:09:01	21.00	681	89.7	8.03	7.19	121	0.3	435.5	84.92	765.00	5.47	34.00	0.12	<0.5	0.036
RT 20	8/27/2013	10:24:21	22.45	732	88.7	7.64	7.14	89	0.4	468.6	75.02	757.00	5.40	31.00	0.08	<0.5	0.018
RT 20	10/22/2013	10:40:47	10.47	588	72.7	8.08	7.12	33	0.3	376.4	60.44	758.00	4.54	3.00	0.06	<0.5	0.022
RT 20	12/10/2013	11:55:06	2.44	576	88.3	12.03	7.25	47	0.3	368.6	32.90	759.00	4.97	12.00	0.07	<0.5	0.019
SUMMER ST	1/24/2013	10:53:02	0.92	286	96.7	13.84	7.68	83	0.1	182.8	10.76	764.00	0.52	0.92	<0.02	<0.5	0.018
SUMMER ST	3/26/2013	11:14:55	6.47	258	100.5	12.22	7.65	73	0.1	164.9	39.74	752.00	0.74	2.10	<0.02	<0.5	0.014
SUMMER ST	7/16/2013	10:26:22	17.33	313	95.9	9.26	7.43	150	0.2	200.2	86.72	765.00	0.30	0.20	<0.05	<0.5	0.06
SUMMER ST	8/27/2013	10:48:52	15.88	309	94.7	9.32	7.47	136	0.1	197.8	76.10	757.00	0.26	0.14	0.16	<0.5	0.018
SUMMER ST	10/22/2013	11:00:50	10.96	287	84.9	9.33	7.43	121	0.1	183.7	61.88	758.00	0.24	0.14	<0.05	<0.5	0.029

Table 24: Sample Results cont.

Site	Date	Time	Ca (mg/L)	Cl (mg/L)	Color (CU)	Lab SpC (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	3/5/2013	9:17:59	10.7	76	54	303	43	0.04	0.42	<0.004	6.88	43.4	8.7	11	0.125	210	0.267	0.832	0.362
HB @ MILL ST	5/2/2013	9:20:39	15.5	83.1	66	352	21	0.035	0.140	<0.01	7.3	52.2	9.76	23	0.116	>2419.6	0.633	1.51	0.512
HB @ MILL ST	8/1/2013	9:10:02	20.2	100	86	411	190	0.027	0.635	<0.004	7.18	60.8	11.6	30.5	0.099	610	1.03	2.73	0.545
HB @ MILL ST	9/19/2013	9:19:20	26.6	109	22	474	150	0.023	0.845	<0.004	7.33	64.9	3.1	43	0.052	>2419.6	0.686	1.78	0.126
HB @ MILL ST	10/29/2013	9:34:17	27	113	35	462	11	0.013	0.64	<0.004	7.14	58.5	5.38	51	0.027	2400	0.423	1.48	0.197
HB @ MILL ST	12/12/2013	11:21:24	21.9		66	539	13	0.097	0.53	0.05	6.95	87.6	7.15	22	0.116	580	0.69	1.62	0.447
SALT DEPOT	3/5/2013	9:40:24	30.4	292	29	963	11	0.34	0.859	0.017	7.11	158	4.95	25	0.057	160	0.584	0.942	0.203
SALT DEPOT	5/2/2013	9:36:58	45.2	348	26	1240	6.2	0.488	0.06	<0.01	7.29	212	4.37	43	0.026	490	0.687	1.35	0.186
SALT DEPOT	8/1/2013	9:30:25	59.3	427	59	1530	>2419.6	0.842	0.776	<0.004	7.21	264	5.47	51.5	0.053	>2419.6	2.6	4.28	0.31
SALT DEPOT	9/19/2013	9:37:45	80.8	645	28	2190	340	0.988	0.843	<0.004	7.26	353	3.26	56.5	0.015	>2419.6	1.32	3.74	0.133
SALT DEPOT	10/29/2013	9:52:20	105	856	25	2640	1300	1.23	0.708	<0.004	6.94	457	5.23	50.5	0.006	2400	0.451	1.13	0.142
LEX BROOK	1/24/2013	9:24:37	38.5	451	8	1440	37	0.285	2.05	<0.004	6.87	242	2.3	54.5	<0.002	820	0.141	0.867	0.079
LEX BROOK	3/26/2013	9:45:36	34	465	13	1520	100	0.168	1.5	<0.004	7.06	248	3.22	39.5	0.015	520	0.48	1.01	0.091
LEX BROOK	7/16/2013	9:03:51	55.3	618	20	1990	310	0.872	1.37	<0.004	7.04	357	5.3	73.5	0.013	>2419.6	0.538	1.42	0.153
LEX BROOK	8/27/2013	9:15:47	59.4	570	11	1960	200	0.143	1.100	0.011	6.98	378	2.34	57	0.018	>2419.6	0.679	1.43	0.066
LEX BROOK	10/22/2013	9:26:35	57.1	623	12	2010	3.1	1.23	1.11	<0.004	6.84	360	3.88	68	0.012	920	0.706	0.525	0.092
LEX BROOK	12/12/2013	10:57:46	64.1	821	14	2860	150	0.581	1.34	0.008	7.17	575	<0.4	62.5	0.03	400	0.673	1.11	0.095
TRACER LANE	3/5/2013	10:12:36	29.6	332	29	1080	5.2	0.083	0.913	<0.004	7.11	187	5.61	25.5	0.034	120	0.532	1.21	0.21
TRACER LANE	5/2/2013	10:09:10	41.1	364	40	627	9.8	0.227	<0.05	<0.01	7.24	211	7.5	49	0.019	1400	0.976	1.87	0.298
TRACER LANE	8/1/2013	10:55:54	40.8	259	180	959	120	1.02	0.713	<0.004	6.78	186	13.8	54.5	0.053	>2419.6	7.9	12.3	0.884
TRACER LANE	9/19/2013	10:07:33	32.1	254	52	920	190	0.381	0.68	<0.004	6.97	153	6.83	51	0.025	>2419.6	2.04	6	0.27
TRACER LANE	10/29/2013	10:19:30	32.8	208	28	920	160	0.132	0.698	<0.004	6.99	156	4.62	47.5	0.014	>2419.6	0.866	3.07	0.167
HB BELOW DAM	1/24/2013	9:51:41	37.9	179	13	692	<1	0.031	0.5	<0.004	7.07	179	4	25	0.005	41	0.072	0.053	0.122
HB BELOW DAM	3/26/2013	10:16:02	20.3	199	16	726	<1	0.019	0.47	<0.004	7.45	104	4.46	24.5	0.004	22	0.271	1.03	0.117
HB BELOW DAM	7/16/2013	9:34:43	27.8	201	34	680	1	1.62	0.52	<0.004	7	140	6.5	33	0.02	1000	1.5	2.02	0.196
HB BELOW DAM	8/27/2013	9:46:39	25	200	15	765	4.1	0.408	<0.05	<0.01	7.33	130	4.85	29.5	0.004	920	0.461	1.04	0.12
HB BELOW DAM	10/22/2013	10:00:33	22.6	217	12	789	3	0.066	0.45	<0.004	7.58	116	4.16	31	0.009	2400	0.323	1.02	0.103
INDUST BROOK	3/12/2013	9:24:01	49.7	624	26	1940	13	0.299	1.18	0.005	6.8	390	3.73	37.5	0.088	2400	1.05	3.72	0.134
INDUST BROOK	6/25/2013	10:19:16	77.2	576	23	1940	81	0.356	0.9	0.025	7.01	323	4.9	70	0.115	>2419.6	0.97	3.06	0.164
INDUST BROOK	8/6/2013	10:19:29	72.9	474	15	1770	36	0.209	1.31	0.008	7.1	294	4.6	74.5	0.058	>2419.6	0.744	1.63	0.127
INDUST BROOK	9/26/2013	10:52:15	62.2	389	20	1460	70	0.534	1.2	<0.004	7.16	238	5.01	75	0.217	>2419.6	1.56	2.01	0.158
INDUST BROOK	11/26/2013	10:11:06	51.3	280	28	1040	14	0.535	1.2	0.006	7	162	NA	68	0.033	550	1.26	3.46	0.146
SB @ VILES	3/5/2013	10:39:31	12.9	47.5	25	239	13	0.031	0.983	<0.004	7.3	25.7	6.07	19.5	0.066	210	0.223	0.842	0.247
SB @ VILES	5/2/2013	11:04:59	20.3	68.8	30	349	280	0.045	0.820	<0.01	7.3	39.1	5.55	31.5	0.052	2000	0.523	1.09	0.247
SB @ VILES	8/1/2013	10:04:49	19.7	66.3	49	324	140	0.04	0.975	<0.004	7.16	39	8.32	32.5	0.033	>2419.6	0.374	1.11	0.338
SB @ VILES	9/19/2013	10:34:40	21.1	77.5	15	376	180	0.019	1.88	<0.004	7.2	43.4	3.58	33.5	<0.002	1700	0.288	0.579	0.128
SB @ VILES	10/29/2013	10:45:47	21.6	84.2	12	369	26	0.012	2.12	<0.004	7.11	43.4	2.78	36	0.375	1700	0.111	0.482	0.093
SB @ VILES	12/10/2013	12:59:15	19.7	74.5	35	335	140	0.031	1.11	<0.004	7.14	41.3	5.00	28	0.05	2400	0.368	1.5	0.224
HB @ KG	3/12/2013	8:58:08	25.5	257	17	864	12	0.161	0.713	0.032	7.09	155	4.32	25.5	0.066	390	0.403	1.43	0.11
HB @ KG	6/25/2013	10:34:22	24.1	205	20	749	40	0.219	0.07	<0.004	7.28	110	5.1	29	0.065	>2419.6	0.486	1.21	0.13
HB @ KG	8/6/2013	10:36:10	23	178	16	710	54	0.263	0.587	<0.004	7.36	109	4.7	32.5	0.025	>2419.6	0.24	0.82	0.132
HB @ KG	9/26/2013	11:11:06	24.1	195	13	145	25	0.079	0.474	<0.004	7.49	118	4.75	32	0.004	>2419.6	0.467	0.46	0.124
HB @ KG	11/26/2013	10:31:41	30.1	202	13	760	5.2	0.273	0.89	<0.004	7.41	121	NA	36	<0.002	150	<0.050	1.07	0.095
MBS	3/5/2013	11:03:27	17.2	152	46	555	8.5	0.056	1.29	<0.004	7.22	98.3	7.25	21	0.108	280	0.463	1.49	0.302
MBS	5/2/2013	10:33:33	21.4	154	46	1270	18	0.068	0.410	<0.01	7.03	102	7.58	32.5	0.071	610	0.394	1.38	0.318
MBS	8/1/2013	10:27:14	23.9	134	66	564	86	0.125	0.543	<0.004	6.62	96.6	9.81	43	0.076	>2419.6	0.952	1.5	0.398
MBS	9/19/2013	10:59:50	21.8	174	45	610	20	0.105	0.732	<0.004	6.76	91.7	9.18	46.5	0.006	1400	0.493	0.756	0.331
MBS	10/29/2013	11:12:07	24.4	163	37	630	16	0.034	0.61	<0.004	7	108	7.47	46	0.101	1700	0.544	2.8	0.264
WA-17	1/24/2013	10:12:16	39.8	306	6	1110	36	0.107	8.3	0.014	7.01	176	1.8	65	0.006	520	<0.050	0.722	0.059
WA-17	3/26/2013	10:38:59	44.8	359	9	1320	14	0.118	7.56	<0.004	7.03	190	2.23	52.5	0.03	1000	0.249	1.29	0.064
WA-17	7/16/2013	9:55:18	58.2	356	16	1310	130	0.087	4.39	0.015	7.42	220	3.9	82	0.115	>2419.6	0.438	1.84	0.088
WA-17	8/27/2013	10:06:52	58.5	280	20	1260	33	0.137	3.00	0.03	7.49	202	2.94	90	0.273	>2419.6	0.867	2.74	0.089
WA-17	10/22/2013	10:23:54	58.2	283	12	1120	37	0.126	1.54	<0.004	7.47	180	3.02	96	0.083	2400	0.497	1.1	0.085
RT 20	1/24/2013	10:33:01	20	114	29	484	9.8	0.134	1.7	0.018	6.95	58.1	4.4	36	0.038	770	0.24	1.6	0.184
RT 20	3/26/2013	10:58:09	18.4	127	23	508	9.8	0.052	1.03	<0.004	7.24	67.8	4.33	24.5	0.027	260	0.255	0.966	0.156
RT 20	7/16/2013	10:09:01	26	181	26	650	230	0.22	0.65	<0.004	7.22	110	6.3	33	0.096	>2419.6	0.739	1.3	0.181
RT 20	8/27/2013	10:24:21	23.3	180.0	15	736	110	0.132	0.170	<0.01	7.34	109	4.68	33	0.058	>2419.6	0.242	0.732	0.127
RT 20	10/22/2013	10:40:47	29.1	127	19	601	91	0.313	1.14	<0.004	7.18	80.1	3.51	47	0.033	1600	0.529	0.936	0.121
RT 20	12/10/2013	11:55:06	23.9		29	550	41	0.201	0.52	<0.004	7.09	78.8	3.45	35	0.022	1700	0.44	1.38	0.182
SUMMER ST	1/24/2013	10:53:02	18.9	39.5	10	283	16	0.037	2.9	<0.004	7.27	26.6	2.4	40	0.042	330	0.172	0.512	0.099
SUMMER ST	3/26/2013	11:14:55	16.6	41.9	12	270	4.1	0.028	1.79	<0.004	7.54	24.5	2.86	27.5	0.032	520	0.464	0.657	0.094
SUMMER ST	7/16/2013	10:26:22	18.4	56.1	7	631	40	0.15	2.11	<0.004	7.47	34.3	2.1	34.5	0.161	>2419.6	0.465	0.645	0.044
SUMMER ST	8/27/2013	10:48:52	17.9	49.0	7	317	78	0.019	2.100	<0.01	7.56	36.9	1.96	36	0.036	>2419.6	<0.050	0.311	0.062
SUMMER ST	10/22/2013	11:00:50	16.5	38.8	13	294	9.7	0.072	2.32	<0.004	7.42	35.4	2.07	40	0.139	1100	0.351	0.28	0.068

Table 25: Sample Results cont.

SiteID	Date	Time	Water temp. (°C)	SpC (µS/cm)	DO (%Saturation)	DO (mg/L)	pH	Orp (mV)	Depth (m)	Salinity (PSS)	TDS (mg/L)	Air temp. (°F)	BP (mmHg)	Water level (Cambridge Datum)
Little Fresh Pond	4/4/2013	9:19:35 AM	7.27	481.2	97	11.81	7.91	66	S	0.23	308	36.68	768	16.02
Little Fresh Pond	6/27/2013	9:22:14 AM	26.09	448.9	66.1	5.34	7.1	134	S	0.21	287.2	69.98	758	16.23
Little Fresh Pond	9/5/2013	8:52:42 AM	23.27	555.2	59	5.03	6.96	123	S	0.26	355.3	64.04	761	15.84
Little Fresh Pond	10/31/2013	9:19:47 AM	8.33	587.6	73.4	8.69	7.51	62	S	0.28	376.1	43.16	767	15.78
North Pond	4/4/2013	9:44:06	7.63	274.8	81.5	9.84	7.56	96	S	0.13	175.8	37.22	768	
North Pond	6/27/2013	9:42:23	25.55	213.6	30.9	2.52	7.11	123	S	0.1	136.7	69.98	758	
North Pond	9/5/2013	9:26:28	20.86	277.4	3.4	0.3	7.16	-124	S	0.13	177.5	64.04	761	
North Pond	10/31/2013	9:49:31	7.28	298.4	78.1	9.49	7.62	105	S	0.14	190.9	44.6	767	
Black's Nook	4/4/2013	10:11:14	7.06	147.8	86.2	10.56	7.67	87	S	0.06	94.6	38.66	768	
Black's Nook	6/27/2013	10:13:33	25.6	134.2	69.6	5.67	7.35	128	S	0.06	85.9	69.98	758	Mid
Black's Nook	9/5/2013	9:49:19	22.24	153	28.5	2.48	6.9	137	S	0.07	97.9	64.04	761	Low
Black's Nook	10/31/2013	10:12:42	8.11	172.5	67.9	8.1	7.42	113	S	0.08	110.4	45.5	767	Low

SiteID	Date	Time	NH3 (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chlorophyll (mg/m3)	Ca (mg/L)	Cl (mg/L)	Color (CU)	Conductivity (umhos/cm)	Mn (mg/L)	NO3 (mg/L)	NO2 (mg/L)
Little Fresh Pond	4/4/2013	9:19:35 AM	0.2	0.89	0.068	15.6	29.7	102	53	495	0.262	0.268	0.006
Little Fresh Pond	6/27/2013	9:22:14 AM	0.13	0.61	0.047	18.8	28.5	87.9	46	443	0.273	0.65	<0.004
Little Fresh Pond	9/5/2013	8:52:42 AM	0.15	0.75	0.072	31.2	34.2	110	52	553	0.455	<0.05	<0.01
Little Fresh Pond	10/31/2013	9:19:47 AM	0.26	1.3	0.063	18.8	37.8	117	44	552	0.318	0.634	<0.004
North Pond	4/4/2013	9:44:06	0.13	0.74	0.049	11.1	35.9	18.2	43	293	0.075	<0.005	<0.004
North Pond	6/27/2013	9:42:23	0.078	0.61	0.051	11.4	29.2	14.1	62	243	0.365	0.79	<0.004
North Pond	9/5/2013	9:26:28	0.35	1.2	0.1	25.3	39.8	17	160	272	1.26	<0.05	0.018
North Pond	10/31/2013	9:49:31	0.13	0.94	0.035	15.8	41.6	19.3	37	287	0.042	1.73	<0.004
Black's Nook	4/4/2013	10:11:14	0.074	<0.5	0.027	12.30	15.5	15	22	152	0.043	<0.005	<0.004
Black's Nook	6/27/2013	10:13:33	0.14	0.52	0.026	6.25	16.4	12.9	24	137	0.058	0.5	<0.004
Black's Nook	9/5/2013	9:49:19	0.29	<0.5	0.039	3.73	15.5	13	22	155	0.053	<0.05	<0.01
Black's Nook	10/31/2013	10:12:42	0.23	0.61	0.032	4.61	18.8	14.8	15	169	0.019	0.47	<0.004

SiteID	Date	Time	Lab pH	Na (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Fe (mg/L)	Lab Turbidity (NTU)	UV254 (abs)	Ecoli (MPN)	Total Coliform (MPN)	TSS (mg/L)
Little Fresh Pond	4/4/2013	9:19:35 AM	7.86	59	4.96	59	0.162	1.29	7.36	0.033	<1	150	
Little Fresh Pond	6/27/2013	9:22:14 AM	7.35	47	6.8	68	0.039	0.914	4.85	0.169	44	>2419.6	9.3
Little Fresh Pond	9/5/2013	8:52:42 AM	7.22	72.7	5.99	75	0.076	1.53	7.19	0.178	16	> 2419.6	
Little Fresh Pond	10/31/2013	9:19:47 AM	7.65	80.5	5.83	67	0.1	1.3	6.85	0.144	0	820	
North Pond	4/4/2013	9:44:06	7.78	11.5	9.15	113	0.002	1.34	7.1	0.014	<1	1300	
North Pond	6/27/2013	9:42:23	7.68	10.6	10.7	86	0.007	3.53	8.59	0.43	330	>2419.6	<2
North Pond	9/5/2013	9:26:28	7.35	14	11.2	109	<0.002	7.28	28.1	0.576	120	> 2419.6	
North Pond	10/31/2013	9:49:31	7.39	15.1	10.2	115	0.003	0.818	4.01	0.238	7.5	200	
Black's Nook	4/4/2013	10:11:14	7.82	9.04	5.11	45	0.013	0.494	2.37	0.014	<1	160	
Black's Nook	6/27/2013	10:13:33	7.62	8.2	6.2	45	0.103	0.633	1.94	0.183	58	>2419.6	<2
Black's Nook	9/5/2013	9:49:19	7.14	9.37	6.51	53	0.005	0.336	1.26	0.162	30	> 2419.6	
Black's Nook	10/31/2013	10:12:42	7.44	10.5	5.66	57	<0.002	0.414	1.07	0.124	5.2	180	

Table 26: 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)	Water Depth (m)
FP @ DH	4/18/2013	9:32:21	10.17	499.0	106.8	12.18	7.75	78	0.39	1.28	0.24	319.3	50.9	15.48
FP @ DH	7/9/2013	8:48:37	26.19	520.4	98.9	8.03	7.50	102	0.29	0.95	0.25	333	70	15.3
FP @ DH	8/15/2013	9:23:48	23.86	540.7	91.3	7.73	7.40	86	0.36	1.20	0.26	346	-65	15.42
FP @ DH	10/3/2013	10:11:35	20.24	570.5	92.9	8.44	7.66	98	0.22	0.72	0.27	365.1	-70	15.57
FP @ DH	11/5/2013	9:15:31	13.24	577.2	87.8	9.43	7.66	125	0.37	1.24	0.28	369.4	37.58	14.64
HB @ DH	4/16/2013	11:02:41	10.14	748.6	107.5	12.24	7.89	113	0.34	1.14	0.36	479.1	57.56	7.32
HB @ DH	7/18/2013	11:23:46	29.08	762.8	105	8.06	8.03	151	0.25	0.83	0.37	488.2	89.6	7.76
HB @ DH	8/20/2013	10:55:27	24.62	751	96.5	8.05	7.42	132	0.27	0.91	0.36	480.6	75.92	7.33
HB @ DH	10/15/2013	10:02:07	16.44	754.3	86.8	8.56	7.60	103	0.25	0.84	0.37	482.7	59.36	6.87
HB @ DH	11/21/2013	10:41:56	6.88	766.6	91.7	11.39	7.61	143	0.36	1.19	0.37	490.6	40.1	6.69
SB @ DH	4/16/2013	9:26:25	10.3	518.9	103.3	11.73	7.67	81	0.31	1.02	0.25	332.1	52.88	7.97
SB @ DH	7/18/2013	9:58:19	30.05	536.8	115.1	8.69	8.11	110	0.29	0.95	0.25	343.5	85.64	8.52
SB @ DH	8/20/2013	9:33:40	23.59	564.6	89.1	7.59	7.31	112	0.34	1.14	0.27	361.3	73.4	8.33
SB @ DH	10/15/2013	10:54:14	17.13	675.9	85.0	8.26	7.45	117	0.34	1.12	0.33	432.6	62.96	8.23
SB @ DH	11/21/2013	9:46:02	7.57	674.4	89.1	10.88	7.63	106	0.27	0.90	0.32	431.6	35.06	7.88

Site ID	Date	Time	BP (mmHg)	Water level (Cambridge Datum)	Secchi depth (meters)	Secchi depth (feet)	NH3 (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chlorophyll (mg/m3)	Ca (mg/L)	Cl (mg/L)	Color (CU)	Lab Conductivity (umhos/cm
FP @ DH	4/18/2013	9:32:21	772.0	15.97	3	9.84	<0.05	<0.50	<0.01	5.28	20.1	301	16	496
FP @ DH	7/9/2013	8:48:37	764	15.72	3.5	11.48	<0.05	<0.50	<0.01	<2	22.1	125	16	518
FP @ DH	8/15/2013	9:23:48	763.0	16.24	3.8	12.47	0.08	<0.5	<0.01	<2	22.4	133	15	541
FP @ DH	10/3/2013	10:11:35	764	16.55	5	16.40	0.14	<0.5	<0.01	<2	22.8	144	10	578
FP @ DH	11/5/2013	9:15:31	780.0	15.70	6.5	21.33	0.1	<0.50	<0.01	<2	22.8	145	10	573
HB @ DH	4/16/2013	11:02:41	771	180.77	2	6.56	0.09	<0.5	0.016	7.82	23.6	200	15	747
HB @ DH	7/18/2013	11:23:46	761	180.46	5	16.4	0.12	0.57	0.064	<2	21.7	202	13	728
HB @ DH	8/20/2013	10:55:27	764	178.87	5	16.4	0.11	<0.5	0.012	<2	22.7	206	12	759
HB @ DH	10/15/2013	10:02:07	768	176.47	3.5	11.48	0.13	<0.5	0.017	<2	23.6	213	12	746
HB @ DH	11/21/2013	10:41:56	777	177.22	4	13.12	0.064	<0.5	0.015	2.12	23.3	206	10	724
SB @ DH	4/16/2013	9:26:25	771	77.47	2.5	8.20	<0.05	<0.50	0.01	*8.29*	23.3	125	26	525
SB @ DH	7/18/2013	9:58:19	761	78.7	4	13.12	<0.05	<0.5	<0.01	*3.11*	21.7	129	29	508
SB @ DH	8/20/2013	9:33:40	764	77.86	2.5	8.20	0.19	<0.5	0.02	*3.37*	27.3	141	26	577
SB @ DH	10/15/2013	10:54:14	768	78.5	3.50	11.48	0.1	<0.5	0.016	<2	24.6	181	13	671
SB @ DH	11/21/2013	9:46:02	777	76.7	3.5	11.48	0.045	<0.5	0.011	*<2*	25.7	171	12	619

Site ID	Date	Time	Mn (mg/L)	NO3 (mg/L)	NO2 (mg/L)	Lab pH	Na (mg/L)	TOC (mg/L)	Alkalinity (mg/L CaCO3)	Al (mg/L)	Fe (mg/L)	Lab Turbidity (NTU)	UV254 (abs)	
FP @ DH	4/18/2013	9:32:21	0.012	2.24	0.009	7.7	66.3	4.63	31	0.024	<0.050	0.774	0.13	
FP @ DH	7/9/2013	8:48:37	0.033	0.82	<0.004	7.44	72.1	4.5	27.5	0.016	0.118	0.533	0.133	
FP @ DH	8/15/2013	9:23:48	0.063	0.69	0.05	7.5	77	4.32	31.5	0.019	<0.050	0.634	0.127	
FP @ DH	10/3/2013	10:11:35	0.062	0.684	<0.004	7.57	78.2	4.05	34.5	0.011	<0.050	0.458	0.108	
FP @ DH	11/5/2013	9:15:31	0.046	0.38	<0.01	7.59	82.2	3.66	34.5	0.022	0.061	0.637	0.099	
HB @ DH	4/16/2013	11:02:41	0.019	0.43	<0.004	7.58	129		24	0.009	0.144	1.18	0.119	
HB @ DH	7/18/2013	11:23:46	0.009	0.326	0.008	7.98	114	5.7	27	0.005	0.071	0.557	0.125	
HB @ DH	8/20/2013	10:55:27	0.025	0.36	<0.004	7.57	122	4.75	28.5	0.003	0.139	0.648	0.116	
HB @ DH	10/15/2013	10:02:07	0.055	0.489	<0.004	7.61	127	4.3	29	0.003	0.461	1.13	0.106	
HB @ DH	11/21/2013	10:41:56	0.015	0.551	<0.004	7.46	126	2	28	<0.002	0.248	0.736	0.091	
SB @ DH	4/16/2013	9:26:25	0.068	0.9	<0.004	7.38	82.6		27	0.032	0.222	1.27	0.158	
SB @ DH	7/18/2013	9:58:19	0.019	0.56	0.004	8.19	76.7	7.7	33	0.015	0.176	1.52	0.228	
SB @ DH	8/20/2013	9:33:40	0.17	0.54	0.008	7.32	99.4	5.41	36.5	0.011	0.613	1.32	0.179	
SB @ DH	10/15/2013	10:54:14	0.093	0.725	<0.004	7.46	109	4.26	36.5	<0.002	0.201	0.845	0.115	
SB @ DH	11/21/2013	9:46:02	0.048	0.934	<0.004	7.52	104	2.2	37.5	<0.002	0.244	0.826	0.1	

Table 27: 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)	Water Depth (m)	BP (mmHg)	Water level	Secchi depth (m)	Secchi depth (feet)	Ecoli (MPN)	Total Coliform (MPN)	Lab Number
FP @ INTAKE	4/18/2013	10:10:53	9.66	499.1	105.5	12.18	7.68	133	0.32	1.05	0.2	319.4	52.7	9.89	772	15.99	3	9.84	<1	<1	2013-1852
FP @ INTAKE	4/18/2013	10:11:59	9.50	499.0	105.7	12.25	7.68	134	1.01	3.34	0.2	319.3	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	4/18/2013	10:12:35	8.73	499.0	105.9	12.50	7.68	135	2.98	9.80	0.2	319.3	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	4/18/2013	10:13:15	8.47	499.0	106.0	12.59	7.66	136	5.04	16.55	0.2	319.3	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	4/18/2013	10:13:59	7.79	498.2	104.8	12.66	7.62	138	6.85	22.48	0.2	318.9	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	4/18/2013	10:16:28	7.02	497.2	100.0	12.31	7.52	142	8.98	29.46	0.2	318.2	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	4/18/2013	10:16:46	6.99	507.4	99.9	12.31	7.49	143	9.89	32.46	0.2	324.7	52.7	9.89	772	15.99	3	9.84			
FP @ INTAKE	7/9/2013	9:54:09	26.12	520.2	98.8	8.03	7.31	147	0.33	1.08	0.3	332.9	70	9.13	764	15.73	3.5	11.48	3.1	330	2013-3247
FP @ INTAKE	7/9/2013	9:54:45	26.12	520.4	98.6	8.02	7.32	149	1.00	3.31	0.3	333.0	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	7/9/2013	9:55:41	25.99	519.9	98.8	8.05	7.32	152	2.98	9.79	0.3	332.7	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	7/9/2013	10:01:01	23.56	514.9	84.8	7.22	7.04	172	5.02	16.48	0.2	329.5	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	7/9/2013	10:02:57	21.52	514.1	77.7	6.88	6.99	176	7.00	22.97	0.2	329.0	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	7/9/2013	10:06:55	20.03	514.4	58.5	5.34	6.86	162	8.71	28.59	0.3	329.2	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	7/9/2013	10:07:07	19.79	516.6	58.6	5.37	6.85	159	9.13	29.98	0.3	330.6	70	9.13	764	15.73	3.5	11.48			
FP @ INTAKE	8/15/2013	10:12:08	23.94	540.7	91.5	7.73	7.26	157	0.30	1.01	0.3	346.0	~65	9.61	763	16.24	3.8	12.47	8.6	220	2013-3947
FP @ INTAKE	8/15/2013	10:13:01	23.93	540.5	91.4	7.72	7.27	160	1.01	3.32	0.3	345.9	~65	9.61	763	16.24	3.8	12.47			
FP @ INTAKE	8/15/2013	10:14:11	23.82	540.4	91.1	7.72	7.27	163	3.07	10.07	0.3	345.8	~65	9.61	763	16.24	3.8	12.47			
FP @ INTAKE	8/15/2013	10:15:37	23.82	540.5	90.8	7.69	7.28	164	4.99	16.39	0.3	345.9	~65	9.61	763	16.24	3.8	12.47			
FP @ INTAKE	8/15/2013	10:16:51	23.82	540.4	90.8	7.69	7.28	167	7.03	23.08	0.3	345.8	~65	9.61	763	16.24	3.8	12.47			
FP @ INTAKE	8/15/2013	10:17:39	23.79	540.1	90.8	7.70	7.28	169	9.07	29.77	0.3	345.6	~65	9.61	763	16.24	3.8	12.47			
FP @ INTAKE	10/3/2013	10:40:11	20.39	570.3	93.4	8.46	7.40	101	0.28	0.94	0.3	365.0	~70	9.61	764	16.54	5	16.40	1	60	2013-4845
FP @ INTAKE	10/3/2013	10:41:25	20.34	570.3	93.1	8.44	7.41	108	1.01	3.33	0.3	365.0	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	10/3/2013	10:42:51	20.25	569.8	93.3	8.47	7.40	115	2.97	9.76	0.3	364.7	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	10/3/2013	10:43:45	20.22	569.6	93.3	8.48	7.39	120	4.85	15.93	0.3	364.5	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	10/3/2013	10:44:29	20.20	569.3	93.2	8.47	7.38	123	6.99	22.95	0.3	364.3	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	10/3/2013	10:45:23	20.15	569.2	92.6	8.42	7.36	126	9.18	30.12	0.3	364.2	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	10/3/2013	10:45:33	20.03	575.8	92.6	8.44	7.32	131	9.61	31.55	0.3	368.5	~70	9.61	764	16.54	5	16.40			
FP @ INTAKE	11/5/2013	9:47:45	13.15	577.2	89.4	9.63	7.48	108	0.32	1.07	0.3	369.4	41.72	9.26	780	15.7	6	19.69	12	43	2013-5360
FP @ INTAKE	11/5/2013	9:48:35	13.14	577.2	89.2	9.60	7.49	110	0.99	3.26	0.3	369.4	41.72	9.26	780	15.7	6	19.69			
FP @ INTAKE	11/5/2013	9:49:11	13.12	577.2	89.3	9.62	7.48	112	3.03	9.96	0.3	369.4	41.72	9.26	780	15.7	6	19.69			
FP @ INTAKE	11/5/2013	9:50:07	13.11	577.3	89.9	9.69	7.47	115	5.06	16.60	0.3	369.4	41.72	9.26	780	15.7	6	19.69			
FP @ INTAKE	11/5/2013	9:50:29	13.10	577.1	90.0	9.70	7.46	116	6.98	22.92	0.3	369.3	41.72	9.26	780	15.7	6	19.69			
FP @ INTAKE	11/5/2013	9:50:49	13.04	577.3	90.0	9.71	7.46	116	9.00	29.55	0.3	369.5	41.72	9.26	780	15.7	6	19.69			
FP @ INTAKE	11/5/2013	9:51:13	13.06	576.4	89.9	9.70	7.45	114	9.26	30.41	0.3	368.8	41.72	9.26	780	15.7	6	19.69			

Table 28: 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 (mmHg)	Water level	Water Depth (m)	Secchi depth (m)	Secchi depth (feet)	E-Coli (MPN)	Total Coliform (MPN)	lab number
HB @ INTAKE	4/16/2013	11:21:36	9.07	748.9	103.9	12.14	7.76	141	0.25	0.83	0.36	479.3	58.46	771	180.78	6.62	2.5	8.2	7	>2419.6	2013-1812
HB @ INTAKE	4/16/2013	11:22:29	9.00	748.3	104.1	12.18	7.77	141	1	3.29	0.36	478.9	58.46	771	180.78	6.62	2.5	8.2			
HB @ INTAKE	4/16/2013	11:24:17	8.87	748.6	107.0	12.56	7.81	142	2.99	9.81	0.36	479.1	58.46	771	180.78	6.62	2.5	8.2			
HB @ INTAKE	4/16/2013	11:26:25	8.72	748.6	104.5	12.31	7.71	145	5.02	16.47	0.36	479.1	58.46	771	180.78	6.62	2.5	8.2			
HB @ INTAKE	4/16/2013	11:27:55	8.50	748.6	100.8	11.93	7.60	142	6.01	19.73	0.36	479.1	58.46	771	180.78	6.62	2.5	8.2			
HB @ INTAKE	4/16/2013	11:28:13	8.45	740.2	89.9	10.66	7.58	143	6.62	21.73	0.36	473.7	58.46	771	180.78	6.62	2.5	8.2			
HB @ INTAKE	7/18/2013	11:23:46	29.08	762.8	105.0	8.06	8.03	151	0.25	0.83	0.37	488.2	89.78	761	180.46	NS	4	13.12	1	210	2013-3417
HB @ INTAKE	8/20/2013	11:26:23	24.92	751.8	96.4	8.01	7.38	155	0.29	0.97	0.36	481.1	75.92	764	178.87	5.77	5	16.4	1	280	2013-4040
HB @ INTAKE	8/20/2013	11:27:07	24.22	750.1	96.0	8.08	7.44	157	1.12	3.69	0.36	480	75.92	764	178.87	5.77	5	16.4			
HB @ INTAKE	8/20/2013	11:28:38	23.83	748.9	97.2	8.24	7.48	162	3.11	10.20	0.36	479.3	75.92	764	178.87	5.77	5	16.4			
HB @ INTAKE	8/20/2013	11:32:39	23.69	748.6	88.3	7.5	7.34	176	5	16.42	0.36	479.1	75.92	764	178.87	5.77	5	16.4			
HB @ INTAKE	8/20/2013	11:33:01	23.19	745.5	81.0	6.95	7.24	169	5.77	18.96	0.36	477.1	75.92	764	178.87	5.77	5	16.4			
HB @ INTAKE	10/15/2013	10:14:16	16.46	754.4	86.4	8.51	7.38	113	0.23	0.75	0.37	482.8	59.36	768	176.47	5.71	3.5	11.48	1	200	2013-5037
HB @ INTAKE	10/15/2013	10:15:46	16.41	754.1	84.9	8.38	7.38	122	1.03	3.38	0.37	482.6	59.36	768	176.47	5.71	3.5	11.48			
HB @ INTAKE	10/15/2013	10:16:40	16.34	753.6	84.3	8.33	7.35	128	3.16	10.39	0.37	482.3	59.36	768	176.47	5.71	3.5	11.48			
HB @ INTAKE	10/15/2013	10:17:34	16.31	753.6	83.6	8.27	7.34	132	5.05	16.58	0.37	482.3	59.36	768	176.47	5.71	3.5	11.48			
HB @ INTAKE	10/15/2013	10:17:50	16.31	726.9	83.5	8.26	7.33	133	5.71	18.75	0.35	465.2	59.36	768	176.47	5.71	3.5	11.48			
HB @ INTAKE	11/21/2013	10:53:30	6.88	766.9	91.6	11.38	7.46	101	0.28	0.91	0.37	490.8	41.18	777	177.22	5.7	4	13.12	0	33	2013-5587
HB @ INTAKE	11/21/2013	10:55:40	6.65	767.9	91.7	11.46	7.47	107	2.99	9.82	0.37	491.5	41.18	777	177.22	5.7	4	13.12			
HB @ INTAKE	11/21/2013	10:56:22	6.60	766.9	91.7	11.47	7.47	109	5.06	16.60	0.37	490.8	41.18	777	177.22	5.7	4	13.12			
HB @ INTAKE	11/21/2013	10:56:50	6.44	767.3	91.6	11.51	7.48	110	5.7	18.72	0.37	491.1	41.18	777	177.22	5.7	4	13.12			
SB @ INTAKE	4/16/2013	9:57:33	10.11	508	103.6	11.82	7.50	127	0.36	1.19	0.24	325.1	54.32	771	77.62	6.62	2.8	9.19	1	>2419.6	2013-1811
SB @ INTAKE	4/16/2013	9:58:29	9.92	506.2	103.6	11.87	7.52	129	1.05	3.44	0.24	324	54.32	771	77.62	6.62	2.8	9.19			
SB @ INTAKE	4/16/2013	10:00:35	9.66	516.2	102.1	11.77	7.50	131	2.96	9.73	0.25	330.3	54.32	771	77.62	6.62	2.8	9.19			
SB @ INTAKE	4/16/2013	10:03:01	8.33	547.4	92.7	11.03	7.35	139	5.03	16.51	0.26	350.3	54.32	771	77.62	6.62	2.8	9.19			
SB @ INTAKE	4/16/2013	10:03:29	7.99	552.6	89.2	10.71	7.29	136	6.62	21.72	0.26	353.6	54.32	771	77.62	6.62	2.8	9.19			
SB @ INTAKE	7/18/2013	10:30:53	29.9	536.2	116.6	8.83	8.25	118	0.32	1.06	0.25	343.1	85.82	761	78.69	7.31	3.5	11.48	9.3	2400	2013-3416
SB @ INTAKE	7/18/2013	10:33:31	29.92	536.1	117.9	8.92	8.26	125	0.98	3.23	0.25	343.1	85.82	761	78.69	7.31	3.5	11.48			
SB @ INTAKE	7/18/2013	10:41:16	24.28	530.5	73.2	6.12	6.90	169	3.00	9.86	0.25	339.5	85.82	761	78.69	7.31	3.5	11.48			
SB @ INTAKE	7/18/2013	10:43:52	22.66	602	66.1	5.71	6.87	174	4.89	16.05	0.29	385.3	85.82	761	78.69	7.31	3.5	11.48			
SB @ INTAKE	7/18/2013	10:51:02	15.65	528.1	0.3	0.03	6.68	86	6.96	22.85	0.25	338	85.82	761	78.69	7.31	3.5	11.48			
SB @ INTAKE	7/18/2013	10:51:14	15.5	547.9	0.2	0.02	6.65	75	7.31	23.98	0.26	350.6	85.82	761	78.69	7.31	3.5	11.48			
SB @ INTAKE	8/20/2013	10:18:21	24.05	564.2	92.1	7.78	7.23	165	0.32	1.06	0.27	361.1	74.48	764	77.86	3.44	2.5	8.20	1	260	2013-4039
SB @ INTAKE	8/20/2013	10:19:05	24.01	563.8	92.2	7.79	7.23	164	0.94	3.10	0.27	360.8	74.48	764	77.86	3.44	2.5	8.20			
SB @ INTAKE	8/20/2013	10:20:55	23.51	563.1	88.5	7.55	7.18	169	3.10	10.18	0.27	360.3	74.48	764	77.86	3.44	2.5	8.20			
SB @ INTAKE	10/15/2013	11:07:19	17.24	675.1	86.6	8.40	7.35	106	0.33	1.09	0.33	432	62.96	768	78.5	6.38	3.50	11.48	0	280	2013-5038
SB @ INTAKE	10/15/2013	11:08:31	17.04	675.5	85.9	8.36	7.35	113	1.08	3.57	0.33	432.3	62.96	768	78.5	6.38	3.50	11.48			
SB @ INTAKE	10/15/2013	11:09:25	16.89	675.4	85.1	8.31	7.33	118	2.96	9.72	0.33	432.2	62.96	768	78.5	6.38	3.50	11.48			
SB @ INTAKE	10/15/2013	11:10:15	16.84	674.7	84.7	8.28	7.32	122	5.05	16.59	0.33	431.8	62.96	768	78.5	6.38	3.50	11.48			
SB @ INTAKE	10/15/2013	11:10:29	16.78	674.4	78.7	7.70	7.29	124	6.38	20.95	0.33	431.6	62.96	768	78.5	6.38	3.50	11.48			
SB @ INTAKE	11/21/2013	10:02:27	7.46	666.9	89.1	10.91	7.55	61	0.30	1.01	0.32	426.8	36.5	777	76.7	6.42	3.5	11.48	1	22	2013-5586
SB @ INTAKE	11/21/2013	10:03:19	7.38	667.6	88.9	10.91	7.55	67	1.00	3.29	0.32	427.3	36.5	777	76.7	6.42	3.5	11.48			
SB @ INTAKE	11/21/2013	10:03:49	7.34	667.4	89.0	10.93	7.54	71	3.03	9.95	0.32	427.1	36.5	777	76.7	6.42	3.5	11.48			
SB @ INTAKE	11/21/2013	10:04:19	7.33	667.5	89.1	10.95	7.53	74	4.95	16.26	0.32	427.2	36.5	777	76.7	6.42	3.5	11.48			
SB @ INTAKE	11/21/2013	10:04:39	7.34	666.3	89.4	10.98	7.50	77	6.42	21.07	0.32	426.4	36.5	777	76.7	6.42	3.5	11.48			

Table 29: 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)	NH3 Ammonia (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Chl-a (mg/m3)	lab number	Comments
HB @ UPPER	3/12/2013	10:18:10	2.56	514.9	91.1	12.44	7.27	114	1.54	0.24	329.5	49.64	763	<0.02	<0.5	0.022	7.65	2013-1208	
HB @ UPPER	6/25/2013	9:23:41	27.39	477.2	105.4	8.32	7.3	106	0.62	0.23	305.4	79.52	759	<0.02	0.6	0.024	9.95	2013-2990	
HB @ UPPER	6/25/2013													<0.02	0.71	0.023	10.70	2013-2991	FDUP
HB @ UPPER	8/6/2013	9:24:44	24.54	660.7	93.9	7.85	7.33	119	0.56	0.32	422.8	70.16	764	<0.02	0.6	0.052	13.80	2013-3777	
HB @ UPPER	9/26/2013	9:26:01	17.75	827.4	94.7	9.02	7.49	79	0.75	0.4	529.5	57.92	762	<0.02	0.93	0.053	35.20	2013-4720	
HB @ UPPER	11/26/2013	9:24:31	1.23	1124	96.2	13.7	8.13	165	0.01	0.54	719.7	33.44	769	<0.02	0.85	0.06	20.80	2013-5667	Approx 0.25" ice formed over basin.
HB @ MIDDLE	3/12/2013	9:53:39	3.91	1048	88.3	11.61	7.32	118	1.37	0.51	671.1	49.28	763	<0.02	<0.5	0.017	3.53	2013-1207	
HB @ MIDDLE	3/12/2013	11:00:43	3.79	1067	87.5	11.54	6.95	137	2.26	0.52	683.3								2nd reading taken from Gatehouse bridge.
HB @ MIDDLE	6/25/2013	9:56:20	24.79	557	109.7	9.08	7.13	126	0.45	0.27	356.5	81.86	759	<0.02	0.6	0.024	29.40	2013-2992	
HB @ MIDDLE	8/6/2013	9:57:50	23.3	696.6	86.6	7.41	7.22	118	0.7	0.34	445.8	71.24	764	<0.02	<0.5	0.029	6.47	2013-3778	
HB @ MIDDLE	8/6/2013													<0.02	<0.5	0.028	6.43	2013-3780	FDUP
HB @ MIDDLE	9/26/2013	9:58:30	18.28	767.1	101.5	9.56	7.63	91	0.59	0.37	490.9	59.36	762	<0.02	0.9	0.054	28.80	2013-4721	
HB @ MIDDLE	11/26/2013	9:51:29	2.65	897.6	82.4	11.3	7.86	163	0.1	0.43	574.5	34.34	769	<0.02	0.59	0.047	13.10	2013-5668	Ice forming along edges of basin, no ice cover.

SITE ID	Date	Time	Ca (mg/L)	Cl (mg/L)	Color (CU)	Lab SpC (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	UV254 (abs)
HB @ UPPER	3/12/2013	10:18:10	15.3	140	46	510	2	0.089	0.548	<0.004	6.8	90.6	7.62	15.5	0.11	610	0.456	1.39	0.305
HB @ UPPER	6/25/2013	9:23:41	15.6	124	72	461	9.7	0.071	<0.005	<0.004	7.4	76.1	11.5	24	0.091	>2419.6	0.781	1.74	0.532
HB @ UPPER	6/25/2013		16.5	124	74	455	9.7	0.076	<0.005	<0.004	7.41	79.5	11.6	23.5	0.098	>2419.6	0.865	1.72	0.522
HB @ UPPER	8/6/2013	9:24:44	25.2	167	64	658	7.4	0.121	0.447	<0.004	7.37	132	9.77	30	0.178	2000	1.9	4.71	0.376
HB @ UPPER	9/26/2013	9:26:01	27	236	48	834	51	0.117	0.342	<0.004	7.26	144	7.09	28	0.189	> 2419.6	1.48	6.46	0.243
HB @ UPPER	11/26/2013	9:24:31	38.8	307	32	1060	2	0.076	0.68	<0.004	7.61	195	NA	28.5	0.109	93	0.652	3.63	0.143
HB @ MIDDLE	3/12/2013	9:53:39	23.9	306	32	1020	3	0.131	0.672	<0.004	6.84	187	5.75	20.5	0.074	160	0.509	1.92	0.207
HB @ MIDDLE	6/25/2013	9:56:20	18	148	80	536	18	0.089	<0.005	<0.004	7.26	84.3	11.6	27	0.081	>2419.6	0.848	2.9	0.53
HB @ MIDDLE	8/6/2013	9:57:50	27	181	57	695	13	0.241	0.499	<0.004	7.35	127	10	36	0.042	2400	1.43	1.79	0.402
HB @ MIDDLE	8/6/2013		22.6	175	56	692	13	0.211	0.537	<0.004	7.34	113	10	35.5	0.016	>2419.6	0.8	1.73	0.396
HB @ MIDDLE	9/26/2013	9:58:30	25.7	204	53	776	4.1	0.168	0.349	<0.004	7.57	135	7.75	33	0.076	730	1.86	7.16	0.294
HB @ MIDDLE	11/26/2013	9:51:29	27	245	44	871	0	0.105	0.51	<0.004	7.41	149	NA	24.5	0.075	47	1.18	4.3	0.217