



Water Quality Monitoring at Minute Man National Historical Park

Northeast Temperate Network 2012 Summary Report

Natural Resource Data Series NPS/NETN/NRDS—2013/539



ON THE COVER

Concord River, July 2012

Photograph by: Bill Gawley

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Introduction

This report on the water quality of Minute Man National Historical Park (MIMA) generated by the Northeast Temperate Network (NETN) Water Quality Monitoring Program includes data gathered in the 2012 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. Appendix A contains tabular data collected in 2012.

The vital signs for freshwater bodies included in the NETN Freshwater Monitoring Protocol (Lombard et al. 2006) are water chemistry, nutrient enrichment, water quantity, and the detection of invasive plant species. These metrics were chosen to address the NPS Inventory and Monitoring Program objective to detect change in the status of physical, chemical, or biological attributes of the ecosystem.

The NETN Freshwater Monitoring Protocol calls for a total of 3 park streams to be sampled monthly from May through October at MIMA. A NETN hydrologic technician measured physical and in-situ water chemistry parameters each month and periodically collected water samples for analysis at the University of Maine's Sawyer Environmental Chemistry Research Laboratory. All monitoring data are incorporated into a series of comprehensive databases that ultimately feed the U.S. Environmental Protection Agency's "STORET" data system, the repository for all NPS water quality and quantity data.

Sampling Sites

Two streams, Mill Brook and Elm Brook, and one river, the Concord River, cut through MIMA (Figure 1). One water quality monitoring site was selected on each of these water bodies for the NETN monitoring program (Table 1). The monitoring site on Mill Brook (MIMASA) is located upstream of Lowell Road with a tape-down point on the bridge. The Mill Brook monitoring site is not located within park boundaries because the brook is intermittent where it flows through the Wayside Unit, and it becomes a wetland where it flows through the North Bridge Unit (Lombard et al 2006).

The site on Elm Brook (MIMASB) is within park boundaries at State Route 2A, 4.3 miles upstream from the confluence of Elm Brook with the Shawsheen River. The sampling results represent water quality conditions in Elm Brook within the park's Battle Road Unit (Lombard et al 2006).

The Concord River site (MIMASC) is at the Old North Bridge, 0.49 miles downstream from the confluence of the Sudbury and Assabet Rivers. The site is within the Minute Man NHP boundary and sampling results are intended to represent water quality conditions in the Concord River within the park's North Bridge Unit. Discharge measurements cannot be made by wading because of the size of the river, and this site also requires specialized techniques to obtain water quality sonde samples.

Mill Brook and Elm Brook are classified as capable of supporting cold water fisheries (National Park Service 1993), loosely defined as waters that can support, on a year-round basis, wild and stocked brook trout (*Salvelinus fontinalis*) or other species requiring similar conditions. The Concord River is considered capable of supporting warm water fish (bass, pickerel, sunfish).

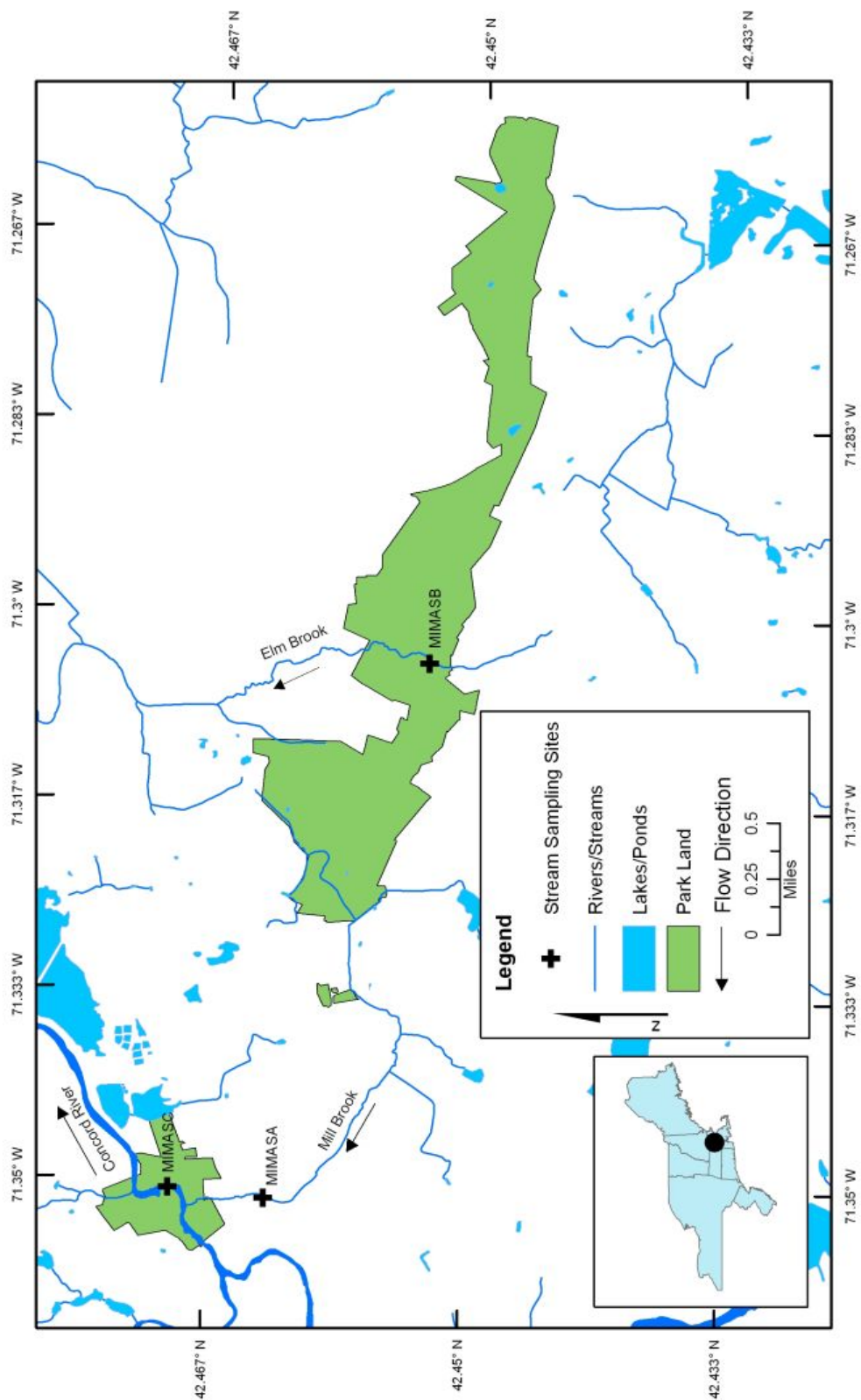


Figure 1. Map of water monitoring sites at Minute Man NHP.

Table 1. Water quality monitoring sites at Minute Man NHP.

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Mill Brook (Stream A)	MIMASA	42.4628000	-71.3514167	Cold water fisheries
Elm Brook (Stream B)	MIMASB	42.4529333	-71.3042167	Cold water fisheries
Concord River (Stream C)	MIMASC	42.4690166	-71.3506333	Warm water fisheries

Methods

Detailed descriptions of all monitoring methods are found in the original protocol (Lombard et al. 2006) and the most recent protocol update (Gawley et al. In Prep). Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, and dissolved oxygen) determined with a YSI 600XL sonde, weather, stream flow (discharge), and stream stage (water level). In May and August, water samples were obtained and analyzed for acid neutralizing capacity (ANC), color, and nutrients. Beginning in 2012, fractions of these water samples were also analyzed for dissolved organic carbon (DOC), chloride, sulfate, and chlorophyll *a*. Nutrient chemistry parameters were analyzed from a grab sample obtained by submerging the sample bottle directly in the stream with a gloved hand. Concord River samples were collected from the bridge using a VanDorn-type water sampler suspended on a line.

Stream discharge was measured using U.S. Geological Survey protocols (Rantz et al 1982), employing a measuring tape, wading rod, and a SonTek FlowTracker current meter or a Price Pygmy current meter to measure a particular cross-sectional area of the stream and the velocity of the water at that cross section. Discharge measurements of the Concord River could potentially be made off of the Old North Bridge, although bridge measurements are too expensive for NETN to cover at this time. Concord River stage was obtained by lowering a measuring tape from a specified point on the bridge to the surface of the water. Stream stage at the two smaller streams was measured by using a folding wooden ruler (engineering scale) to “tape down” from a fixed datum point on large boulders to the surface of the water. Bolts were installed to permanently mark the Elm Brook and Mill Brook datum points in July 2012.

In-situ stream water chemical and physical measurements and water samples were collected within 5 meters from the location of the discharge measurement. Sonde measurements were taken in the main stream flow with care taken that the sonde was not resting directly on the stream bottom. In the Concord River, two-point sonde measurements were taken from the bridge (at pylons 2 and 4) at each monitoring visit to better characterize river conditions. A seven-point set of cross-sectional measurements is taken (at varied depths) once each year to confirm that the two-point measurement strategy is still representative.

Water Quality Standards

Massachusetts surface-water quality standards designate Class A waters as “excellent habitat for fish, other aquatic life and wildlife, and suitable for primary and secondary contact recreation” (Massachusetts Department of Environmental Protection 2007). Outstanding Resource Waters (ORW) is used to denote those waters, other than Public Water Supplies, designated for protection as outstanding resources. “Class A waters shall have DO concentrations of not less than 6 mg/L unless background conditions are lower. Temperatures shall not exceed 68° F [20° C] in cold water fisheries or 83° F [28.3° C] in warm water fisheries, and natural and seasonal variations shall be maintained. The pH shall range from 6.5 to 8.3 standard units but not more than 0.5 units outside of the background range. Class A waters shall be free from color in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class” (Massachusetts Department of Environmental Protection 2007).

Table 2. Massachusetts stream water quality standards.

Water quality classification code	Minimum Dissolved Oxygen (mg/L)	pH range (standard units)	Maximum Total Nitrogen (µg/L)	Maximum Total Phosphorus (µg/L)
A	6.0	6.5 – 8.3	As naturally occurs	As naturally occurs

EPA Ecoregion 14 water quality criteria (Table 3; U.S. Environmental Protection Agency 2000) are also used as a benchmark in this report. EPA water quality criteria for nutrients help translate narrative criteria within State or Tribal water quality standards by establishing values for causal variables (e.g., total nitrogen and total phosphorus) and response variables (e.g., turbidity and chlorophyll *a*). Causal variables are necessary to provide sufficient protection of designated uses before impairment occurs and to maintain downstream uses. Early response variables are necessary to provide warning signs of possible impairment and to integrate the effects of variable and potentially unmeasured nutrient loads (U.S. Environmental Protection Agency 2002).

Table 3. EPA Ecoregion 14 nutrient criteria for streams.

Nutrient Criteria	Value
Total Phosphorus	31.25 µg/L
Total Nitrogen	0.71 mg/L

These criteria were developed specifically for Ecoregion 14 (which includes Minute Man NHP, Saugus Iron Works NHS, and Weir Farm NHS) and are designed to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient over-enrichment from cultural eutrophication. The values are EPA's scientific recommendations regarding ambient concentrations of nutrients that protect aquatic resource quality. They do not have any regulatory impact or meaning.

The criteria were established based on the lower 25th percentile of streams for which the EPA found data. This percentile of all streams is expected to approximately correspond to the 75th percentile of reference (undisturbed) streams. In other words, 75% of streams in the ecoregion do not meet the criteria, nor do roughly 25% of reference streams. (U.S. Environmental Protection Agency 2000).

Results

Monitoring results for 2012 are displayed in scatter-plot graphs showing all data for each site for a given parameter. The scatter plots of 2012 data are overlaid on box plots representing the overall range and distribution of data values collected from 2006 through 2012 for the specified parameter and site (Appendix A contains all data in tabular form). A box plot (Figure 2) is a summary plot that graphs data as a box representing statistical values. The boundary of the box closest to zero indicates the 25th percentile, a line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers (error bars) above and below the box indicate the 90th and 10th percentiles respectively. Outliers are displayed as black filled circles. At least nine data points are required to compute the 5th, 10th, 90th and 95th percentiles. If a percentile point cannot be computed, that set of points is not drawn. If EPA or other water quality criteria exist for a particular parameter they are displayed on the graphs as specification lines.

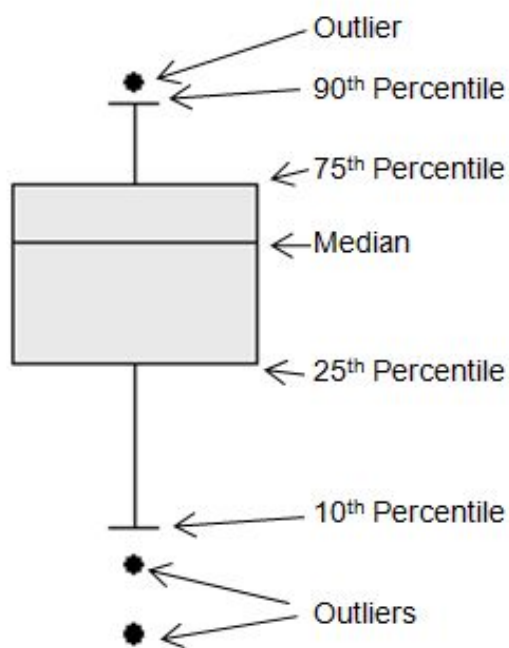


Figure 2. Explanation of box plot graph

Water Quality

Measures of water quality include specific conductance, pH, water temperature, dissolved oxygen (DO), acid neutralizing capacity (ANC), and apparent color. Assessment of water quality data aids in the interpretation of the biotic condition and ecological processes of surface water resources.

Specific Conductance

Specific conductance (Figure 3) is a measure of the ability of water to carry an electrical current, and is directly related to the level of dissolved ions in the water. An increase in specific conductance can be an indicator of pollutants in the water. Naturally occurring values range from less than 20 to more than 1,000 microsiemens per centimeter ($\mu\text{S}/\text{cm}$). Specific conductance values from 2012 were within the appropriate range for high ionic strength waters, and were generally within the range of the data from previous years, with two higher values from Mill Brook in July and September.

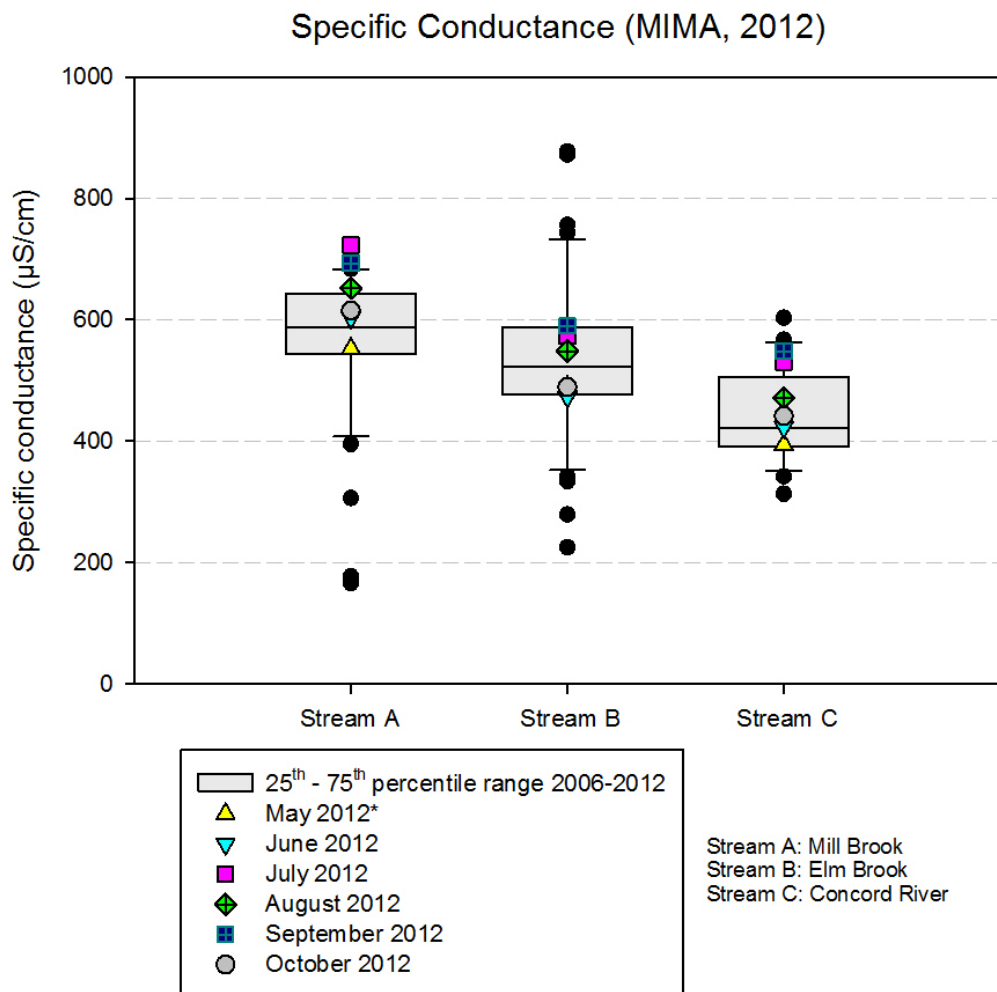


Figure 3. Specific conductance from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

pH Level

The pH of a water body reflects how acidic or basic the water is, measured on a scale of 1 to 14, with 7 being neutral. Acid waters are below 7, and alkaline waters are above 7. A one unit change in pH represents a 10-fold change in acidity or alkalinity. Massachusetts standards, similar to those of most northeast states, indicate that a pH between 6.5 and 8.3 is within the acceptable range. pH values from the 2012 monitoring season (Figure 4) were circumneutral or slightly basic and were all between the upper and lower Massachusetts water quality standards.

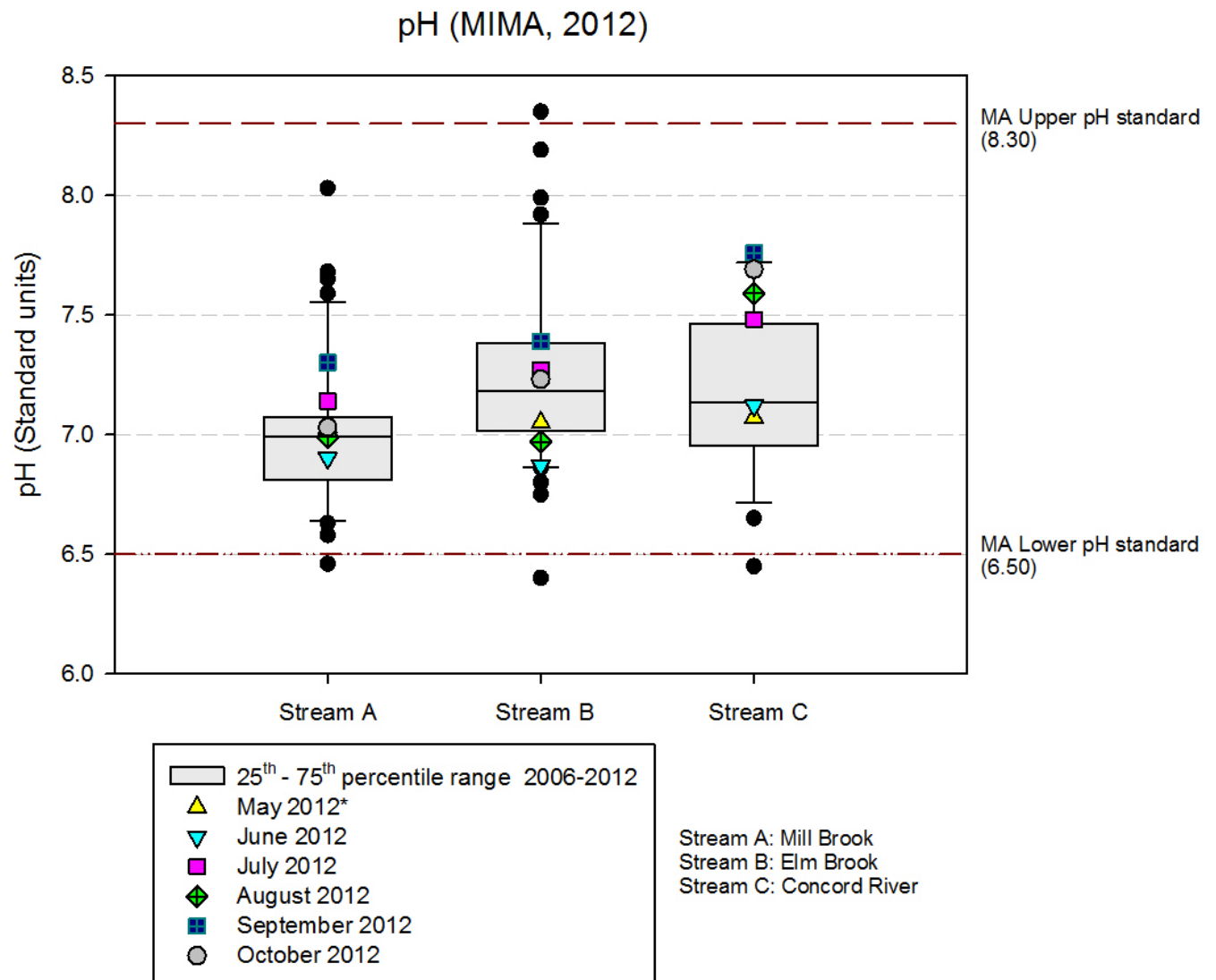


Figure 4. pH from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

Temperature

Temperature can affect water chemistry and biology. For example, the amount of oxygen that water can hold is directly related to the temperature of the water. The higher the temperature, the less oxygen water can hold, which can be observed in both diel (day and night) and seasonal shifts. Oxygen will naturally decline during the summer months as water temperatures rise. Temperature can also determine the kinds of plants and animals found in the lake or pond. Certain species of fish, insects, and algae will predominate during the cooler temperatures of the spring and fall, yet be less apparent during the warmer temperatures of summer. Surface water temperatures in 2012 (Figure 5) were generally within the state water quality standards for the appropriate stream types, excepting the June and August Mill Brook measurements which likely reflected the contributions of low flow and high air temperature and solar radiation.

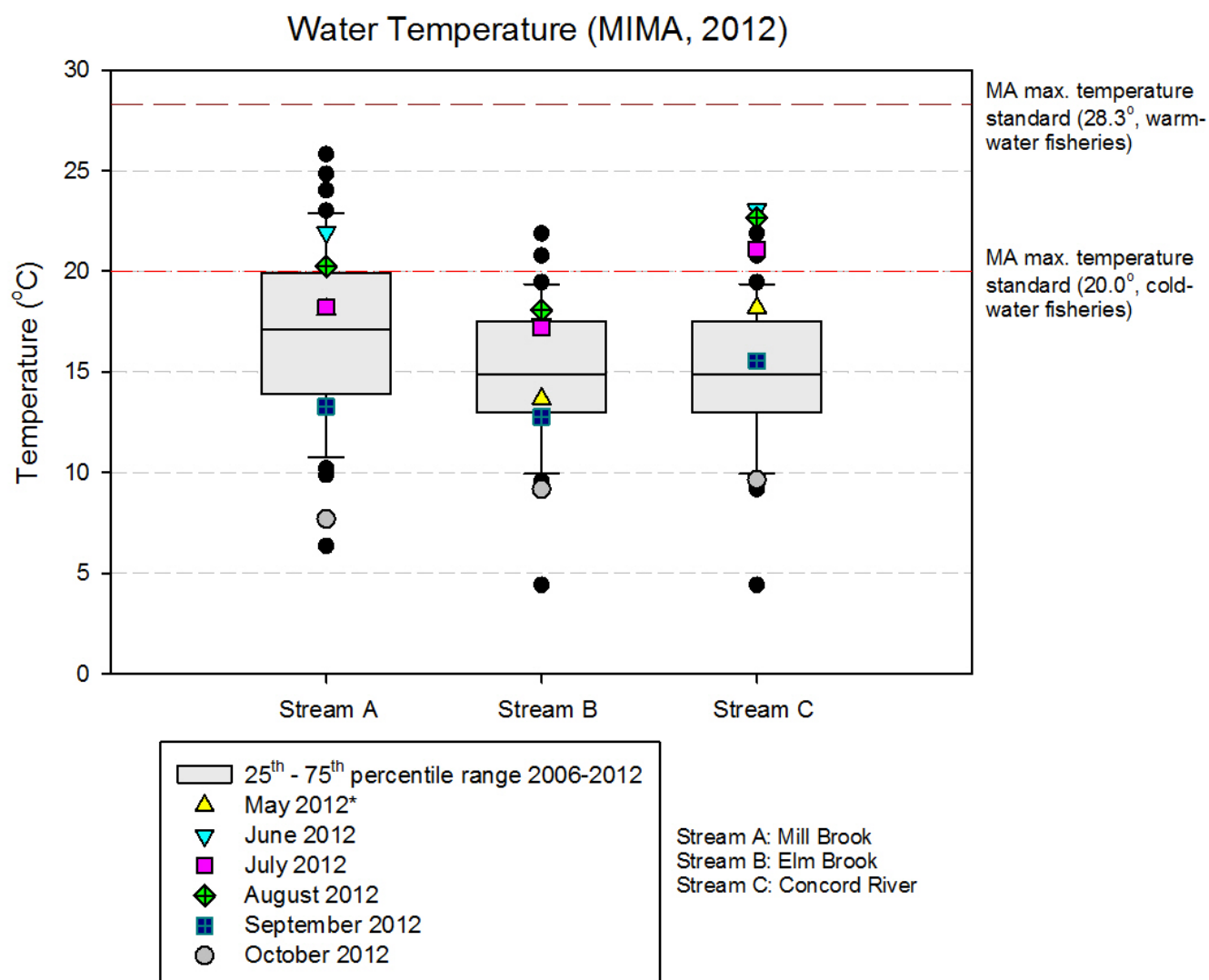


Figure 5. Water temperature (surface) from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

Dissolved Oxygen

Dissolved oxygen (DO) is a critical indicator of water quality because aquatic life generally needs DO concentrations at or above 5 mg/L to thrive. Low oxygen can directly kill or stress organisms such that they will not be able to successfully reproduce or grow. Water with less than 1 part per million (ppm) of oxygen is considered anoxic (no oxygen present). Elm Brook (Stream B) was well oxygenated throughout 2012 (Figure 6), and most measurements from the two other sites were above the (6 mg/L) state DO standard. The August measurement from Mill Brook (Stream A) was slightly below the state DO standard.

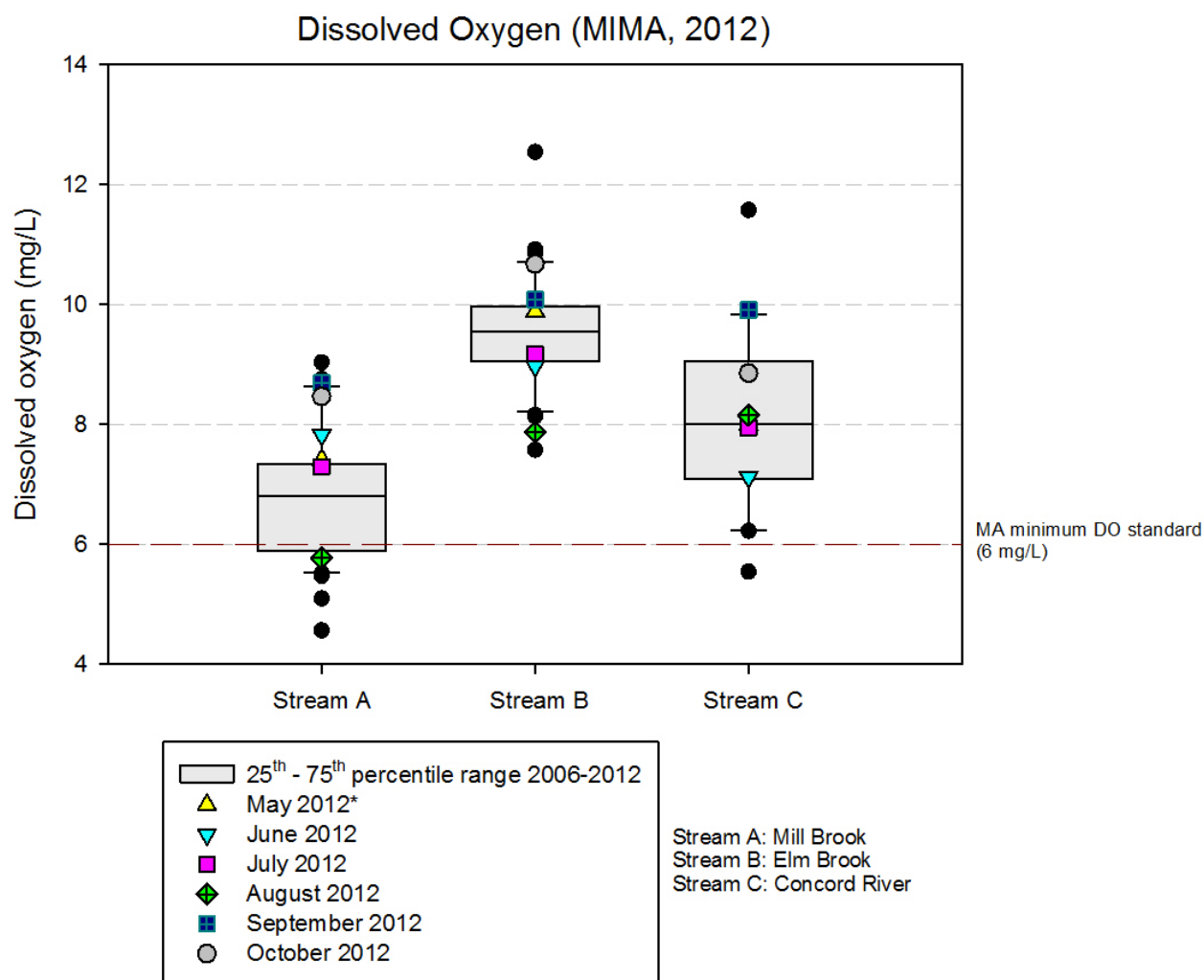


Figure 6. Dissolved oxygen (surface) from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

Acid Neutralizing Capacity

Acid neutralizing capacity (ANC) is also known as alkalinity, or buffering capacity. It is due primarily to the presence of naturally available bicarbonate, carbonate, and hydroxide ions, with bicarbonate being the major form. Most states do not have numerical criteria for ANC in their water-quality standards. ANC values greater than 100 $\mu\text{eq/L}$ are considered well-buffered, while values less than zero typify acidic waters (Stoddard et al. 2003). Acid neutralizing capacity measured in the 2012 samples (Figure 7) illustrates that MIMA streams were well-buffered, likely due to the underlying geology. May (spring) 2012 ANC measurements follow the typical seasonal pattern of being lower than August (summer) values. This effect is likely due to the contribution of episodic acidification from spring snowmelt and runoff (and also illustrates the ability of the robust ANC to counteract the acidification pulses).

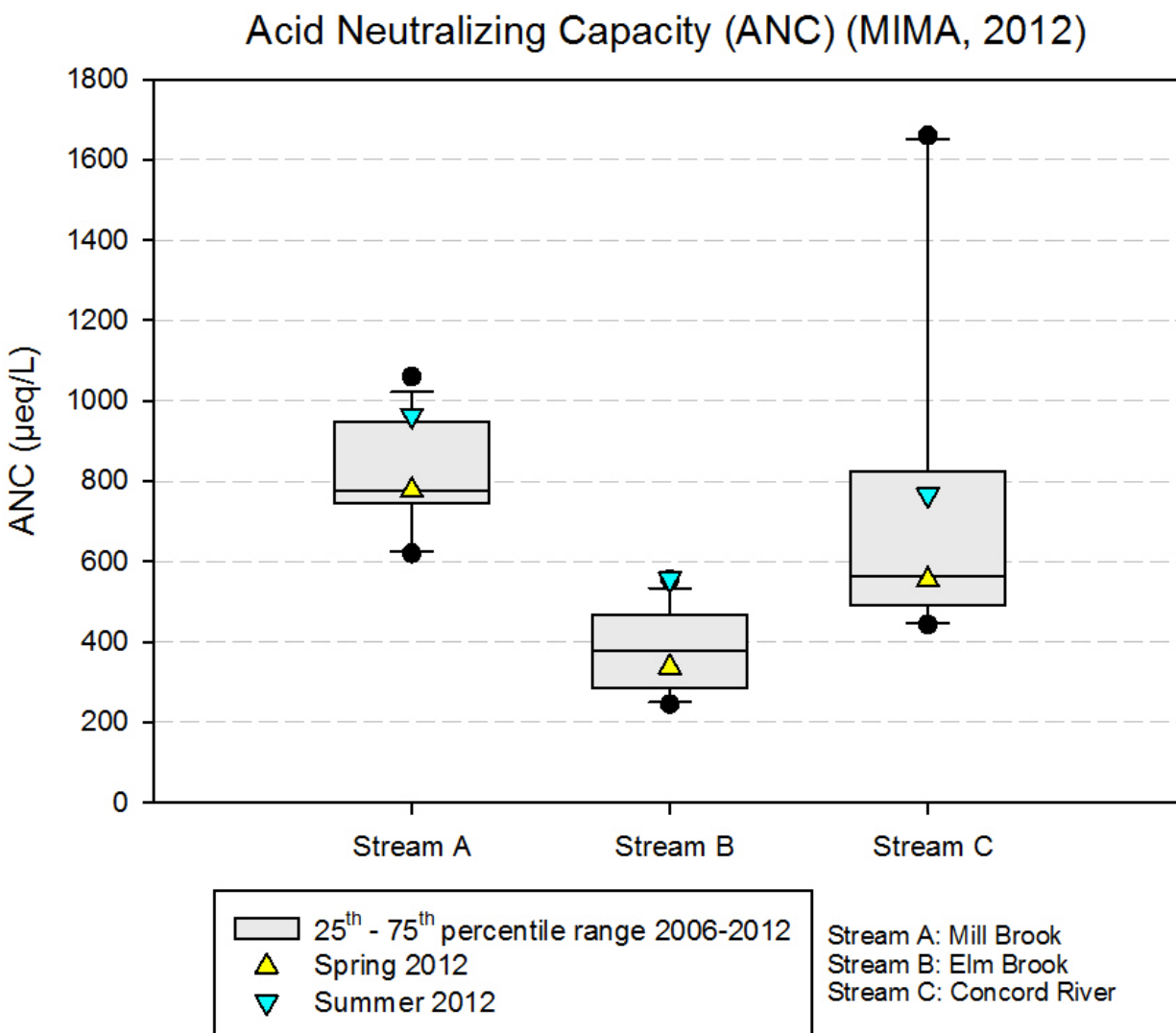


Figure 7. Acid neutralizing capacity from 2012 water samples overlaid on a box plot of measurements taken from 2006-2012.

Apparent Color

Color in pond and stream water is caused by natural metallic ions, humus and peat materials, plankton, weeds, and industrial wastes. Color is reported in Pt-Co units (PCU). True color is the color measurement of water from which suspended particles have been removed by filtration. Apparent color (the measurement method utilized by NETN) is determined on original samples without filtration. Color can be a rough indicator for organic acidity.

Water bodies with apparent color values of greater than 25 PCU are considered to be highly colored, and often exhibit reduced water clarity and high phosphorus concentrations. Values of color are usually not included in water quality standards, except to note that they should be “as naturally occurs”.

Median color values from 2006 to 2012 monitoring (Figure 8) show that MIMA streams tend to be highly colored. Spring and summer measurements from Elm Brook were very close to each other in value and just below the overall median, while the Mill Brook and Concord River values were more variable. Much of the color is likely due to runoff and sediment input to the streams, rather than dissolved constituents, since the samples were not filtered before analysis.

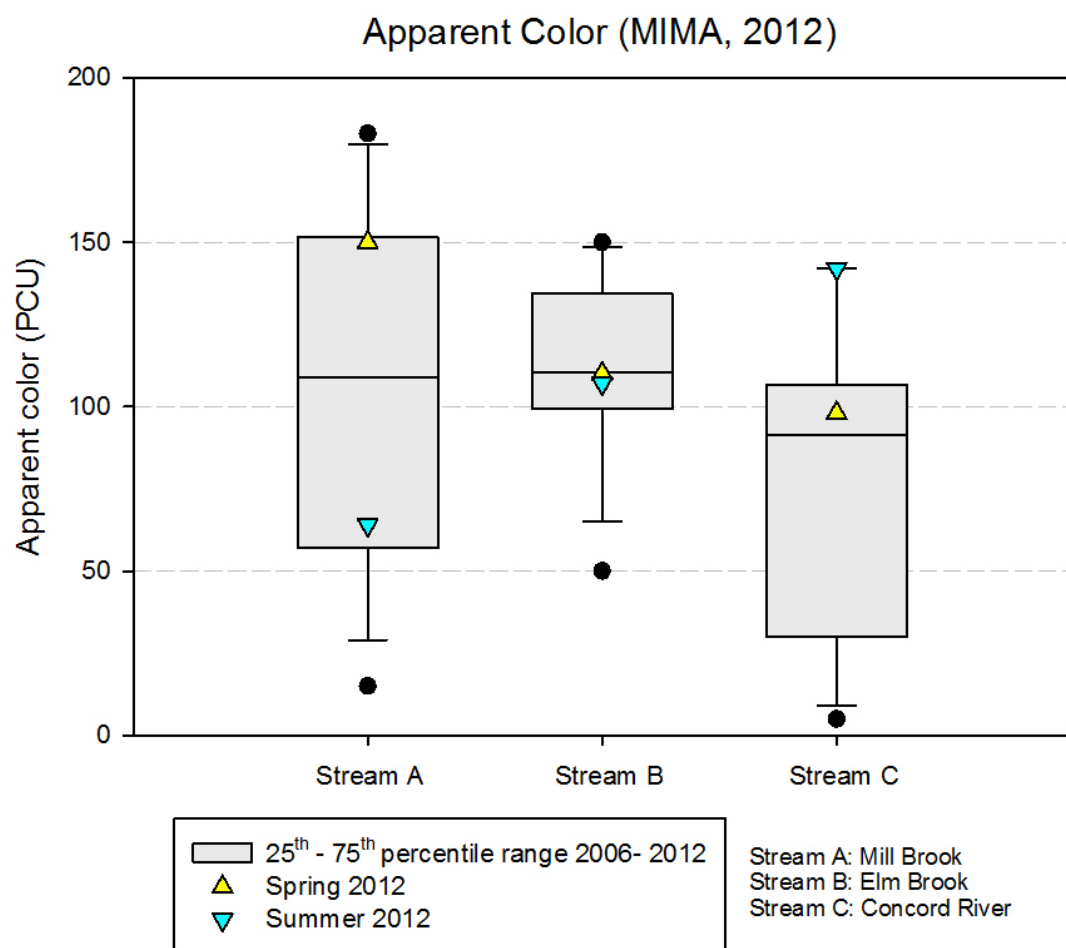


Figure 8. Apparent color from 2012 water samples overlaid on a box plot of measurements taken from 2006-2012.

Dissolved Organic Carbon

NETN began measuring dissolved organic carbon in 2012. Carbon is a nutrient required for biological processes. Sources of organic carbon in water include humic substances from plant and soil organic matter, wetland peat deposits, and atmospheric deposition. Certain forms of DOC can contribute to “tea” color in water, which can affect light attenuation. DOC is also an important part of the energy balance and acid-base chemistry in many freshwater systems. It also affects the transport (solubility and bioavailability) of metals, including mercury, in aquatic systems.

DOC concentrations in most streams in temperate zones range from 1 mg/L to 20 mg/L, with a worldwide mean of 5.75 mg/L (Meybeck 1982). MIMA DOC concentrations (Figure 9) were moderate in 2012, with most values slightly higher than this mean.

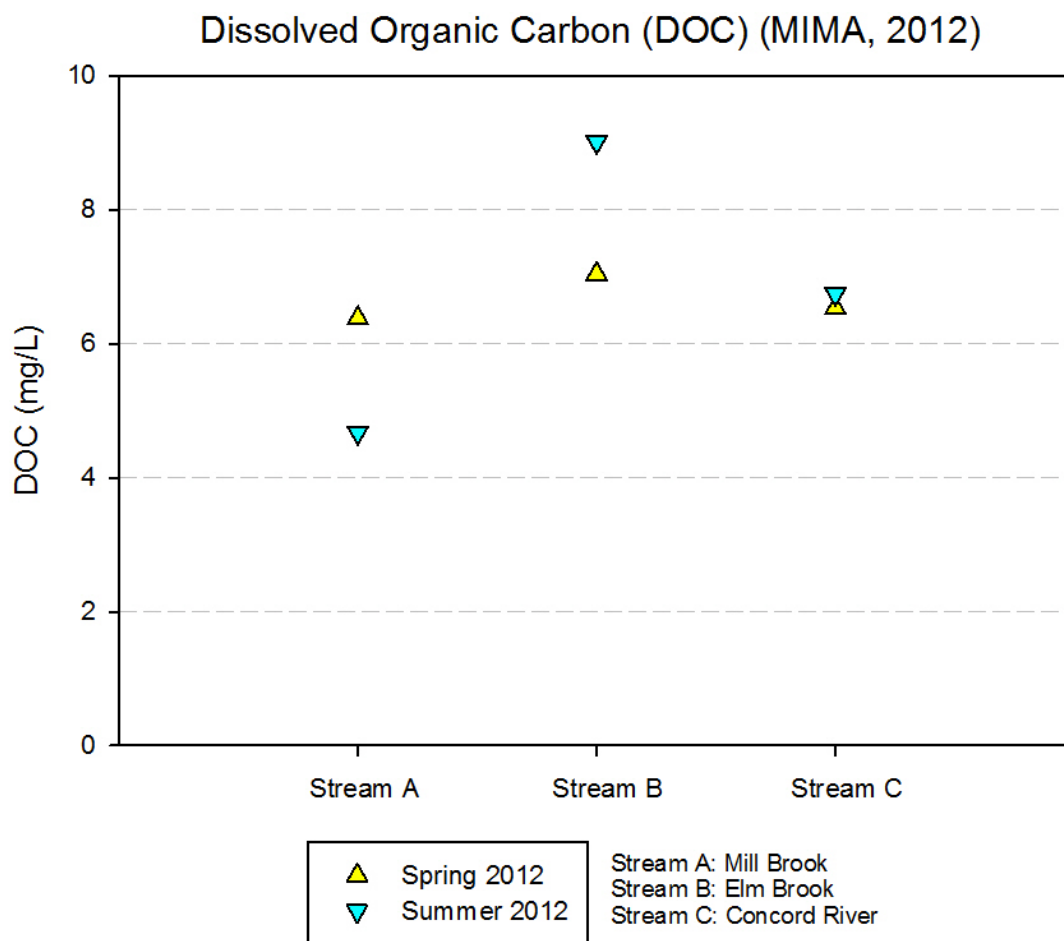


Figure 9. Dissolved organic carbon (DOC) from 2012 spring and summer water samples.

Turbidity

Turbidity is the measure of the relative clarity of a liquid. It is measured by passing light through a water sample to determine how much light is scattered, and the results are reported in nephelometric turbidity units (NTU). Turbidity is caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms. In natural waters, turbidity is often used as an indicator of water quality and productivity. Turbidity is measured in the field using an electronic meter.

Turbidity in the water can create aesthetic, ecological, and health issues. Turbid water may indicate runoff from construction, roads, agriculture or other types of pollution. Suspended sediment can carry nutrients and pesticides throughout the water system. Suspended particles near the surface absorb additional heat from sunlight, raising the water temperature. High turbidity levels can reduce the amount of light reaching lower depths of lakes and streams, which can inhibit growth of submerged aquatic plants, and reduce dissolved oxygen levels. Suspended materials can clog fish gills, affecting fitness, growth, and reproduction (U.S. Environmental Protection Agency 1997). Turbidity values measured in all MIMA streams during 2012 (Figure 10), the first year of NETN turbidity testing, were all in the low range of dry-weather turbidity of surface waters, which normally ranges from 0 to 10 NTU (U.S. Environmental Protection Agency 1999).

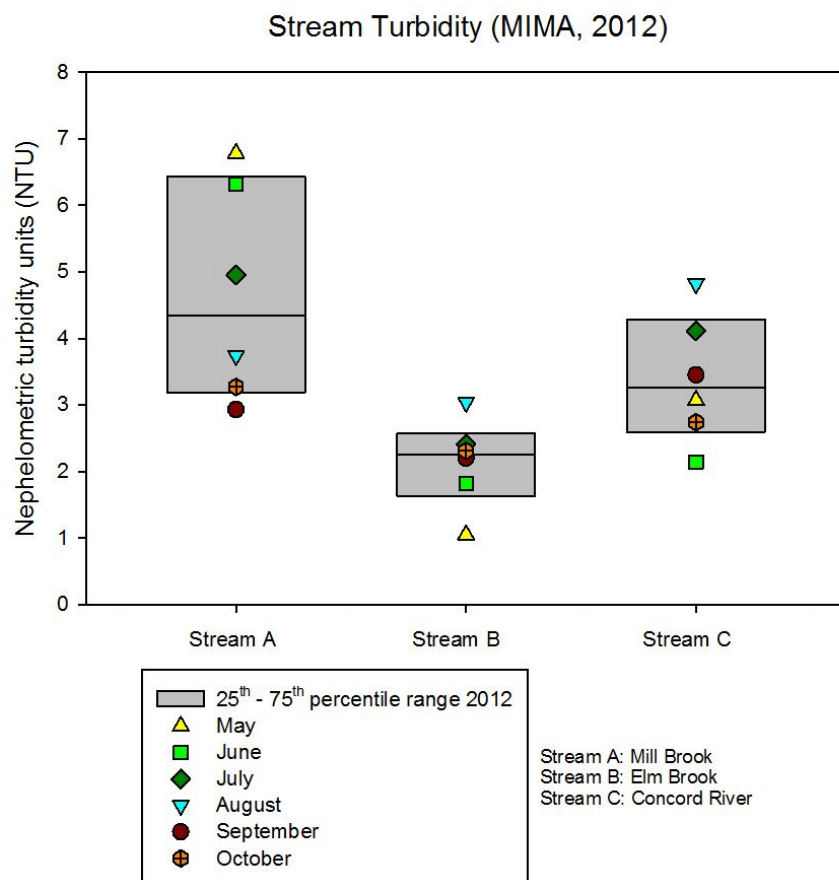


Figure 10. Stream turbidity from 2012 monthly measurements. The data are overlaid on a box plot of measurements taken in 2012.

Nutrient Enrichment

Nutrient enrichment and the acceleration of eutrophication have been identified in most NETN parks as one of the stressors of greatest concern. Total phosphorus and several forms of nitrogen are measured to give managers information regarding the trophic status and productivity of freshwater systems.

Phosphorus

Phosphorus (P) is one of the major nutrients needed for plant growth. It is generally present in small amounts in natural systems and limits the plant growth in streams and ponds. Total phosphorus (TP) is a measure of both inorganic and organic forms of phosphorus, and is the common water quality standard or criteria metric. Although several forms of phosphorus were tested individually since 2006, tests for total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP) were discontinued in 2012.

In 2012 all phosphorus concentrations (Figure 11) were in the high range. All TP values were well above the EPA Region 14 criterion of 31.25 µg/L. As described above (“Water Quality Standards”), the EPA criteria do not have any regulatory meaning. There are no numeric Massachusetts TP standards.

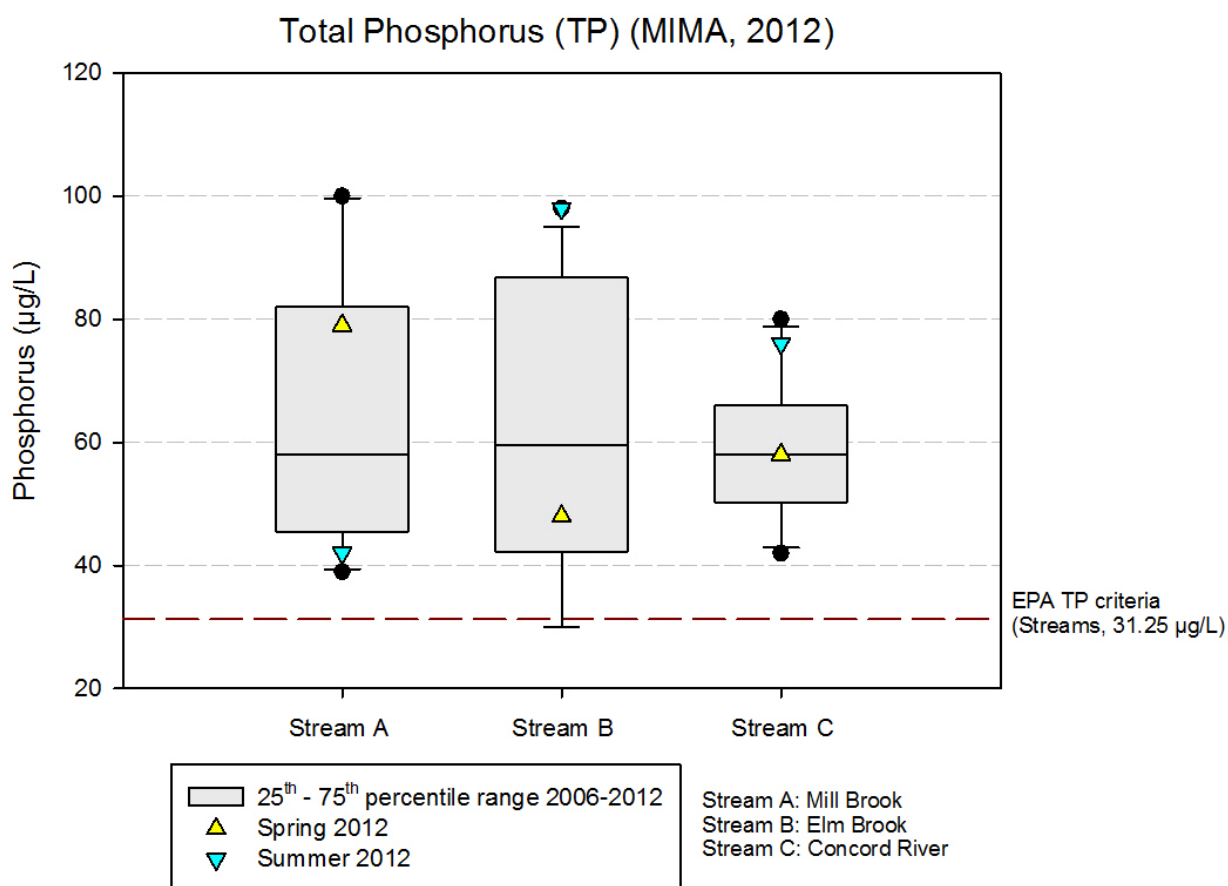


Figure 11. Total phosphorus (TP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2012.

Nitrogen

Total nitrogen (TN) is a measure of all forms of nitrogen (organic and inorganic). Nitrogen is an essential plant element and is often the limiting nutrient in marine waters, and it can also limit some freshwater systems. The importance of nitrogen in the aquatic environment varies according to the relative amounts of the forms of nitrogen present, including nitrate, nitrite, and ammonia. Nitrate (NO_3) is the most oxidized and stable form of nitrogen in a water body, and is the primary form of nitrogen used by plants as a nutrient. Nitrite (NO_2) is an unstable form of nitrogen that is either rapidly oxidized to nitrate (nitrification) or reduced to nitrogen gas (denitrification). This form of nitrogen can also be used as a source of nutrients for plants. Ammonia (NH_3) is generated by bacteria as a decomposition product of nitrogenous organic compounds, and is also readily assimilated by plants. Results of NO_3 , NO_2 , and NH_3 tests are all reported as the concentrations of the N component of these compounds, expressed in mg/L.

Test results for several forms of nitrogen are shown in Figure 12. All but one of the 2012 TN values exceeded the EPA Region 14 criterion of 0.71 mg/L, although as with TP this criterion does not have regulatory meaning. All of the TN results were below 2.0 mg/L, the value used as a TN standard in several northeast states (Massachusetts has no numeric TN standard). Nitrate appeared to be a substantial contributor to TN levels at all sites. Nitrite test results in all streams were low, and all 2012 ammonia test results were below the method reporting limit of 0.08 mg/L.

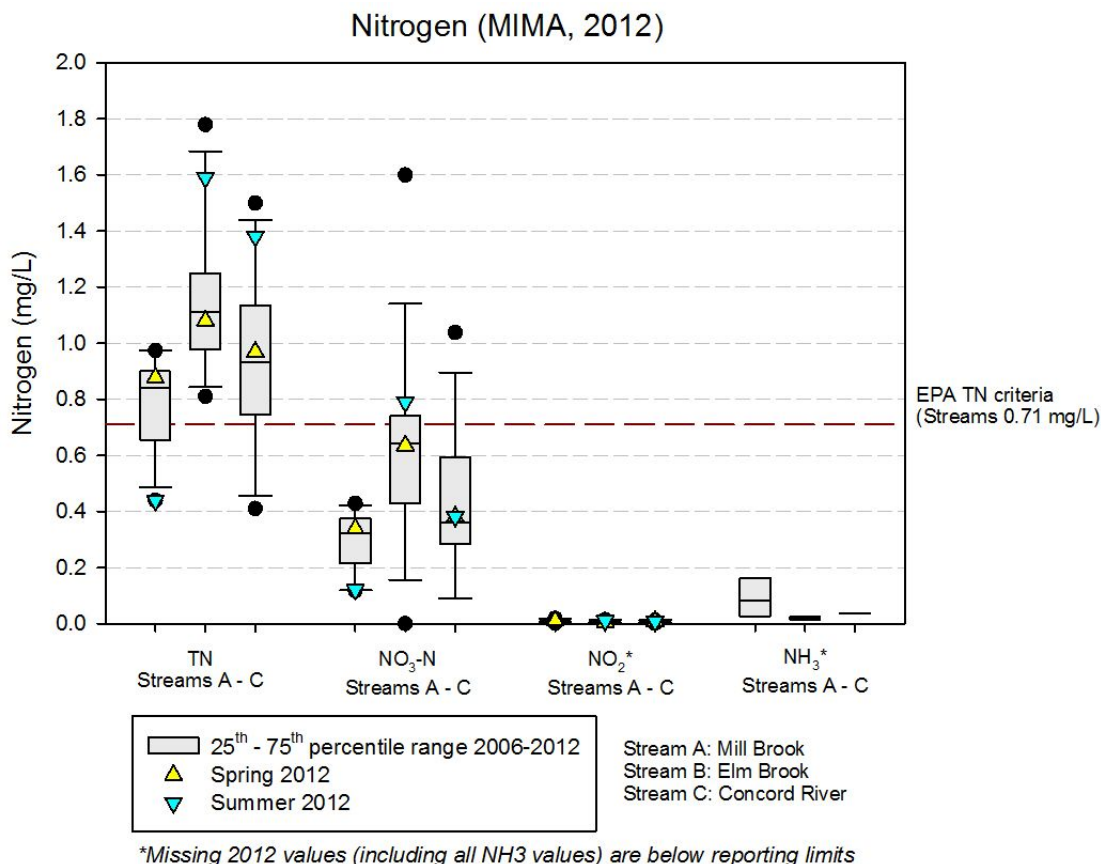


Figure 12. Total nitrogen (TN), nitrate ($\text{NO}_3\text{-N}$), nitrite (NO_2) and ammonia (NH_3) from 2012 water samples. The data are overlaid on a box plot of measurements taken from 2006-2012.

Other Analytes

Chloride

Chloride is one of the major negatively-charged ions in fresh water systems. The chloride content of natural surface waters will depend to a great extent on the geology of the area. Concentrations are generally greater in lakes that are in proximity to marine regions. Another source of chloride is road run-off from de-icing materials. Chloride is important in terms of metabolic processes, as it influences osmotic salinity balance and ion exchange.

Average chloride concentration in natural fresh water is 234.1 μ eq/L (Wetzel 1983). Chloride values in MIMA samples were extremely high in 2012 (Figure 13), especially at Mill Brook and Elm Brook, which are both in close proximity to major roads.

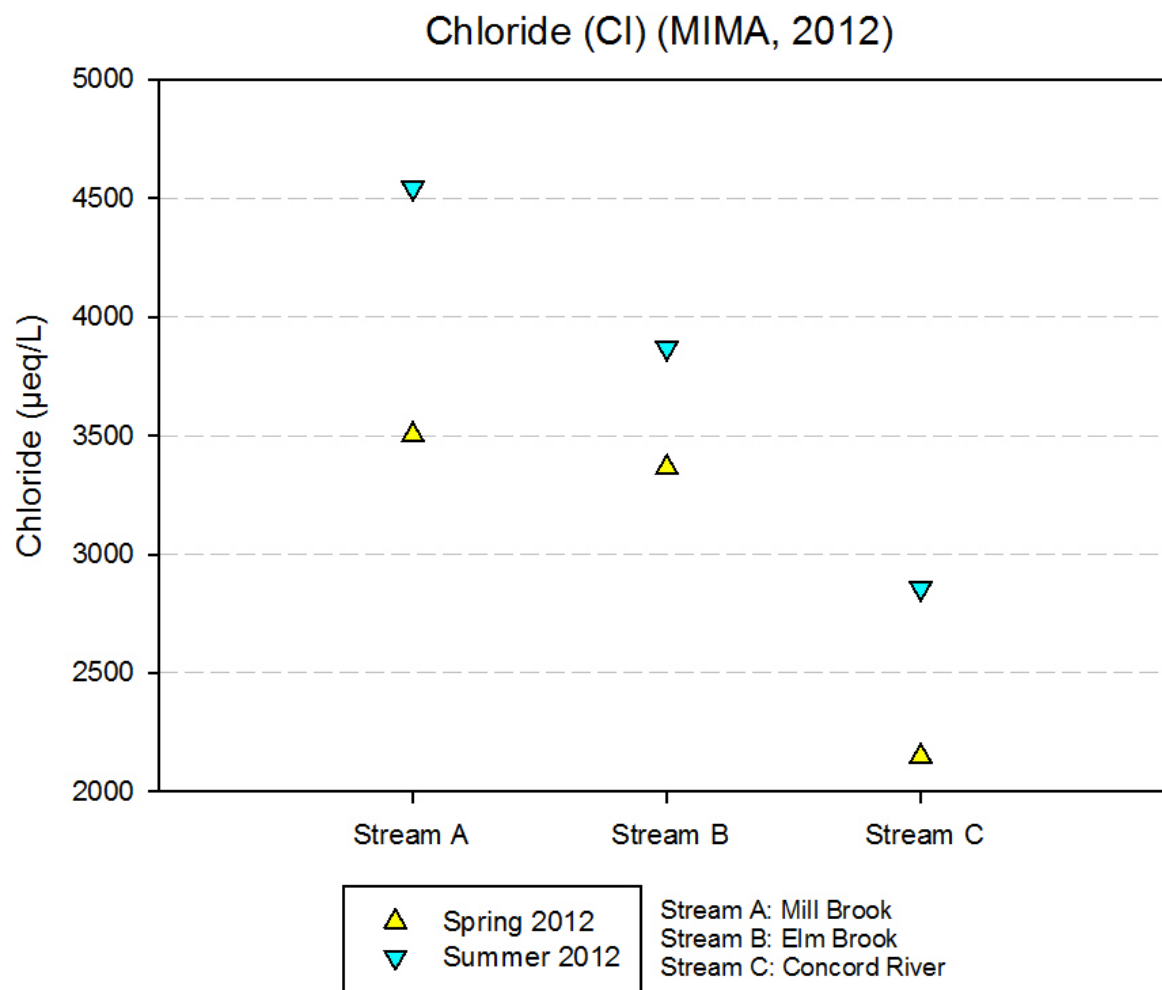


Figure 13. Chloride from 2012 spring and summer water samples.

Sulfate

Sulfate is found in most natural waters, originating from watershed geology and soils, and also from atmospheric transport and deposition (in precipitation) of by-products from the combustion of fossil fuels. Sulfate can play a major role in acidification of lakes and streams. Sulfate concentrations in atmospheric deposition have declined significantly since 1982, in part due to the 1995 implementation of Phase I controls of the Clean Air Act Amendments and in part to other long-term pollution reduction efforts (Kahl 1999).

The usual range of sulfate concentration in natural water is 104 $\mu\text{eq/L}$ to 695 $\mu\text{eq/L}$ (Wetzel 1983). Sulfate concentrations at MIMA were moderate in 2012 (Figure 14).

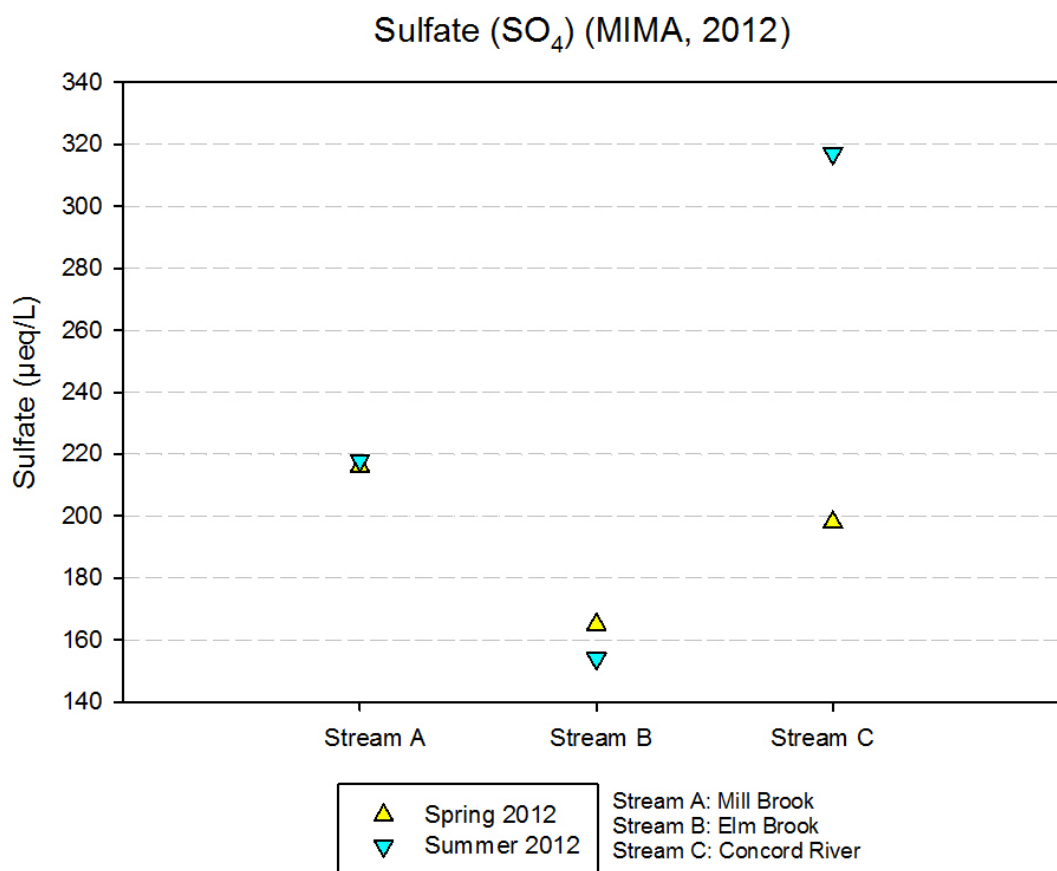


Figure 14. Sulfate from 2012 spring and summer water samples.

Water Quantity

Monthly stream discharge measurements, taken with a current meter and wading rod, can be used to calculate loading of nutrient chemical constituents (flow times concentration), and also provide a record of variations in stream flow. Stream stage (height of water) measurements can be paired with discharge values and over time a stage to discharge relationship can be calculated. Once this relationship is established, investigators can interpolate the stream discharge from the stage measurement alone. Numerous discharge measurements at all ranges of streamflow are required to establish and maintain an accurate stage to discharge relationship. Stream stage measurements from 2012 are graphed in Figure 15. Discharge and stage measurements from 2012 are listed in Table A3 in Appendix A. No discharge measurements are available for the Concord River (Stream C).

Streamflow followed the expected seasonal sequence of high discharge in May to minimal flow in July and August, with partial recovery in October. NETN staff are continuing to review discharge and stage measurement methodology and quality assurance/quality control procedures in order to enhance the quality and utility of the water quantity data. A stage to discharge relationship graph will be produced once sufficient data are collected.

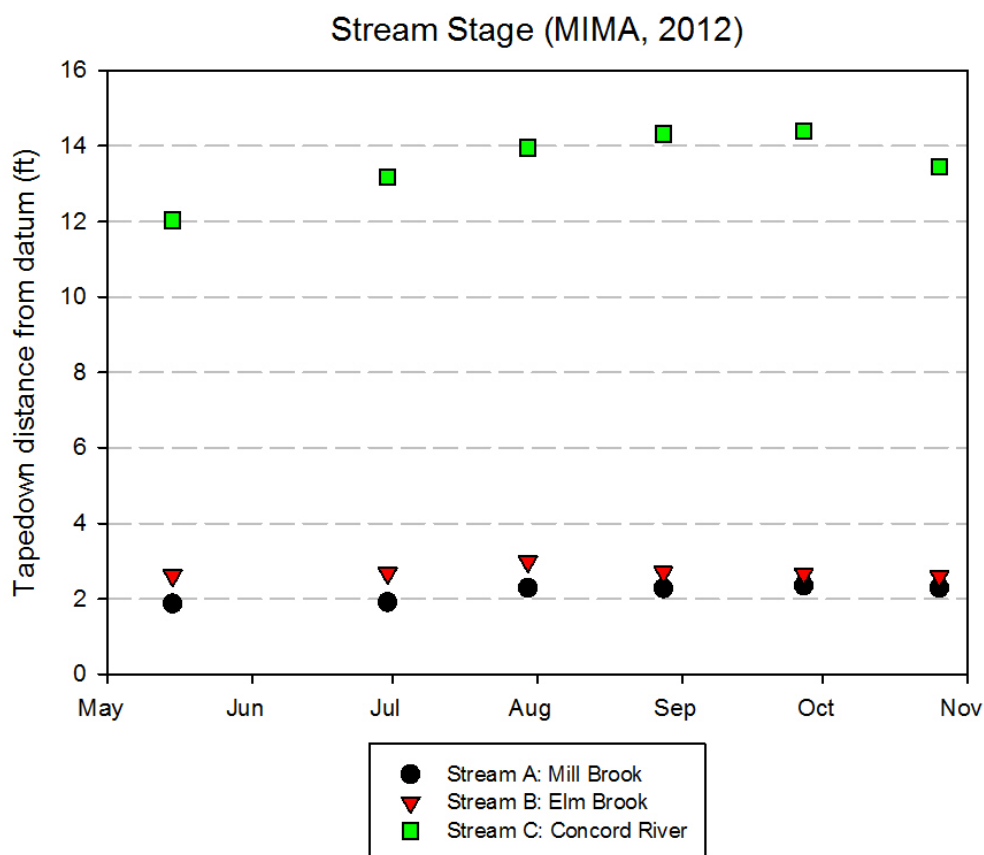


Figure 15. Stream stage obtained in 2012 by measuring from a permanent datum point down to the water surface. *Note: Larger tapedown distances indicate LOWER water levels.*

Invasive Aquatic Plants

Invasive aquatic plant monitoring was not conducted at MIMA during the 2012 monitoring season, since the protocol specifies that targeted invasive aquatic plant monitoring is only conducted at pond and lake sites. However, during future visits to all NETN parks, monitoring crews will be increasingly attentive for the presence of Didymo (*Didymosphenia geminata*), also known as “rock snot,” a highly invasive algae species that has recently invaded the northern reaches of the Connecticut River in New Hampshire and the White River and Battenkill Rivers in Vermont. This species has a great potential to alter habitats and displace native species, and is of great concern to officials in regions where infestations have been established.

Didymo can easily be spread by waders and potentially by water monitoring equipment and other gear that touches the bottoms of streams in infested areas. Just one cell breaking off and drifting downstream can spread the algae. Enhanced equipment cleaning and decontamination procedures are being included in the latest NETN monitoring protocol revision (Gawley et al. In Prep).

Since non-native, invasive plants have recently been detected with increasing frequency in New England lakes and ponds, it has become crucial to closely monitor the status of park waters. The early detection of an infestation can make eradication or control more feasible, and it can lead to efforts that reduce the spread of the plant to neighboring water bodies. Designating the early detection of these plants as a NETN vital sign and the ongoing partnership with state and local monitoring and eradication efforts are highly effective prevention strategies.

Summary

Most water quality parameters for the monitored streams were within state standards, and were generally within the range of EPA criteria, where applicable. The majority of values were within the ranges of the historic NETN monitoring data from MIMA. ANC measurements showed that all streams had sufficient buffering to avoid severely depressed pH values from spring snowmelt and runoff that can contribute acidity and sediment to the stream water.

Test results for TN and NO₃ were moderately high in most 2012 samples. Results for NO₂ were low at all sites. All ammonia (NH₃) test results were below the method reporting limit of 0.08 mg/L. All total phosphorus results for 2012 were high, and significantly above the EPA Region 14 criterion of 31.25µg/L. These results indicate that some nutrient enrichment is occurring in MIMA streams.

Seven years of monitoring under the NETN protocol have provided critical baseline information on the chemical and physical status of the streams monitored in Minute Man National Historical Park. Several changes implemented in the 2012 monitoring season, including the addition of sulfate, chloride, and dissolved organic carbon (DOC) analyses to the spring and summer water chemistry testing, will expand the scope and usefulness of the monitoring data. As more data are collected, the ability to detect changes outside this natural range of variability will increase, which in turn will more clearly indicate the status of the vital signs of water quality, nutrient enrichment, water quantity, and the detection of invasive plant species.

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Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2012.

Table A1. YSI sonde in-situ stream water quality measurements collected at MIMA.

Site	NETN Code	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (µS/cm)
Mill Brook (Stream A)	MIMASA	5/15/2012	0.59	18.12	7.41	7.03	552.00
Mill Brook (Stream A)	MIMASA	6/30/2012	0.40	21.93	7.82	6.90	603.00
Mill Brook (Stream A)	MIMASA	7/30/2012	0.34	18.23	7.29	7.14	723.00
Mill Brook (Stream A)	MIMASA	8/28/2012	0.24	20.24	5.77	6.99	652.00
Mill Brook (Stream A)	MIMASA	9/27/2012	0.33	13.28	8.69	7.30	693.00
Mill Brook (Stream A)	MIMASA	10/26/2012	0.29	7.69	8.46	7.03	615.00
Elm Brook (Stream B)	MIMASB	5/15/2012	0.35	13.67	9.88	7.05	490.00
Elm Brook (Stream B)	MIMASB	6/30/2012	0.13	17.36	8.97	6.87	473.00
Elm Brook (Stream B)	MIMASB	7/30/2012	0.26	17.19	9.17	7.27	573.00
Elm Brook (Stream B)	MIMASB	8/28/2012	0.09	18.08	7.87	6.97	548.00
Elm Brook (Stream B)	MIMASB	9/27/2012	0.32	12.78	10.08	7.39	590.00
Elm Brook (Stream B)	MIMASB	10/26/2012	0.16	9.18	10.67	7.23	489.00
Concord River	MIMASC	5/15/2012	0.54	18.20	7.99	7.07	394.00
Concord River	MIMASC	5/15/2012	0.86	18.21	8.02	7.06	376.00
Concord River	MIMASC	6/30/2012	0.71	23.09	7.04	7.01	422.00
Concord River	MIMASC	6/30/2012	0.73	23.05	7.12	7.12	423.00
Concord River	MIMASC	7/30/2012	0.43	21.10	7.94	7.48	530.00
Concord River	MIMASC	7/30/2012	0.64	21.09	7.93	7.45	532.00
Concord River	MIMASC	8/28/2012	0.57	22.66	8.15	7.59	471.00
Concord River	MIMASC	8/28/2012	0.63	22.76	8.31	7.56	469.00
Concord River	MIMASC	9/27/2012	0.52	15.55	9.90	7.76	548.00
Concord River	MIMASC	9/27/2012	0.52	15.42	9.93	7.73	548.00
Concord River	MIMASC	10/26/2012	0.69	9.65	8.85	7.69	441.00
Concord River	MIMASC	10/26/2012	0.79	9.64	8.75	7.37	444.00

Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2012 (continued).

Table A2. Laboratory nutrient chemistry data for MIMA. “<MRL” indicates the result was below the method reporting limit (0.1 for TN, 0.005 for NO₂, and 0.08 for NH₃). *Missing values indicate data are unavailable.*

Site	Date	ANC (µeq/L)	Apparent Color (PCU)	DOC (mg/L)	TP (µg/L)	TN (mg/L)	NO ₃ (µeq/L)	NO ₃ - N [calc.] (mg/L)	NO ₂ (mg/L)	NH ₃ (mg/L)	Cl (µeq/L)	SO ₄ (µeq/L)
Mill Brook (Stream A)	5/15/2012	777.00	150	6.38	79	0.877	24	0.338	0.0100	<MRL	3,502	216
Mill Brook (Stream A)	8/28/2012	964.00	64	4.67	42	0.439	8.5	0.120	<MRL	<MRL	4,543	218
Elm Brook (Stream B)	5/15/2012	337.00	110	7.04	48	1.080	45	0.635	0.0055	<MRL	3,364	165
Elm Brook (Stream B)	8/28/2012	556.00	107	9.01	98	1.590	56	0.790	0.0093	<MRL	3,869	154
Concord River	5/15/2012	554.00	98	6.53	58	0.969	27	0.381	0.0087	<MRL	2,148	198
Concord River	8/28/2012	766.00	142	6.74	76	1.380	27	0.381	0.0069	<MRL	2,858	317

Appendix A. Minute Man (MIMA) Water Monitoring Data, 2012 (continued).

Table A3. Stream stage and discharge data for MIMA. *Missing values indicate data are unavailable.*

Site	Date	Tapedown from datum (ft)	Total cross section area (sqft)	Average velocity (f/s)	Discharge (cfs)
Mill Brook (Stream A)	5/15/2012	1.87	13.47	0.26	3.49
Mill Brook (Stream A)	6/30/2012	1.91	12.83	0.14	1.80
Mill Brook (Stream A)	7/30/2012	2.29	7.54	0.19	1.44
Mill Brook (Stream A)	8/28/2012	2.28	5.69	0.28	1.62
Mill Brook (Stream A)	9/27/2012	2.35	4.59	0.15	0.71
Mill Brook (Stream A)	10/26/2012	2.29	3.95	0.28	1.12
Elm Brook (Stream B)	5/15/2012	2.61	1.01	0.59	0.62
Elm Brook (Stream B)	6/30/2012	2.67	0.76	0.25	0.19
Elm Brook (Stream B)	7/30/2012	2.98	0.80	0.13	0.11
Elm Brook (Stream B)	8/28/2012	2.70	1.12	0.11	0.12
Elm Brook (Stream B)	9/27/2012	2.66	1.43	0.06	0.09
Elm Brook (Stream B)	10/26/2012	2.59	1.72	0.15	0.25
Concord River	5/15/2012	12.03			
Concord River	6/30/2012	13.17			
Concord River	7/30/2012	13.96			
Concord River	8/28/2012	14.32			
Concord River	9/27/2012	14.39			
Concord River	10/26/2012	13.45			

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