



Water Quality Monitoring at Saint-Gaudens National Historic Site

Northeast Temperate Network 2012 Summary Report

Natural Resource Data Series NPS/NETN/NRDS—2013/542



ON THE COVER

Blow-Me-Down Pond, July 2012

Photograph by: Bill Gawley

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Introduction

This report on the water quality of Saint-Gaudens National Historic Site (SAGA) 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 one park pond and two streams to be sampled monthly from May through October at SAGA. NETN lakes and ponds were not monitored in May of 2012, due to administrative issues. 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

Three water quality monitoring sites have been selected at SAGA for the long-term monitoring program (Table 1). The three sites selected to represent the two streams and the major impoundment in the park are all water quality sites that have been measured by the park since 1997 (Walasewicz 2003). The site behind the impoundment on Blow-Me-Down Pond (SAGAPA) was the park's historic Site 5. The stream site on Blow-Me-Up Brook (SAGASA) was historic Site 1, and the site on Blow-Me-Down Brook (SAGASB), located below the confluence with Blow-Me-Up Brook, was historic Site 3 (Figure 1).

Blow-Me-Up Brook is classified as a cold water fishery, loosely defined as water that can support, on a year-round basis, wild and stocked brook trout (*Salvelinus fontinalis*) or other species requiring similar conditions. Blow-Me-Down Brook is considered a warm water fishery, capable of supporting bass, pickerel, sunfish, and similar species.

Table 1. Water quality monitoring sites at Saint-Gaudens NHS.

Waterbody	NETN Site Code	Latitude	Longitude	Site Remarks
Blow-Me-Down Pond (Pond A)	SAGAPA	43.4972500	-72.3754000	
Blow-Me-Up Brook (Stream A)	SAGASA	43.5018833	-72.3708333	Cold water fisheries - includes trout
Blow-Me-Down Brook (Stream B)	SAGASB	43.5033333	-72.3790833	Warm water fisheries- includes sunfish

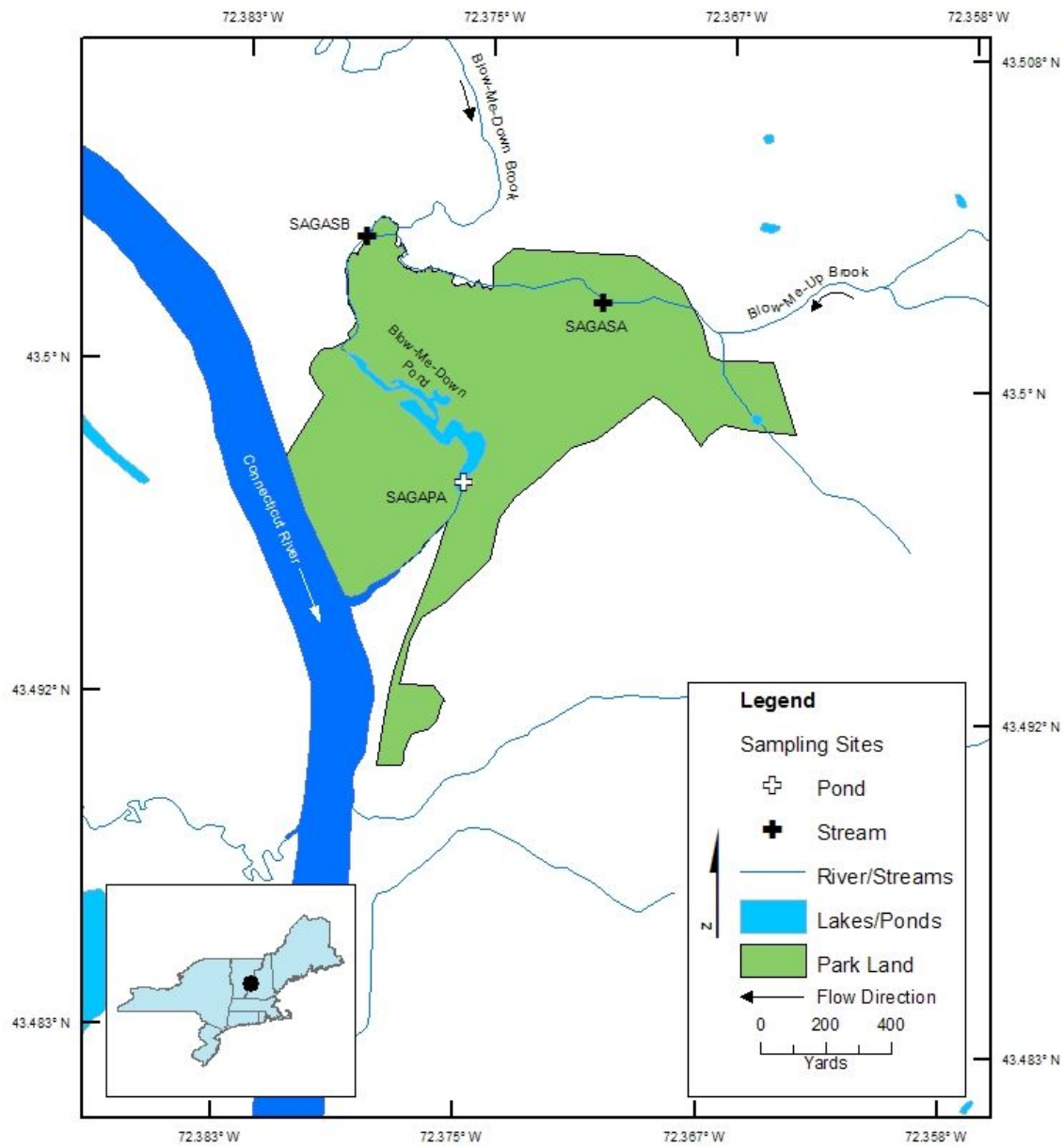


Figure 1. NETN water monitoring sites at Saint-Gaudens NHS.

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, transparency (pond site only), weather, stream flow (discharge), and stream and pond stage. In May (stream only), June (pond only) and August (both sites), 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*. The pond sampling procedure entailed collecting all in-situ measurements and water samples from the deepest point of the pond (approximately 3 meters). Nutrient chemistry parameters were analyzed from a half-meter grab sample, obtained by submerging the sample bottle directly in the pond with a gloved hand.

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. Stream and pond stage were obtained by using a folding wooden ruler (engineering scale) to measure from a fixed datum point on a large boulder or other stable surface to the surface of the water. Bolts were installed to permanently mark several stream datum points in July 2012.

In-situ stream water chemical and physical measurements and water samples were collected within 5 meters of 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. Grab samples were obtained by submerging the sample bottle directly in the stream with a gloved hand.

Water Quality Standards

Surface waters of National Forests and surface waters designated as natural are considered outstanding resource waters (ORW) in New Hampshire. “Water quality shall be maintained and protected in surface waters that constitute ORW” (New Hampshire Department of Environmental Services 1999). Class A is the most protective surface-water classification in New Hampshire’s Surface-Water Quality Regulations (New Hampshire Department of Environmental Services 1999). “Standards for temperature, pH, Color, nitrogen, and phosphorus are as naturally occurring in Class A waters. The pH of class B, the next most restrictive class, ranges from 6.5 to 8.0. Class A waters have a DO content standard of at least 75 percent saturation on the basis of a daily average, and an instantaneous minimum of at least 6 mg/L at any place or time except when concentrations of DO are less than 6 mg/L from natural causes. In cold water fish spawning areas from October 1 through May 14, the instantaneous minimum DO concentration shall be at least 8 mg/L” (New Hampshire Department of Environmental Services 1999).

“Surface waters within the top 25 percent of depth of thermally unstratified lakes, ponds, impoundments, and reservoirs or within the epilimnion shall contain a DO concentration of at least 75 percent saturation and instantaneous minimum DO concentration of at least 5 mg/L” (New Hampshire Department of Environmental Services 1999).

Table 2. New Hampshire stream water quality standards.

Water Body	Minimum Dissolved Oxygen (mg/L)	pH range (standard units)	Maximum Total Nitrogen (µg/L)	Maximum Total Phosphorus (µg/L)
Streams	6.0	6.5-8.0	As naturally occurs	As naturally occurs
Lakes and Ponds	5.0	6.0-9.0	As naturally occurs	As naturally occurs

EPA Ecoregion 8 water quality criteria (Table 2; U.S. Environmental Protection Agency 2000a, 2000b) 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 8 nutrient criteria.

Nutrient Criteria	Streams	Lakes
Total Phosphorus	10 µg/L	8 µg/L
Total Nitrogen	0.38 mg/L	0.24 mg/L
Chlorophyll <i>a</i>	0.63 µg/L	2.43 µg/L
Secchi disk depth	N/A	4.93 m

These criteria were developed specifically for Ecoregion 8 (which includes the entire states of Maine, New Hampshire, and Vermont) 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.

For lakes (water bodies greater than 10 acres and with mean water residence time of 14 or more days; U.S. Environmental Protection Agency 2000a), the criteria were established based on the lower 25th percentile of lakes that EPA found data for. This percentile of all lakes is expected to approximately correspond to the 75th percentile of reference (undisturbed) lakes. In other words, 75% of lakes in the ecoregion do not meet the criteria, nor do roughly 25% of reference lakes. For streams and rivers, a parallel approach was used to establish the nutrient criteria (U.S. Environmental Protection Agency 2000b).

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.

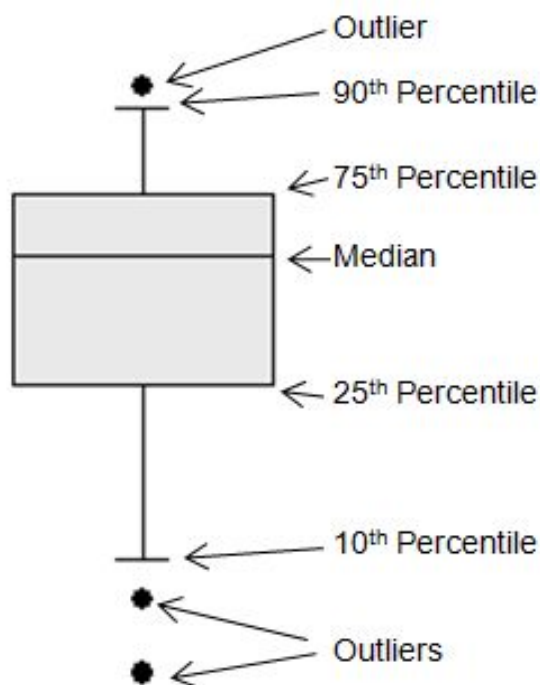


Figure 2. Explanation of box plot graph.

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 moderate to high ionic strength waters, and were generally within the upper range of the data from previous years.

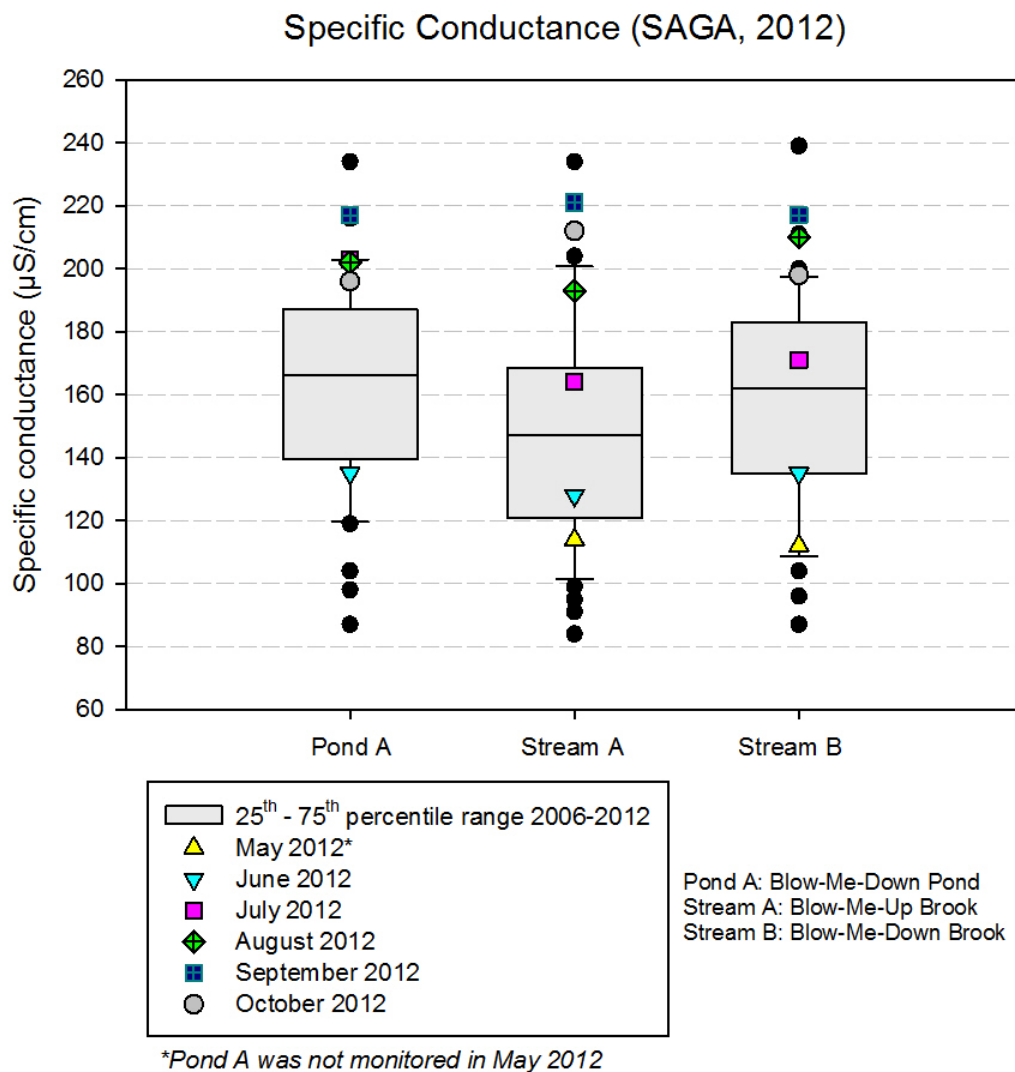
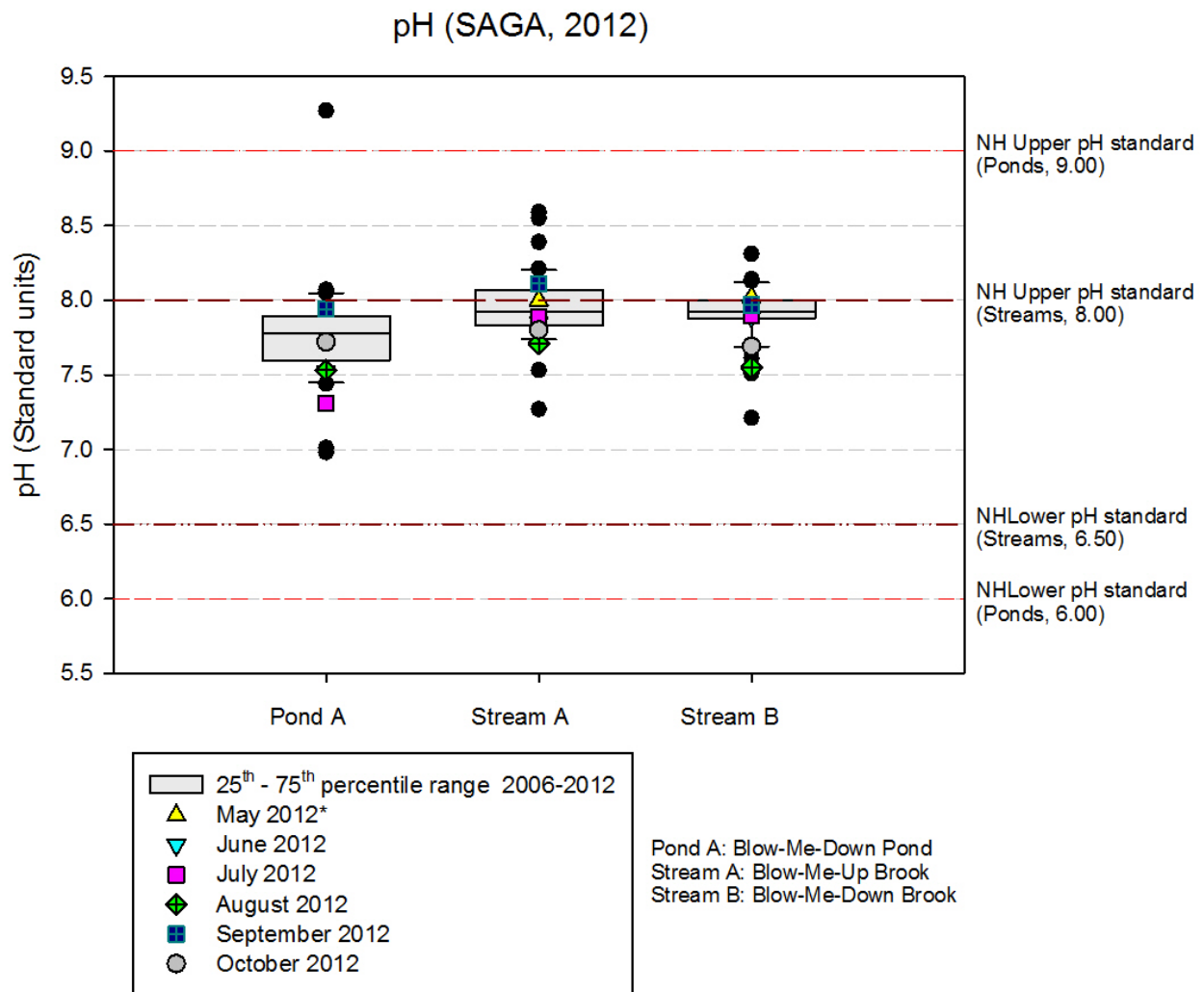


Figure 3. Specific conductance from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

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. New Hampshire stream water quality standards, similar to those of most northeast states, indicate that a pH between 6.5 and 8.0 is within the acceptable range. The pH range for New Hampshire lake and pond water quality standards is from 6.0 to 9.0. The pH values from the 2012 monitoring season (Figure 4) were basic, with the majority of values between the upper and lower New Hampshire water quality standards. The September measurement from Blow-Me-Up Brook and the May measurement from Blow-Me-Down Brook were slightly above the upper New Hampshire pH standard for streams.



*Pond A was not monitored in May 2012

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 (Figure 5) appeared to be within the normal range of variability in 2012, though the July values reflected the contributions of high air temperature and solar radiation. The July measurement for Blow-Me-Down Brook was the highest recorded at the site to date.

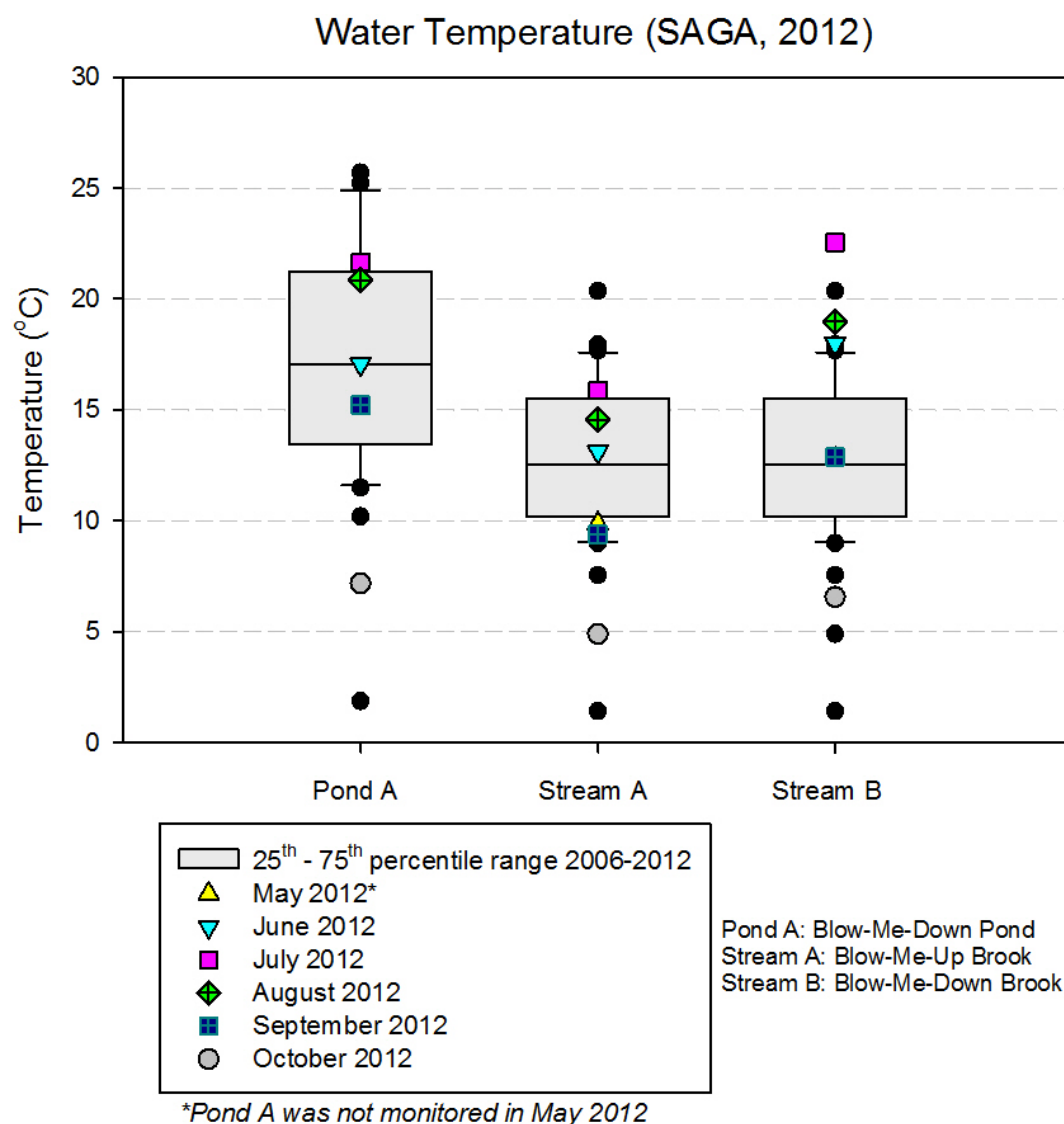


Figure 5. Water temperature (surface) from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

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). All DO measurements at SAGA in 2012 (Figure 6) showed the surface water was well oxygenated and were above the more stringent (6 mg/L) state stream DO standard (although the July value for Blow-Me-Down Pond was the lowest recorded to date). Complete data from pond water column profiles can be found in Appendix A.

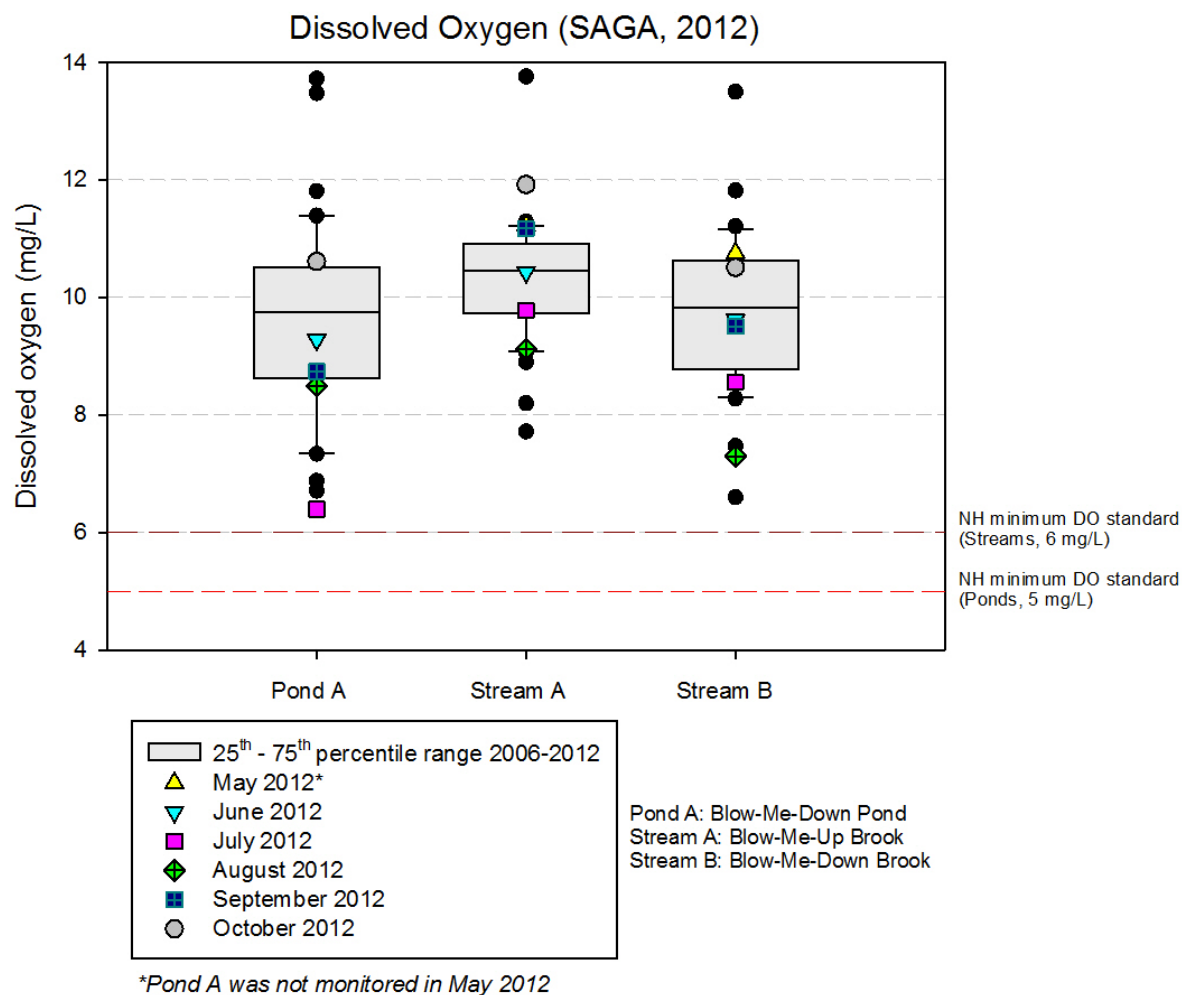


Figure 6. Dissolved oxygen (surface) from 2012 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2012.

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) follow the typical seasonal pattern of ANC in spring samples being lower than August (summer) values. This 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). All sites were very well-buffered, likely due to the underlying geology.

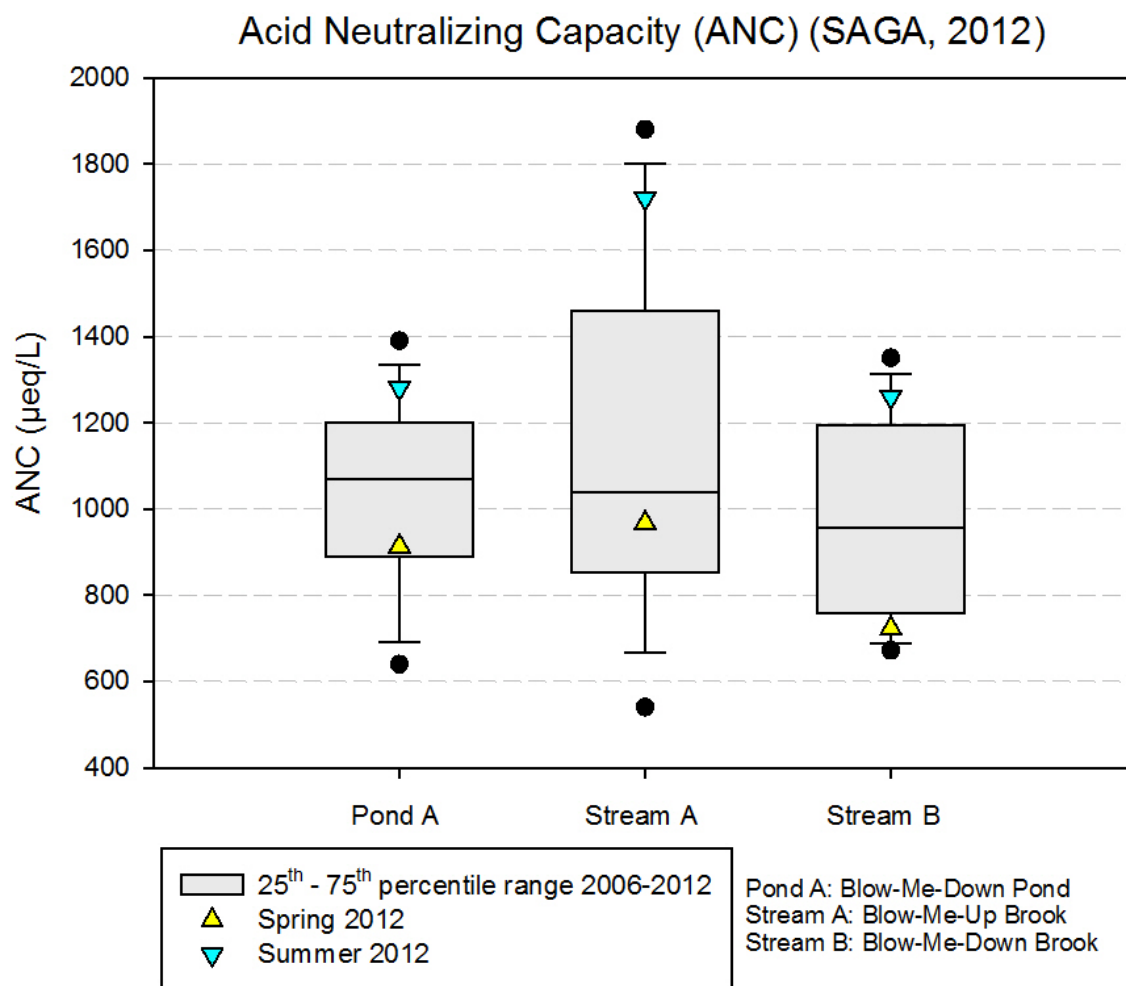


Figure 7. Acid neutralizing capacity from 2012 water samples overlaid on a box plot of measurements taken from 2006-2012.

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”.

Color values from Blow-Me-Up-Brook (Stream A) were low, both in 2012 samples and in the boxplot data (Figure 8). Blow-Me-Down-Brook (Stream B) and Blow-Me-Down-Pond (Pond A) were highly colored and all measurements were more variable. This could be the effect of runoff and sediment input to the systems, rather than dissolved constituents, since the samples were not filtered before analysis.

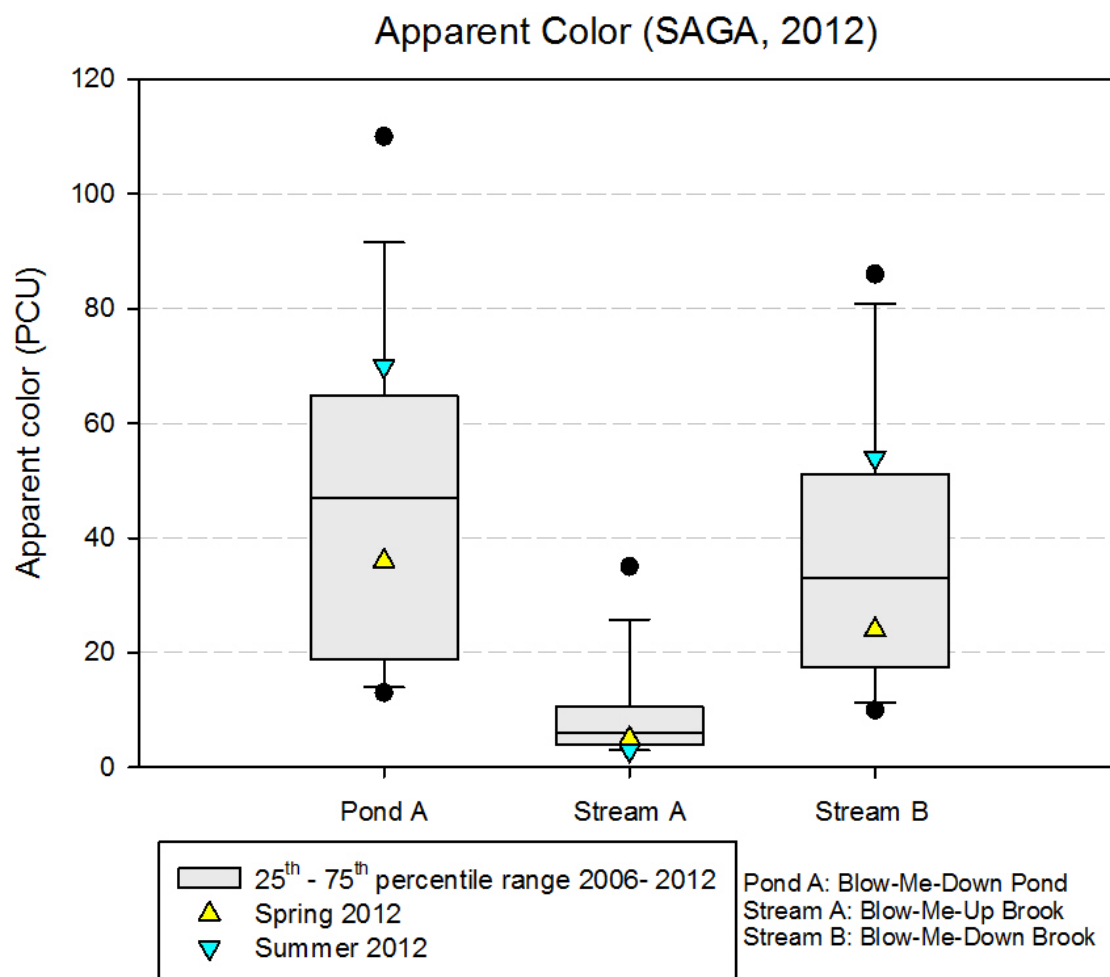


Figure 8. Apparent color from 2012 water samples overlaid on a box plot of measurements taken from 2006-2012.

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.

The DOC concentrations in most lakes and streams range from 1 mg/L to 20 mg/L, with a mean of 5.75 mg/L in streams (Meybeck 1982) and a mean of 7.58 in lakes (Sobek, et al 2007). SAGA DOC concentrations (Figure 9) were low in 2012, and closely reflected apparent color values.

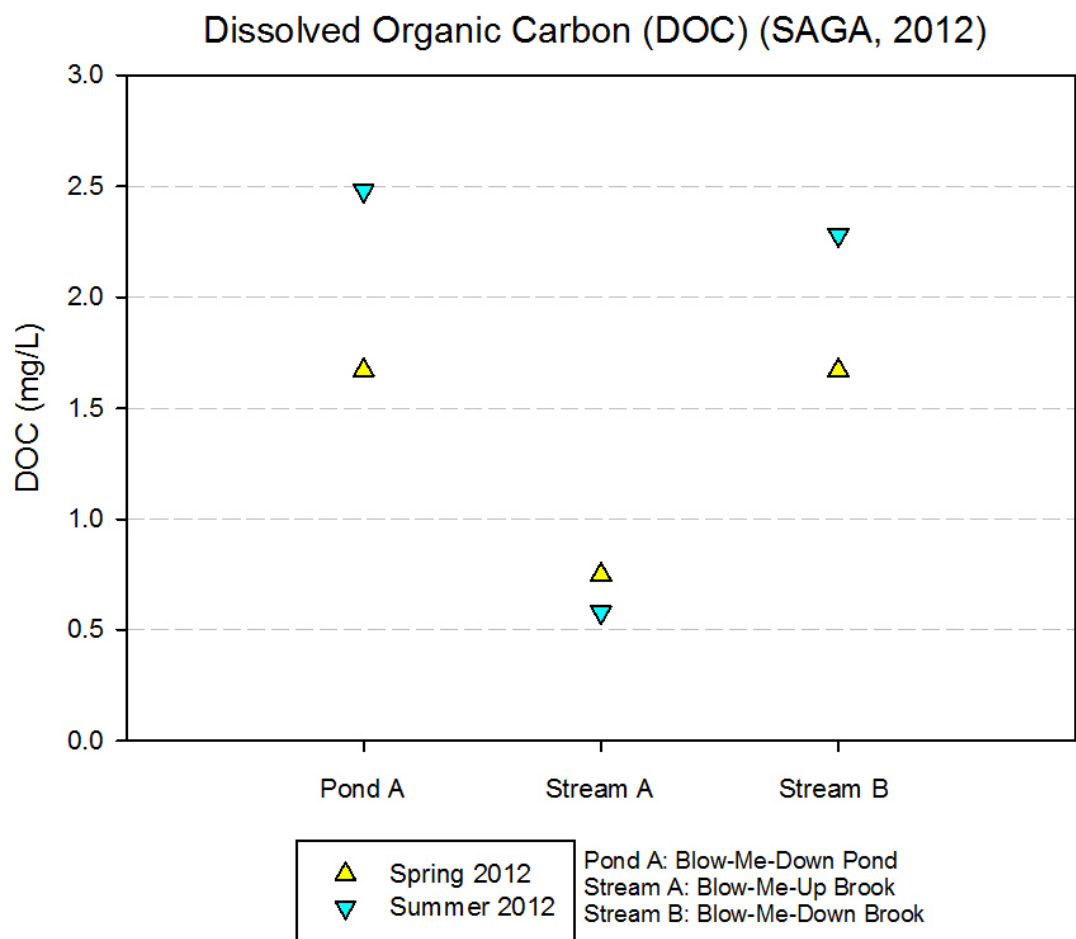


Figure 9. Dissolved organic carbon (DOC) from 2012 spring and summer water samples.

Light Penetration Profiles

It is difficult to obtain transparency measurements with a Secchi disk in Blow-Me-Down Pond. Due to the pond's shallow depth, the disk hit the pond bottom before disappearing from the observer's view in all NETN measurements. Beginning in 2012, the NETN measured light attenuation in ponds. Light penetration profiles can tell us much about the conditions affecting lakes and ponds. Nearly all the energy that drives and controls lake processes is derived from solar energy, which is converted to chemical energy via photosynthesis. This chemical energy is then transported to other areas of the ecosystem as various forms of organic matter. Solar energy, absorbed by the lake and dissipated as heat, plays a large role in defining a lake's thermal structure, stratification, and circulation patterns. These factors in turn affect nutrient cycling and the distribution of dissolved gasses. By understanding the quantity and behavior of the light entering a lake system, we can learn more about how the light is utilized in the system (Wetzel and Likens 2000).

A light penetration profile is obtained using two solar radiation sensors and a datalogger to determine photosynthetically available radiation or "PAR". One of the sensors is lowered into the water column on a weighted lowering frame, while the second sensor ("deck cell") is left on the surface to record ambient light. The datalogger records and processes readings from both sensors, dividing the measurement of light reaching any given depth by the measurement of ambient light, to yield a percentage. Measurements are taken at half-meter increments of the water column until the light penetration drops below 1% or the PAR cell reaches the pond bottom. Graphs of 2012 light penetration profiles are found in Figure 10 and tabular profile data are presented in Appendix A.

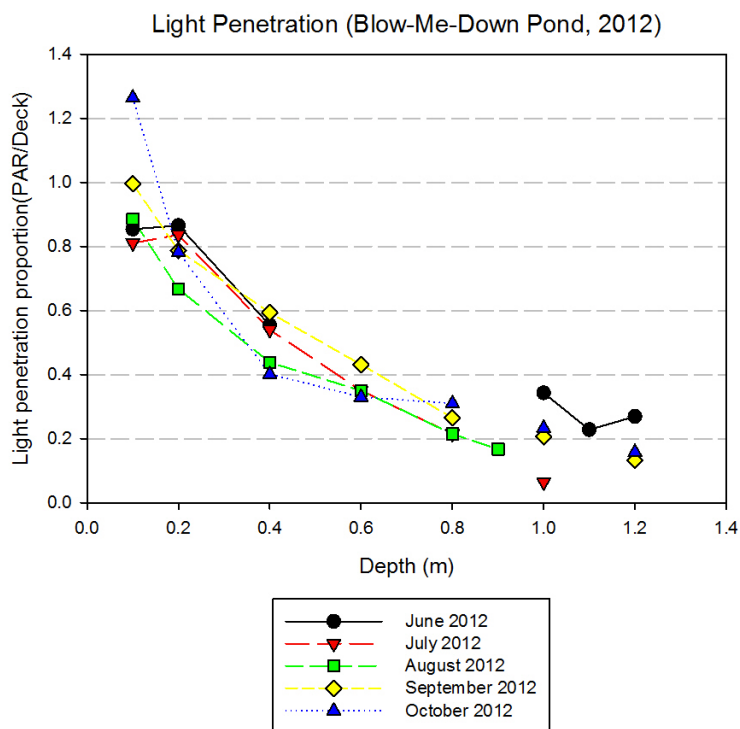


Figure 10. Light penetration profiles from Blow-Me-Down Pond.

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 2012 (Figure 11), the first year of NETN turbidity testing, were 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).

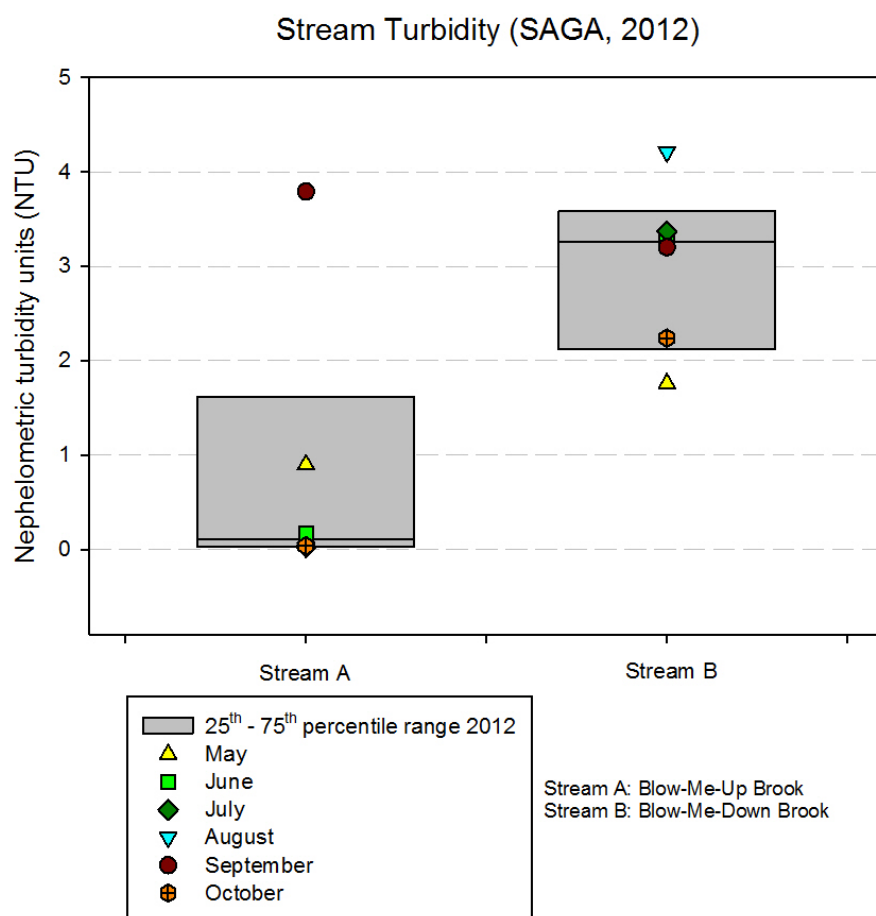


Figure 11. Stream turbidity from 2012 monthly measurements. The data are overlaid on a box plot of measurements taken in 2012.

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, most total phosphorus concentrations (Figure 10) were moderately high, and showed the expected seasonal variation of lower spring values. Blow-Me-Up Brook (Stream A) had higher TP concentrations in May (spring) samples. The more elevated August (summer) TP values in Blow-Me-Down Brook (Stream B) and Blow-Me-Down Pond (Pond A) indicate the possibility of runoff and sediment input to the water prior to the monitoring visit. The summer value for Blow-Me-Down Pond was the highest recorded to date. All TP values were near or above the EPA Ecoregion 8 criteria of 10 µg/L and 8 µg/L for streams and ponds, respectively. As described above (“Water Quality Standards”), the EPA criteria do not have any regulatory meaning.

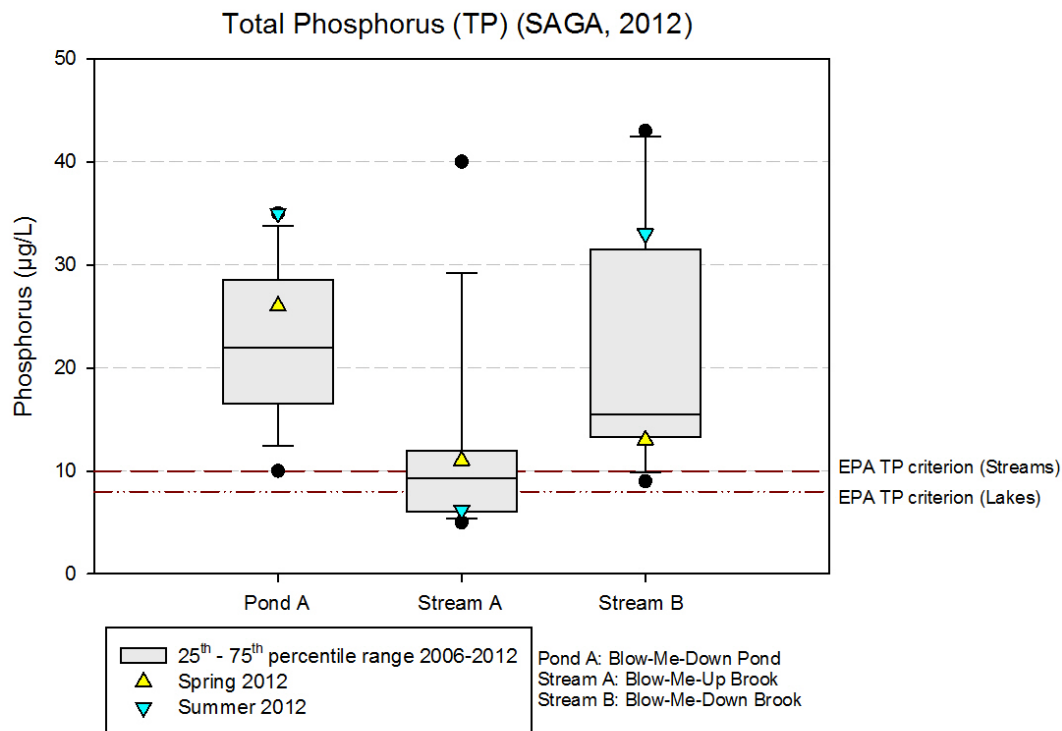


Figure 12. Total phosphorus (TP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2012.

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 nitrogen are shown in Figure 13. Stream TN values were below the EPA Region 8 criterion of 0.38 mg/L, and TN values in Blow-Me-Down Pond were slightly above the 0.24 mg/L EPA criterion, although as with TP this criterion does not have regulatory meaning. All TN measurements were well below 2.0 mg/L, the value used as a TN standard in several northeast states (New Hampshire has no numeric TN standard). All NO_2 and NH_3 results were below the method reporting limits.

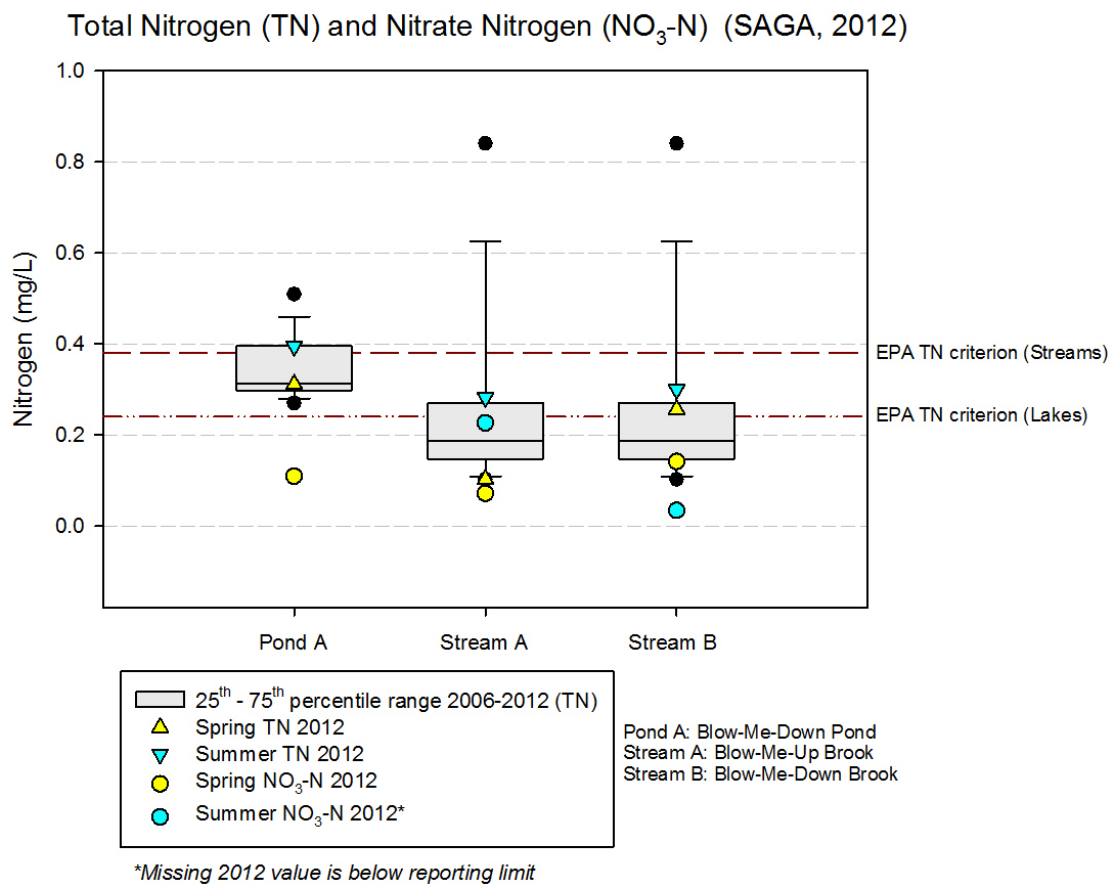


Figure 13. Total nitrogen (TN) and the nitrogen component of nitrate ($\text{NO}_3\text{-N}$) from 2012 water samples. The data are overlaid on a box plot of TN measurements taken from 2006-2012.

Chlorophyll *a*

The amount of chlorophyll *a* in a water sample is a measure of the concentration of suspended phytoplankton and can be used as an indicator of algal biomass and thus of water quality. Chlorophyll *a* is responsible for photosynthesis and is found in various forms within the living cells of algae, phytoplankton, and other plant matter. Like other biological response variables, chlorophyll *a* tends to integrate the stresses of various parameters over time, and thus is often an important nutrient-stress parameter to measure.

Although the chlorophyll *a* concentration in the spring 2012 sample from Blow-Me-Down Pond was below the New Hampshire median value of 4.4 µg/L (New Hampshire Department of Environmental Services 1997), the summer sample value was significantly higher (Figure 14). These chlorophyll measurements, along with the TP data indicate that Blow-Me-Down Pond is a moderate to highly productive pond (New Hampshire Department of Environmental Services 1997).

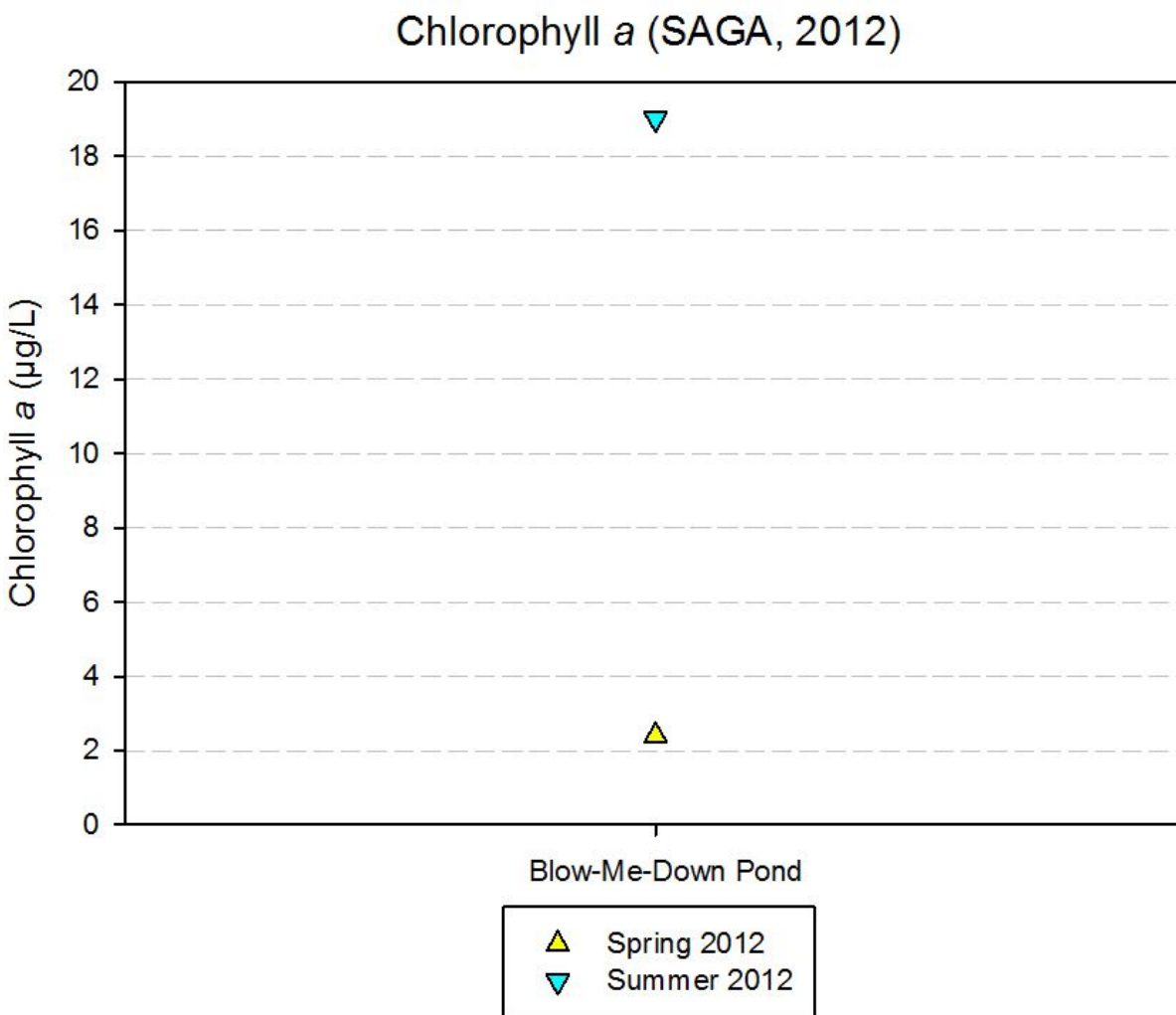


Figure 14. Chlorophyll *a* from 2012 spring and summer water samples.

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 from 2012 SAGA samples were very low in Blow-Me-Up Brook, and moderate to high in Blow-Me-Down Pond and Blow-Me-Down Brook (Figure 15). The latter sites are in closer proximity to major roads.

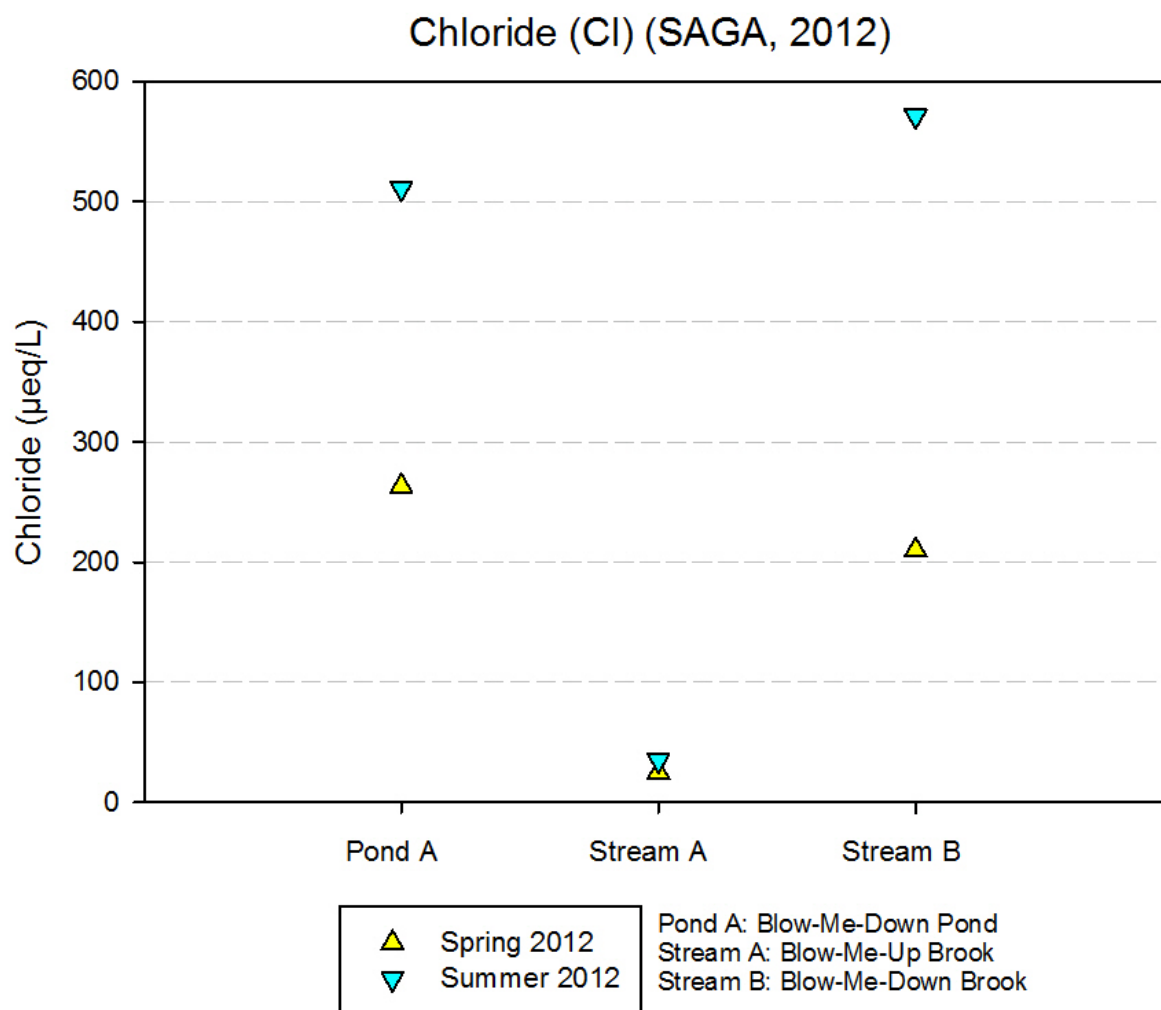


Figure 15. Chloride from 2012 spring and summer water samples.

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 SAGA were relatively low in 2012 (Figure 16).

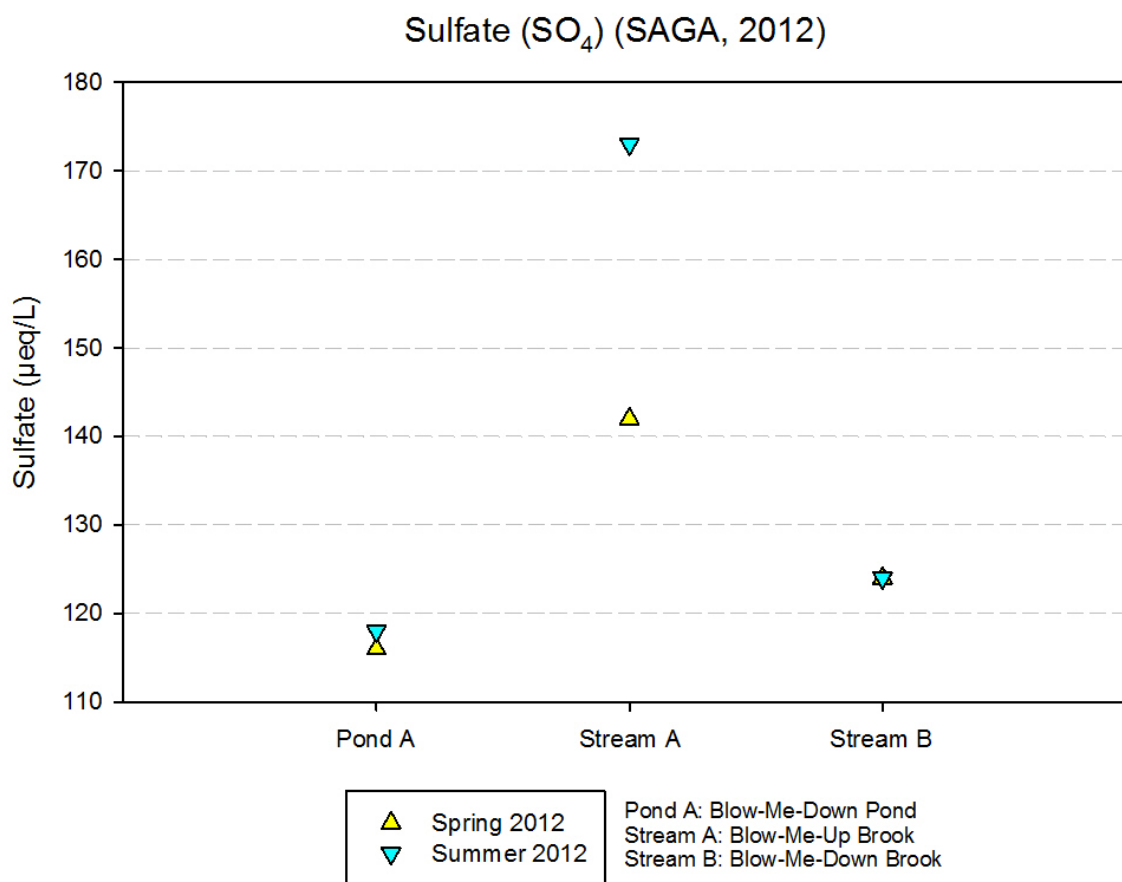


Figure 16. Sulfate from 2012 spring and summer water samples.

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. Discharge measurements from 2012 are listed in Appendix A. 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 and pond stage measurements (Figure 17) were taken by measuring to the water surface from a fixed datum point. No datum point has been established at Blow-Me-Down Brook. Also, a long beaver pond prevented a discharge measurement from being taken at Blow-Me-Down Brook in August, September, and 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. Stream and pond stage measurements from 2012 are listed in tabular form in Appendix A.

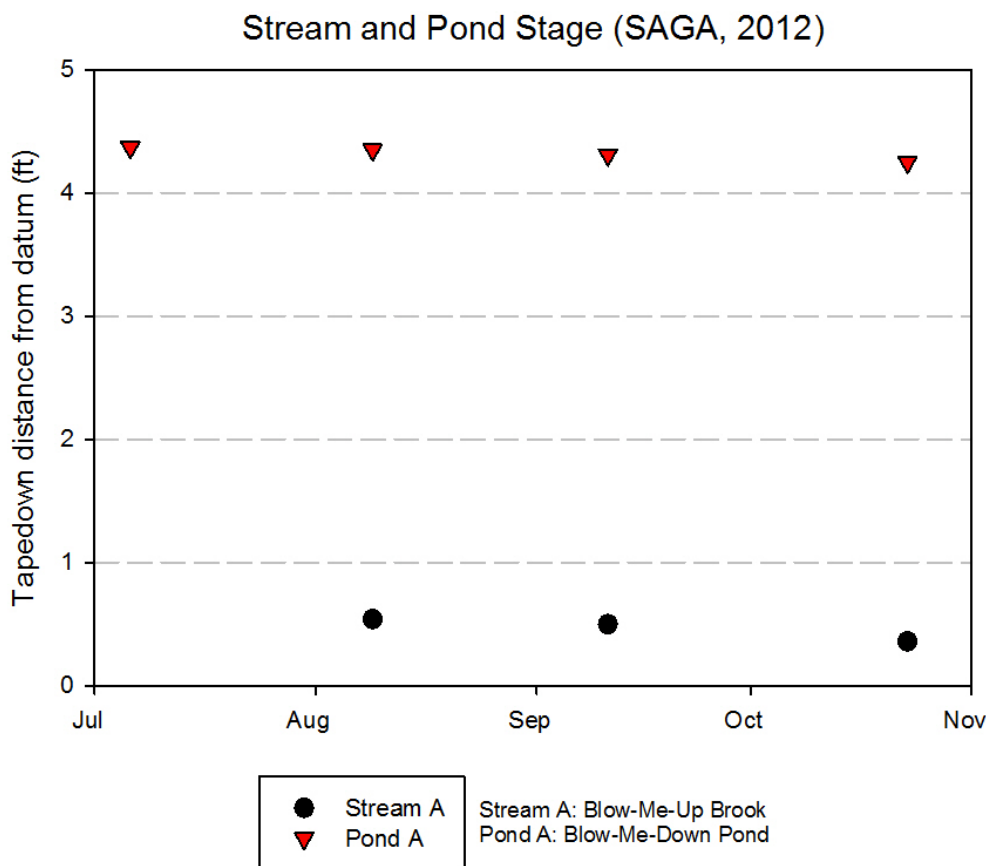


Figure 17. Stream and pond stage obtained in 2012 by measuring from a permanent datum point down to the water surface. *Note: Larger tapedown distances indicate LOWER water levels.*

Invasive Aquatic Plants

NETN's methods for invasive aquatic plant monitoring were adapted from the Maine Center for Invasive Aquatic Plants (MCIAP), a division of the Maine Volunteer Lake Monitoring Program (VLMP). Investigators utilize a level 3 survey, which involves surveying the entire shoreline and transects covering the littoral zone. Detailed survey instructions can be found in the NETN protocol (Lombard et al. 2006).

The primary targets of the invasive plant surveys were the 11 plants currently listed by the MCIAP (Table 4). Surveyors also looked for species on a secondary list (Table 5), compiled from the USGS Nonindigenous Aquatic Species website (<http://nas3.er.usgs.gov/>). The database was queried to obtain species of concern for each of the states containing NETN park units. This list includes some species that have not been located in some states in which NETN monitors (CT, NH, VT), but are of regional concern. The New Hampshire Department of Environmental Services (NHDES) specifically targets all species listed in Table 4 as well as the species in bold type in Table 5 as prohibited exotic species in the state. Common reed (*Phragmites australis*) is also listed on the NHDES "Frightful Fourteen" list of priority invasive aquatic species (http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/frightful_fourteen.pdf).

Invasive aquatic plant monitoring was conducted at the Blow-Me-Down Pond during the 2012 monitoring season. Results indicated that invasive aquatic plants do not currently exist at the Blow-Me-Down Pond.

During future visits to all NETN parks, monitors 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.

Table 4. Maine Center for Invasive Aquatic Plants species of concern.

Common name	Latin name
European Frogbit	<i>Hydrocharis morsus-ranae</i>
Water Chestnut	<i>Trapa natans</i>
Yellow Floating Heart	<i>Nymphoides peltata</i>
Eurasian Water Milfoil	<i>Myriophyllum spicatum</i>
Variable Water Milfoil	<i>Myriophyllum heterophyllum</i>
Parrot Feather	<i>Myriophyllum aquaticum</i>
Fanwort	<i>Cabomba caroliniana</i>
Hydrilla	<i>Hydrilla verticillata</i>
Brazilian Elodea	<i>Egeria densa</i>
European Naiad	<i>Najas minor</i>
Curly-Leaved Pondweed	<i>Potamogeton crispus</i>

Table 5. U.S. Geological Survey Nonindigenous Aquatic Species of concern.

Common name	Latin name	State(s) listed
Flowering Rush	<i>Butomus umbellatus</i>	NY,NH,CT,VT
Pond water-starwort	<i>Callitriche stagnalis</i>	NY,CT, MA
Water Hyacinth	<i>Eichhornia crassipes</i>	NY
Yellow Iris	<i>Iris pseudacorus</i>	NY, NH, VT, MA, CT
Dotted Duckweed	<i>Landoltia salicaria</i>	MA
Water Primrose	<i>Ludwigia hexapetala</i>	NY
Purple Loosestrife	<i>Lythrum salicaria</i>	NY, MA, CT, NH, VT
European Water-clover	<i>Marsilea quadrifolia</i>	NY, CT
Water-cress	<i>Nasturtium officinale</i>	NY, CT, NH, VT, MA
Sacred Lotus	<i>Nelumba nucifera</i>	NY
Water Lettuce	<i>Pistia straitotes</i>	NY
Amphibious Yellow-cress	<i>Rorippa amphibia</i>	NY, CT, VT

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 2012 water quality parameters for the pond and streams monitored in Saint-Gaudens National Historical Park were within state standards, and are generally within the range of EPA criteria, where applicable. The majority of values were within the ranges of the historic NETN monitoring data from SAGA. Apparent color and TP measurements from the August (summer) samples from Blow-Me-Down-Brook (Stream B) and Blow-Me-Down-Pond (Pond A) demonstrate the effects of runoff and sediment input on water chemistry.

Seven years of monitoring under the NETN protocol have provided critical baseline information on the chemical and physical status of the water resources Saint-Gaudens National Historical Park. Several changes implemented in the 2012 monitoring season, including the addition of sulfate, chloride, chlorophyll *a*, 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. Saint-Gaudens National Historic Site (SAGA) Water Monitoring Data, 2012.

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

Site	NETN Code	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	SpCond (µS/cm)
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.01	17.05	9.28	7.52	135.00
Blow-Me-Down Pond	SAGAPA	6/12/2012	1.02	16.83	9.31	7.50	135.00
Blow-Me-Down Pond	SAGAPA	6/12/2012	1.08	16.90	9.33	7.52	135.00
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.00	21.66	6.40	7.31	203.00
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.52	21.40	5.55	7.19	204.00
Blow-Me-Down Pond	SAGAPA	7/23/2012	1.02	20.70	2.93	7.01	207.00
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.00	20.85	8.49	7.53	202.00
Blow-Me-Down Pond	SAGAPA	8/9/2012	1.02	20.03	6.26	7.32	204.00
Blow-Me-Down Pond	SAGAPA	8/9/2012	1.17	19.80	5.23	7.24	204.00
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.00	15.21	8.74	7.94	217.00
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.51	13.99	8.03	7.46	216.00
Blow-Me-Down Pond	SAGAPA	9/11/2012	1.00	13.61	7.66	7.41	215.00
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.00	7.18	10.61	7.72	196.00
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.00	7.19	10.60	7.71	196.00
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.51	7.02	10.57	7.60	197.00
Blow-Me-Down Pond	SAGAPA	10/23/2012	1.00	6.95	10.81	7.60	196.00
Blow-Me-Up Brook (Stream A)	SAGASA	5/14/2012	0.22	9.88	11.22	8.00	114.00
Blow-Me-Up Brook (Stream A)	SAGASA	6/12/2012	-0.03	13.10	10.43	7.85	128.00
Blow-Me-Up Brook (Stream A)	SAGASA	7/6/2012	0.27	15.88	9.78	7.89	164.00
Blow-Me-Up Brook (Stream A)	SAGASA	8/9/2012	0.25	14.56	9.12	7.71	193.00
Blow-Me-Up Brook (Stream A)	SAGASA	9/11/2012	0.36	9.38	11.17	8.11	221.00
Blow-Me-Up Brook (Stream A)	SAGASA	10/23/2012	0.24	4.90	11.92	7.80	212.00
Blow-Me-Down Brook (Stream B)	SAGASB	5/14/2012	0.35	12.78	10.76	8.02	112.00
Blow-Me-Down Brook (Stream B)	SAGASB	6/12/2012	0.10	17.98	9.62	7.89	135.00
Blow-Me-Down Brook (Stream B)	SAGASB	7/6/2012	0.37	22.55	8.56	7.90	171.00
Blow-Me-Down Brook (Stream B)	SAGASB	7/6/2012	0.42	22.50	8.58	7.91	172.00
Blow-Me-Down Brook (Stream B)	SAGASB	8/9/2012	0.68	18.98	7.30	7.55	210.00
Blow-Me-Down Brook (Stream B)	SAGASB	9/11/2012	0.88	12.89	9.51	7.97	217.00
Blow-Me-Down Brook (Stream B)	SAGASB	10/23/2012	0.63	6.57	10.51	7.69	198.00

Appendix A. Saint-Gaudens National Historic Site (SAGA) Water Monitoring Data, 2012 (continued).

Table A2. Laboratory nutrient chemistry data for SAGA. “<MRL” indicates the result was below the method reporting limit (1.0 for NO₃, 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)	Chla (µg/L)	Cl (µeq/L)	SO ₄ (µeq/L)
Blow-Me-Down Pond	6/12/2012	913.00	36	1.67	26.0	0.311	7.7	0.109	<MRL	<MRL	2.4	263	116
Blow-Me-Down Pond	8/9/2012	1280.00	70	2.48	35.0	0.395	<MRL	<MRL	<MRL	<MRL	19.0	511	118
Blow-Me-Up Brook (Stream A)	5/14/2012	967.00	5	0.75	11.0	0.102	5.0	0.071	<MRL	<MRL		25	142
Blow-Me-Up Brook (Stream A)	8/9/2012	1720.00	3	0.58	6.2	0.282	16.0	0.226	<MRL	<MRL		35	173
Blow-Me-Down Brook (Stream B)	5/14/2012	723.00	24	1.67	13.0	0.256	10.0	0.141	<MRL	<MRL		210	124
Blow-Me-Down Brook (Stream B)	8/9/2012	1260.00	54	2.28	33.0	0.300	2.4	0.034	<MRL	<MRL		571	124

Appendix A. Saint-Gaudens National Historic Site (SAGA) Water Monitoring Data, 2012 (continued).

Table A3. Pond stage and stream stage and discharge data for SAGA. *Missing values indicate data are unavailable.*

Site	Date	Tapedown from datum (ft)	Total cross section area (sqft)	Average velocity (f/s)	Discharge (cfs)
Blow-Me-Down Pond	6/12/2012	3.95			N/A
Blow-Me-Down Pond	7/23/2012	4.37			N/A
Blow-Me-Down Pond	8/9/2012	4.35			N/A
Blow-Me-Down Pond	9/11/2012	4.31			N/A
Blow-Me-Down Pond	10/23/2012	4.25			N/A
Blow-Me-Up Brook (Stream A)	5/14/2012		2.55	0.98	2.50
Blow-Me-Up Brook (Stream A)	6/12/2012		1.75	0.50	0.87
Blow-Me-Up Brook (Stream A)	7/6/2012		1.62	0.13	0.21
Blow-Me-Up Brook (Stream A)	8/9/2012	0.54	1.24	0.05	0.06
Blow-Me-Up Brook (Stream A)	9/11/2012	0.50		0.00	
Blow-Me-Up Brook (Stream A)	10/23/2012	0.36	1.42	0.04	0.06
Blow-Me-Down Brook (Stream B)	5/14/2012		25.29	1.74	43.98
Blow-Me-Down Brook (Stream B)	6/12/2012		13.81	1.02	14.07
Blow-Me-Down Brook (Stream B)	7/6/2012		7.83	0.64	5.04
Blow-Me-Down Brook (Stream B)	8/9/2012			0.00	
Blow-Me-Down Brook (Stream B)	9/11/2012		54.20	0.04	1.99
Blow-Me-Down Brook (Stream B)	10/23/2012			0.00	

Appendix A. Saint-Gaudens National Historic Site (SAGA) Water Monitoring Data, 2012 (continued).

Table A4. Light penetration profiles for SAGA .

Site	NETN Code	Date	Depth (m)	Deck cell ($\mu\text{mol s}^{-1} \text{m}^{-2}$)	PAR cell ($\mu\text{mol s}^{-1} \text{m}^{-2}$)	Proportion of penetration (PAR/Deck)
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.10	610.71	533.42	0.88
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.10	742.89	632.90	0.85
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.20	579.89	502.05	0.87
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.40	772.34	426.75	0.55
Blow-Me-Down Pond	SAGAPA	6/12/2012	0.40	582.36	435.32	0.75
Blow-Me-Down Pond	SAGAPA	6/12/2012	1.00	602.89	207.12	0.34
Blow-Me-Down Pond	SAGAPA	6/12/2012	1.10	590.16	134.98	0.23
Blow-Me-Down Pond	SAGAPA	6/12/2012	1.20	612.67	164.96	0.27
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.10	532.13	431.77	0.81
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.20	399.09	333.90	0.84
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.40	422.48	228.31	0.54
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.60	440.41	154.50	0.35
Blow-Me-Down Pond	SAGAPA	7/23/2012	0.80	441.97	95.21	0.22
Blow-Me-Down Pond	SAGAPA	7/23/2012	1.00	606.57	39.98	0.06
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.10	602.65	534.34	0.89
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.20	558.33	372.60	0.67
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.40	577.60	253.24	0.44
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.60	569.41	202.05	0.35
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.80	664.48	143.24	0.22
Blow-Me-Down Pond	SAGAPA	8/9/2012	0.90	612.17	102.85	0.17
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.10	1,682.40	1,676.90	1.00
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.20	1,617.00	1,273.90	0.79
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.40	1,630.30	968.41	0.59
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.60	1,645.10	710.45	0.43
Blow-Me-Down Pond	SAGAPA	9/11/2012	0.80	1,656.60	440.39	0.27
Blow-Me-Down Pond	SAGAPA	9/11/2012	1.00	1,601.90	331.45	0.21
Blow-Me-Down Pond	SAGAPA	9/11/2012	1.20	1,608.00	214.13	0.13
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.10	1,153.70	1,222.70	1.26
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.20	1,155.20	904.08	0.78
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.40	1,165.50	466.25	0.40
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.60	1,124.30	370.26	0.33
Blow-Me-Down Pond	SAGAPA	10/23/2012	0.80	1,079.00	335.29	0.31
Blow-Me-Down Pond	SAGAPA	10/23/2012	1.00	1,113.90	260.46	0.23
Blow-Me-Down Pond	SAGAPA	10/23/2012	1.20	1,163.90	184.28	0.16

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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