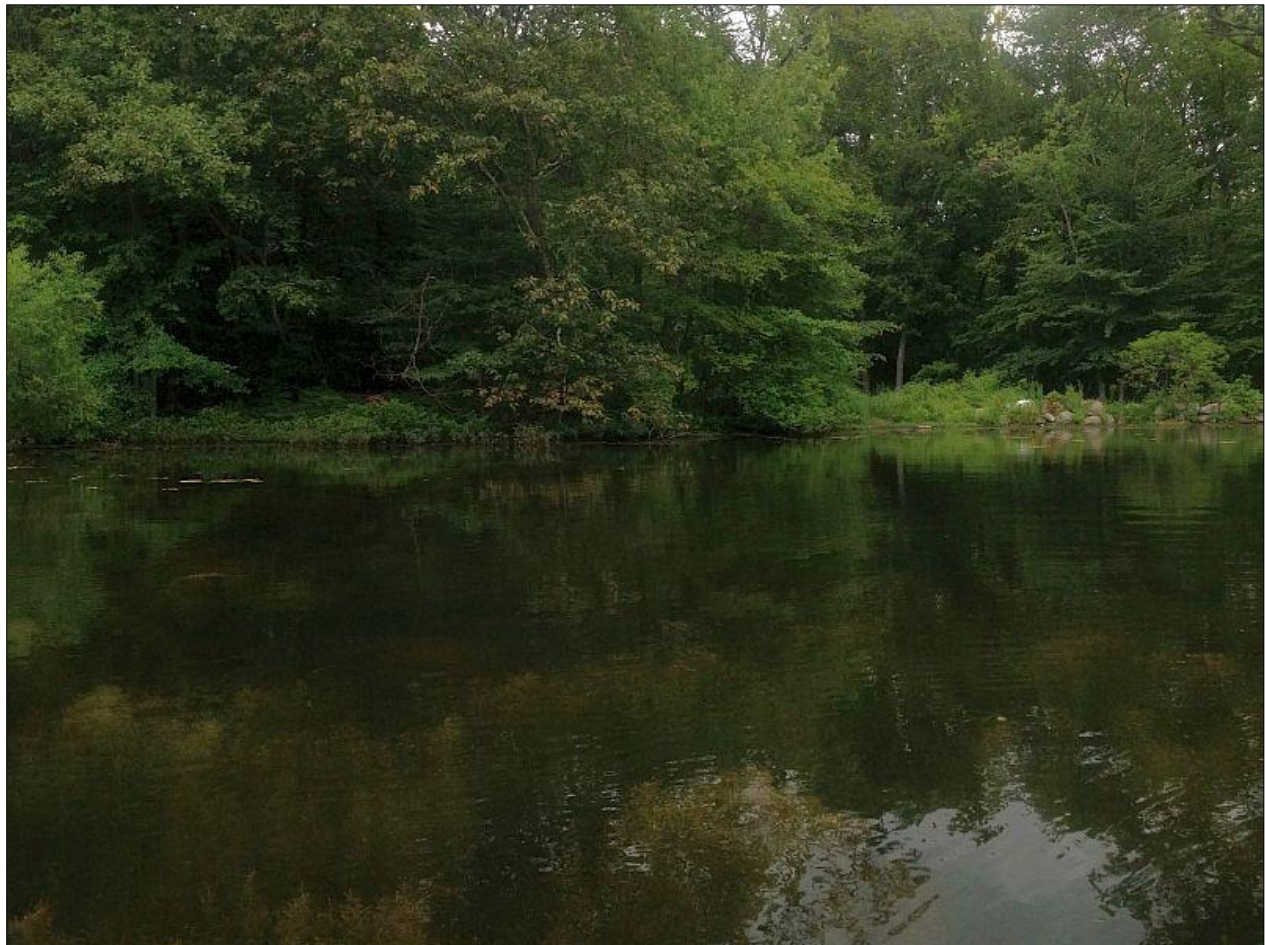




Water Quality Monitoring at Weir Farm National Historic Site

Northeast Temperate Network 2014 Summary Report

Natural Resource Data Series NPS/NETN/NRDS—2016/1029



ON THE COVER

Weir Pond, August 2014

Photograph by: Liza McElroy

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William G. Gawley
National Park Service
Acadia National Park
PO Box 177
Bar Harbor, Maine 04609

Fred W. Dieffenbach
National Park Service
Northeast Temperate Network
54 Elm Street
Woodstock, VT 05091

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Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Executive Summary

This report on the water quality of Weir Farm National Historic Site (WEFA) includes data gathered by the Northeast Temperate Network (NETN) in the 2014 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. The data address the NETN objective to detect change in the status of physical, chemical, or biological attributes of park freshwater bodies.

The NETN Freshwater Monitoring Protocol calls for one pond at WEFA to be sampled monthly from May through October. Staff 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.

Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, and dissolved oxygen), light penetration, weather, and stage. In May and August, water samples were obtained and analyzed for acid neutralizing capacity (ANC), color, nutrients, dissolved organic carbon (DOC), chloride, sulfate, and chlorophyll *a*.

In general, most 2014 water quality parameters for Weir Pond in Weir Farm National Historic Site were within state standards, and were above the EPA Ecoregion 14 criteria, where applicable. Several metrics showed a great deal of variability relative to their respective historic range, and where variability was least the measures were frequently biased toward one end of the range. Specific conductance measurements were all at the high end of the historic range, with only one measurement being below the 90th percentile. pH varied throughout the entire historical range, with two readings exceeding the high state standard. Temperature and dissolved oxygen were similarly variable throughout the sampling season. Both spring and summer chloride values were among the highest recorded by the NETN to date. Most of the remaining metrics were not as variable, and fell within their historic ranges. Spring (June) total phosphorus levels were nearly double those of the August samples, and were likely responsible for high spring chlorophyll *a* concentrations in the pond, which may have been an indication of a small to moderate algal bloom.

Introduction

This report on the water quality of Weir Farm National Historic Site (WEFA) generated by the Northeast Temperate Network (NETN) Water Quality Monitoring Program includes data gathered in the 2014 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. Appendix A contains tabular data collected in 2014.

The vital signs for freshwater bodies included in the original 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 one pond (Figure 1) at WEFA to be sampled monthly from May through October. Two NETN Student Conservation Association (SCA) interns 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.

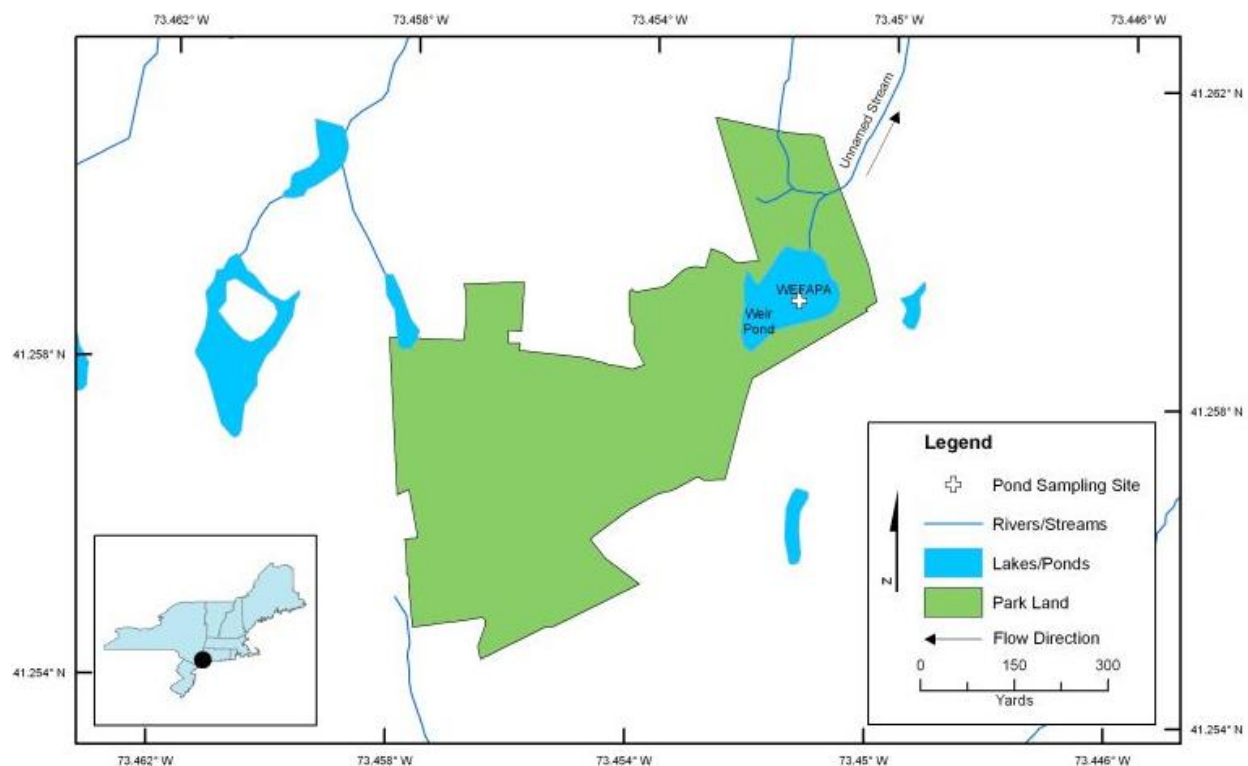


Figure 1. NETN water monitoring site at Weir Farm NHS.

Sampling Sites

There is a minimal amount of water quality data available that have been collected at WEFA, so a long-term monitoring site was set up in Weir Pond, the largest fresh water body in the park (Table 1). The deepest point of the pond (approximately 1.5 meters) is monitored monthly from May-October for high priority vital signs including temperature, pH, specific conductance, dissolved oxygen (DO), and water clarity. A tape down point was established to monitor water levels in the pond.

Table 1. Water quality monitoring sites at Weir Farm NHS, Connecticut.

Water Body	NETN Site Code	Latitude	Longitude	Site Remarks
Weir Pond	WEFAPA	41.25952	-73.45150	Site at deepest point in pond

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. 2014). Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, and dissolved oxygen) determined with a YSI 600XL sonde, transparency and light penetration, weather, and pond stage. In June 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*. The pond sampling procedure entailed collecting all in-situ measurements and water samples from the deepest point of the pond (approximately 1.5 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.

Pond stage was measured by using a measuring tape or folding ruler to “tape down” or “tape up” from a fixed datum point to the surface of the water, or by reading the water level off of a staff gauge. A bolt was installed to permanently mark the datum point in July 2011.

Water Quality Standards

Connecticut water quality standards define ranges of total phosphorus, total nitrogen, chlorophyll *a*, and Secchi disk transparency which are assessed collectively to determine the trophic state of a lake or pond. For the purpose of determining consistency with the water quality standard, the natural trophic state of a lake or pond is compared with the current trophic state to determine if it has been altered due to excessive anthropogenic inputs. Lakes and ponds in advanced trophic states which exceed their natural trophic state due to anthropogenic sources are considered to be inconsistent with water quality standards. Connecticut does not have parallel standards for streams, but does have standards for temperature, DO, pH, and nutrients (State of Connecticut Department of Energy and Environmental Protection 2013).

Historically, Weir Pond (the only NETN pond in Connecticut) ranges between mesotrophic (moderately productive) and eutrophic (highly productive) conditions. Mesotrophic ponds are defined as having total phosphorus concentrations ranging from 10 to 30 µg/L and total nitrogen concentrations ranging from 200 to 600 µg/L in spring and summer. Eutrophic ponds are defined as having total phosphorus concentrations ranging from 30 to 50 µg/L and total nitrogen concentrations ranging from 600 to 1,000 µg/L NO₃ in spring and summer. Mid-summer chlorophyll *a* ranges are defined as being from 2 to 15 µg/L in mesotrophic ponds and from 15 to 30 µg/L in eutrophic ponds. Mid-summer Secchi disk depths range from 2 to 6 m in mesotrophic lakes and from 1 to 2 m in eutrophic lakes (State of Connecticut Department of Environmental Protection 2013). Numeric water quality standards are listed in Table 2.

Table 2. Connecticut water quality standards.

Water quality classification code	Max Temp (°C)	Min Dissolved Oxygen (mg/L)	pH Range (standard units)	Total Nitrogen (µg/L)	Total Phosphorus (µg/L)	Color	Max Chlorophyll <i>a</i> (µg/L)	Min Secchi Disk Depth (m)
Mesotrophic	29.4	5.0	6.5-8.0	200-600	10-30	None other than of natural origin	2-15	2-6
Eutrophic				600-1,000	30-50	None other than of natural origin	15-30	1-2

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 lakes and ponds.

Nutrient Criteria	Value
Total Phosphorus	8 µg/L
Total Nitrogen	0.32 mg/L
Chlorophyll <i>a</i> - fluorometric	2.9 µg/L
Secchi disk depth	4.5 m

These criteria were developed specifically for Ecoregion 14 (which includes Minute Man NHP, Saugus Ironworks 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 lakes and ponds for which the EPA found data. 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. (U.S. Environmental Protection Agency 2000).

Results

Monitoring results for 2014 are displayed in scatter-plot graphs showing all data for each site for a given parameter. The scatter plots of 2014 data are overlaid on box plots representing the overall range and distribution of data values collected from 2006 through 2014 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.

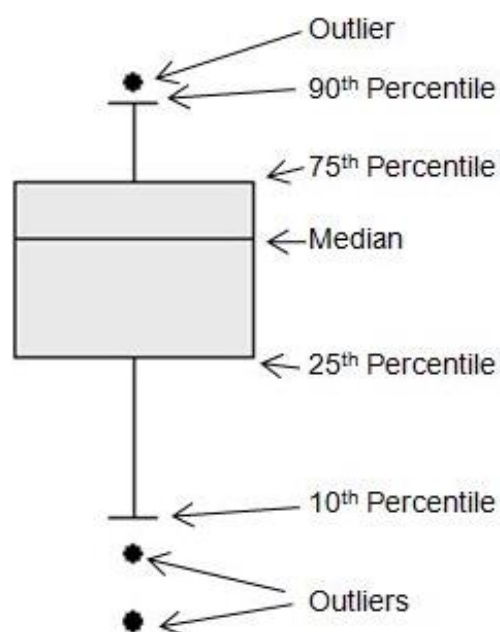


Figure 2. Explanation of box plot graph

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 2014 were

within a typical range for moderate ionic strength waters; however, all of the values were higher than the 75th percentile and all but October were at or above the 90th percentile.

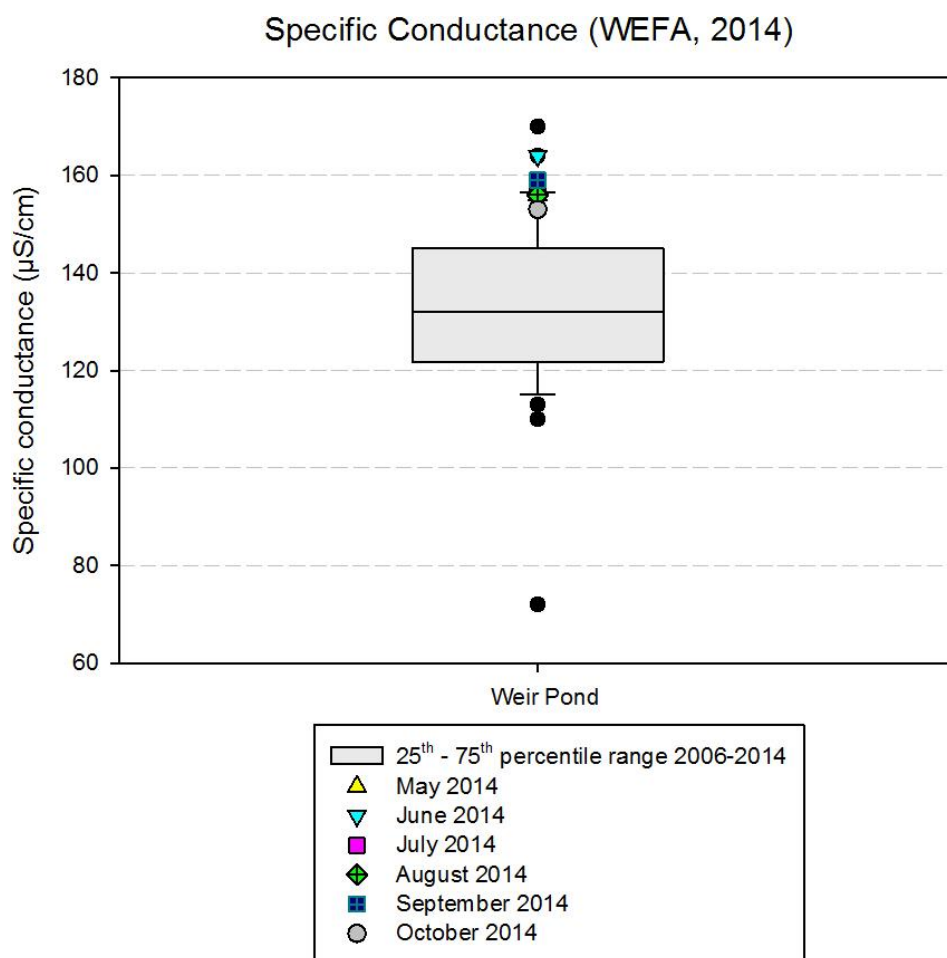


Figure 3. Specific conductance from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

pH Level

The pH of a water body measures 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. Although Connecticut has no numeric water quality standards for pH in Class AA waters, the Class B 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. All but two of the pH values from the 2014 monitoring season (Figure 4) were within this range. August and September were above the upper state standard, with the August reading being substantially above the 90th percentile in outlier territory. The accuracy of the August reading is highly suspect since lab pH of a fraction of the nutrient water sample was 7.86.

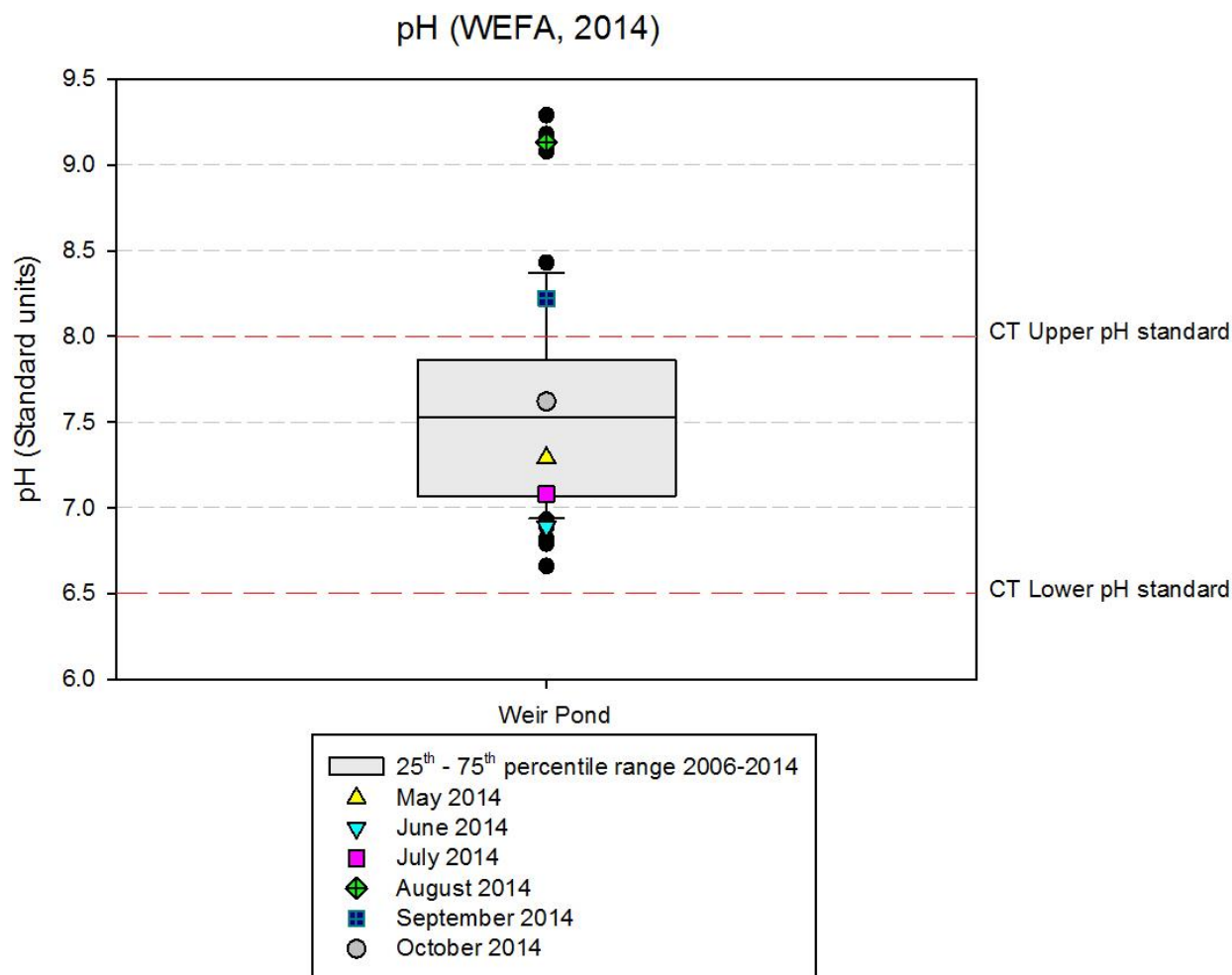


Figure 4. pH from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

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) ranged widely in 2014, extending from nearly the 10th percentile to the 90th percentile. None of the measurements exceeded the maximum state temperature standard in 2014.

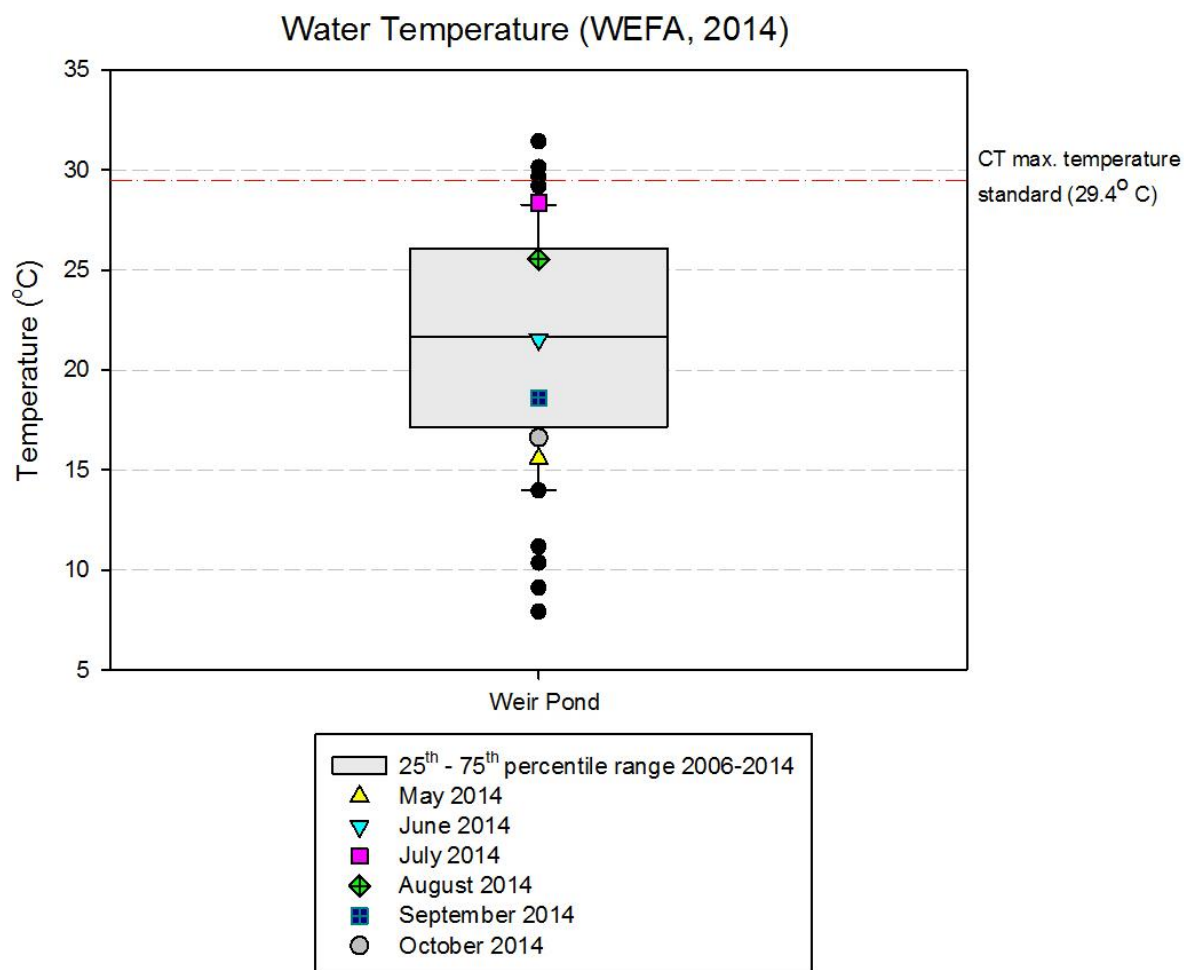


Figure 5. Water temperature (surface) from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

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 WEFA in 2014 (Figure 6) were above the state minimum DO standard, but the measurements varied widely with all being near or outside of the 25th and 75th percentiles. Only the October measurement was well within the range defined by the 25th and 75th percentiles. Despite the high variation throughout the season, these readings appear to be appropriate for the corresponding water temperature measurements taken during the monitoring events. Complete data from water column profiles can be found in Appendix A.

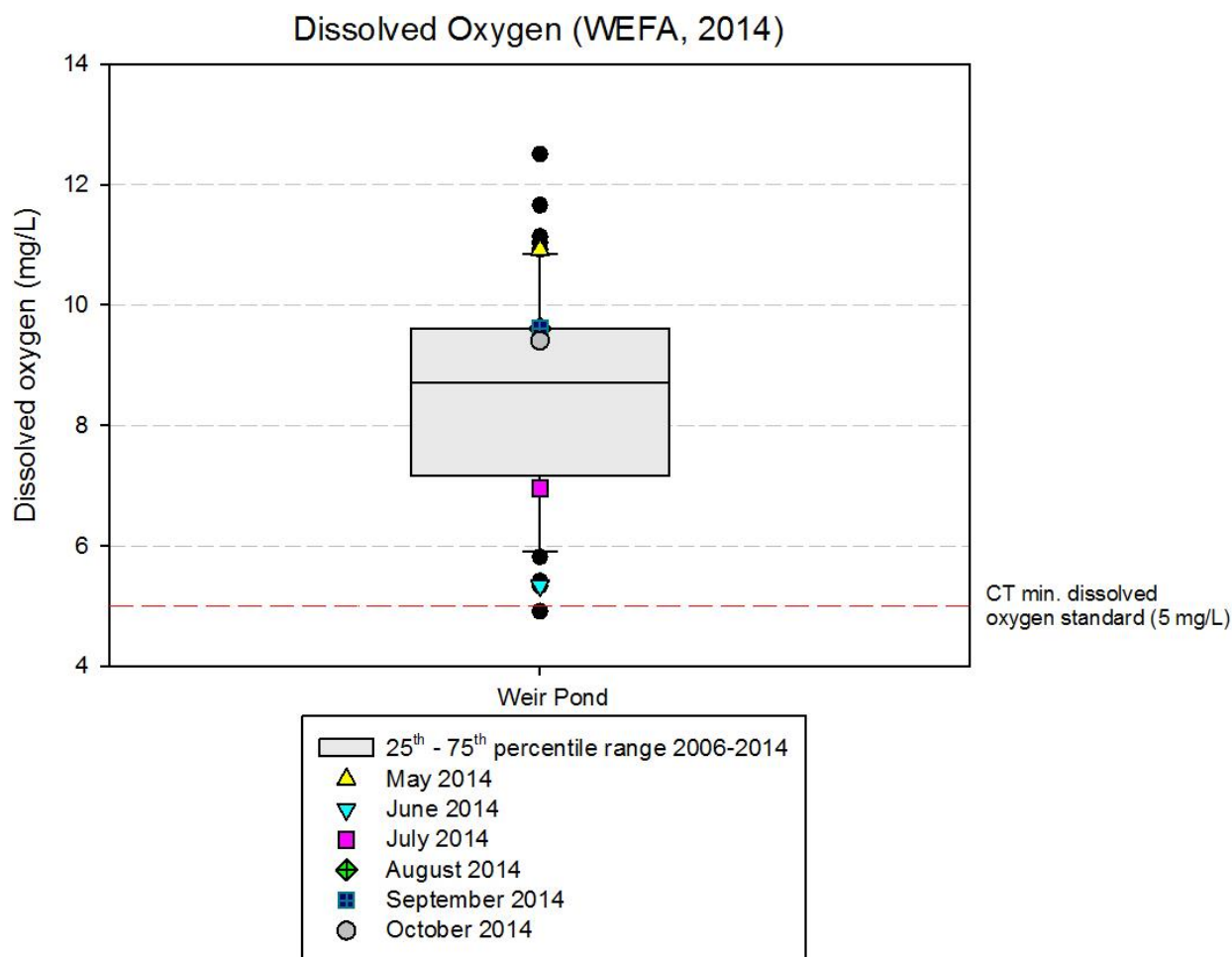


Figure 6. Dissolved oxygen (surface) from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

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 2014 samples (Figure 7) illustrates that Weir Pond is very well-buffered, likely due to the underlying geology.

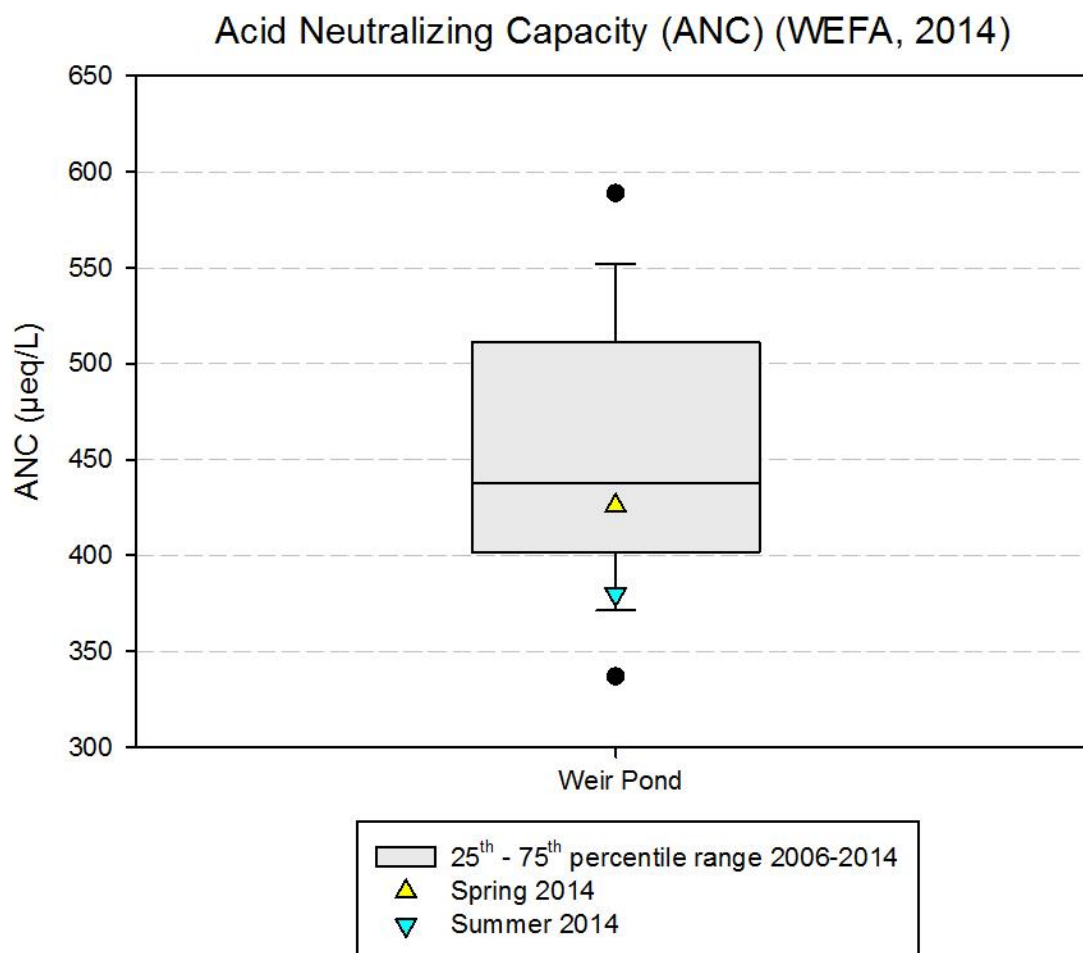


Figure 7. Acid neutralizing capacity from 2014 water samples overlaid on a box plot of measurements taken from 2006-2014.

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 the 2014 samples (Figure 8) were relatively high. The summer value was near the 25th percentile of historic measurements while the spring value was approaching the 90th percentile. Since the spring (June) DOC (a common driver of water color) measurement is actually lower than the DOC in the August sample (which had a far lower color reading), it is likely that the high spring color was caused by suspended matter in the unfiltered sample, such as sediment, plankton, or pollen.

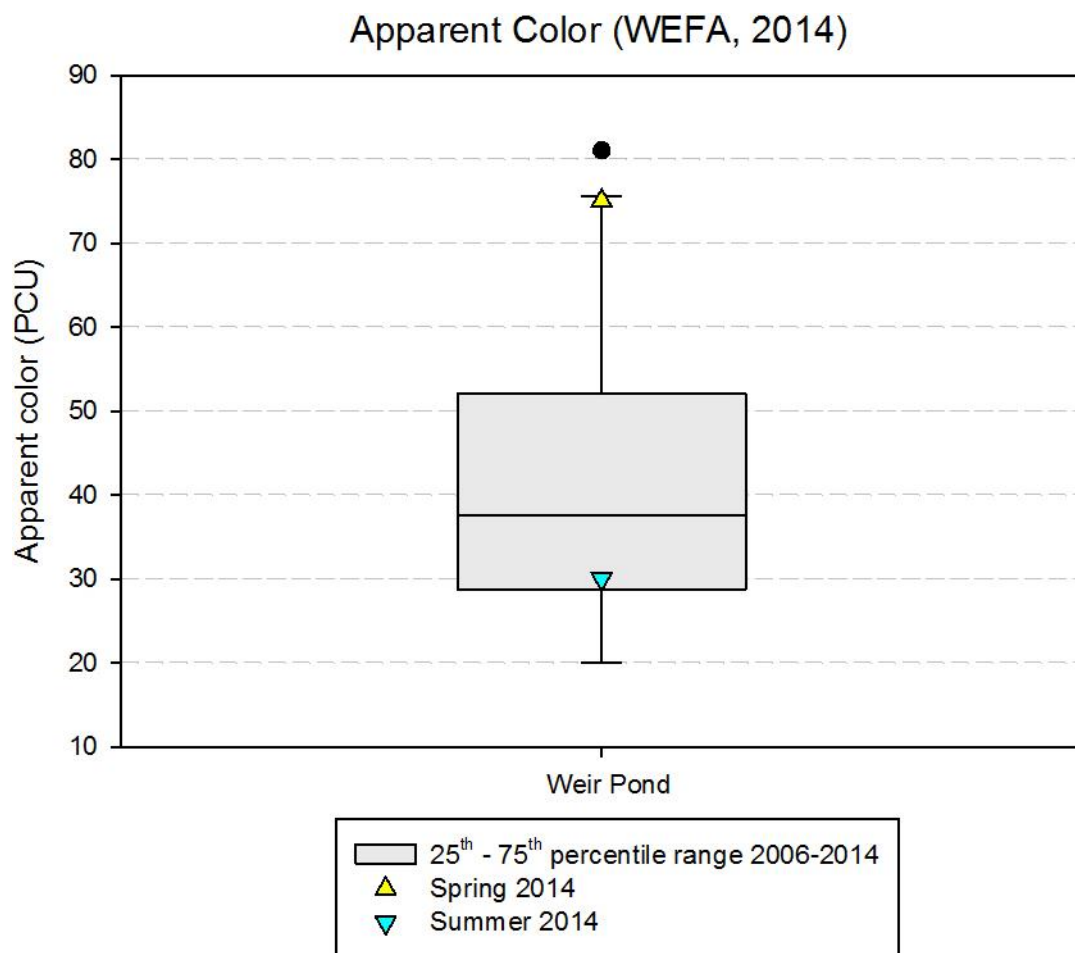


Figure 8. Apparent color from 2014 water samples overlaid on a box plot of measurements taken from 2006-2014.

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 7.58 in lakes (Sobek, et al 2007). Weir Pond DOC concentrations (Figure 9) were moderate in 2014 and near the median of historic values.

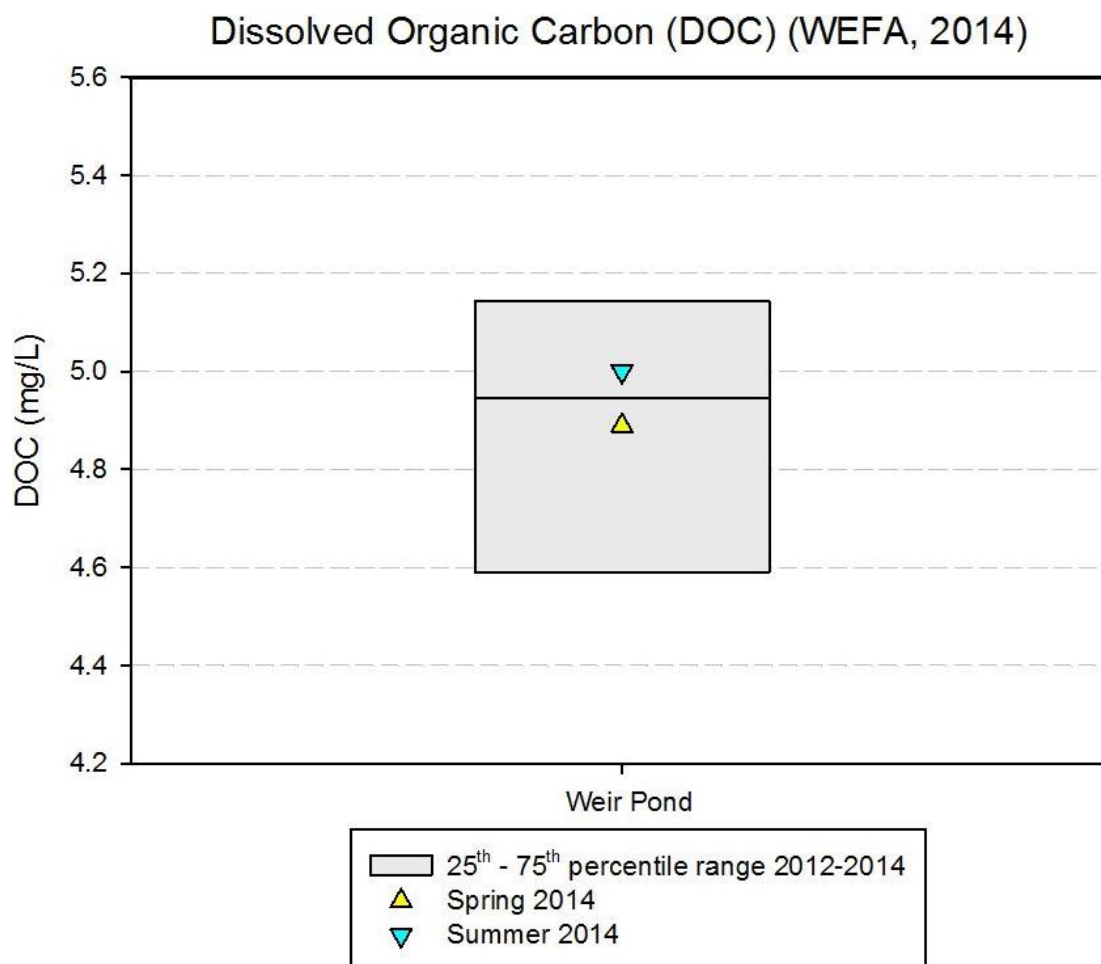


Figure 9. Dissolved organic carbon (DOC) from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

Light Penetration Profiles

Transparency measurements can provide simple and affordable assessments of pond and lake productivity. Variation in precipitation is one of the major factors contributing to annual shifts in transparency. Often during drier conditions lakes and ponds will become clearer due to lower runoff of nutrient and soil inputs. In contrast, decreased transparency readings can often be attributed to the effects of high levels of spring and fall precipitation, as well as the cumulative effects of a high rainfall year. It is difficult to obtain transparency measurements with a Secchi disk in Weir 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, NETN measured light attenuation in ponds using light penetration profiles.

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. A light attenuation coefficient can be calculated through analysis of the profile data to quantify the loss of light transmission per meter of depth. A low attenuation coefficient denotes clear water and, conversely, a higher coefficient signifies reduced water clarity. Graphs of 2014 light penetration profiles and a listing of light attenuation coefficients are found in Figure 10. Field notes indicate that the readings from below 0.5m in the August profile were affected by dense submerged aquatic vegetation. Due to the shading of the PAR cell in these lower readings, this profile attenuation coefficient (calculated from all of the profile values) probably does not accurately represent the actual light transmission properties of the water.

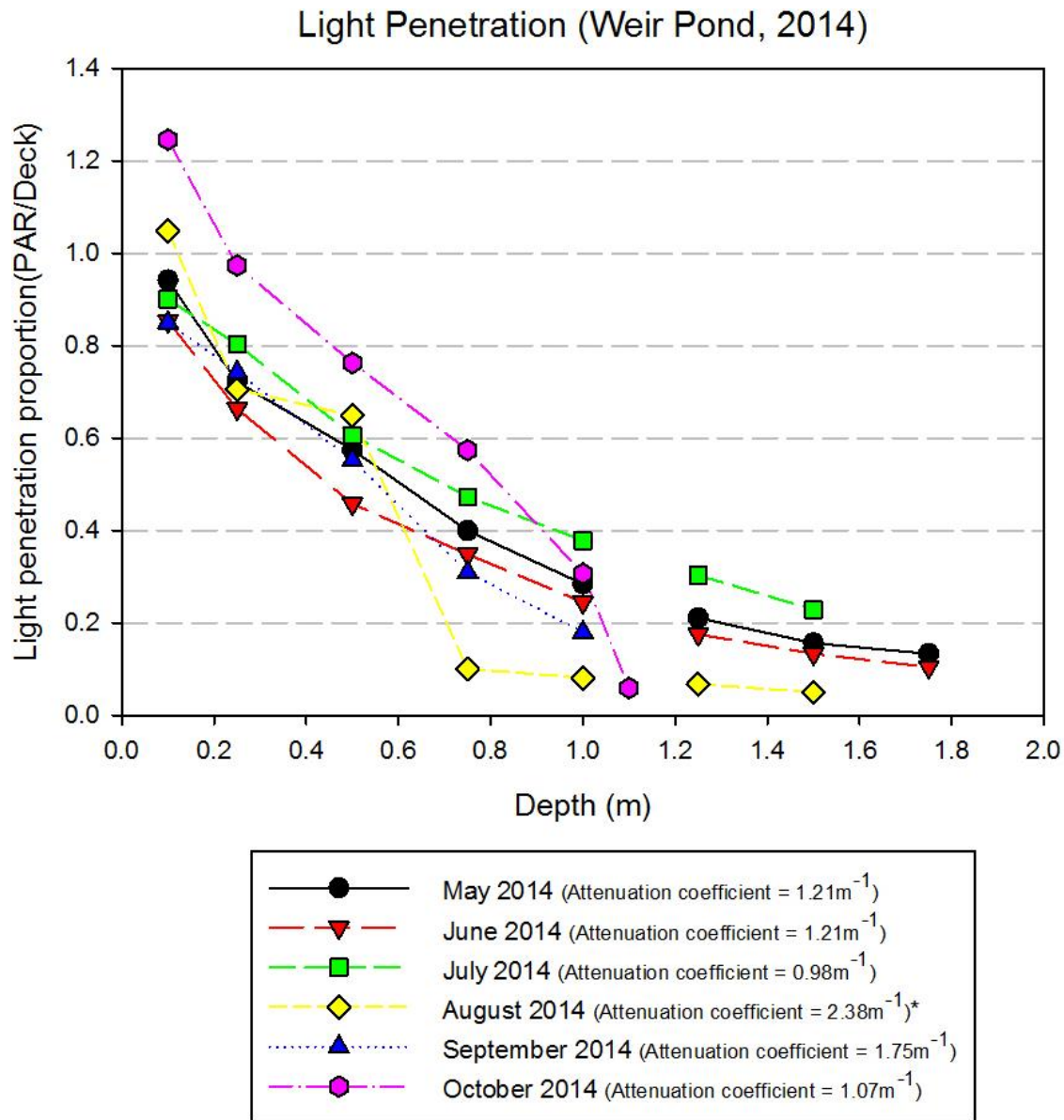


Figure 10. Light penetration profiles from Weir Pond.

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.

Although there are no numeric Connecticut TP standards, 2014 total phosphorus concentrations in Weir Pond (Figure 11) were within the state-defined range for mesotrophic ponds (10 µg/L to 30 µg/L). The 2014 TP values were well above the EPA Ecoregion 14 criterion of 8 µg/L for ponds, however. As described above (“Water Quality Standards”), the EPA criteria do not have any regulatory meaning. The spring (June) TP levels were nearly double those of the August samples, and were likely responsible for the high spring chlorophyll *a* concentrations in the pond.

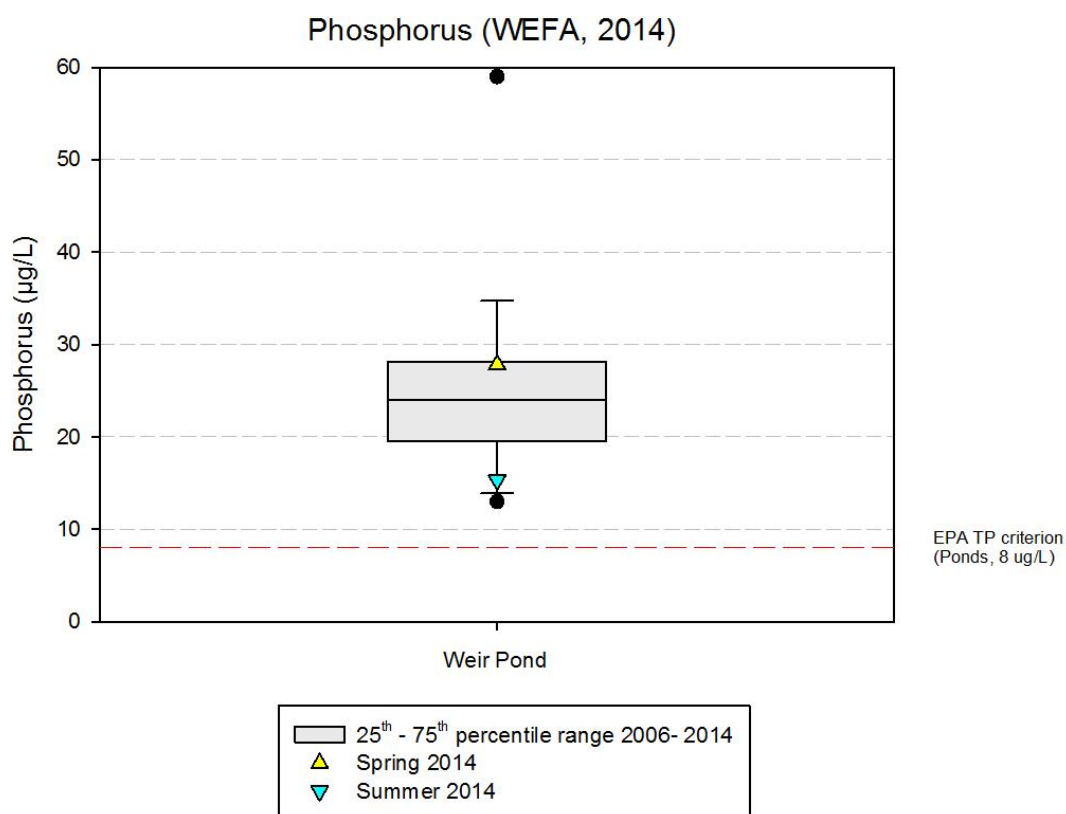


Figure 11. Total phosphorus (TP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2014.

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 (NO₃) 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 (NO₂) is an unstable form of nitrogen that is either

rapidly oxidized to nitrate (nitrification) or reduced to nitrogen gas (de-nitrification). 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 12. The 2014 spring TN measurement was within the appropriate range (0.30 mg/L to 0.60 mg/L) defined by the state for mesotrophic ponds (Connecticut has no numerical standard for TN); however, the 2014 summer value was higher. TN values exceeded the EPA Ecoregion 14 criterion for ponds of 0.32 mg/L, although as with TP this criterion does not have regulatory meaning. Nitrate, nitrite and ammonia concentrations were all below the method reporting limits.

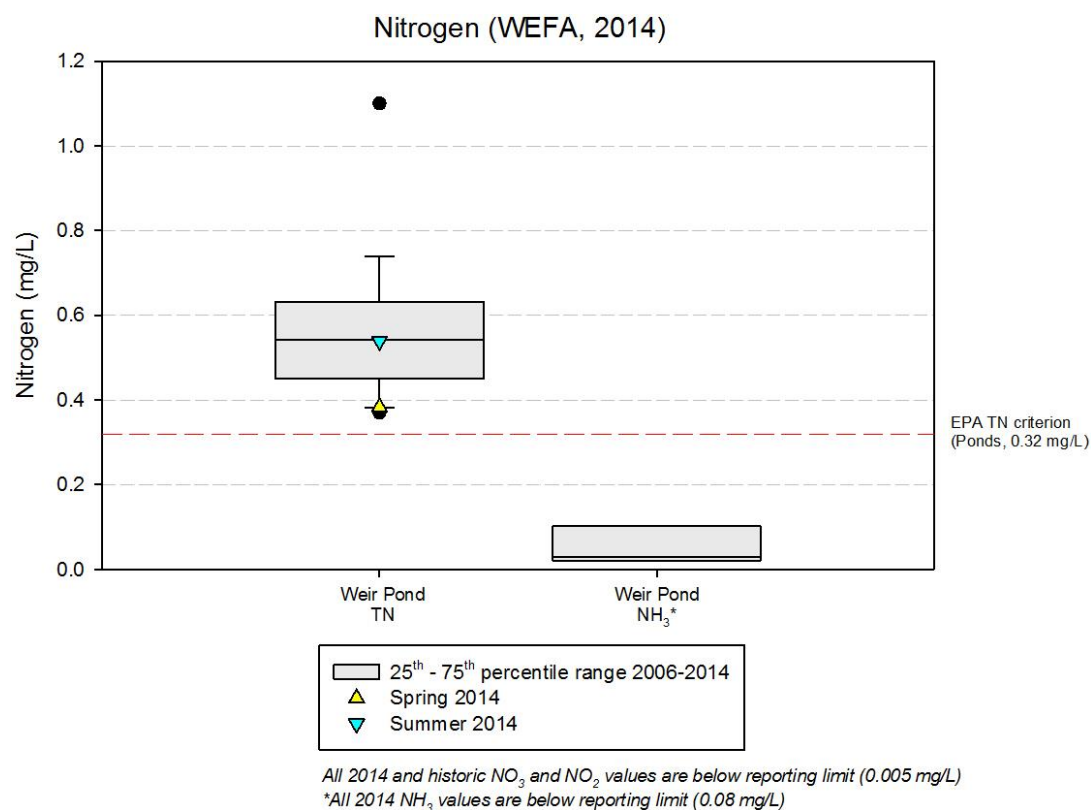


Figure 12. Total nitrogen (TN) and ammonia (NH_3) from 2014 water samples. The data are overlaid on a box plot of measurements taken from 2006-2014.

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.

2014 chlorophyll *a* concentrations in Weir Pond (Figure 13) were above (spring) and below (summer) the range defined by the 25th and 90th percentiles, but are generally within the range the state sets for a mesotrophic pond (2 to 15 µg/L). It is somewhat unusual for spring chlorophyll *a* concentrations to be significantly higher than summer values, but this elevation is likely correlated to higher spring TP levels. The high spring chlorophyll readings may be an indication of a small to moderate algal bloom.

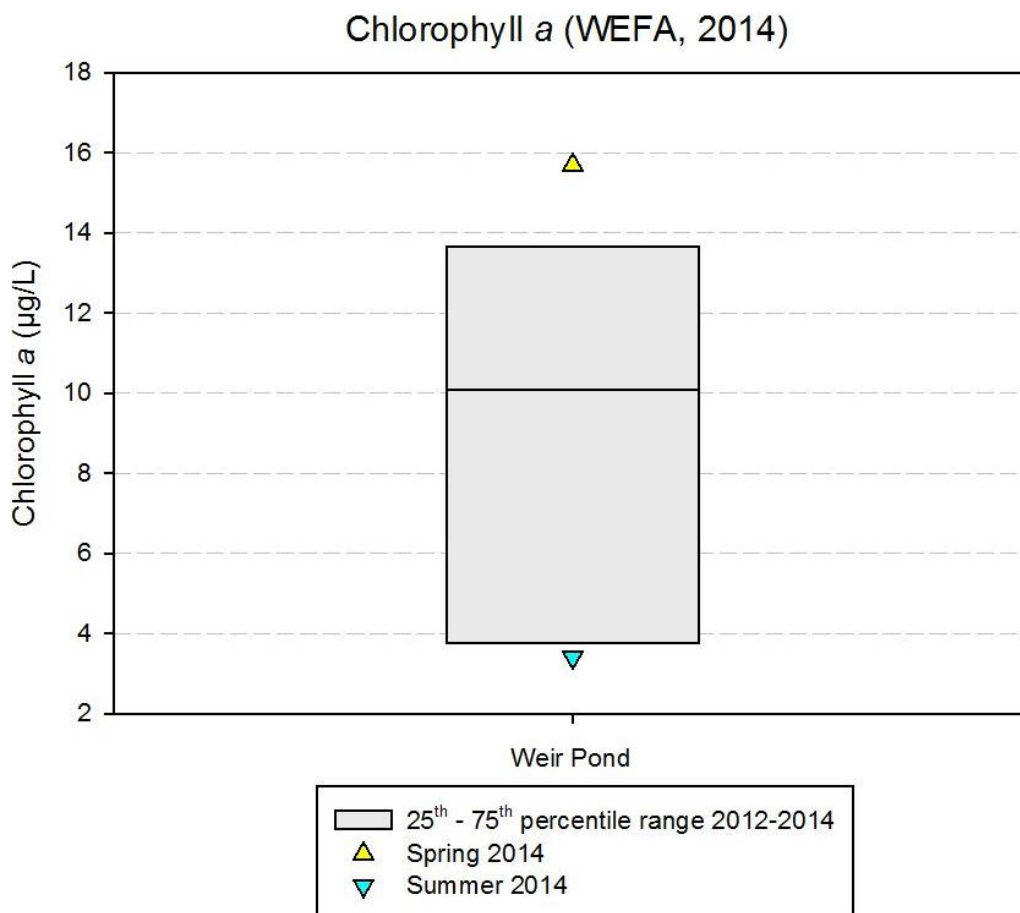


Figure 13. Chlorophyll *a* from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

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 WEFA samples were high in 2014 (Figure 14), at (spring) or above (summer) the 75th percentile for historic data.

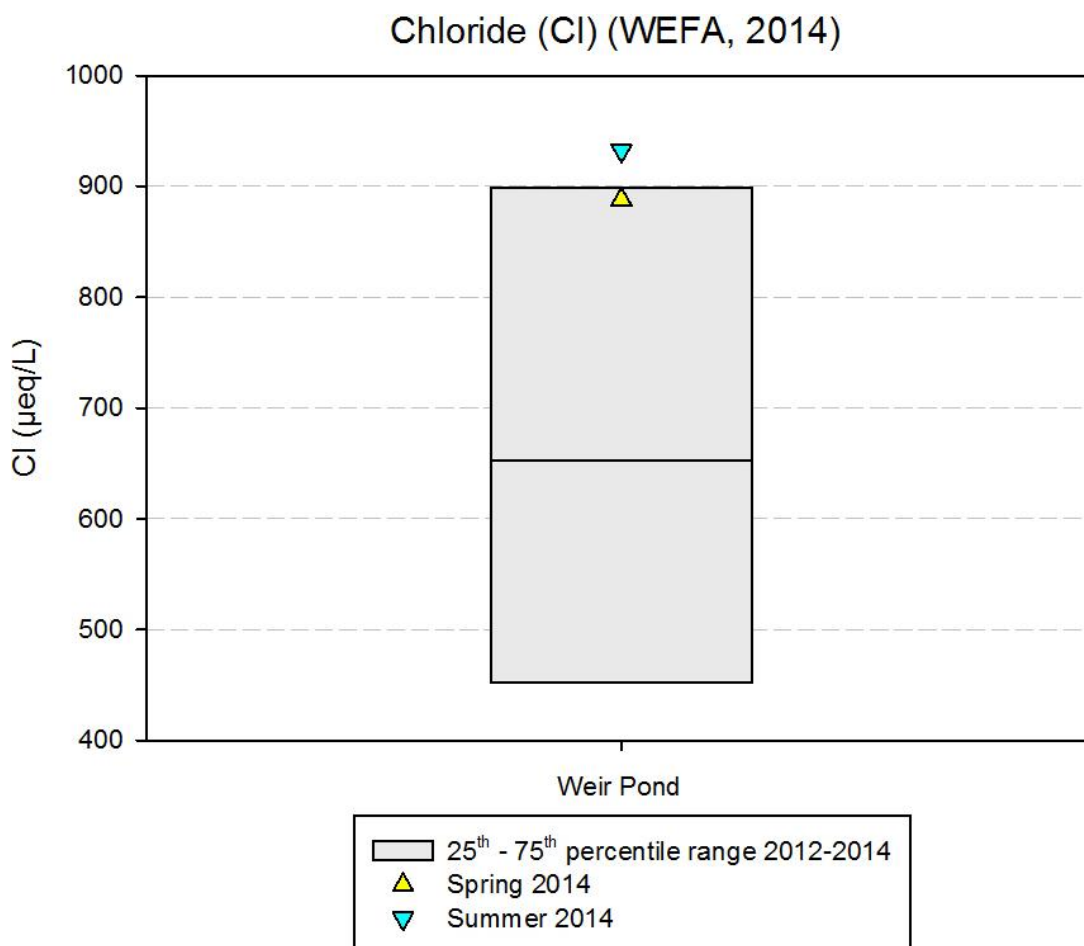


Figure 14. Chloride from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

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 μ eq/L to 695 μ eq/L (Wetzel 1983), and sulfate concentrations at WEFA were at or below this range in 2014 (Figure 15).

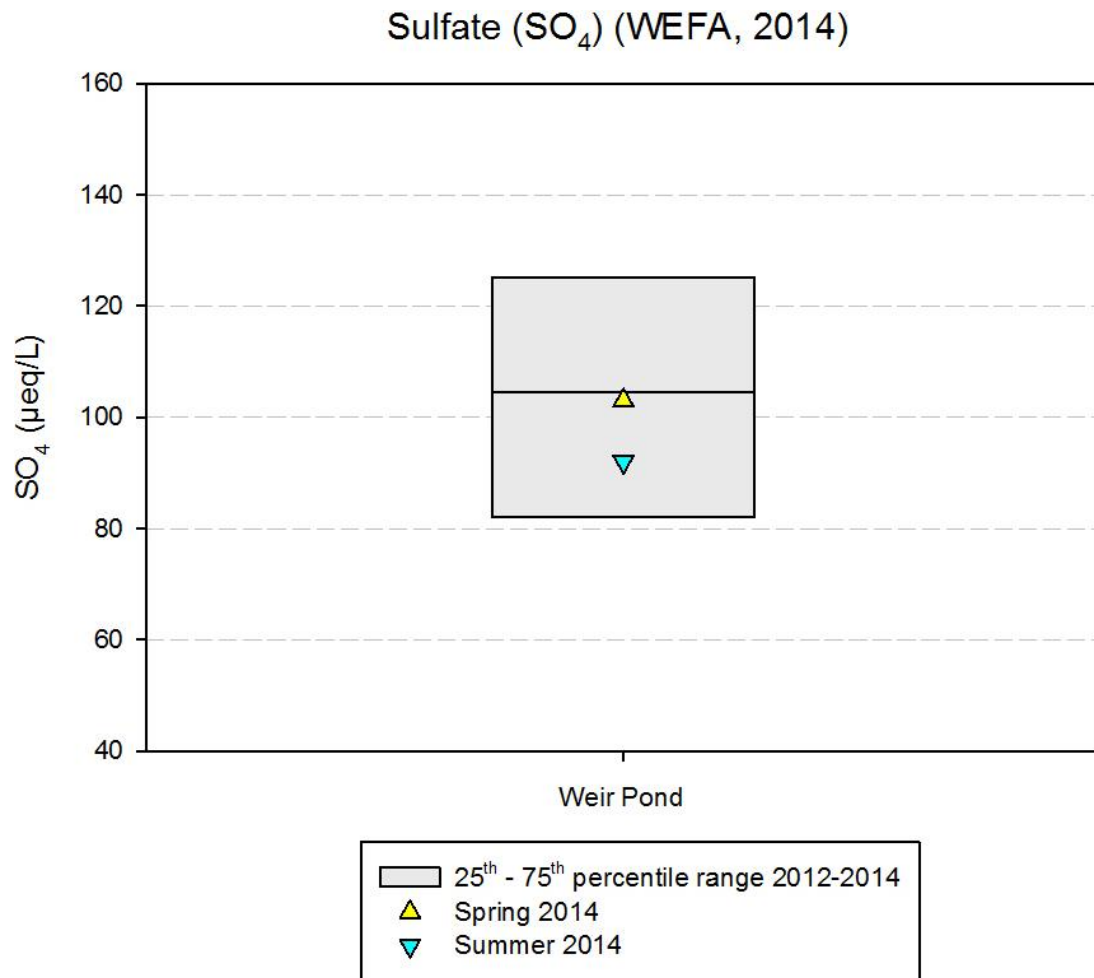


Figure 15. Sulfate from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

Water Quantity

Pond Stage

Pond stage measurements were taken by measuring to the water surface from a fixed datum point. Stage measurements from 2014 are graphed in Figure 16.

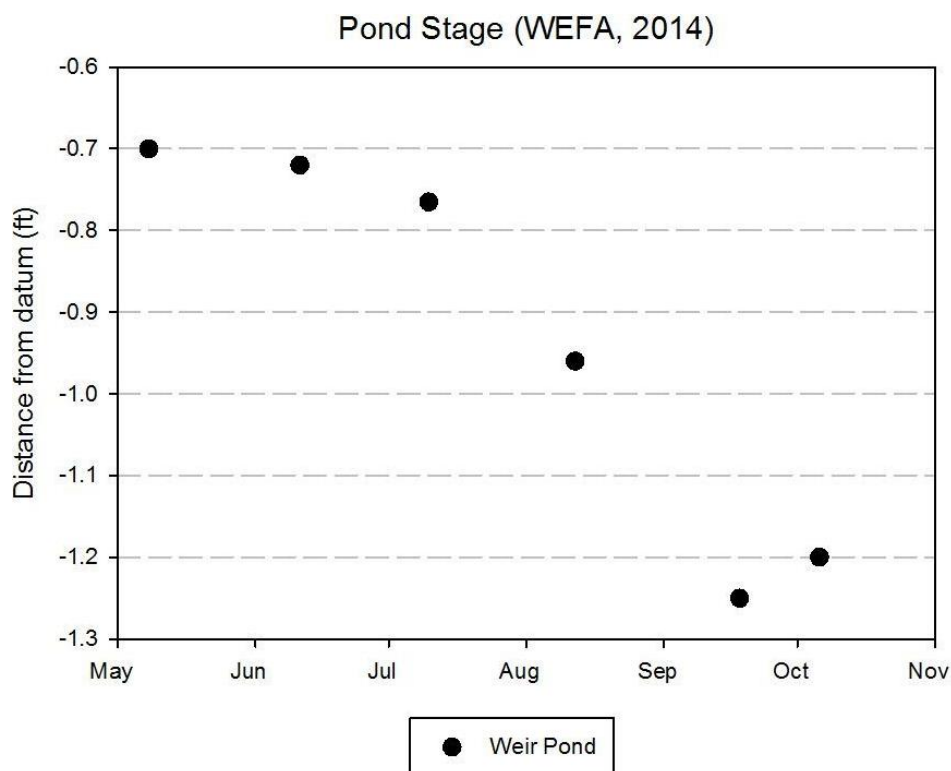


Figure 16. Pond stage obtained in 2014 by measuring from a permanent datum point to the water surface.

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 Connecticut Department of Energy and Environmental Protection (DEEP) website (http://www.ct.gov/deep/cwp/view.asp?a=2696&q=322690&deepNav_GID=1630). All of the MCIAP species of concern listed in Table 4, with the exception of European Frogbit, are also on the DEEP list.

Invasive aquatic plant monitoring was conducted at the Weir Pond during the 2014 monitoring season. Results indicated that invasive aquatic plants were not detected at Weir 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. Connecticut Department of Energy and Environmental Protection species of concern.

Common name	Latin name
Common Reed	<i>Phragmites australis</i>
Pond Water-starwort	<i>Callitriche stagnalis</i>
American Water Lotus	<i>Nelumbo lutea</i>
Yellow Iris	<i>Iris pseudacorus</i>
Giant Salvinia	<i>Salvinia molesta</i>
Purple Loosestrife	<i>Lythrum salicaria</i>
Onerow Yellowcress	<i>Rorippa microphylla</i>
Watercress	<i>Rorippa nasturium-aquaticum</i>

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. 2014).

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.

Quality Assurance and Quality Control (QA/QC)

QA/QC is important to the success of a long-term data collection and trend detection program. Quality assurance (QA) is achieved through the establishment and use of the NETN Freshwater Monitoring Protocol. Specific procedures are used to control critical components of a project such as sampling at the right place with the right equipment and using the right methods. Over the years, staff will change, equipment may be updated, and methods may evolve. Although these changes will be kept to a minimum, changes are inevitable and therefore following an established and well-documented protocol will ensure that the data remain valid.

QA requirements incorporated in the protocol include consistency and low turnover in project leaders and staff, consistency in staff training and oversight, consistency in equipment used and calibration methods, the selection of a well-established chemical laboratory with a proven track record, and a robust sample design that includes an adequate number of field and laboratory quality control (QC) samples.

QC includes the assessment of bias and variability through the use of additional samples such as blank and replicate samples. QC samples are an objective assessment of whether or not QA protocols are adequate. The protocol calls for the collection of two blank and two replicate samples (one each from lakes/ponds and streams, respectively) during both the spring and summer nutrient sampling months at Acadia NP, and the same number, distribution, and schedule at the combined eight “Lower NETN” parks. Sample collection sites are selected at random from both monitoring groups.

The latest (2014) protocol revision requires in situ measurements, including Secchi transparency, sonde water quality, and stream discharge, to be periodically replicated to ensure that field equipment and observers are performing within the required precision standards. Water quality sonde temperature, pH and specific conductance measurements are to be compared monthly in the laboratory with similar measurements made with a NIST-traceable thermometer and benchtop pH and conductivity meters. Sonde dissolved oxygen measurements will be compared in the field to measurements made using a LaMotte dissolved oxygen test kit (Winkler titration method). These additional procedures will begin network-wide in the 2014 monitoring season.

Nutrient QC Sample Results

Analysis results of all 2014 blank samples collected from Lower NETN ponds and streams (Appendix B, Table B1) were near or below the method reporting limits, indicating little or no contamination was introduced during the sampling, handling and analysis processes. However, new instrumentation utilized at the analytical lab in June and August provided lower detection and reporting limits for several analytes (NO₂, NH₃, SO₄), allowing quantification of some levels of possible contamination not detected in the past. Replicate sample analysis results (Appendix B, Table B2) showed that most Lower NETN samples were in the acceptable range of precision (relative percent difference or precision objective in units, depending on sample concentration).

Summary

Most 2014 water quality parameters for Weir Pond in Weir Farm National Historic Site were within state standards, and were above the EPA Ecoregion 14 criteria, where applicable. Several metrics showed a great deal of variability relative to the historic range, and where variability was least the measures were frequently biased toward one end of the range. Specific conductance measurements were all at the high end of the historic range, with only one measurement being below the 90th percentile. pH varied throughout the entire historical range, with two readings exceeding the high state standard, including one exceeding the 90th percentile (although this value is suspected of being inaccurate due to equipment problems). Temperature and dissolved oxygen were similarly variable throughout the sampling season. Both spring and summer chloride values were among the highest recorded by the NETN to date. Most of the remaining metrics were not as variable, and fell within their historic ranges.

Spring (June) TP levels, however, were nearly double those of the August samples, and were likely responsible for high spring chlorophyll *a* concentrations in the pond, which may have been an indication of a small to moderate algal bloom. This was possibly a result of sediment or other contaminant input from watershed runoff. High spring apparent color without corresponding elevated DOC concentrations also points toward increased presence of suspended matter in the color sample fractions. TN measurements were moderate throughout the season, and within the appropriate range defined by the state for mesotrophic ponds.

Monitoring under the NETN protocol builds on the historic water quality monitoring by the National Park Service and other agencies to provide critical baseline information on the chemical and physical status of the water resources at Weir Farm National Historic Site. 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, are helping to 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. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2014.

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

Site	NETN Code	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (µS/cm)
Weir Pond	WEFAPA	5/8/2014	0.00	15.57	10.92	7.29	156.00
Weir Pond	WEFAPA	5/8/2014	0.51	15.46	10.92	7.21	156.00
Weir Pond	WEFAPA	5/8/2014	1.00	15.25	10.25	7.03	158.00
Weir Pond	WEFAPA	5/8/2014	1.50	14.94	9.92	6.96	159.00
Weir Pond	WEFAPA	5/8/2014	1.60	14.90	9.18	6.99	160.00
Weir Pond	WEFAPA	6/11/2014	-0.01	21.53	5.34	6.89	164.00
Weir Pond	WEFAPA	6/11/2014	0.50	21.52	5.31	6.89	164.00
Weir Pond	WEFAPA	6/11/2014	1.00	21.52	5.37	6.89	164.00
Weir Pond	WEFAPA	6/11/2014	1.50	21.43	4.31	6.80	166.00
Weir Pond	WEFAPA	6/11/2014	1.63	21.20	2.03	6.66	175.00
Weir Pond	WEFAPA	7/10/2014	-0.01	28.34	6.95	7.08	157.00
Weir Pond	WEFAPA	7/10/2014	0.50	27.13	7.09	6.89	157.00
Weir Pond	WEFAPA	7/10/2014	1.01	26.62	7.02	6.75	156.00
Weir Pond	WEFAPA	7/10/2014	1.50	26.44	8.60	7.47	155.00
Weir Pond	WEFAPA	7/10/2014	1.68	25.55	6.10	6.20	164.00
Weir Pond	WEFAPA	8/12/2014	0.00	25.53	9.61	9.13	156.00
Weir Pond	WEFAPA	8/12/2014	0.51	25.42	9.32	9.15	155.00
Weir Pond	WEFAPA	8/12/2014	1.05	25.23	8.98	8.98	155.00
Weir Pond	WEFAPA	8/12/2014	1.38	24.97	6.85	7.20	154.00
Weir Pond	WEFAPA	9/18/2014	0.10	18.61	9.61	8.22	159.00
Weir Pond	WEFAPA	9/18/2014	0.50	18.25	10.09	8.63	159.00
Weir Pond	WEFAPA	9/18/2014	1.00	18.11	7.96	8.43	161.00
Weir Pond	WEFAPA	9/18/2014	1.20	18.12	8.33	8.10	173.00
Weir Pond	WEFAPA	9/18/2014	1.21	18.20	5.91	7.66	185.00
Weir Pond	WEFAPA	10/6/2014	-0.04	16.62	9.41	7.62	153.00
Weir Pond	WEFAPA	10/6/2014	0.50	15.49	9.48	7.40	153.00

Appendix A. Acadia National Park (ACAD) Water Monitoring Data, 2012 (continued).

Table A1 (continued). YSI sonde in-situ stream water quality measurements collected at WEFA.

Site	NETN Code	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (μ S/cm)
Weir Pond	WEFAPA	10/6/2014	0.50	15.49	9.45	7.41	153.00
Weir Pond	WEFAPA	10/6/2014	0.90	15.46	9.51	7.39	154.00

Appendix A. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2014 (continued).

Table A2. Laboratory nutrient chemistry data for WEFA. “<MRL” indicates the result was below the method reporting limit (0.1 for TN, 1.0 for NO₃, 0.005 for NO₂, and 0.08 for NH₃).

Site	Date	ANC (µeq/L)	A Color (PCU)	DOC (mg/L)	TP (µg/L)	TN (mg/L)	NO ₃ (µeq/L)	NO ₃ -N (mg/L Calc)	NO ₂ (mg/L)	NH ₃ (mg/L)	Chla (µg/L)	Cl (µeq/L)	SO ₄ (µeq/L)
Weir Pond	6/11/2014	425.82	75	4.89	27.8	0.383	<MRL	<MRL	<MRL	<MRL	15.7	888	103
Weir Pond	8/12/2014	379.76	30	5.00	15.3	0.539	<MRL	<MRL	<MRL	0.032	3.4	932	92

Appendix A. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2014 (continued).

Table A3. Pond stage data for WEFA.

Site	Date	Datum name	Distance from datum (ft)
Weir Pond	5/8/2014	Bolt1	-0.700
Weir Pond	6/11/2014	Bolt1	-0.720
Weir Pond	7/10/2014	Bolt1	-0.765
Weir Pond	8/12/2014	Bolt1	-0.960
Weir Pond	9/18/2014	Bolt1	-1.250
Weir Pond	10/6/2014	Bolt1	-1.200

Table A4. Pond water transparency data for WEFA. “B” after transparency value indicates disk pattern still visible at pond bottom.

Site	Date	Secchi Depth (m)	(B=disk hit bottom)
Weir Pond	5/8/2014	1.80	
Weir Pond	6/11/2014	1.82	
Weir Pond	7/10/2014	1.80	B
Weir Pond	8/12/2014	1.65	B
Weir Pond	9/18/2014	1.10	
Weir Pond	10/6/2014	1.31	

Appendix A. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2014 (continued).

Table A5. Light penetration profiles for WEFA.

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)
Weir Pond	WEFAPA	5/8/2014	0.10	278.86	262.73	0.94
Weir Pond	WEFAPA	5/8/2014	0.25	291.08	209.98	0.72
Weir Pond	WEFAPA	5/8/2014	0.50	302.53	173.93	0.57
Weir Pond	WEFAPA	5/8/2014	0.75	302.52	120.89	0.40
Weir Pond	WEFAPA	5/8/2014	1.00	318.46	90.51	0.28
Weir Pond	WEFAPA	5/8/2014	1.25	334.56	70.46	0.21
Weir Pond	WEFAPA	5/8/2014	1.50	343.91	53.67	0.16
Weir Pond	WEFAPA	5/8/2014	1.75	352.82	46.98	0.13
Weir Pond	WEFAPA	6/11/2014	0.10	210.55	179.94	0.85
Weir Pond	WEFAPA	6/11/2014	0.25	218.66	145.03	0.66
Weir Pond	WEFAPA	6/11/2014	0.50	226.85	103.78	0.46
Weir Pond	WEFAPA	6/11/2014	0.75	253.27	88.22	0.35
Weir Pond	WEFAPA	6/11/2014	1.00	266.83	65.27	0.24
Weir Pond	WEFAPA	6/11/2014	1.25	288.89	50.61	0.18
Weir Pond	WEFAPA	6/11/2014	1.50	295.56	39.26	0.13
Weir Pond	WEFAPA	6/11/2014	1.75	338.26	35.32	0.10
Weir Pond	WEFAPA	7/10/2014	0.10	1903.20	1714.50	0.90
Weir Pond	WEFAPA	7/10/2014	0.25	1883.60	1512.30	0.80
Weir Pond	WEFAPA	7/10/2014	0.50	1842.60	1116.10	0.61
Weir Pond	WEFAPA	7/10/2014	0.75	1810.80	855.90	0.47
Weir Pond	WEFAPA	7/10/2014	1.00	1740.60	658.38	0.38
Weir Pond	WEFAPA	7/10/2014	1.25	1735.10	525.42	0.30
Weir Pond	WEFAPA	7/10/2014	1.50	1722.00	393.61	0.23
Weir Pond	WEFAPA	8/12/2014	0.10	356.19	373.63	1.05
Weir Pond	WEFAPA	8/12/2014	0.25	362.99	256.33	0.71
Weir Pond	WEFAPA	8/12/2014	0.50	331.06	214.92	0.65
Weir Pond	WEFAPA	8/12/2014	0.75	308.88	31.00	0.10
Weir Pond	WEFAPA	8/12/2014	1.00	296.04	23.82	0.08
Weir Pond	WEFAPA	8/12/2014	1.25	322.46	21.67	0.07

Appendix A. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2014 (continued).

Table A5 (continued). Light penetration profiles for WEFA.

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)
Weir Pond	WEFAPA	8/12/2014	1.50	375.30	18.52	0.05
Weir Pond	WEFAPA	9/18/2014	0.10	1531.70	1303.70	0.85
Weir Pond	WEFAPA	9/18/2014	0.25	1580.10	1170.40	0.74
Weir Pond	WEFAPA	9/18/2014	0.50	1242.50	685.08	0.55
Weir Pond	WEFAPA	9/18/2014	0.75	1551.70	479.75	0.31
Weir Pond	WEFAPA	9/18/2014	1.00	1631.90	293.20	0.18
Weir Pond	WEFAPA	10/6/2014	0.10	998.63	1243.10	1.25
Weir Pond	WEFAPA	10/6/2014	0.25	1084.70	1055.20	0.97
Weir Pond	WEFAPA	10/6/2014	0.50	1178.30	898.63	0.76
Weir Pond	WEFAPA	10/6/2014	0.75	1240.90	712.65	0.57
Weir Pond	WEFAPA	10/6/2014	1.00	1190.40	365.36	0.31
Weir Pond	WEFAPA	10/6/2014	1.10	839.61	50.47	0.06

Appendix B. Weir Farm National Historic Site (WEFA) Blank and Replicate Water Samples, 2014.

Table B1. 2014 Blank sample analysis results (Lower NETN).

Site	Date	ANC (µeq/L)	A Color (PCU)	DOC (mg/L)	Chla (µg/L)	Cl (µeq/L)	SO ₄ (µeq/L)	TP (µg/L)	TN (mg/L)	NO ₂ (mg/L)	NO ₃ (µeq/L)	NH ₃ (mg/L)
SARASC	5/20/2014	-1.70	1	<MRL 0.5		<MRL 2	<MRL 2	<MRL 1	<MRL 0.100	<MRL 0.005	<MRL 1	<MRL 0.080
WEFAPA	6/11/2014	-2.12	1	<MRL 0.5	<MRL 1	<MRL 2	<MRL 2	<MRL 1	0.017	<MRL 0.005	<MRL 1	<MRL 0.080
MABISA	8/4/2014	-2.95	1	<MRL 0.5		<MRL 2	<MRL 2	<MRL 1	0.0180	<MRL 0.001	<MRL 1	<MRL 0.003
MABIPA	8/4/2014	-1.44	1	<MRL 0.5	0.2	<MRL 2	<MRL 2	<MRL 1	<MRL 0.100	<MRL 0.001	<MRL 1	0.010

Table B2. Replicate sample analysis results and measurement quality analysis (Lower NETN).

Site	Date	Color Reg	Color Rep	Diff (PCU)	% Diff	DOC Reg	DOC Rep	Diff (mg/L)	% Diff	ANC Reg	ANC Rep	Diff (µeq/L)	% Diff
MIMASA	5/22/2014	207	204	3.0	1.4%	8.85	8.62	0.23	2.60%	755.0	749.0	6.0	0.8%
MABIPA	6/3/2014	26	26	0.0	0.0%	2.30	2.39	-0.09	3.91%	1632.6	1628.9	3.7	0.2%
WEFAPA	8/12/2014	30	32	-2.0	6.7%	5.00	5.00	0.00	0.00%	379.8	378.4	1.3	0.4%
MORRSB	8/12/2014	19	22	-3.0	15.8%	2.00	1.85	0.15	7.50%	789.7	791.6	-1.9	0.2%

Site	Date	Chla Reg	Chla Rep	Diff (µg/L)	% Diff	TP Reg	TP Rep	Diff (µg/L)	% Diff	TN Reg	TN Rep	Diff (mg/L)	% Diff
MIMASA	5/22/2014					124.0	136.0	-12.0	9.7%	0.77	0.87	-0.11	13.7%
MABIPA	6/3/2014	6.1				10.3	10.3	0.0	0.0%	0.28	0.30	-0.02	7.8%
WEFAPA	8/12/2014	3.4				15.3	15.0	0.3	2.0%	0.54	0.45	0.09	16.5%
MORRSB	8/12/2014					28.4	30.3	-1.9	6.7%	0.49	0.48	0.01	2.1%

Appendix B. Weir Farm National Historic Site (WEFA) Blank and Replicate Water Samples, 2013.

Site	Date	NO ₃ Reg	NO ₃ Rep	Diff (µeq/L)	% Diff	NO ₂ Reg	NO ₂ Rep	Diff (mg/L)	% Diff	NH ₃ Reg	NH ₃ Rep	Diff (mg/L)	% Diff
MIMASA	5/22/2014	8.9	8.4	0.50	5.6%	0.0072	0.0073	0.000	1.4%	< MRL	< MRL		
MABIPA	6/3/2014	< MRL	< MRL			< MRL	< MRL			< MRL	< MRL		
WEFAPA	8/12/2014	< MRL	< MRL			< MRL	< MRL			0.032	0.03	0.002	6.3%
MORRSB	8/12/2014	28	28	0.00	0.0%	< MRL	< MRL			0.024	< MRL		

Site	Date	SO ₄ Reg	SO ₄ Rep	Diff (µeq/L)	% Diff	Cl Reg	Cl Rep	Diff (µeq/L)	% Diff
MIMASA	5/22/2014	213	199	14.0	6.6%	4330	3985	345.0	8.0%
MABIPA	6/3/2014	88	88	0.0	0.0%	17	17	0.0	0.0%
WEFAPA	8/12/2014	92	89	3.0	3.3%	932	932	0.0	0.0%
MORRSB	8/12/2014	291	300	-9.0	3.1%	170	175	-5.0	2.9%

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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National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov



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