ABSTRACT

CAIN, JESSICA LEIGH. Water Quality and Stratification in Jordan Lake: Assessment of Spatial, Temporal and Inter-Annual Variability. (Under the direction of Matt Polizzotto).

B. Everett Jordan Lake supplies the drinking water for approximately 300,000 residents in the Towns of Cary, Apex, and Morrisville, North Carolina. The lake was added to the North Carolina impaired waters list in 2002 due to over-enrichment of nutrients and algal growth. During summer stratification, low dissolved oxygen and high concentrations of dissolved iron, manganese, and nutrients occur near the bottom. Additionally, phytoplankton, including species that produce geosmin and 2-methyl-isoborneol (MIB), grow abundantly near the surface. Water quality concerns and taste and odor issues, along with the increased costs associated with water treatment needs, provided motivation for evaluating water quality and stratification patterns. Accordingly, the Town of Cary asked the United States Geological Survey to determine spatial and temporal variability in lake water quality parameters in the vicinity of their water-supply intake. The research objectives are to assess water quality differences among sampling locations, determine the extent of seasonal and inter-annual variability in water quality parameters, and evaluate if chlorophyll *a* can be useful as an indicator of taste and odor compounds. Biweekly samples were collected from April through November during 2012 and April through October 2013 at four locations in the New Hope arm of Jordan Lake. Constituents for data collection included: secchi depth, the depth to one percent incident light, turbidity, iron, manganese, chlorophyll *a*, geosmin, 2-methylisoborneol, and nutrients (ammonia plus organic nitrogen, ammonia, total organic nitrogen, nitrate plus nitrite, total nitrogen, orthophosphate, and phosphorus). Vertical profiles of pH, specific conductance, dissolved oxygen, and water temperature were also measured. Based on regression analyses and Wilcoxon signed-rank tests, the occurrence of spatial variation among the study sites was low. The parameters which varied significantly among sites included turbidity, secchi depth, depth to one percent light, total iron, and total manganese. Spatial variation was most pronounced between the Intake site, which is the most downstream site, and Buoy 9, which is the most upstream site. Seasonal and inter-annual differences were observed for most parameters and constituents, with the exception of secchi depth, depth to one percent light, and orthophosphate. Generally, metal and nutrient concentrations were consistently higher during summer stratification near the bottom, although some parameters differed by year. Evaluation of chlorophyll *a*, MIB and geosmin correlation plots and timing of peak values determined that chlorophyll *a* is not a good predictor of taste and odor compounds. Results suggest that only minor differences in water quality parameters were observed among the study sites, whereas more substantial differences were noted seasonally and between the two years of the study. These results indicate the importance of sampling multiple years to account for natural water quality variability to support decision making. Overall, the benefit of the project provides a more in-depth understanding of water quality and stratification in an area of the lake where the Town of Cary plans to install a large water-column destratification system. Documenting pre-installation conditions will facilitate future evaluations of the effects of the mixing system on water quality in this high-profile reservoir.

Water Quality and Stratification in Jordan Lake: Assessment of Spatial, Temporal and Inter-Annual Variability.

by
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DEDICATION

I am forever grateful to my supervisors, colleagues, and friends at the U.S. Geological Survey for this educational opportunity. This thesis is also dedicated to my parents, Scott Cain and Linda Hahn, my sister, Katheryn Koren, my brother, Christopher Cain, and my fiancé, David Kennedy. I learned the fundamentals of independence and the value of education from my family and without those values, this thesis and degree would not have been possible.

BIOGRAPHY

Jessica Cain grew up in Pensacola, FL and attended the University of Florida in Gainesville, FL where she earned a Bachelor of Science in Food and Resource Economics in 2003 with minors in Environmental Studies and Natural Resource and Environmental Ethics and Policy. Upon graduation, Jessica worked briefly on the Lake Okeechobee Watershed Project for the U.S. Geological Survey in Altamonte Springs, FL, and then spent three years employed by private environmental consulting firms as an Environmental Scientist. In 2009, Jessica returned to the USGS as a Hydrologic Technician. The USGS took Jessica's career to Raleigh, NC in July 2012 where she continues to work on various water quality projects and surface water streamgaging. In August 2013, Jessica began earning her Master of Science in Soil Science at North Carolina State University part-time, while continuing to work for the USGS full-time.

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1 INTRODUCTION

1.1 Lake and Reservoir Ecosystems

Lakes and reservoirs are dynamic water systems, which many organisms depend on for their livelihood and existence. These bodies of water are vital for many reasons including: sources of drinking water, aquatic habitat, fisheries, irrigation, dilution of pollutants, industrial activity, and recreation. The management of lakes and reservoirs should be based on an understanding that these ecosystems are multifaceted and dynamic.

The primary issue facing many surface waters today is cultural eutrophication, which is defined as excessive plant growth resulting from nutrient enrichment by human activity (Smith and Schindler, 2009). Eutrophication is a natural occurrence; however, human activity increases the rate in many lakes, reservoirs and streams. Increases in agricultural fertilization and land development may result in higher inputs of nutrients, such as nitrogen and phosphorus, into both rural and urban streams and lakes. According to the U.S. Environmental Protection Agency (USEPA), more than 100,000 miles of rivers and streams, close to 2.5 million acres of lakes, reservoirs and ponds, and more than 800 square miles of bays and estuaries in the United States have poor water quality because of nitrogen and phosphorus pollution (USEPA, 2017a). Implementation of restrictions of nutrient inputs will be essential for eutrophication management (Smith and Schindler, 2009).

1.2 Water Quality Issues and Concerns

Phosphorus and nitrogen are two nutrients that can have a significant impact on the eutrophication of lake and reservoir systems. They are essential for plant growth; however, excess nutrients can result in overproduction of organic matter. The sources of nutrient enrichment can be placed in two categories: point sources and nonpoint sources. Point source pollution can be derived from industrial wastewater, domestic wastewater, treated water from sewage treatment plants, and wastewater from livestock or aquaculture (Inamori and Fujimoto, 2010). Nonpoint sources of nutrients include runoff from animal manure, excess fertilizer, and atmospheric deposition (U.S. Geological Survey, 1994). The main factors that contribute to an escalation in nutrients in lakes and reservoirs include the increasing use of fertilizers, the disposal of wastes (livestock and human), and changes in land use (World Health Organization, 2011a). Specifically, changes in land use include erosion from agriculture, logging and construction, mine drainage, and hydrologic changes (Carpenter, et al., 1998). These changes can also lead to siltation in lakes and further degradation of water quality.

Nitrogen is a major nutrient that affects the productivity of lake systems. The nitrogen cycle is a biogeochemical cycle by which nitrogen is altered by fixation, assimilation, and reduction of nitrate to molecular nitrogen by denitrification (Wetzel, 2001). In lakes, this cycle is mostly microbial: bacterial oxidation and reduction of nitrogen compounds coupled with photosynthetic assimilation and utilization by algae, bacteria and larger aquatic plants (Wetzel, 2001). The dominant forms of nitrogen in lakes include: ammonia, nitrite, nitrate and organic nitrogen (e.g., amino acids, amines, nucleotides, proteins, and humic compounds of low nitrogen content). Ammonia is the reduced form of inorganic nitrogen and is produced by bacteria under anaerobic conditions (Harter and Rollins, 2008). Thus, levels of ammonia increase in conditions with low oxygen. Nitrate and nitrite are the oxidized forms of nitrogen found in aerobic conditions (Harter and Rollins, 2008). In conditions with low oxygen, nitrate and nitrite are rapidly denitrified to nitrogen, which is either fixed (converted to ammonia) or lost to the environment (Wetzel, 2001). Within lakes and reservoirs, the distribution of nitrogen can change rapidly based on depth, lake stratification and oxygen conditions.

The over-enrichment of nitrogen may have many negative impacts to lakes, reservoirs, and human and aquatic health. High concentrations of nitrogen in the form of nitrate can cause public-health problems and life-threatening conditions. Blue baby syndrome or methemoglobinemia, in which an infant may lose the ability to incorporate oxygen into his/her blood, can be the result of drinking water with nitrate levels higher than 10 milligrams per liter (mg/L) (United Nations Environment Programme, 2017). Regarding the nutrient species, nitrate plus nitrite is the only nutrient fraction for which a NC state water quality standard currently exists for water supply (10 mg/L); however, the state is currently working on other nutrient standards (North Carolina Department of Environment and Natural Resources, 2017a).

Additionally, phosphorus can be a limiting nutrient in biological productivity. Even at low concentrations, the presence of phosphorus can result in overproduction of plants and algae, which contributes to eutrophication (Harter and Rollins, 2008). Orthophosphate is the only directly functional form of soluble inorganic phosphorus (Wetzel, 2001). The solubility of phosphorus is dependent on the redox status of the environment, oxygen supply, and activities of bacteria. If oxygen levels are low, phosphate may become soluble due to reducing conditions and dissolution of redox-active minerals to which phosphate commonly binds (Wetzel, 2001). Thus, phosphorus levels may increase in anaerobic conditions. Phosphorus is not considered to be directly toxic to humans and animals; therefore, a water quality threshold has not been set (Carpenter et al., 1998).

Excessive masses of algae, supported by an overabundance of nutrients, may cause additional water quality issues. Most major groups of freshwater algae contain some harmful or nuisance species. These groups include the eukaryotic green algae or chlorophytes, dinoflagellates, cryptophytes, chrysophytes, diatoms, and the prokaryotic blue-green algae or cyano-bacteria (Paerl, 2001). Nuisance algae include taste and odor producers, toxin producers, food web disruptors, hypoxia-generating, and aesthetically undesirable types. Some species of cyanobacteria produce cyanotoxins, which accumulate during their development and can be released into the water when the algae die (Herman, 2016). Toxic blooms have been linked to liver disease, human cancers, and deaths (Paerl, 2001). The recreational value of lakes and reservoirs may decrease as a result of higher water turbidity, limited access for fishing, boating or swimming due to plant accumulation, and possible production of toxic substances. Higher concentrations of algae, as well as nutrients and metals, also result in higher treatment costs for municipalities. On a broader scale, biodiversity and abundance of aquatic organisms in a eutrophic system may decrease due to limited oxygen availability, less light penetration, and higher competition with algae and other aquatic plants (Bricker et al., 2008). In general, the measure of chlorophyll *a*, a common photosynthetic pigment found in all plants, including algae, may be used to represent the population density of algae in a lake and can be a vital determination of water quality in lakes and reservoirs (Wetzel, 2001).

As a consequence of nutrient loading and algal growth, taste and odor compounds from algae cause water quality issues in some lakes and reservoirs. Geosmin and 2-methylisoborneol (MIB) have been identified to be the main taste and odor-causing compounds in drinking water obtained from surface water, and these compounds are mostly associated with cyanobacteria, or blue-green algae (Graham et al., 2010). These compounds have a distinct earthy and musty taste and aroma when released. Production of geosmin and MIB has been reported to occur during the active growth period, stationary period, and death (Journey et al., 2011). The presence of these taste and odor compounds is primarily an aesthetic concern and has not been connected to any health effects on humans or aquatic ecosystems; however, consumers may still perceive the odors as unsafe and file complaints with water treatment plants (Srinivasan and Sorial, 2011).

Due to the non-toxic nature of geosmin and MIB, water quality standards for these parameters do not exist. Odor threshold concentrations for geosmin and MIB generally range from 5 to 10 nanograms per liter (ng/L) (Water Research Foundation, 2013). Geosmin and MIB cannot be removed from drinking water by traditional treatment processes. Additional applications of powdered activated carbon (PAC) or other strong oxidants may be necessary to remove these compounds (Bruce et al., 2002). With the aim of better detecting water quality issues and lowering water treatment costs, various water quality monitoring programs have attempted to establish correlations between taste and odor compounds, cyanobacteria densities and chlorophyll *a* concentrations.

High concentrations of dissolved iron and manganese also cause water-treatment concerns. During summer stratification, bacterial decomposition exhausts oxygen in the bottom of the water column. In these conditions where oxygen has been depleted, metals such as iron and manganese become increasingly soluble and are released from the sediments into the hypolimnion (USEPA, 1990). Iron and manganese are essential micronutrients for human, animal and plant growth. Iron in drinking water is unlikely to cause adverse effects for humans, with the exception of lethal doses at 200,000 micrograms per kilogram (μg/kg) of body weight (World Health Organization, 2011b). Ingesting manganese in drinking water is considered one of the least toxic elements; although some cases of ingesting high levels of manganese have caused neurological impairment (World Health Organization, 2011b). Generally, effects of iron and manganese in drinking water are aesthetic, leading to water discoloration, laundry staining, and metallic taste and odors. Thus, water quality standards for North Carolina do not exist for these metals.

1.3 Lake Stratification and Mixing

Vertical stratification is a natural phenomenon in lakes and reservoirs (Wetzel, 2001). The properties of water density and the heating effects of sunlight result in an annual cycle of mixing and stratification of the water column. Figure 1 provides an illustration of typical mixing and stratification in temperate lakes during each season (Young, 2004). During the winter, lakes in central North Carolina typically are isothermal, with a constant temperature throughout the entire water column, and the water column is uniformly mixed. During the summer, the water temperature on the lake's surface (epilimnion) warms due to solar heating and heat exchange with the overlying air; however, the bottom (hypolimnion) of the lake remains cool. As a result, a thermocline develops between the upper and lower levels (Monismith and MacIntyre, 2009). Cold water is denser than warm water and resists mixing (Dodds and Whiles, 2010). The thermocline is the horizontal plane of water across the lake through the point of the greatest temperature change. Annual stratification patterns vary based on location. In central North Carolina, lakes typically mix once per year (monomictic). Turnover, or complete mixing of the water column, occurs once a year in the fall after surface temperatures cool. Because ice rarely covers lakes in this region, under-ice stratification and spring turnover rarely occur.

In eutrophic lakes, stratification can produce unfavorable water quality conditions in both surface and bottom waters. Surficial waters may contain high concentrations of algae, which could increase the formation of disinfection by-products and (or) result in taste-and-odor issues (Graham et al., 2010). The epilimnion may have very high levels of dissolved oxygen during daylight hours, due to phytoplanktonic photosynthesis. However, as previously stated, as the plankton die and sink to the bottom, the process of decomposition depletes the dissolved oxygen levels. Thus, the hypolimnion may have hypoxic conditions where the dissolved oxygen levels are less than 1.0 mg/L. Hypoxic conditions lead to high concentrations of dissolved iron, manganese, and nutrients (Wetzel, 2001). If lake bottom waters are being utilized as a source of drinking water, these water quality issues can result in high treatment costs for water treatment plants.

1.4 B. Everett Jordan Lake

Numerous studies of stratification and water quality concerns have been conducted on B. Everett Jordan Lake (Jordan Lake), located in Chatham County, NC. Construction of Jordan Lake began in 1967 with the purpose of modulating flow in the Cape Fear River Basin. Following a devastating hurricane in 1946, which caused catastrophic flooding in the Cape Fear River Basin, the U.S. Congress directed the U.S. Army Corps of Engineers (USACE) to study the need for, and potential consequences of a new reservoir on the Haw River. In 1963, Congress authorized impoundment of the New Hope Reservoir, whose name was later changed to B. Everett Jordan Lake (Kreutzberger and Baughman, 2014). Construction of the lake was delayed due to litigation from stakeholders and the North Carolina Conservation Council, citing expectations of consequential decreases in water quality. However, the litigation was terminated in 1977. The lake was impounded in September 1981 and ready for use in 1982. According to the USACE, additional uses for Jordan Lake were authorized, including recreation, water supply, fish/wildlife support, and water quality.

Currently, Jordan Lake covers an area of 13,940 acres, which extends 17.9 miles up the New Hope River and 4.7 miles up the Haw River (U.S. Army Corps of Engineers, 2017). The total length of the shoreline is about 200 miles. Development has increased in the Jordan Lake watershed, and eutrophication continues to be a concern. Non-point sources, such as runoff from the towns of Cary, Chapel Hill, and Durham as well as point sources from wastewater inputs from Durham and Chapel Hill create a mixture of nutrient-rich inputs into Jordan Lake. These inputs can support eutrophication and algal growth in Jordan Lake. High levels of dissolved oxygen near the surface and photic zone result from algal photosynthesis. Additionally, hypoxia occurs near the bottom of the lake along with high levels of iron, manganese and nutrients.

Jordan Lake became popular for recreational use soon after it was filled, and it is used for sources of drinking water for nearby developing communities. North Carolina declared the reservoir a Nutrient Sensitive Water (NSW) in 1983 and required waste treatment plants to reduce their phosphorus inputs; however, nonpoint sources were not regulated (Manuel, 2010). Subsequently, the lake was listed on the federal "impaired" waters [303(d)] list in 2002 (Manuel, 2010). In 2009, nutrient reduction goals for Jordan Lake were passed into law by the General Assembly. The goal for the Upper New Hope arm was 35 percent reduction in nitrogen load and 8 percent reduction in phosphorus load relative to a 2001 baseline (Manuel, 2010). The Haw River arm reduction goal for nitrogen was 8 percent for nitrogen and 5 percent for phosphorus. Additionally, the goal for the Lower New Hope arm was to match the 2001 baseline year (Manuel, 2010). Modifications and disapproval of the rules by the General Assembly delayed implementation from 2009 to 2013. In 2013, the Jordan Lake Rules were effectively delayed to allow time for testing of a lake circulation technology known as "SolarBees" (Kreutzberger and

Baughman, 2014). Removal of the SolarBees was announced in May 2016, due to lack of effectiveness in improving water quality.

The hydraulic retention time is the average length of time that a compound remains within a lake or impoundment (Martin and McCutcheon, 1998). The mean water volume is divided by the mean flow to calculate the hydraulic retention time. This retention time can influence water quality and mixing characteristics. The New Hope arm of the lake has an average hydraulic retention time of 418 days (North Carolina Department of Environment, Health, and Natural Resources, 1992). In comparison, mean residence times in the Great Lakes range from three years for Lake Erie to 180 years for Lake Superior (Martin and McCutcheon, 1998).

Approximately 300,000 residents in the towns of Cary, Apex, and Morrisville depend on Jordan Lake for their source of drinking water provided by the Cary/Apex Water Treatment Plant. The water treatment plant has a maximum daily capacity of approximately 40 million gallons (Town of Cary, 2017). When Jordan Lake is at full pool, the top of the water-supply intake pipe is approximately 2.7 meters deep. This depth is considered to be marginally below the projected photic zone depth. The centerline of the water-supply intake pipe is approximately 3.4 meters deep. When the lake levels are lower from drought or increased withdrawals, the treatment plant must withdraw raw water from the lower intake, which may have more water quality concerns than the top intake. Currently, the Cary/Apex Water Treatment Plant utilizes treatment techniques such as activated carbon adsorption and advanced oxidation by ozone to minimize taste and odor issues (Town of Cary, 2017). The plant also monitors the raw water withdrawn from the Intake site daily for iron and manganese, turbidity, pH, conductivity, and several additional constituents.

The Town of Cary currently (May 2017) is installing a mechanical mixing system near the intake in Jordan Lake. The goal of the mixing system is to improve the raw water quality prior to intake and water treatment. The system is designed to de-stratify the water column, increase dissolved oxygen levels throughout the column, and decrease levels of dissolved iron and manganese. Most likely, the mixing also will impact nutrient and algal dynamics. The desired result is a reduction in taste and odor issues from Jordan Lake, improved raw water quality from the Intake, and a decrease in costs for the Cary/Apex Water Treatment Plant.

1.5 Research Goals

The overall goal of this thesis is to evaluate water quality and stratification patterns in one segment of the New Hope arm of Jordan Lake. In particular, the research objectives are to assess water-quality differences among sampling locations and depths, seasonal patterns, and inter-annual variability resulting from hydrologically different years.

Specifically, the following research questions are addressed with the goal of evaluating water quality and stratification patterns in Jordan Lake:

- How does water quality differ spatially among the four sampling locations in the study area?
- How does water quality vary annually and seasonally?
- Is chlorophyll *a* useful as an indicator of the presence of taste and odor compounds?

To address the study objectives and research questions, biweekly samples were collected at four sites during the 2012 and 2013 growing seasons. Constituents for data collection included: secchi depth, the depth to one percent incident light, turbidity, iron, manganese, chlorophyll *a*, geosmin, MIB, and nutrients (ammonia plus organic nitrogen, ammonia, total organic nitrogen, nitrate plus nitrite, total nitrogen, orthophosphate, and phosphorus). Additionally, vertical profiles of pH, specific conductance, dissolved oxygen, and water temperature were measured. To interpret data, various statistical analyses, including regression analyses and the Wilcoxon signed-rank test, were performed to summarize the spatial patterns among the four sampling locations. Date and scatter plots were utilized to compare seasonal and inter-annual variability.

The benefit of the project is a more comprehensive assemblage of water quality and stratification data in an area of Jordan Lake where the Town of Cary plans to install a large water-column destratification system. Results will be useful for the water treatment plant to determine the best location for the proposed vertical mixing system. In the future, the results presented in this thesis will be compared with results following installation of the mixing system to evaluate the effectiveness of the system on improving the raw water quality. Providing baseline data will be valuable for Jordan Lake water management. Ideally, the town of Cary can utilize the analysis from this thesis to improve raw water quality near their drinking water intake and lower their water treatment costs.

2 MATERIALS AND METHODS

2.1 Site Description

The U.S. Geological Survey collected samples approximately biweekly during April through October in 2012 and 2013, from four different locations in the New Hope arm of Jordan Lake. The study area extends from the Farrington Road Bridge downstream to the U.S. Highway 64 causeway (Figure 2). Data collection was spatially and temporally dense relative to other monitoring efforts in Jordan Lake. The four study sites include: Jordan Lake above US Highway 64 at Wilsonville, NC (Intake); Jordan Lake White Oak Creek Arm below secondary road (SR) 1008 at Bells, NC (White Oak); Jordan Lake near Buoy 8 near Bells, NC (Buoy 8); and Jordan Lake at Buoy 9 near Farrington, NC (Buoy 9).

The Intake site is the location closest to the intake for the Cary/Apex Water Treatment Plant and in proximity to the proposed location of the destratification system. The White Oak site is located east of the Intake site, near the White Oak Creek tributary. The northernmost site is Buoy 9, and Buoy 8 is situated south of Buoy 9. The study area map shows the specific sampling locations (fig. 3, table 1).

2.2 Data Collection

The U.S. Geological Survey planned to collect samples approximately biweekly during April through October in 2012 and 2013; however, due to a Federal government shutdown in October 2012, sampling was extended into early November. Samples generally were not collected during November through March because Jordan Lake is mixed during that time. At all four of the sites, the secchi depth, the depth to one percent incident light, and turbidity were measured near the surface. The secchi depth, defined as the water clarity of the sampling location, is measured by using a secchi disk (Wetzel, 2001). The disk, typically an 8-inch-diameter black and white metal or weighted plastic disk, is attached to a measured line and lowered into a lake until it can no longer be seen. This measurement is multiplied by two to estimate the lower extent of the photic zone. The photic zone reflects the depth where only one percent of the surface photosynthetic available radiation (PAR) remains (Kirk, 1994). The photic zone not only measures the water clarity, but it is also an important indicator for the depth which primary production takes place. The depth to one percent light measurement is used as companion data to the secchi and photic depths.

Vertical profiles of the water column were also documented to include readings at one-meter intervals at each of the four study locations. The parameters for the vertical profiles included pH, specific conductance, dissolved oxygen, and water temperature (table 2). A YSI 600XLM multi-parameter water quality sonde was used for each vertical profile. The water quality sonde was calibrated each morning before sampling for each parameter based on USGS protocol (Gibs et al., 2007).

Water quality samples were collected from 3 depths at each lake site (table 2), following protocols described by Oblinger (2004). Iron and manganese (total and dissolved fractions) were sampled from depths near the top and bottom of the water column. These grab samples were collected using a Wildco® Van Dorn water sampler. Additionally, a vertical-composite sample of the photic zone was collected using a Lab-Line sampler, consistent with North Carolina Department of Environmental Quality lake-sampling protocols. Photic-zone samples were analyzed for nutrients (ammonia plus organic nitrogen, ammonia, organic nitrogen, nitrate plus nitrite, total nitrogen, orthophosphate, and phosphorus) and chlorophyll *a*. Nutrients were also collected from the bottom using a Van Dorn sampler. Only at the Intake site, additional samples for taste and odor compounds (geosmin and 2-methylisoborneol) were collected from the photic zone and the bottom. Pall Versapor® 0.45 micrometer (μm) capsule filters were used to filter samples for dissolved-phase analyses (orthophosphate, nitrate plus nitrite, ammonia, iron and manganese).

Quality-control samples, including blank and replicate environmental samples, were collected throughout the project to ensure that project data quality objectives were met. USGS protocols were followed for all equipment cleaning, sample collection, and sample processing (U.S. Geological Survey, variously dated).

Additionally, several government websites were utilized to gather information regarding the drought index, precipitation and streamflow. Monthly Palmer Hydrological Drought Index scores for the Central Piedmont area of North Carolina, 2012 and 2013, were obtained from the State Climate Office of North Carolina (*http://www.nc-climate.ncsu.edu/climate/climdiv.php*). Monthly precipitation data from the Raleigh-Durham International Airport were also obtained from the State Climate Office of North Carolina (*http://www.nc-climate.ncsu.edu/cronos*) for the 2012-2013 study period. Long-term (30-year), monthly mean precipitation data for the Raleigh-Durham International Airport were gathered from the National Oceanic and Atmospheric Administration website (*http://www.ncdc.noaa.gov/cdo-web/datatools/normals*). Additionally, average streamflow data from the USGS station 02097314, New Hope Creek near Blands, NC, in the Cape Fear River Basin were collected from the U.S. Geological Survey's WaterWatch website (*https://waterwatch.usgs.gov/index.php*).

2.3 Laboratory Analysis

Nutrient, iron, and manganese analyses were performed at the USGS National Water Quality Laboratory in Denver, Colorado. Chlorophyll *a* analyses were performed by Meritech, Inc. in Reidsville, NC. Taste and odor compound (geosmin and MIB) analyses were performed by Eurofins Eaton Analytical in Monrovia, CA. All field parameters including secchi depth, the depth to one percent incident light, turbidity, pH, specific conductance, dissolved oxygen, and water temperature were measured directly by USGS personnel. Specific measurement and analytical methods for all analyses are summarized in table 3.

2.4 Graphical and Statistical Analysis

The spatial and annual differences among the four study sample locations were analyzed using various graphical and statistical methods. Linear regressions were computed with R software (R Foundation for Statistical Computing, Vienna, Austria) comparing Buoy 8, Buoy 9, and White Oak with the base site (Intake). Three regressions were computed for each parameter using Buoy 8, Buoy 9, or White Oak as the dependent variable and the Intake site as the independent variable. The comparison being made for each parameter's regression is that Buoy 8, Buoy 9, and White Oak will have similar slopes and intercepts (not significantly different) to the Intake site. The slope of the regression was used to determine if a significant relationship exists. A probability level of 5 percent ($p<0.05$) was chosen as the significance level because it is the default of statistical tradition (Helsel and Hirsch, 1992). If the regression was significant, with slope approximately equal to one and the intercept approximately equal to zero, then the parameters at the two sites were considered to be coincident. The R-squared (R^2) values indicate the percent variability accounted for by the regression. For these computations, the adjusted R^2

value was used, which adjusts for the number of predictors. If the R^2 value is high, then the two sites being compared are highly correlated. A value of greater than 75 percent was chosen as the criteria to determine correlation. This value was chosen because there is no general rule for R^2 values for a useful regression equation (Helsel and Hirsch, 1992).

The Wilcoxon signed-rank test was used to further explain variability among sampling sites, but it was only computed if all of the following occurred: the regression was found to be significant, the regression was not coincident and percent of variance explained by the regression was less than 75 percent. The Wilcoxon signed-rank test with continuity correction was performed using R software (wilcox.test). Date and scatter plots were used to determine annual and seasonal variability between the four study sites. Also, correlation plots with corresponding R^2 values comparing chlorophyll *a* with geosmin and MIB are provided.

2.5 Quality Assurance

Quality-control samples, consisting of sampling-equipment blanks, field blanks and replicate samples, were collected and reviewed throughout the period to ensure that project data-quality objectives were met (appendixes 1, 2; Oblinger, 2004). Deionized water was produced in the USGS Raleigh laboratory and was used to clean sampling equipment. The source solution for field blanks was inorganic-blank water obtained from the USGS National Field Service Supply. Approximately 14.7 percent of the sample load consisted of quality-control samples. Quality-control samples and collection procedures are described in Chapter 4 of the USGS National Field Manual (U.S. Geological Survey, variously dated).

During April 2012 through October 2013, 1 deionized-water blank, 2 sampling-equipment blanks, and 29 field blanks were collected and analyzed for iron, manganese, nutrients, chlorophyll *a*, geosmin, and 2-methylisoborneol (appendix 1). In all, 12 constituents were analyzed and 206 blank results were generated. Almost 95 percent of the results were below censoring levels, indicating minimal contamination during this period. Overall, 11 quantified blank results were detected (results above constituent censoring levels) which represented approximately 5% of the results. Five of these were low-level detections of filtered manganese; the remaining six detections were distributed among five different constituents. It therefore does not appear that the corresponding environmental samples have been compromised.

A detection rate of less than 10 percent was deemed acceptable for this study (Mueller, et al., 2015). If a constituent was detected in greater than 10 percent of the combined deionized, equipment and field blanks, then its results were assessed for the potential to positively bias the environmental results. Only 2 constituents exceeded the 10 percent blank-detection threshold, including chlorophyll *a* (25 percent) and filtered manganese (33 percent). For these constituents, blank detections were further evaluated based on proximity to censoring levels and relevance to corresponding environmental concentrations. Environmental concentrations less than five times the median of the quantified blank detections generally were considered to have some potential for contamination.

Chlorophyll *a* was detected in one of four field blanks with a concentration of 0.6 μg/L, which is below the censoring level of 1.0 μg/L. Environmental samples with chlorophyll *a* concentrations less than 3.0 ug/L would have been potentially biased; however, all environmental samples had chlorophyll *a* concentrations above this threshold. Thus, the detection of chlorophyll *a* in one field blank likely does not indicate a positive bias in the environmental data.

Filtered manganese was detected in 5 field blanks with a median detection concentration of 0.22 μg/L. Therefore, environmental filtered manganese concentrations greater than or equal to 0.16 (the censoring level) and less than 1.10 μg/L were considered potentially biased due to contamination. During April 2012 through October 2013, approximately 32 percent of the filtered manganese concentrations were within this range and should be interpreted with caution. The filtered manganese detections in the field blanks were likely caused by manganese contamination in water samples processed with 0.45-μm high-capacity Pall Versapor® capsule filters (U.S. Geological Survey, 2016b). Filtered manganese concentrations <0.16 μg/L (censored values) were not considered to be positively biased, since they were reported as non-detections.

The variability of sampling and analysis is presented with 34 sets of field replicates (appendix 2). Among the 34 sets of field replicates, there were a total of 163 replicate-result pairs. Paired concentrations with a relative percent difference (RPD, absolute difference times 100 divided by the average) less than 25 percent were considered to demonstrate acceptable reproducibility (Mueller, et al., 2015). Of the 163 replicate set pairs, approximately 91 percent had RPDs less than 25 percent.

Ammonia, nitrate plus nitrite, orthophosphate, chlorophyll *a*, and 2-methylisoborneol each had a single replicate set with a RPD greater than 25 percent, while filtered manganese and filtered iron had six and three replicate sets, respectively, with RPDs greater than 25 percent. The occurrences of high RPDs for ammonia, nitrate plus nitrite, and 2-methylisoborneol were isolated and not representative of the dataset as a whole. Large RPD values are common and accepted without further discussion when they result from small absolute differences near the constituent censoring level. For example, one ammonia replicate set had an RPD of 46.2;

however, the absolute difference was 0.01 mg/L, and the censoring level was 0.01 mg/L, so that the difference is considered to be negligible.

When the absolute concentration difference is greater than or equal to three times the censoring level and is associated with a large RPD, high variability is indicated. Two of the filtered manganese, one filtered orthophosphate, and one chlorophyll *a* replicate pair met these criteria. The filtered manganese pairs had RPDs of 27 percent and 29 percent and absolute differences of 1.03 μg/L and 1.14 μg/L, respectively. Some variability may have occurred due to manganese contamination in water samples processed with 0.45-μm high-capacity Pall Versapor® capsule filters (U.S. Geological Survey, 2016b). The orthophosphate replicate pair with an RPD of 157 percent and an absolute difference of 0.03 mg/L appears to be an isolated occurrence during this period. The chlorophyll *a* pair with an RPD of 60 percent and an absolute difference of 8.60 μg/L also appears to be an isolated occurrence. Overall, results for replicate pairs indicated acceptable reproducibility for all water quality constituents measured during this period.

3 RESULTS AND DISCUSSION

3.1 Meteorological and Hydrological Conditions during Study Period

There were notable differences in precipitation and hydrologic conditions between 2012 and 2013, which influenced water quality conditions in the Jordan Lake study area among years. Meteorological and hydrological data, including precipitation records, a hydrologic drought index, and streamflow conditions, discussed below, aided interpretation of observed seasonal and inter-annual differences in water quality.

Precipitation measured at the Raleigh-Durham International Airport, North Carolina (National Weather Service station KRDU) from April 2012 through October 2012 totaled 28.0 inches, which is 1.7 inches higher than the long-term mean precipitation of 26.3 inches for April through October (fig. 4; State Climate Office of North Carolina, 2016b; National Oceanic and Atmospheric Administration, 2016). From April 2013 through October 2013, precipitation at the Raleigh-Durham Airport measured 30.8 inches, which is 4.5 inches above the long-term mean precipitation of 26.3 inches for April through November. The sampling period for 2013 measured approximately 2.8 inches of precipitation higher than the sampling period for 2012. The highest monthly precipitation for the two-year period occurred in June 2013 (10.1 inches) as of a result of precipitation associated with Tropical Storm Andrea (*www.nhc.noaa.gov/data/tcr/AL012013_Andrea.pdf*). Additionally, September 2012 had the second highest monthly precipitation during the study period (7.8 inches), which was tied to a low pressure system that moved north out of the Gulf of Mexico (*https://www.ncdc.noaa.gov/sotc/national/201209*).

An indication of hydrologic conditions is provided by the monthly Palmer Hydrological Drought Index scores for water years 2012 and 2013 (fig. 5; State Climate Office of North Carolina, 2016a). This index reflects the long-term, cumulative impacts of drought on hydrologic characteristics such as reservoir levels and streamflow. Negative values designate dry periods, and positive values designate wet periods. The Palmer Hydrological Drought Index is separated into 11 categories as defined by Palmer (1965). Among these categories are values greater than or equal to 4.00 which are classified as extremely wet. Near normal conditions are considered to be from 0.49 to -0.49, and extreme drought conditions are considered to be less than or equal to -4.00. In the Central Piedmont (including Chatham and Wake Counties) of North Carolina (fig. 5), mild drought to moderate drought conditions were observed in the area from April 2012 through February 2013. Incipiently drought conditions were seen in the region from March 2013 through May 2013. During June 2013 through October 2013, slightly wet to very wet conditions were seen in the Central Piedmont.

As indicated by the Palmer Hydrological Drought Index scores, the 2012 sampling period was classified as drought, even though this period had 1.6 more inches than the long-term mean precipitation. The winter leading up to the 2012 sampling period was very dry, which explains the drought classification for the 2012 sampling period.

In-stream flow conditions during the study period are illustrated using records from USGS station 02097314, New Hope Creek near Blands, NC, located upstream from the study area in the Cape Fear River Basin (figs. 2, 6; U.S. Geological Survey, 2017a). The black line on the hydrograph is the seven-day moving average of streamflow in cubic feet per second (cfs). For reference, it is overlain on the period-of-record flow percentiles (fig. 6). During water year 2012, streamflow was generally below the normal range, which is defined by the 25th to 75th

percentiles. During the late summer of 2012, streamflow briefly rose into the normal range. Streamflow was well below normal during November 2012 to January 2013, below to near normal during spring 2013, and within the normal to high range during summer 2013. The higher streamflow in the 2013 sampling period could have resulted in higher inputs of nutrients.

The hydraulic retention time is the average length of time that a compound remains within a lake or impoundment (Martin and McCutcheon, 1998). The mean water volume is divided by the mean flow to calculate the hydraulic retention time. This retention time can influence water quality and mixing characteristics. The New Hope arm of the lake has an average hydraulic retention time of 418 days (North Carolina Department of Environment, Health, and Natural Resources, 1992). In comparison, mean residence times in the Great Lakes range from three years for Lake Erie to 180 years for Lake Superior (Martin and McCutcheon, 1998).

3.2 Overview of Water Quality

3.2.1 Data Presentation

Water quality data were reviewed, quality assured, and published in the USGS 2012 and 2013 Water Data Reports (*http://nc.water.usgs.gov/reports/WDR/*) (U.S. Geological Survey, 2016a). The data are presented in appendix 3 and also are available online via the National Water Information System (NWIS) (*http://dx.doi.org/10.5066/F7P55KJN*) (U.S. Geological Survey, 2017b). Dissolved oxygen percent saturation and total nitrogen were computed by using NWIS algorithms.

Ranges of concentrations observed at each site for 22 water quality properties or constituents are summarized and grouped by position in the water column (table 4). Top (near the water surface) and photic-zone results are grouped together because they represent conditions in the epilimnion. Bottom, or hypolimnetic, results are summarized separately. Box plots of selected parameters are provided, grouped by top or photic and near-bottom observations with 2012 and 2013 data combined (fig. 7-13). The box plots provide the median along with the 25^{th} and 75^{th} percentiles of the data. Additionally, the 5^{th} and 95^{th} percentiles are illustrated with closed circles in each plot; outliers were not included in the graphic display.

Relevant North Carolina ambient water quality criteria are provided for comparison (North Carolina Department of Environment and Natural Resources, 2017a). Maximum contaminant levels (MCLs) and secondary drinking water regulations (SDWR) values are applicable only to treated drinking water rather than untreated surface waters; however, they are also provided for reference and not further discussed (USEPA, 2017b).

3.2.2 Temperature, Dissolved Oxygen, pH, and Specific Conductance

The highest and lowest water temperatures of 30.2 and 10.2 degrees Celsius were measured at White Oak on August 2, 2012 and April 3, 2013, respectively (fig. 7A, table 4). The highest dissolved oxygen of 13.1 mg/L was measured on April 3, 2013 at the Intake and the lowest dissolved oxygen of 0.1 mg/L was measured on July 5, 2012 at Buoy 9, near the bottom of the water column (fig. 7B, table 4). The box plots for temperature and dissolved oxygen demonstrate similarities between sites for the top and near-bottom observations (fig. 7). Concentrations of dissolved oxygen below the State standard of 5.0 mg/L (daily average) are expected in lake bottom waters due to natural causes and are not considered to indicate problems. Dissolved oxygen may also be expressed in terms of percent saturation, which is computed using dissolved oxygen concentration, water temperature, and barometric pressure. Dissolved oxygen percent saturation levels greater than the State standard for dissolved gases of 110 percent were periodically observed at all four sites in Jordan Lake (table 4).

The State's acceptable range for pH values is 6.0 to 9.0 standard units. Almost all of the pH values measured during this study were within this range. Only one recorded reading of 9.1 standard units at Buoy 8 on July 5, 2012 exceeded the State's range. The ranges appeared to be similar among the sites when comparing the near-bottom observations; however, the top observations had more variability (fig. 8A). The lowest pH value of 6.6 standard units was measured at the Intake and Buoy 9 on May 28, 2013 and April 16, 2013, respectively.

The range in measurements for top and near-bottom observations was similar among the sites (fig. 8B). The highest specific conductance of 229 microsiemens per centimeter (μS/cm) at 25 degrees Celsius was measured on August 15, 2012 at the Intake. Buoy 9 had the lowest conductance value of 94 μS/cm measured on July 9, 2013.

3.2.3 Measures of Water Clarity: Turbidity, Secchi Depth, Depth to One Percent Light

The State's standard for non-trout lakes and reservoirs is 25 nephelometric turbidity units (NTU). The turbidity results for the Jordan Lake study are in nephelometric turbidity ratio units (NTRU) due to the optics of the specific meter used. For comparative purposes, the units can be considered equivalent. During the study period, no turbidity measurements exceeded the State's threshold of 25 NTU. The box plots illustrate variation between the sampling sites, particularly the higher values at Buoy 9 (fig. 9A). The highest turbidity reading of 18 NTU was measured at Buoy 9 on October 11, 2012, which is the most upstream sampling site. Buoy 8 had the lowest turbidity reading of 4.3 NTU on April 30, 2013.

The variation in values between the study sites for secchi depth and depth to one percent light is demonstrated by the box plots (fig. 9B, 9C). Secchi depths ranged from a minimum of

0.5 m at Buoy 9 (April 3, 2013, June 25, 2013, and July 23, 2013), to a maximum of 1.3 m at the Intake site (June 21, 2012). Approximately 1.1 m was the minimum depth to one percent light measured at Buoy 9 on September 12 and 26, 2012, at Buoy 8 on September 26, 2012 and at White Oak on November 7, 2012. Comparatively, 3.6 m was the maximum depth to one percent light, measured at Buoy 8 on April 30, 2013 and White Oak on June 21, 2012.

3.2.4 Iron and Manganese

The State aquatic-life standards for total recoverable iron and total recoverable manganese were previously 1,000 mg/L and 200 mg/L, respectively; however, the U.S. EPA approved removal of these standards in 2016 because iron and manganese occur naturally in the State's water systems (*http://deq.nc.gov/document/trirev-epa-decisiondoc-2007-2015*; North Carolina Department of Environment and Natural Resources, 2017b). Thus, these standards are not discussed further in this thesis.

The box plots provide a display of the variation among the study sites and depths for total and filtered iron (fig. 10A, 10B). Higher concentrations were measured at the near-bottom depths for all the sites. The maximum total recoverable iron was measured on September 26, 2012 at White Oak at a concentration of 2,570 µg/L; the minimum was measured on July 18, 2012 at White Oak at a concentration of 45.8 µg/L. The highest filtered iron value of 918 µg/L was measured on June 25, 2013 at the Intake site; however, many values throughout the sampling period were less than the reporting limit of 3.2 µg/L.

The box plots provide a display of the variation among the study sites and depths for total and filtered manganese (fig. 10C, 10D). Higher concentrations were measured at the near-bottom depths for all the sites. The maximum total recoverable manganese concentration of

2,710 µg/L was measured on June 25, 2013, in the hypolimnion at the Intake. The minimum of 37 µg/L was measured on April 16, 2013 at White Oak. The maximum filtered manganese value of 2,710 µg/L was measured on June 25, 2013 at the Intake site, and the lowest value of 0.26 µg/L was found on October 30, 2013 at the Intake site.

3.2.5 Nutrients

The nutrient species that were analyzed included ammonia plus organic nitrogen, ammonia, nitrate plus nitrite, orthophosphate, and total phosphorus. Total nitrogen and total organic nitrogen were computed using data from the other nitrogen fractions. Nitrate plus nitrite is the only nutrient constituent for which a State water quality standard currently exists (10 mg/L as N); however, the State is in the process of developing updated nutrient standards (North Carolina Department of Environment and Natural Resources, 2017a). There were no concentrations which exceeded the State water quality standard for nitrate plus nitrite during this study.

Generally, low variation of ammonia plus organic nitrogen occurred in concentrations between the study sites; however, values were higher at the near-bottom depths for all the sites (fig. 11A). A maximum concentration of ammonia plus organic nitrogen (2.7 mg/L as N) was measured on April 3, 2013 at White Oak. The source of this unusually high ammonia plus organic nitrogen (attributed to the total organic nitrogen value) is unknown. There may have been an influx of nutrients from the White Oak Creek tributary after a rainfall event, which could have caused a spike in the total organic nitrogen concentration. The subsequent sampling event on April 16, 2013 remained relatively high (1.1 mg/L as N). The lowest values of 0.61 mg/L as N were measured on June 6, 2012 and June 11, 2013 at White Oak and the Intake, respectively. Box plots of ammonia illustrate higher concentrations for the near-bottom observations compared to the photic observations (fig. 11B). The highest concentration of ammonia (0.781 mg/L as N) was observed on August 2, 2012 at the Intake site in the hypolimnion, but approximately 41 percent of ammonia concentrations were less than the detection level (0.01 mg/L as N).

As previously discussed, the highest value of total organic nitrogen (2.7 mg/L as N) was measured at White Oak on April 3, 2013. The ranges in concentrations were similar among the study sites and depths for total organic nitrogen values (fig. 11C, table 4). Ranges for nitrate plus nitrite were similar among the study sites with higher values at the Intake site (fig. 11D, table 4). The highest value of nitrate plus nitrite (0.23 mg/L as N) was measured on May 10, 2012 at the Intake site, but approximately 64 percent of nitrate plus nitrite values were less than the detection level (0.01 mg/L as N). The total nitrogen box plots demonstrate higher values and greater variation in ranges near the bottom (fig. 12A). The photic values appear similar between the sites with some slight variation at the Intake site. The maximum value of total nitrogen was calculated to be 2.7 mg/L White Oak on April 3, 2013; however, the minimum of 0.62 mg/L was measured at White Oak on June 6, 2012 and the Intake site on June 11, 2013.

Generally low variation between sites and limited values above the detection level are demonstrated by the box plots for orthophosphate (fig. 12B). Approximately 94 percent of orthophosphate concentrations were less than the detection level of 0.004 mg/L as P. The maximum value of orthophosphate was 0.033 mg/L as P on several dates at the Intake. Box plots for phosphorus concentrations show generally low variation between sites, with the exception of a few high values at near-bottom observations (fig. 12C). The maximum and minimum values of phosphorus were 0.286 mg/L as P and 0.03 mg/L as P at White Oak on September 26, 2012 and the Intake on July 5, 2012, respectively.

3.2.6 Chlorophyll *a*, Geosmin and MIB

During the study period, chlorophyll *a* concentrations greater than the North Carolina water quality standard of 40 µg/L were observed once at the Intake site, six times at Buoy 9, and three times at Buoy 8. Box plots grouped by study site are provided for chlorophyll *a* values (fig. 13A). Overall, the chlorophyll *a* ranges appear similar among sites. A maximum chlorophyll *a* value (63.7 µg/L) was recorded at Jordan Lake near Buoy 8 on July 5, 2012. A minimum chlorophyll *a* value (9.1 µg/L) was recorded at Buoy 8 on June 6, 2012.

As previously stated, geosmin and MIB were collected only at the Intake site for this study. Box plots of geosmin and MIB grouped by photic and near-bottom observations are provided (fig. 13B, 13C). A maximum geosmin value of 250 nanograms per liter (ng/L) was recorded on April 16, 2013. During the study, approximately 45 percent of geosmin samples were below the reporting level of 3 ng/L. A maximum MIB value (49 ng/L) was recorded on September 3, 2013. Approximately 77 percent of samples had MIB below the lab reporting level of 5 ng/L.

3.3 Comparison of Spatial Variability among Sampling Sites

3.3.1 Approach to Assessing Spatial Variability

The box plots provided in the previous section give a broad overview of water quality variability at Jordan Lake; however, the plots do not allow for evaluation of variations between each study site. Thus, regressions and Wilcoxon signed-rank tests were used for selected parameters to provide water quality specifics that the U.S. Geological Survey and Town of Cary need for this project. Instead of grouping both years together, these analyses were separated by year because water quality conditions can vary between years, due to hydrological and meteorological conditions, as well as anthropogenic factors. As previously stated, the Intake site was used as the independent variable in the regressions, and Buoy 8, Buoy 9, and White Oak were used as the dependent variables. The Intake site was used as the independent site because conditions near the intake are of the most critical interest to the Town of Cary. A goal of the USGS investigation is to evaluate the spatial extent of the mixer's effects, once it's operational. Analyzing whether there are differences among the sites can inform future monitoring strategies. Sites that are found to have redundant results could be removed from the sampling regime.

The regression analysis and the Wilcoxon signed-rank approaches, rather than more traditional approaches such as analysis of variance (ANOVA) or the Kruskal-Wallis test, were used because the data in this thesis do not have a normal distribution. A parametric test is typically used if the data follow a particular distribution, usually a normal distribution, but a nonparametric test is used if the data do not follows a particular distribution (Helsel and Hirsch, 1992). ANOVA was initially computed for this thesis; however, the results were not useful in determining differences between the study sites. When parametric tests are applied to non-normal data, their power to detect differences which are truly present is much lower than that for the equivalent nonparametric test (Bradley, 1968). Even though the regression is a parametric test, it was used to describe the statistical relationship between the independent variable (the Intake site) and the dependent variables (Buoy 9, Buoy 8 and White Oak sites). The hypothesis test in regression is useful to determine whether the slope coefficient is significantly different from zero (Helsel and Hirsch, 1992).

The Wilcoxon signed-rank test was only computed if all of the following occurred: (a) the regression was found to be significant; (b) the regression was not coincident; and (c) percent of variance did not exceed 75 percent. The signed-rank test is nonparametric and is used to determine whether the median difference between paired observations equal zero (Helsel and Hirsch, 1992). In this case, the sign-rank test was used to determine if the median difference between selected parameters of the Intake site compared to the other three sites was significantly different than zero.

The top and photic data were combined for these computations and summary statistics; however, the bottom data are not discussed in this section. Temperature, dissolved oxygen, and pH were not included in the statistical calculations, because they vary more with season and (or) time of day than sampling location. Summaries of the regression statistics and the Wilcoxon signed-rank test for selected parameters or constituents are provided in tables 5 and 6.

3.3.2 Specific Conductance and Turbidity

The regression is plotted for specific conductance for Buoy 9, Buoy 8 and White Oak against the Intake site, grouped by year (fig. 14). As illustrated by the regressions, each site had low variation for 2012, as well as 2013 when regressed against the Intake site. Based on the slope of the regressions, there is a statistically significant relationship between data from the Intake site and the remaining three sites for both years. Buoy 8 and Buoy 9 are coincident when regressed against the Intake for 2013 (slope is approximately equal to one and intercept is approximately equal to zero), and the percentage of variance exceeds 75 percent; thus, these data are not analyzed further. The regression for specific conductance for Buoy 8 in 2012 and White Oak for both years was not coincident; however, the R^2 value exceeds criterion. Buoy 9 is coincident in 2012, but the R^2 value does not exceed criterion. Thus, the Wilcoxon signed rank-test was not computed for specific conductance data, because the relationships were not statistically significant.

A significant relationship for turbidity exists between data from the Intake site and Buoy 9, Buoy 8 and White Oak for both years (fig. 15). The R^2 values do not exceed the criteria for turbidity at Buoy 8 for both years, Buoy 9 for 2012 and White Oak for 2012; however, these regressions are all coincident and not discussed further. The regression for White Oak for 2013 is not coincident, but the percent of variability does exceed criterion. The regression for Buoy 9 against the Intake site for 2013 was not coincident and had an R^2 value less than 75 percent, which suggests that the pair should be further tested.

The Wilcoxon signed-rank test was used as a comparison test for Buoy 9 against the Intake site for the 2013 data. Based on this test, the p-value equals 0.0058, which is considered significant and suggests that the data between the two sites are different over time. Thus, turbidity data for April 2013 through October 2013 between the Intake site and Buoy 9 appear to be spatially different. Buoy 9 is the most upstream site and greatest distance from the Intake site, which may explain the variability in turbidity data.

3.3.3 Secchi Depth, Depth to One Percent Light, and Chlorophyll *a*

Based on the regression slopes, there is a statistically significant relationship between the Intake site and Buoy 9, Buoy 8 and White Oak for secchi depth data (fig. 16). The R^2 values are greater than 75 percent and the data are coincident for both years at Buoy 8 and 2013 at White Oak. The regressions for both years at Buoy 9 with the Intake site and 2012 for White Oak were not coincident and the R^2 values did not exceed the criteria, which suggests that these pairs should be further examined.

The Wilcoxon signed-rank test was performed for Buoy 9 compared to the Intake site for both years of data, as well as White Oak for the 2012 data. Based on these tests, White Oak is not statistically significant; however, both years of data for Buoy 9 are statistically significant. Buoy 9 is the most upstream site, which may explain the secchi depth data variation when compared to the Intake site.

The regression was plotted for the depth to one percent light data for Buoy 9, Buoy 8 and White Oak against the Intake site (fig. 17). The relationship between the Intake site and Buoy 9 for 2013 is not statistically significant, but there is a statistically significant relationship with the remaining sites regressed against the Intake site. The R^2 value exceeds criterion for White Oak for both years of data, but does not exceed for Buoy 8 for 2013. Additionally, these three sets of data are coincident. The regressions for Buoy 8 and Buoy 9 for 2012 were not coincident and did not exceed criterion of correlation; thus, these pairs are further examined.

The Wilcoxon signed-rank test was computed for Buoy 8 and Buoy 9 with the Intake site for 2012. The test comparing Buoy 8 with the Intake site is not significant, but the test comparing Buoy 9 with the Intake site is significant. Based on the statistical analyses, the depth to one percent light data for April 2012 through November 2012 between the Intake site and Buoy 9 is spatially different. Buoy 9 is the most upstream site, which may explain why the depth to one percent light data is statistically different when compared to the Intake site.

The slopes of the regressions indicate there is a statistically significant relationship between the Intake site and the remaining three sites for chlorophyll *a* (fig. 18). The percentage of variance exceeds criterion for Buoy 9 for the data in 2013 but not for any of the remaining sites. In contrast, all the regressions are coincident. Thus, the Wilcoxon signed-rank test was not computed for chlorophyll *a* data because the relationships were not statistically significant.

3.3.4 Iron and Manganese

Regression plots are provided for filtered iron data for Buoy 9, Buoy 8 and White Oak regressed against the Intake site (fig. 19). Most of the filtered iron points are clustered with low concentration, with the exception of a few elevated points. The slopes specify that a statistically significant relationship exists between the Intake site and the remaining three sites. Buoys 8 and 9 for 2013 are not coincident; however, the remaining sites are coincident. In contrast, the R^2 values exceed criterion for all the sites regressed against the Intake site, which means the sites are highly correlated. Thus, the Wilcoxon signed-rank test was not computed for filtered iron data because the relationships were not statistically significant.

Based on the slopes of the regressions for total iron, there is a statistically significant relationship between the Intake site and the remaining three sites (fig. 20). White Oak for 2012 is not coincident with the Intake site; however, the percent of variance exceeds criterion. Buoy 8 for 2012 is coincident with the Intake site and the percent of variance exceeds criterion. The remaining sites, with the exception of Buoy 9 for 2012, are coincident but the percentage of variance do not exceed criterion. The regression for Buoy 9 for 2012 is not coincident and does not exceed the percentage of variance criterion, which suggests that this pair are not highly correlated and should be further examined.

The Wilcoxon signed-rank test was performed to compare Buoy 9 with the Intake site for 2012. Based on this test, the p-value is 0.006, which is statistically significant and illustrates that the data are different through time. Variation occurs when comparing the total iron data of Buoy 9 with the Intake site for April 2012 through November 2012. Buoy 9 and the Intake site account for the greatest distance between sites, which may explain why the total iron data are statistically significant.

In general, most of the filtered manganese values are clustered within a small range of relatively low concentrations, with the exception of outliers at Buoy 9 in 2013, Buoy 8 in 2013 and White Oak in 2012 (fig. 21). Reasons for these outliers are not known. The regression plots for filtered manganese for Buoy 9, Buoy 8 and White Oak regressed against the Intake site indicate that a significant relationship exists between the Intake site and Buoy 9 and Buoy 8 for 2012. There is no statistically significant relationship between the Intake site and the remaining sites. The percent of variance does not exceed criterion for Buoy 9 and Buoy 8 for 2012, nor are they coincident, which suggests that these pairs are not highly correlated and should be further tested.

The Wilcoxon signed-rank test was performed to compare the Intake site with Buoy 9 and Buoy 8 for 2012 for filtered manganese. Based on this test, the p-values are 0.266 and 0.132 when comparing the Intake site to Buoy 9 and Buoy 8 for 2012, respectively, which means the comparisons are not statistically significant and the filtered manganese data are similar through time. The reasons for the outliers at Buoy 9 on September 17, 2013 and White Oak on September 26, 2012 are not known.

The regressions were plotted for total manganese data for Buoy 9, Buoy 8 and White Oak against the Intake site (fig. 22). A significant relationship does not exist between the Intake site and Buoy 9 for 2012; however, there is a statistically significant relationship between the Intake site and the remaining sites. The variance does not exceed 75 percent for Buoy 9 for 2013, Buoy 8 for 2012 and White Oak for 2013, but they are all coincident. Buoy 8 for 2013 is coincident and the percent of variance exceeds 75 percent. The regression for White Oak for 2012 is not coincident and does not exceed the criterion of variance, which suggests that this pair is not highly correlated and should be further tested.

The Wilcoxon signed-rank test was performed to compare the Intake site with White Oak for 2012. Based on this test, the comparison is statistically significant and the total manganese data are different through time. Spatial variation of total manganese occurs when comparing White Oak to the Intake site for the period April 2012 through November 2012. White Oak receives inputs from the White Oak Creek tributary, which may explain why the total iron data are statistically significant.

3.3.5 Nutrients

Regression analysis was performed for ammonia plus organic nitrogen for Buoy 9, Buoy 8 and White Oak against the Intake site (fig. 23). The reason for the unusually high value at White Oak in 2013 is unknown. Statistically significant relationships occur between the Intake site and the remaining three sites. The percent of variance is less than criterion for Buoy 8, Buoy 9 and White Oak for the data in 2012 and Buoy 9 for 2013; however, all of these regressions are coincident. The regressions for Buoy 8 and White Oak for 2013 were not coincident and did not exceed the R^2 value criterion, which suggests that these pairs are not highly correlated and should be further tested.

The Wilcoxon signed-rank test was used as a comparison for Buoy 8 and White Oak with the Intake site for 2013. These comparison tests with the Intake site are not statistically significant, which means the ammonia plus organic nitrogen data are similar over time for Buoy 8 and White Oak.

The regressions were plotted for ammonia for Buoy 9, Buoy 8 and White Oak against the Intake site (fig. 24). The slopes suggest a significant relationship between the Intake site and the remaining three sites for both years of data. All the sites are coincident, with the exception of Buoy 9 for 2012. Additionally, the percentage of variance of the regression exceeds criterion for all the sites, with the exception of Buoy 9 for both years. Thus, the Wilcoxon signed-rank test was performed for Buoy 9 compared the Intake site for the 2012 data. Based on this test, the ammonia data are not statistically significant among the study sites.

Significant relationships exist between the Intake site and the remaining sites for total organic nitrogen (fig. 25). As previously noted, the reason for the unusually high value at White Oak in 2013 is unknown. The regressions do not explain much of the variation among the sites; although, the remaining sites are coincident, with the exception of White Oak for 2013. The Wilcoxon signed-rank test was completed for White Oak compared with the Intake site for the 2013 data. Based on this test, the total organic nitrogen data are not statistically significant and do not appear to have spatial variability among the study sites.

Most of the nitrate plus nitrite values were below the reporting limit (0.01 mg/L as N), thus fewer points are visible on the regressions (fig. 26). Based on the regressions, a significant relationship does not exist between the Intake site and Buoy 9 for 2013; however, there is a statistically significant relationship between the Intake site and the remaining sites. The remaining sites are not coincident, but the R^2 values exceed criterion for these sites, with the exception of White Oak for 2013. The Wilcoxon signed rank test was computed to compare White Oak with the Intake site for the 2013 data; however, the relationship between the pair is not significant and does not differ through time. Based on the statistical analyses, there does not appear to be spatial variability among the sites for nitrate plus nitrite concentrations.

Significant relationships exist between the Intake site and the remaining sites for total nitrogen (fig. 27). The regression's percent of variance does not exceed 75 percent for these sites, but the remaining sites are coincident, with the exception of Buoy 8 for 2013. Thus, the Wilcoxon signed rank-test was performed to compare Buoy 8 with the Intake site, and the p-value does not differ through time and is not significant. In conclusion, the total nitrogen data do not appear to be spatially different.

Approximately 94 percent of orthophosphate concentrations from April 2012 through October 2013 were less than the detection level of 0.004 mg/L as P; therefore, the regressions were not plotted and figures are not provided for this parameter. Spatial variation does not occur among the sites for orthophosphate concentrations.

The regressions were plotted for phosphorus data for Buoy 9, Buoy 8 and White Oak regressed against the Intake site (fig. 28). Based on the slopes of the regressions, a significant relationship does not exist between the Intake site and White Oak for 2013; however, there is a statistically significant relationship between the Intake site and the remaining sites. The percent of variance does not exceed criterion for these sites, but the remaining sites are coincident, with the exception of White Oak for 2012. The Wilcoxon signed-rank test was performed for White Oak compared with the Intake site. Based on this test, the data are not statistically significant. The phosphorus data do not appear to be spatially different among the sites.

3.4 Seasonal and Inter-Annual Variations in Water Quality

3.4.1 Approach to Assessing Seasonal and Inter-Annual Variability

Seasonal and inter-annual variations in water quality were evaluated. As would be expected, water quality varied from April through October each year in response to changes in temperature and other seasonal factors. The Intake site was used solely as the focus for comparing water quality between the 2012 and 2013 sampling periods since this site is the most significant to the Town of Cary. Vertical profile-plots, scatter plots, and date plots of the in-lake data, grouped by season and year, were useful for illustrating seasonal and annual variations. The spring season is defined as measurements between March 20 and June 20, summer is defined as measurements between June 21 and September 21, and fall is defined as measurements between September 22 and December 21.

3.4.2 Water Temperature, Dissolved Oxygen, Specific Conductance, and pH

Vertical-profile plots of water temperature and dissolved oxygen for selected dates illustrate the progression of stratification at the Intake site during 2012 and 2013 (fig. 29). Although the overall pattern of stratification was similar in both years, the timing of key events differed. During 2012, stratification of the water column had begun to develop on April 4 (fig. 29A). At 0.2 m, the temperature was 18.4 degrees C, and the dissolved oxygen was 5.5 mg/L; however, at 4.0 m, the temperature was lower at 16.3 degrees C, and the dissolved oxygen was 1.6 mg/L. Also, hypoxia was evident on this date, with dissolved oxygen concentrations less than 1.0 mg/L from 6.0 m to 8.0 m. By the May 10, 2012 site visit, hypoxia was fully established below the photic zone. In contrast, in early April 2013, water temperatures were cooler than in April 2012, and the entire water column was well mixed and oxygenated (fig. 29B). On April 3, 2013, water temperatures measured 12.6 degrees C, 12.4 degrees C, and 10.5 degrees C at 0.2 m, 4.0 m, and 8.6 m, respectively. The surface temperature was 5.8 degrees C higher in April 2012 than April 2013. Also, dissolved oxygen measured 13.1 mg/L, 12.8 mg/L, and 10.2 mg/L at 0.2 m, 4.0 m, and 8.6 m, respectively. Thus, hypoxia was not evident in April

2013, but was first noted during the May 28, 2013 site visit. The earlier onset of hypoxia in April 2012 was due to the high surficial water temperature and low precipitation, which resulted in lower than normal water inflows into Jordan Lake and stagnant lake water.

The temperature and dissolved oxygen profiles were similar during the June and August site visits in 2012 and 2013. Hypoxia was fully established below the photic zone during the summer measurements for both years of sampling. During these sampling events, hypoxia extended upward in the water column (0.5 mg/L at 5.0 m on August 8, 2012 and 0.2 mg/L at 5.5 m on August 6, 2013). The September measurements for both years are similar as well; however, turnover occurred slightly earlier in 2013. As the surficial water temperatures cool, the water becomes denser and begins to sink. The water column mixes completely, and higher dissolved oxygen levels return to the bottom (fig. 1).

Specific conductance varied seasonally, particularly during 2013, and also differed notably between 2012 and 2013 (fig. 30). In the spring of both years, specific conductance was in the range of 183-207 μS/cm. However, during the summer and fall of 2013, specific conductance was lower. The 2012 measurements did not have as much seasonal variability as 2013. This difference can be attributed to higher rainfall in 2013, which dilutes the water and lowers the specific conductance.

During the spring and summer, pH values had a wider range in variation; however, the fall for both years appears to have a smaller range (fig. 31). Overall, pH is higher and more variable at the top of the water column than near the bottom. Both the seasonal and top/bottom differences likely reflect the influence of algal productivity near the surface. In lakes with low alkalinity, like Jordan Lake, algal uptake of carbon dioxide for photosynthesis results in higher pH levels. It must be noted that all measurements for this study were collected during daylight hours when phytoplankton were likely to have been actively photosynthesizing.

3.4.3 Secchi Depth, Depth to One Percent Light, and Chlorophyll *a*

The secchi depth, depth to one percent light, and chlorophyll *a* were measured only within the photic zone; therefore, there are no "bottom" data for these parameters. The spring and summer data for secchi depth and depth to one percent light have more variability than do the fall data (figs. 32, 33). Also, the summer appears to exhibit a wider range of measurements for both parameters. Overall, seasonal variation appears to be minimal for the secchi depth and depth to one percent light.

The ranges of chlorophyll *a* data observed each year were fairly similar, but concentration patterns during April through July differed among years (fig. 34). The spring of 2013 had higher concentrations compared to the spring of 2012; however, during the July samples, chlorophyll *a* values were higher in 2012 than 2013. The higher chlorophyll *a* values in 2013's spring may have been due to higher precipitation, which could have brought in a flux of nutrients. Also, the late fall concentrations were higher during 2012 than 2013.

3.4.4 Iron and Manganese

Concentrations of iron and manganese near the surface were at or below detection limits and did not vary much seasonally or between years. In contrast, iron and manganese (both total and filtered) concentrations in bottom waters were high during both summers (figs. 35-38). Elevated concentrations coincided with periods when the lake was stratified and dissolved oxygen was depleted in the hypolimnion (fig. 29). The majority of the iron and manganese in the bottom of the water column was in the dissolved form, likely resulting due to reductive dissolution and release from the lake bottom sediments.

3.4.5 Nutrients

Photic-zone samples were analyzed for nutrients (ammonia plus organic nitrogen, ammonia, total organic nitrogen, nitrate plus nitrite, total nitrogen, orthophosphate, and phosphorus). These nutrients were also collected one meter above the lake bed. Total organic nitrogen was computed by subtracting ammonia from ammonia plus organic nitrogen. Total nitrogen was computed by summing nitrate plus nitrite with ammonia plus organic nitrogen.

Surface concentrations for ammonia plus organic nitrogen did not show a distinct seasonal pattern. Bottom concentrations generally were higher than those from surface, with the most pronounced deviations during summer stratification. During periods when the water column was well mixed, such as during the fall of both years and April 2013, surface and bottom concentrations were very similar (figs. 39, 29). Forms of organic nitrogen (dead phytoplankton, detritus, and other organic matter) sink and accumulate in the hypolimnion over the growing season. Also, ammonia is produced from decomposition by bacteria under anaerobic conditions (Harter and Rollins, 2008), which explains why bottom ammonia plus organic nitrogen concentrations were generally higher than surface concentrations.

A sizable portion of the variation observed for hypolimnetic ammonia plus organic nitrogen could be attributed to fluctuations in ammonia, which showed a similar seasonal pattern (fig. 40). Ammonia is a reduced form of inorganic nitrogen; thus, it is more likely to be present during anaerobic conditions (Harter and Rollins, 2008). During summer stratification, decomposition generates a large demand for oxygen in the hypolimnion. The thermocline prevents the hypolimnion from mixing with the better-oxygenated epilimnion. As a result, dissolved oxygen is depleted from the hypolimnion, producing conditions which favor ammonia production. In contrast, low ammonia concentrations were typically observed in top waters of Jordan Lake, where oxygen was plentiful and phytoplankton would readily take up any available ammonia.

Total organic nitrogen tended to be relatively higher in the late summer and fall of both 2012 and 2013. Unusually high values of total organic nitrogen were observed during April 2013, coinciding with a taste-and-odor event. Although minor differences between top and bottom concentrations were observed, patterns were inconsistent (fig. 41). Total organic nitrogen is present in the form of photosynthetic producers and other living organisms in the epilimnion during the growing season. However, the hypolimnion consists of organic nitrogen in the form of detritus and decomposing organic matter.

Nitrate plus nitrite is an oxygenated form of inorganic nitrogen that is readily taken up by phytoplankton. Therefore, concentrations tended to be very low in surface samples from Jordan Lake during times when phytoplankton were actively growing (fig. 42). Because nitrate and nitrite are rapidly reduced when dissolved oxygen is low, concentrations in the hypolimnion tend to be very low during stratification. For this study, nitrate plus nitrate generally was observed in the hypolimnion only when the water column was well mixed and/or the hypolimnion was oxygenated, as was the case during April-May 2012, April-May 2013, and November 2013 (fig. 42). The source of the unusually high nitrate in the hypolimnion in May 2012 is unknown. However, Jordan Lake was relatively warm and already thermally stratified in April 2012. It is possible that inflows from springtime storm events were cooler than the lake surface water and therefore entered the lake as interflows—meaning they sunk to a deeper layer of water with a similar temperature (Martin, 2013).

Total nitrogen was computed by summing nitrate plus nitrite with ammonia plus organic nitrogen. Because nitrate plus nitrate concentrations were generally low in Jordan Lake, temporal patterns observed for total nitrogen closely tracked with those observed for ammonia plus organic nitrogen (fig. 43).

Seasonal patterns for total phosphorus were similar to ammonia plus organic nitrogen and ammonia (fig. 44). The maximum values were measured near the bottom of Jordan Lake during the summers of 2012 and 2013. Phosphorus typically becomes elevated in the hypolimnion of eutrophic lakes through decomposition of organic matter in the water column. Under hypoxic conditions, phosphorus is also released from the sediment into the water overlying the lake bed. Approximately 94 percent of measured orthophosphate concentrations from April 2012 through October 2013 were less than the laboratory method detection level; thus, seasonal and inter-annual variations were not evaluated.

3.5 Relation of Chlorophyll *a* with Geosmin and MIB

The relationships between concentrations of chlorophyll *a* with those of geosmin and MIB have not been widely researched, but the prediction and consequent modeling of taste and odor compounds are often based on chlorophyll *a* data. Geosmin and MIB measurements were collected at the Intake site from the photic and bottom depths during the sampling period; however, chlorophyll *a* measurements were only collected at the photic depth. Thus, only samples from the photic zone for geosmin, MIB, and chlorophyll *a* will be used in this discussion.

Peak values for chlorophyll *a* generally occurred in the late summer, but also occurred in April 2013 (fig. 45B). The maximum chlorophyll *a* value of 41.3 μg/L occurred on April 3, 2013, which was the only time the data from the Intake site exceeded the North Carolina water quality standard of 40 μg/L. Concentrations remained relatively low during the late spring and early summer of each year.

A maximum geosmin value of 250 ng/L was recorded on April 16, 2013 (fig. 45A). During the study, approximately 39 percent of geosmin samples were below the lab reporting level of 3 ng/L. Geosmin values exceeded the human perception threshold of 5 to 10 ng/L three times in 2012 and five times in 2013. Approximately 81 percent of MIB samples were below the lab reporting level of 5 ng/L. In general, MIB was only detected during late summer to early fall in both years of sampling. The maximum MIB concentration of 24 ng/L was recorded on September 3, 2013 (fig. 45A). MIB values exceeded the human perception threshold of 5 to 10 ng/L three times in both 2012 and 2013.

Correlation analysis of geosmin with chlorophyll *a* yields an R^2 value of 0.109, which is considered low (fig. 46A). Correlation of MIB with chlorophyll *a* yields an R^2 value of only 0.08, which indicates essentially no relationship (fig. 46B). Based on these correlation analyses, neither geosmin nor MIB concentrations had strong relationships with chlorophyll *a* concentrations in Jordan Lake during the study period. When outliers were removed from the correlation analysis of geosmin with chlorophyll *a*, the R^2 value equaled 0.237, which resulted in an inverse relationship. Moreover, the inverse relationship between the two constituents that is suggested by the correlation plot is counter-intuitive and provides further evidence of poor agreement.

Overall, the peaks for geosmin and MIB occurred in April 2013 and September 2013, respectively; however, the peaks for chlorophyll *a* typically occurred in the late summer and April 2013. In general, geosmin and MIB were not always detected when chlorophyll *a* was high. Geosmin and chlorophyll *a* share a peak in April 2013; however, MIB remained below its respective detection level. MIB only exceeded its detection level in the late summer of 2012 and 2013. In conclusion, chlorophyll *a* did not correlate well with geosmin and MIB and was not useful as an indicator of the presence of these compounds in this study.

According to a taste and odor study performed by the U.S. Geological Survey, geosmin and MIB production occur across all cyanobacterial community types (Graham et al., 2010). Additionally, the release of geosmin and MIB compounds can vary during the growth phase or during death. With this amount of variation, it is difficult to determine which type of algae is releasing the taste and odor compounds and at which life stage. Taylor (2006) reported that chlorophyll *a* density is only a good predictor of geosmin if the geosmin-producing species make up a significant portion of the total algal biomass. Obtaining chlorophyll *a* concentrations does not determine which specific type of algae is producing taste and odor compounds and which type is not involved in the compound production.

Similar development of tools to predict the onset of geosmin and MIB have had varying results. Smith et al. (2002) observed a good correlation between the concentration of taste and odor compounds to the concentration of chlorophyll *a* and concluded that the trophic state of a reservoir was a good predictor of geosmin and MIB. In contrast, one study revealed that increasing light intensity resulted in increased geosmin concentrations with a corresponding decrease in chlorophyll *a* production in cultures of an *Anabaena* species (Blevins, et al., 1995).

Thus, predictions of geosmin and MIB are complex and may have different results among reservoirs or lakes with various types of algae.

3.6 Discussion of Thesis Results

There were noticeable differences in precipitation and hydrologic conditions between 2012 and 2013, which influenced water-quality conditions in the Jordan Lake study area among years. The sampling period for 2013 was wetter than the sampling period for 2012. Streamflow was generally below the normal range in 2012, but within the normal to high range in 2013. Jordan Lake is relatively slow-moving with the hydraulic retention time for the New Hope arm at 418 days. Also, two water quality parameters exceeded the State's standards during the sampling period at Jordan Lake. The State's range for pH was exceeded at Buoy 8 in July 2012. Chlorophyll *a* exceeded the State's standard once at the Intake site, six times at Buoy 9, and three times at Buoy 8 during the sampling period.

Buoy 9 had the highest turbidity, lowest dissolved oxygen, lowest secchi depth and lowest depth to one percent light. This site is the furthest upstream site in the study area and is the first recipient from the flow of nutrients and metals from an upstream segment of the lake and its tributary streams. Accordingly, sediment and other constituents may settle out when moving southward along the lake. The remaining three sites consistently had lower turbidity and greater secchi depths.

Maximum values of temperature, total iron, ammonia plus organic nitrogen, phosphorus, organic nitrogen, and total nitrogen were measured at White Oak. The high concentrations at White Oak may be due to the White Oak Creek tributary located northeast of the White Oak sampling site. Influxes of these constituents during rainfall events may be causing higher values at the White Oak site compared to the remaining sites. The highest values of dissolved oxygen, secchi depth, specific conductance, filtered iron, total and filtered manganese, ammonia, nitrate plus nitrite, orthophosphate were observed at the Intake site. The greater depth of the water column in the vicinity of the Intake site may be contributing to the relatively higher concentrations of metals and inorganic nutrients. During summer months, stratification and hypolimnetic hypoxia are strong at this location and likely influence nutrient and metals dynamics. The maximum pH, depth to one percent light, and chlorophyll *a* concentrations were located at Buoy 8.

Based on a combination of regression analyses and Wilcoxon signed-rank tests, the occurrence of spatial differences in water quality parameters between Buoy 9, Buoy 8, White Oak and the Intake site was low. The exception of parameters include turbidity data for 2013 at Buoy 9, the secchi depth data for both years of sampling at Buoy 9, depth to one percent light and total iron data for 2012 at Buoy 9, and total manganese data for 2012 at White Oak. Buoy 9 and the Intake site account for the greatest distance between the sites and Buoy 9 is the most upstream site, which may explain why the majority of spatial differences occur between these sites.

Additionally, the seasonal and annual variations were analyzed using vertical profile-plots, date plots and scatter plots. Water quality varied from April through October each year in response to fluctuations in temperature and other seasonal influences. Hypoxia had an earlier onset in 2012 than 2013. It was noted in April for the 2012 sampling year; however, it was not noted until May 28 for the 2013 sampling year. The earlier onset of hypoxia in April 2012 was due to warmer weather and low precipitation, which resulted in high surficial water temperature and below-normal water flow into Jordan Lake. Also, fall turnover occurred slightly earlier in 2013 than 2012, which may be due to higher precipitation and an increase in inflow.

Seasonal and inter-annual differences were noted for most parameters, with the exception of secchi depth, depth to one percent light, and orthophosphate. Chlorophyll *a* concentrations patterns during April through July differed among years with higher concentrations in the spring of 2013 compared to the spring of 2012. This inter-annual difference may have been due to higher precipitation and an influx of nutrients in the spring of 2013.

Iron (filtered and total), manganese (filtered and total), ammonia plus organic nitrogen, ammonia, total nitrogen, and phosphorus concentrations were consistently higher during summer stratification near the bottom, although some parameters differed by year. Under anoxic conditions, these metals and nutrients are more likely to accumulate in the bottom. Generally, surface concentrations for the nutrients and metals in this study did not vary seasonally or between years. In contrast, total organic nitrogen in 2013 and nitrate plus nitrate for both years measured higher values in the spring as opposed to the other seasons. Nitrate and nitrite are rapidly reduced when dissolved oxygen is low, thus, concentrations in the hypolimnion tend to be very low during summer stratification.

Evaluation of chlorophyll *a*, MIB and geosmin correlation plots and timing of peak values determined that chlorophyll *a* is not a good predictor of taste and odor compounds. Given that the release of taste and odor compounds can occur across all cyanobacterial types, it can be difficult to determine which type of algae is releasing the compounds and at which stage in their life cycle.

Overall, hydrologic and climate conditions can affect water quality parameters, algal growth, onset of stratification and mixing, and seasonal and inter-annual patterns of constituent concentrations. To obtain an understanding of water quality at Jordan Lake, therefore, it is essential to obtain multiple years of data. Biweekly sampling described both seasonal and inter-annual trends. It is also important to note that hypolimnetic sampling provided a much more comprehensive picture of water quality than would have been observed by only sampling the top and photic zone.

Similar conclusions regarding hydrologic and climate conditions affecting water quality parameters were noted from a study evaluating Lake Erie's 2011 algal bloom. Due to the long-term trends in agriculture, coupled with meteorological conditions, Lake Erie experienced record-breaking nutrient loads in 2011. It was concluded that nutrient yields (specifically phosphorus) were related to precipitation intensity (higher intensity increasing yields) (Michalak, et al., 2013). Additional factors that contributed to the algal bloom included warmer temperatures, weak lake circulation, and calm water conditions. This conclusion was further supported in 2012 with substantially lower discharge leading to lower nutrient concentrations and a weaker algal bloom (Michalak, et al., 2013).

4 CONCLUSION

4.1 Summary of Thesis

Water quality and stratification patterns in one segment of the New Hope arm of Jordan Lake were assessed by collecting biweekly samples during 2012 from April through November and 2013 from April through October. This thesis considered spatial differences among the four sampling locations, studied annual and seasonal variance of water quality, and evaluated if chlorophyll *a* could be a useful indicator of taste and odor compounds.

Regression analyses and Wilcoxon signed-rank tests were utilized to determine spatial variations between Buoy 9, Buoy 8, White Oak and the Intake site. The differences were limited, with the exception of turbidity data for 2013 at Buoy 9, the secchi depth data for both years of sampling at Buoy 9, depth to one percent light and total iron data for 2012 at Buoy 9, and total manganese data for 2012 at White Oak. The majority of spatial variation occurred between Buoy 9 and the Intake, which may be due to Buoy 9 being the most upstream site.

Seasonal and inter-annual differences were observed for the majority of parameters, with the exception of secchi depth, depth to one percent light, and orthophosphate. Most of the nutrient and metal concentrations were higher during summer stratification near the bottom and generally stable near the surface between seasons. The variations, including onset of hypoxia and timing of turnover, may have been due to fluctuations in precipitation, temperature, and other climate and hydrologic conditions. Overall, water quality varied from April through October each year in response to these influences.

Correlation plots and timing of peak values determined that chlorophyll *a* is not a good predictor of taste and odor compounds in this study. The release of MIB and geosmin compounds can transpire across all cyanobacterial types, and the specific types in Jordan Lake releasing these compounds are not known. Predictions of geosmin and MIB are complex and may have contrasting outcomes among reservoirs or lakes with various types of algae.

4.2 Local Implications of Research

The local benefit of this research is a more in-depth understanding of the water quality and stratification in the area where the Town of Cary plans to install a large vertical mixing system. This system is intended to de-stratify the water column in the vicinity of the drinking water intake. The envisioned results of destratification include decreases in dissolved iron, manganese and nutrients, and increases in dissolved oxygen near the bottom. This research data can also be helpful for the Cary/Apex Water Treatment Plant to determine the best depths from which to draw water for better water quality. These data thus provide pre-installation conditions, which can be used post-installation to evaluate if the mixing system is working as intended. Ideally, the water treatment plant will be able to improve its cost efficiency.

This research suggests that there are still many unknowns about the long-term trends of water quality at Jordan Lake. This thesis provided a detailed evaluation of water quality and stratification during the growing seasons of 2012 through 2013. However, a comprehensive assessment of water quality from the time of the lake's impoundment to present has not been done to determine if the lake has become more eutrophic. Many stakeholders agree; efforts to lower nutrient loads in Jordan Lake must be made (Manuel, 2010). Jordan Lake is unique and courses of action from management and regulatory perspectives can be complex. As suggested by results of the correlation plots comparing chlorophyll *a* with geosmin and MIB, there is not much known about taste and odor compounds and exactly which type of algae are releasing these compounds. Understanding the mechanisms of algae growth is the key to prevention. Also, the effectiveness and consequences of the vertical mixing system once installed and operational are not known.

4.3 Studies of Artificial Mixing Systems

Artificial circulation of the water column during stratification is one of the common methods used to manage lake water quality and will be implemented at Jordan Lake. Water circulation by pumps, jets, and bubbled air or other gases destratifies the water strata, which results in raising the temperature of the whole lake (Cooke, et al., 2005). A study of artificial circulation at Crystal Lake in Robbinsdale, MN concluded that circulation: (1) led to a 2- to 3-fold increase in the phosphorus by increasing the availability of internal phosphorus supplies; (2) maintained the dominance of blue-green algae and increased their overall abundance; and (3) was not at an adequate rate, so weak stratification existed and oxygen depletion occurred, increasing the likelihood of summertime fish kill, which also occurred (Osgood, et al., 1990). The lake had been circulated for 12 years and the study examined differences in the two years after circulation ceased. An additional study of Bleiloch Reservoir in Thuringia, Germany concluded that artificial mixing caused an increase in algal biomass and diversity due to supply of hypolimnetic nutrients to the epilimnion and expansion of favorable habitat for phytoplankton (Becker, et al., 2006).

In contrast, a small eutrophic reservoir (18.8 acres) in LaMoure County, North Dakota was evaluated for two years to study the effectiveness of a destratification system placed in the deepest area of the reservoir. Overall, the mean chlorophyll *a* concentration decreased significantly with the aeration and suggested a shift of the dominant algae group (Balangoda, 2015).

Based on aforementioned studies of artificial mixing systems, each lake or reservoir is unique and requires a detailed understanding and evaluation of destratification effects. The results of the destratification system to be utilized at Jordan Lake are unknown. These studies suggest the need for in-depth research of the proper mixing rate to achieve desired results and evaluation of algal community effects. Depending on the mixer's effects, the water treatment plant may want to alter the depth at which water is taken or adjust mixing rates accordingly.

4.4 Global Effects

The water quality concerns evaluated at Jordan Lake are increasingly common throughout lakes and reservoirs across the United States and worldwide. For example, Lake Okeechobee in Florida has experienced accelerated eutrophication and increases in the biomass of bloom-forming taxa associated with post-1950s escalation of agriculture (Engstrom, et al., 2006). Eutrophication has emerged on a global scale to include Lake Victoria in Africa, Lake Taihu in China, and Lake Baikal in Russia (United Nations Environment Programme, 2017). With growing use of fertilizers and pesticides and rapid development, nutrients are entering lakes and streams at alarming rates. Continued exposure to these and other pollutants can lead to changes in biological communities, loss of habitat availability, and a loss of freshwater biodiversity (Wetzel, 2001). Regulation efforts can be complex due to many stakeholders involved including developers, agricultural, environmental, and local government.

Aside from the regulation of pollutants, there are a variety of options that could be utilized to help minimize nutrient inputs. Various options include a worldwide increase in the use of sustainable farming methods and the restoration of wetlands and riparian vegetation that help buffer nutrient loading (Carpenter, et al., 1998). It is likely that any successful effort to reduce nutrient loading will include the combination of many options to meet the varied needs of diverse ecosystems. Effective lake and reservoir management on a global scale is essential to meet the growing demands for freshwater and continued ecosystem biodiversity. Reservoir management is also vital at Jordan Lake to maintain over-enrichment of nutrients and continue to provide cost-efficient drinking water to growing communities.

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Table 1. Study network monitored for water quality and stratification in Jordan Lake, April 2012 through November 2012 and April 2013 through October 2013.

[USGS, U.S. Geological Survey; B.E., Benjamin Everett; HWY, highway; NC, North Carolina; SR, secondary road]

USGS station number	USGS station name	Decimal latitude	Decimal longitude
0209799150	B.E. Jordan Lake above US Hwy 64 at Wilsonville, NC	35.7417	-79.0192
0209791010	Jordan Lake White Oak Creek Arm below SR1008 at Bells, NC	35.7489	-79.0094
0209781125	Jordan Lake Near Buoy 8 Near Bells, NC	35.7519	-79.0292
0209771550	Jordan Lake at Buoy 9 Near Farrington, NC	35.775	-79.0272

Table 2: Biweekly samples collected at four sites in Jordan Lake, April 2012 through November 2012 April 2013 through November 2013.

Property or Constituent	Type of sample: Vertical profile	Grab, 1 meter below surface	Photic-zone composite	Grab, 1 meter above lake bed
Field Properties				
Water temperature	X			
Dissolved oxygen	X			
Specific conductance	X			
pH	X			
Turbidity		X		
Secchi depth		At surface		
Depth to 1% incident light		At surface		
Iron and Manganese				
Iron, total		X		X
Iron, dissolved		X		X
Manganese, total		X		X
Manganese, dissolved		X		X
Nutrients				
Nitrogen, ammonia, dissolved			X	X
Nitrogen, total ammonia + organic			X	X
Nitrogen, nitrite + nitrate, dissolved			X	X
Phosphorus, orthophosphate, dissolved			X	X
Phosphorus, total			X	X
Phytoplankton and Taste and Odor Compounds				
Chlorophyll *a*			X	
Geosmin			X(1)	X(1)
2-Methylisoborneol (MIB)			X(1)	X(1)

(1) Collected only at Intake site

Table 3. Chemical constituents and physical properties analyzed for the Jordan Lake study sites, and the methods used for sample analyses, April 2012 through November 2012 and April 2013 through October 2013.

[degree Celsius; m, meter; °C; USEPA, U.S. Environmental Protection Agency; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; pH, negative log (base 10) of the hydrogen ion activity; N, nitrogen; P, phosphorus; NWQL, National Water Quality Laboratory; µg/L, microgram per liter; -, not applicable; ng/L, nanograms per liter; EEA, Eurofins Eaton Analytical; SPME, solid-phase microextraction.]

Constituent	Parameter code	Method code	Method reference	Laboratory detection level	Report start	Report end	Analyzing entity
Temperature, water, in °C	00010	THM01	U.S. Geological Survey (variously dated)	--	--	--	Field
Transparency, Secchi, in m	00078	SECCH	USEPA (1997a)	--	--	--	Field
Specific conductance, in µS/cm at 25 °C	00095	SC001	U.S. Geological Survey (variously dated)	--	--	--	Field
Dissolved oxygen, in mg/L	00300	LUMIN	American Society for Testing and Materials (2005)	--	--	--	Field
pH, in standard units	00400	PROBE	U.S. Geological Survey (variously dated)	--	--	--	Field
Ammonia plus organic nitrogen, unfiltered, in mg/L as N	00625	KJ008	Patton and Truitt (2000)	0.07	10/1/2011	9/30/2016	NWQL
Ammonia, filtered, in mg/L as N	00608	SHC02	Fishman (1993)	0.01	10/1/2011	9/30/2014	NWQL
Nitrate plus nitrite, filtered, in mg/L as N	00631	RED02	Fishman (1993)	0.01	10/1/2011	9/30/2014	NWQL
Orthophosphate, filtered, in mg/L as P	00671	PHM01	Fishman (1993)	0.004	10/1/2011	9/30/2014	NWQL
Phosphorus, unfiltered, in mg/L as P	00665	CL021	USEPA (1993)	0.004	10/1/2011	9/30/2014	NWQL
Iron, unfiltered, in µg/L	01045	PLA15	Garbarino and Struzeski (1998)	4.6	10/1/2011	9/30/2014	NWQL
Iron, filtered, in µg/L	01046	PLA11	Garbarino and Struzeski (1998)	3.2	10/1/2011	9/30/2012	NWQL
				4.0	10/1/2012	9/30/2014	NWQL
Manganese, unfiltered, in µg/L	01055	PLA15	Garbarino and Struzeski (1998)	0.20	10/1/2011	9/30/2014	NWQL
Manganese, filtered, in µg/L	01056	PLA11	Garbarino and Struzeski (1998)	0.16	10/1/2011	9/30/2013	NWQL
				0.20	10/1/2013	9/30/2014	NWQL
Chlorophyll *a* , in µg/L	70953	445.0	USEPA (1997b)	1.0	4/1/2012	10/31/2013	Meritech
2-Methyl-isoborneol, unfiltered, in ng/L	68289	6040D	Standard Methods (2016)	5.0	4/1/2012	10/31/2013	EEA
Geosmin, unfiltered, in ng/L	68288	6040D	Standard Methods (2016)	3.0	4/1/2012	10/31/2013	EEA

Table 3 (continued). Chemical constituents and physical properties analyzed for the Jordan Lake study sites, and the methods used for sample analyses, April 2012 through November 2012 and April 2013 through October 2013.

[degree Celsius; m, meter; °C; USEPA, U.S. Environmental Protection Agency; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; pH, negative log (base 10) of the hydrogen ion activity; N, nitrogen; P, phosphorus; NWQL, National Water Quality Laboratory; µg/L, microgram per liter; -, not applicable; ng/L, nanograms per liter; EEA, Eurofins Eaton Analytical; SPME, solid-phase microextraction.]

Constituent	Analytical method
Temperature, water, in °C	Thermistor
Transparency, Secchi, in m	Secchi disk
Specific conductance, in µS/cm at 25 °C	Electrometry, Wheatstone bridge
Dissolved oxygen, in mg/L	Electrometry, luminescence quenching
pH, in standard units	Electrometry, ion-selective electrode
Ammonia plus organic nitrogen, unfiltered, in mg/L as N	Organic nitrogen is converted to ammonium ions at a temperature of 370 degrees C in a reaction medium of surlfuric acid, potassium sulfate, and mercery (II). An air-segmented continuous flow analyzer is used to automate the photometric determination of ammonium ions in resolvated Kjeldahl digests by the salicylate analog of the Berthelot reaction. Gases pass through the microporous polypropylene membrane; particles do not. Before passage through the gas diffusion cell, ammonium ions in acidic resolvated Kjeldahl digests mix with the alkaline donor stream and are converted to ammonia. Inside the diffusion cell, gas-phase ammonia in the donor stream passes through the polypropylene membrane and is trapped in the interferent-free recipient stream.
Ammonia, filtered, in mg/L as N	Ammonia reacts with hypochlorite and salicylate ions in the presence of ferricyanide ions to form the salicylic acid analog of indophenol.
Nitrate plus nitrite, filtered, in mg/L as N	Nitrate is reduced to nitrite by cadmium metal. The sample stream then is treated with sulfanilamide under acidic conditions to yield a diazo compound, which couples with N-1-naphthylethylenediamine dihydrochloride to form an azo dye, the absorbance of which is measured colorimetrically. The result is the sum of the nitrite originally present plus that formed by the reduction of the nitrate.
Orthophosphate, filtered, in mg/L as P	Orthophosphate ion reacts with ammonium molybdate in acidic solution to form phosphomolybidic acid, which upon reduction with ascorbic acid produces an intensely blue complex. Antimony potassium tartrate is added to increase the rate of reduction.
Phosphorus, unfiltered, in mg/L as P	Ammonium molybdate and antimony potassium tartrate react in an acid medium with dilute solutions of phosphorus to form an antimony-phosphomolybdate complex. The complex is reduced to an intensely blue-colored complex by ascorbic acid. The color is proportional to the phosphorus concentration.
Iron, unfiltered, in µg/L	Inductively coupled plasma-optical emission spectrometry is used. The solution is pumped into a high dissolved-solids tolerant nebulizer to produce an aerosol. The aerosol is transported by argon gas through a spray chamber and torch assembly into an inductively coupled plasma source where the sample is desolvated, atomized, and the resultant atoms or ions excited. The intensity of light emission that results when the excited-state atoms or ions relax to their ground state is directly propotional to the concentration of the emitting species in solution.
Iron, filtered, in µg/L	
Manganese, unfiltered, in µg/L	Inductively coupled plasma-optical emission spectrometry is used. The solution is pumped into a high dissolved-solids tolerant nebulizer to produce an aerosol. The aerosol is transported by argon gas through a spray chamber and torch assembly into an inductively coupled plasma source where the sample is desolvated, atomized, and the resultant atoms or ions excited. The intensity of light emission that results when the excited-state atoms or ions relax to their ground state is directly propotional to the concentration of the emitting species in solution. Also, mass spectrometry is used. The aerosol produced undergoes desolvation, atomization, and ionization. Ions are sampled through the mass spectrometer. An electron multiplier detects the ions by generating an electrical current that is directly proportional to the concentration of the element present in the sample.
Manganese, filtered, in µg/L	
Chlorophyll *a* , in µg/L	Fluorescence detection is used for low level determination of chlorophyll *a* and its magnesium free derivative, pheophytin a, in marine and freshwater phytoplankton.
2-Methyl-isoborneol, unfiltered, in ng/L	The SPME method is used. It relies on the adsorption of target compounds on a SPME fiber. The fiber is placed in the headspace above the sample in a closed vessel and allowed to equilibrate with the aqueous sample. After equilibration time, the fiber is removed and inserted directly into the injection port.
Geosmin, unfiltered, in ng/L	The SPME method is used. It relies on the adsorption of target compounds on a SPME fiber. The fiber is placed in the headspace above the sample in a closed vessel and allowed to equilibrate with the aqueous sample. After equilibration time, the fiber is removed and inserted directly into the injection port.

Table 4. Summary of water-quality results for four sites in Jordan Lake, April 2012 through November 2012 and April 2013 through October 2013.

[NCDWR, North Carolina Division of Water Resources; MCL, maximum contaminant level; SDWR, secondary drinking water regulation; n, number of observations; range, minimum and maximum values; --, not available or constituent not sampled; NTRU, nephelometric ratiometric turbidity units; m, meter; mg/L, milligram per liter; >, greater than; <, less than; µS/cm, microsiemens per centimeter; C, Celsius; N, nitrogen; P, phosphorus; µg/L, microgram per liter; ng/L, nanogram per liter; **bold text** indicates an exceedance of the NCDWR water-quality threshold]

Property or Constituent	NCDWR standard[1]	MCL or *SDWR*[2]	Jordan Lake at Buoy 8		Jordan Lake at Buoy 9		Jordan Lake at Intake		Jordan Lake White Oak Creek Arm	
			n	range	n	range	n	range	n	range
Near Top and Photic										
Transparency, Secchi Disc (m)	--	--	31	0.6 - 1.2	31	0.5 - 0.9	31	0.6 - 1.3	31	0.6 - 1.1
Dissolved oxygen (mg/L)	**<5.0**	--	31	**5.6 - 12.4**	31	**5.4 - 11.8**	31	**4.4 - 13.1**	31	**5.6 - 12.6**
Dissolved oxygen (percent saturation)	**110**	--	31	**68.0 - 123**	31	**64 - 128**	31	**53 - 123**	31	**68 - 125**
pH (standard units)	**6.0-9.0**	*6.5-8.5*	31	**7.0 - 9.1**	31	7.0 - 9.0	31	7.1 - 8.9	31	7.2 - 9.0
Specific conductance at 25 degrees C (µS/cm)	--	--	31	123 - 206	31	124 - 206	31	124 - 204	31	123 - 201
Temperature, water (degrees C)	32	--	31	11.7 - 29.8	31	11.4 - 30.0	31	12.6 - 29.6	31	12.9 - 30.2
Turbidity (NTRU)	**>25 (Lakes)**	--	31	4.3 - 12	31	4.7 - 18	31	4.5 - 14	31	4.4 - 12
Depth to 1% Light (m)	--	--	30	1.1 - 3.6	30	1.1 - 2.8	30	1.2 - 3.0	30	1.1 - 3.6
Iron, unfiltered, recoverable (µg/L)	--	*300*	31	62.1 - 232	31	74.1 - 254	31	59.5 - 226	31	45.8 - 225
Iron, filtered (µg/L)	--	*300*	30	<3.2 - 71.2	31	<3.2 - 72.4	31	<3.2 - 40.4	30	<3.2 -47.4
Manganese, unfiltered, recoverable (µg/L)	--	*50*	31	39.6 - 191	31	43.2 - 222	31	39.1 - 176	31	37 - 162
Manganese, filtered (µg/L)	--	*50*	30	0.30 - 11.1	31	0.480 - 29.2	31	0.26 - 4.32	30	0.34 - 25.2
Ammonia plus organic nitrogen, unfiltered (mg/L as N)	--	--	31	0.69 - 1.0	31	0.65 - 1.10	31	0.61 - 1.0	30	0.61 - 2.70
Ammonia, filtered (mg/L as N)	--	--	31	<0.01 - 0.111	31	<0.01 - 0.132	31	<0.01 - 0.118	30	<0.01 - 0.110
Nitrate plus nitrite, filtered (mg/L as N)	10 (WS)	*10*	31	<0.01 - 0.09	31	<0.01 - 0.07	31	<0.01 - 0.12	30	<0.01 - 0.10
Orthophosphate, filtered (mg/L as P)	--	--	31	<0.004	31	<0.004 - 0.01	31	<0.004	30	<0.004 - 0.025
Phosphorus, unfiltered (mg/L as P)	--	--	31	0.037 - 0.055	31	0.037 - 0.061	31	0.03 - 0.053	30	0.031 - 0.051
Total Nitrogen, unfiltered (mg/L)	--	--	31	<0.70 - 1.1	31	<0.66 - 1.1	31	<0.62 - 1.0	30	<0.62 - 2.70
Total Organic Nitrogen, unfiltered (mg/L as N)	--	--	31	<0.69 - 1.0	31	<0.65 - 1.1	31	0.60 - 1.0	31	<0.61 - 2.70
Chlorophyll *a* , filtered (µg/L)	**40**	--	31	**9.1 - 63.7**	31	**6.3 - 49.3**	31	**11.9 - 41.3**	31	9.5 - 36.1
Geosmin, unfiltered (ng/L)	--	--	--	--	--	--	31	<3.0 - 250	--	--
2-Methyl-isoborneol, unfiltered (ng/L)	--	--	--	--	--	--	31	<5.0 - 24.0	--	--
Near Bottom										
Dissolved oxygen (mg/L)	**<5.0**	--	31	**0.2 - 11.7**	31	**0.1 - 10.7**	31	**0.2 - 10.3**	31	**0.2 - 9.8**
Dissolved oxygen (percent saturation)	**110**	--	31	2 - 108	31	2 - 98	31	2 - 94	31	3 - 95
pH (standard units)	**6.0-9.0**	*6.5-8.5*	31	6.7 - 8.3	31	6.6 - 8.1	31	6.6 - 8.0	31	6.7 - 8.0
Specific conductance at 25 degrees C (µS/cm)	--	--	31	109 - 226	31	94 - 214	31	114 - 229	31	124 - 203
Temperature, water (degrees C)	32	--	31	11.6 - 28	31	11.3 - 29.7	31	11.1 - 26.3	31	10.8 - 29.1
Iron, unfiltered, recoverable (µg/L)	--	*300*	31	74.9 - 1,440	31	83.8 - 862	31	104 - 1,220	31	52.4 - 2,570
Iron, filtered (µg/L)	--	*300*	30	<3.2 - 830	31	<3.2 - 398	31	6.7 - 918	30	<3.2 - 442
Manganese, unfiltered, recoverable (µg/L)	--	*50*	31	74.3 - 2,510	31	44.9 - 1,010	31	98.0 - 2,710	31	70.7 - 1,350
Manganese, filtered (µg/L)	--	*50*	30	0.39 - 2,590	31	0.47 - 872	31	7.27 - 2,710	30	0.7 - 1,350
Ammonia plus organic nitrogen, unfiltered (mg/L as N)	--	--	31	0.67 - 1.3	31	0.63 - 1.1	31	0.69 - 1.7	31	0.65 - 1.1
Ammonia, filtered (mg/L as N)	--	--	31	<0.01 - 0.58	31	<0.01 - 0.307	31	<0.01 - 0.781	31	<0.01 - 0.386
Nitrate plus nitrite, filtered (mg/L as N)	10 (WS)	*10*	31	<0.01 - 0.17	31	<0.01 - 0.10	31	<0.01 - 0.23	31	<0.01 - 0.09
Orthophosphate, filtered (mg/L as P)	--	--	31	<0.004 - 0.032	31	<0.004 - 0.007	31	<0.004 - 0.033	31	<0.004 - 0.008
Phosphorus, unfiltered (mg/L as P)	--	--	31	0.036 - 0.144	31	0.039 - 0.096	31	0.037 - 0.103	31	0.033 - 0.286
Total Nitrogen, unfiltered (mg/L)	--	--	31	<0.69 - 1.40	31	<0.64 - 1.10	31	0.70 - 1.70	31	0.66 - 1.10
Total Organic Nitrogen, unfiltered (mg/L as N)	--	--	31	0.60 - 1.00	31	0.61 - 1.10	31	0.55 - 0.94	31	0.58 - 0.93
Geosmin, unfiltered (ng/L)	--	--	--	--	--	--	31	<3.0 - 120	--	--
2-Methyl-isoborneol, unfiltered (ng/L)	--	--	--	--	--	--	31	<5.0 - 49.0	--	--

[1] NCDWR criteria listed are the most stringent of either freshwater aquatic life, water supply (WS), or human health standards; N=narrative standard; dissolved oxygen percent saturation is evaluated relative to the total dissolved gases standard. Surface Water Standards: NC Surface Water Quality Standards Tables (accessed July 28, 2016 at: http://deq.nc.gov/about/divisions/water-resources/planning/classification-standards/surface-water-standards#WQSTables.).

[2] Maximum Contaminant Levels for drinking water are listed if available; Secondary Drinking Water Regulations are listed in italics if MCLs are not available (accessed February 19, 2017 at: https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals).

Table 5. Summary of regression statistics for selected properties and constiutents for four sites in Jordan Lake, NC, April 2012 through November 2012 and April 2013 through October 201:
Grey shading indicates the Wilcoxon signed-rank test was computed.
[red font, significant (p<=0.05); black font, not significant (p>0.05); R^2, R-squared; N, nitrogen; P, phosphorus.]

Property or Constituent	Intake - Buoy 9					Intake - Buoy 8					Intake - White Oak				
	Slope	Intercept	P-value of slope	Adjusted R^2	Coincident	Slope	Intercept	P-value of slope	Adjusted R^2	Coincident	Slope	Intercept	P-value of slope	Adjusted R^2	Coincident
April 2012 through November 2012															
Specific Conductance	0.740	54.5	6.76E-05	0.668	Yes	0.767	47.9	9.32E-06	0.748	No	0.743	49.6	1.07E-06	0.814	No
Turbidity	1.32	-0.528	0.041	0.212	Yes	0.924	0.983	0.005	0.407	Yes	0.615	2.11	0.048	0.200	Yes
Transparency, Secchi Disc	0.504	0.309	3.61E-04	0.581	No	0.916	0.066	4.63E-06	0.772	Yes	0.523	0.401	2.75E-03	0.447	No
Depth to One Percent Light	0.571	0.584	7.58E-03	0.416	No	0.658	0.545	1.57E-04	0.685	No	1.08	0.051	3.37E-06	0.832	Yes
Chlorophyll *a*	1.02	2.91	3.24E-05	0.700	Yes	1.21	-1.79	9.49E-05	0.652	Yes	0.840	3.92	6.31E-05	0.671	Yes
Iron, total	0.830	45.3	7.40E-05	0.664	No	0.965	14.2	1.78E-09	0.925	Yes	0.811	12.5	1.21E-07	0.864	No
Iron, filtered	1.08	-0.299	7.96E-10	0.933	Yes	1.09	0.437	1.55E-09	0.940	Yes	1.23	0.563	9.48E-06	0.774	Yes
Manganese, total	0.391	85.7	0.093	0.130	No	0.841	27.8	5.67E-05	0.676	Yes	0.569	27.3	0.003	0.432	No
Manganese, filtered	0.440	0.718	0.004	0.419	No	0.393	0.676	0.015	0.326	No	-0.093	3.28	0.954	-0.077	Yes
Ammonia + Organic N, unfiltered, as N	1.02	0.030	3.01E-03	0.441	Yes	1.04	-0.002	2.27E-04	0.607	Yes	0.935	0.043	5.73E-03	0.414	Yes
Ammonia, filtered, as N	0.534	0.011	6.70E-03	0.378	No	0.945	0.007	4.59E-06	0.772	Yes	0.795	0.006	3.25E-05	0.727	Yes
Organic Nitrogen, unfiltered, as N	0.763	0.230	9.66E-03	0.347	Yes	1.05	-0.014	1.53E-04	0.628	Yes	0.901	0.067	7.98E-03	0.386	Yes
Nitrate + Nitrite, filtered, as N	0.593	0.003	2.16E-14	0.985	No	0.741	0.004	9.79E-08	0.868	No	0.706	0.002	1.46E-11	0.971	No
Total Nitrogen, unfiltered	1.07	-0.024	7.03E-04	0.541	Yes	0.954	0.072	1.92E-03	0.474	Yes	0.823	0.134	7.79E-03	0.388	Yes
Phosphorus, unfiltered, as P	0.923	0.009	5.870E-04	0.552	Yes	0.804	0.011	3.153E-04	0.589	Yes	0.513	0.018	0.010	0.369	No
April 2013 through October 2013															
Specific Conductance	1.06	-8.74	1.60E-11	0.970	Yes	1.06	-9.03	1.54E-12	0.979	Yes	0.92	10.5	1.39E-12	0.980	No
Turbidity	2.57	0.781	1.61E-04	0.653	No	1.87	0.795	9.44E-05	0.680	Yes	1.49	0.714	2.77E-07	0.868	No
Transparency, Secchi Disc	0.203	0.615	8.75E-04	0.555	No	0.079	0.866	2.82E-05	0.733	Yes	0.014	1.02	7.81E-06	0.780	Yes
Depth to One Percent Light	1.36	0.180	0.196	0.058	No	-0.210	1.09	2.08E-04	0.640	Yes	0.336	0.849	1.93E-05	0.748	Yes
Chlorophyll *a*	1.48	1.11	1.24E-05	0.764	Yes	2.26	0.942	4.30E-05	0.716	Yes	3.91	0.807	9.67E-05	0.679	Yes
Iron, total	58.0	0.796	0.02926262	0.263	Yes	17.2	0.991	4.30E-04	0.599	Yes	12.4	0.936	1.24E-04	0.667	Yes
Iron, filtered	-0.598	1.75	4.52E-06	0.798	No	-4.36	1.67	1.97E-07	0.874	No	1.85	1.08	5.64E-05	0.704	Yes
Manganese, total	22.7	0.959	1.55E-03	0.515	Yes	5.16	1.04	2.32E-06	0.817	Yes	4.12	0.875	1.90E-04	0.645	Yes
Manganese, filtered	4.15	-0.495	0.779	-0.070	Yes	1.85	0.027	0.967	-0.077	Yes	0.776	0.194	0.259	0.027	No
Ammonia + Organic N, unfiltered, as N	0.251	0.765	4.60E-04	0.595	Yes	0.318	0.627	1.10E-03	0.539	No	-1.48	3.11	5.02E-03	0.425	No
Ammonia, filtered, as N	0.002	1.12	9.59E-04	0.548	Yes	0.000	1.07	1.10E-07	0.885	Yes	0.000	1.00	3.89E-06	0.802	Yes
Organic Nitrogen, unfiltered, as N	0.191	0.832	1.83E-03	0.503	Yes	0.244	0.715	2.20E-03	0.490	Yes	-1.93	3.76	9.95E-04	0.546	No
Nitrate + Nitrite, filtered, as N	0.012	0.033	0.634	-0.058	No	0.004	0.608	1.35E-08	0.917	No	0.003	0.610	1.07E-04	0.674	No
Total Nitrogen, unfiltered	0.204	0.823	4.41E-04	0.597	Yes	0.335	0.610	8.17E-04	0.559	No	-1.26	2.76	1.27E-02	0.344	Yes
Phosphorus, unfiltered, as P	0.015	0.808	0.011	0.354	Yes	0.012	0.788	0.015	0.329	Yes	0.032	0.240	0.365	-0.009	No

Table 6. P-values of selected constiutents of the Wilcoxon signed-rank test for significant differences between water-quality samples, collected at Jordan Lake, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[red font, significant ($p<=0.05$); black font, not significant ($p>0.05$); --, not analyzed; N, nitrogen; P, phosphorus.]

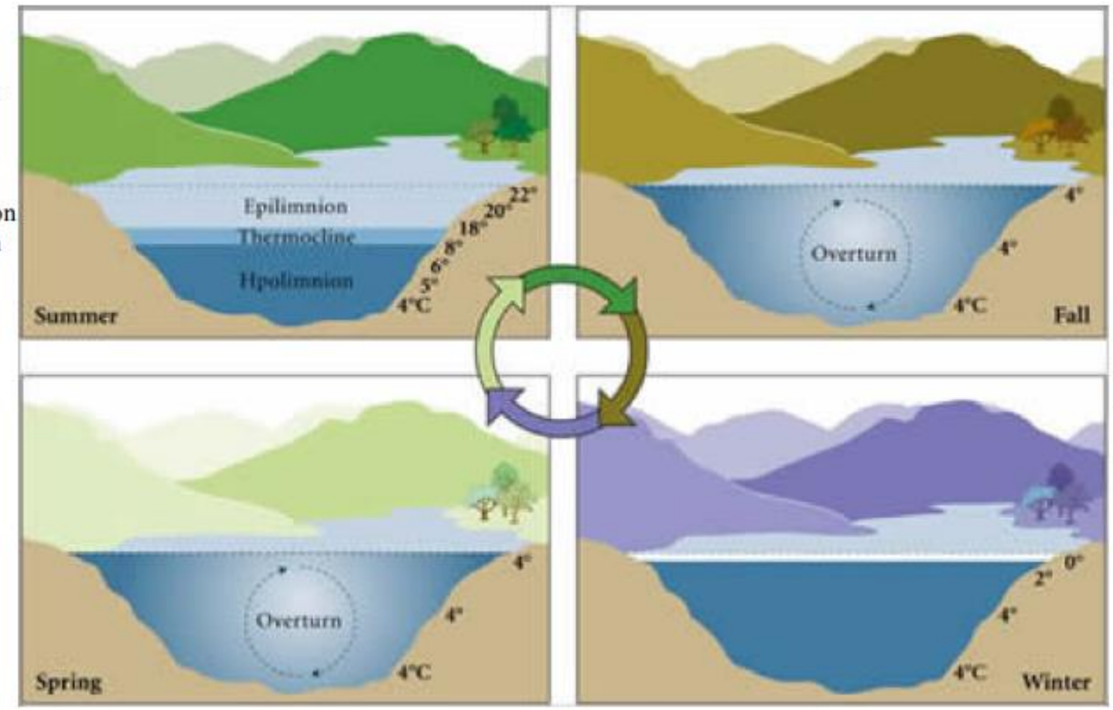
April 2012 through October 2012			
Constituent	**P-value (Intake - Buoy 9)**	**P-value (Intake - Buoy 8)**	**P-value (Intake - White Oak)**
Transparency, Secchi Disc	0.034	--	0.692
Depth to One Percent Light	0.028	0.138	--
Iron, total	0.006	--	--
Manganese, total	--	--	0.004
Manganese, filtered	0.266	0.132	--
Ammonia, filtered, as N	0.933	--	--
Phosphorus, unfiltered, as P	--	--	0.173
April 2013 through October 2013			
Constituent	**P-value (Intake - Buoy 9)**	**P-value (Intake - Buoy 8)**	**P-value (Intake - White Oak)**
Turbidity	0.0058	--	--
Transparency, Secchi Disc	0.009	--	--
Ammonia + Organic N, unfiltered, as N		0.187	0.105
Nitrate + Nitrite, filtered, as N	--	--	0.100
Total Nitrogen, unfiltered	--	0.245	--
Organic Nitrogen, unfiltered, as N	--	--	0.084

__Summer__

--Lake is stratified
--Thermocline is present
--Low dissolved oxygen in the hypolimnion
--High nutrients and metals in the hypolimnion
--High dissolved oxygen in the epilmnion

__Fall__

--Turnover occurs



__Spring__

--Turnover occurs

__Winter__

--Lake is completely mixed and isothermal

Figure 1. Figure showing the annual pattern of lake and reservoir mixing (from Young, 2004).

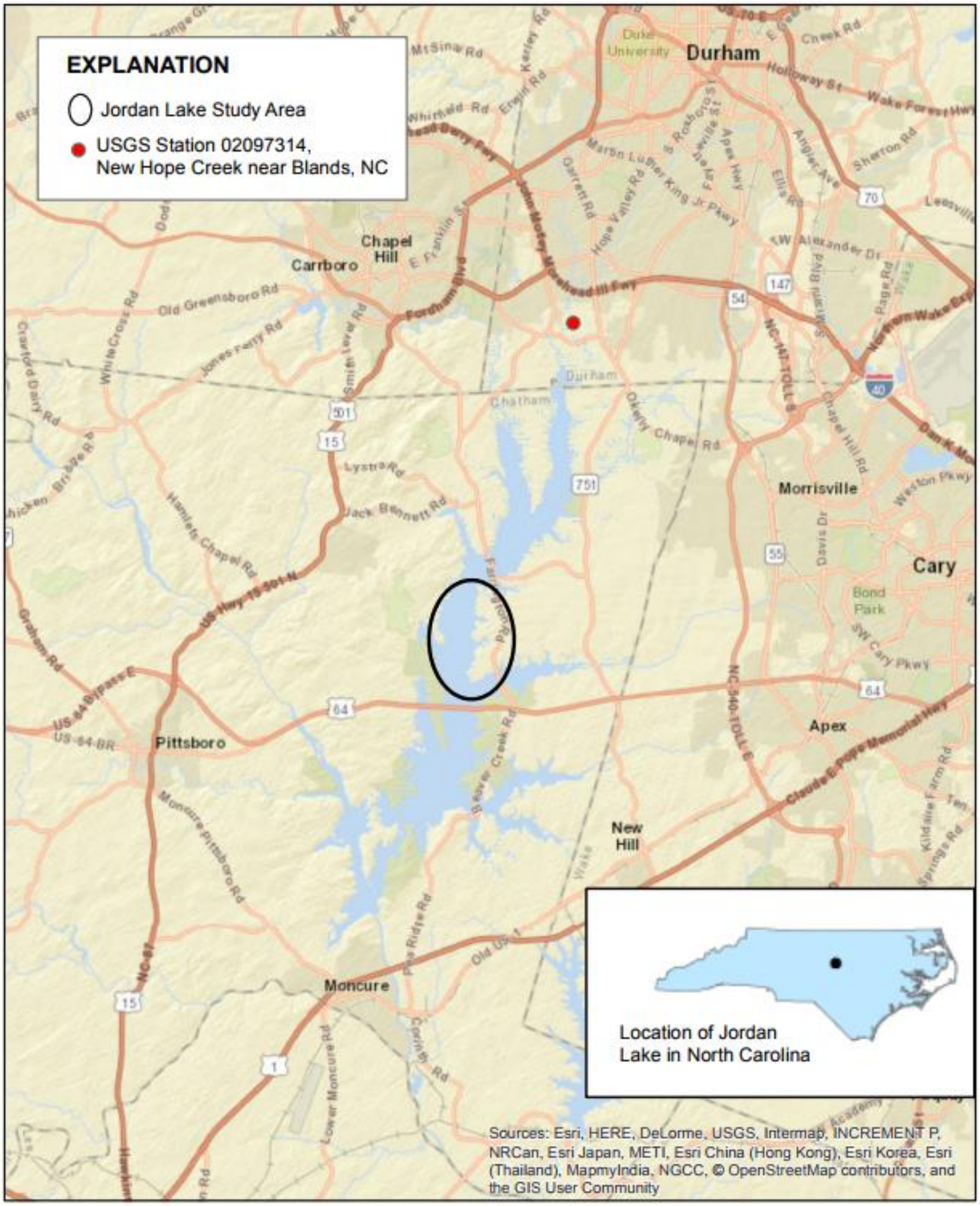


Figure 2. Map showing the study area location of Jordan Lake.

0 2.25 4.5 9 Miles

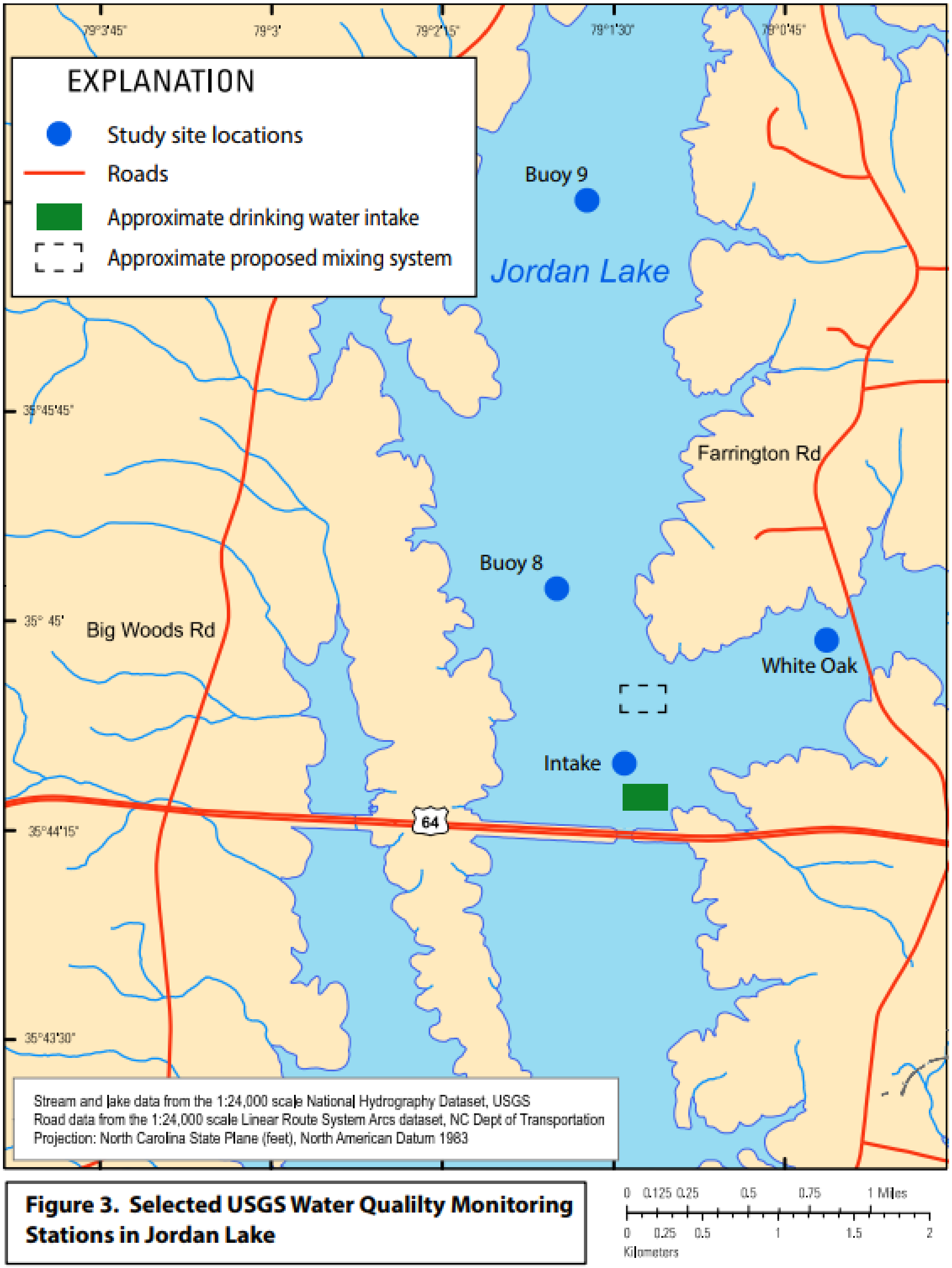


Figure 3. Selected USGS Water Quality Monitoring Stations in Jordan Lake

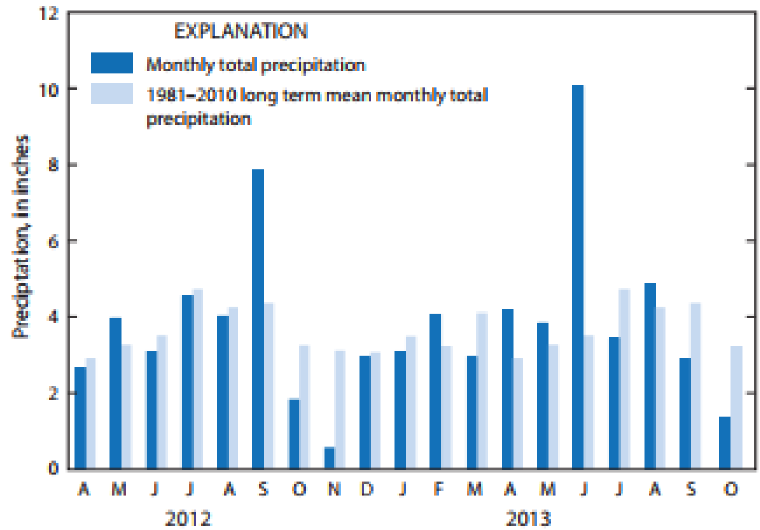


Figure 4. Precipitation measured at Raleigh-Durham International Airport.

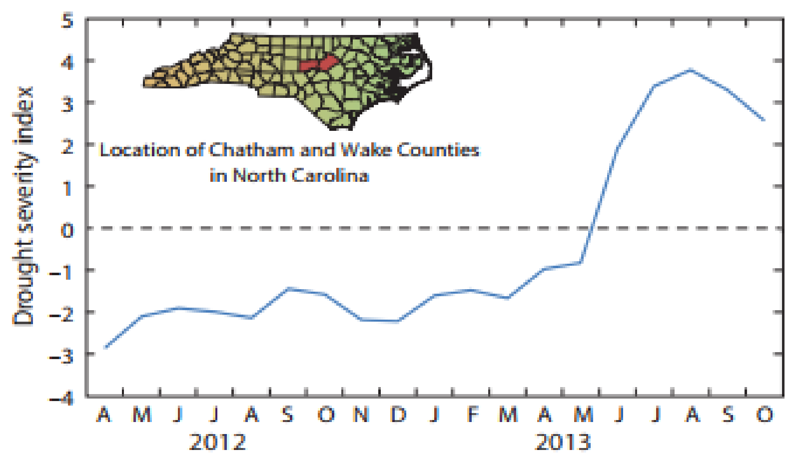


Figure 5. Palmer Hydrologic Drought Index for the Central Piedmont of NorthCarolina, NC State Climate Office

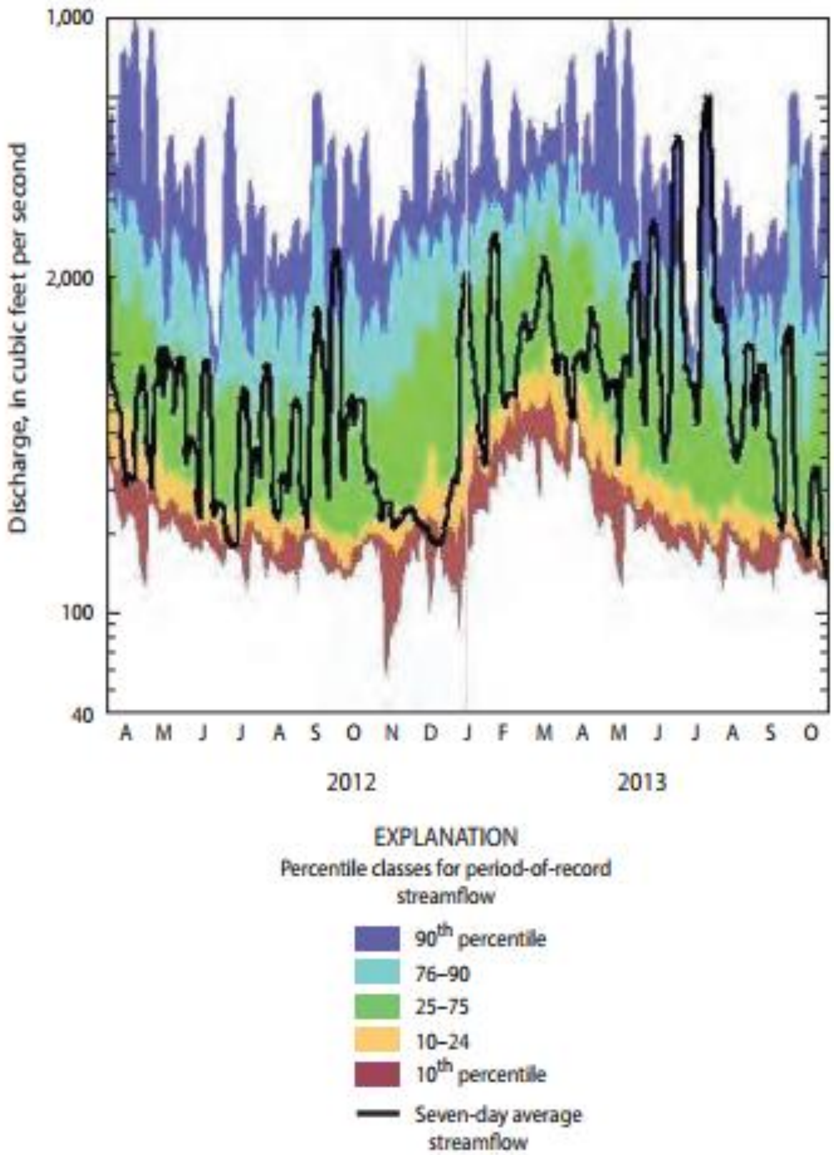


Figure 6. Seven-day average streamflow, in cubic feet per second, overlaid on period-of-record flow percentiles at New Hope Creek near Blands, NC for the period of April 2012 to October 2013

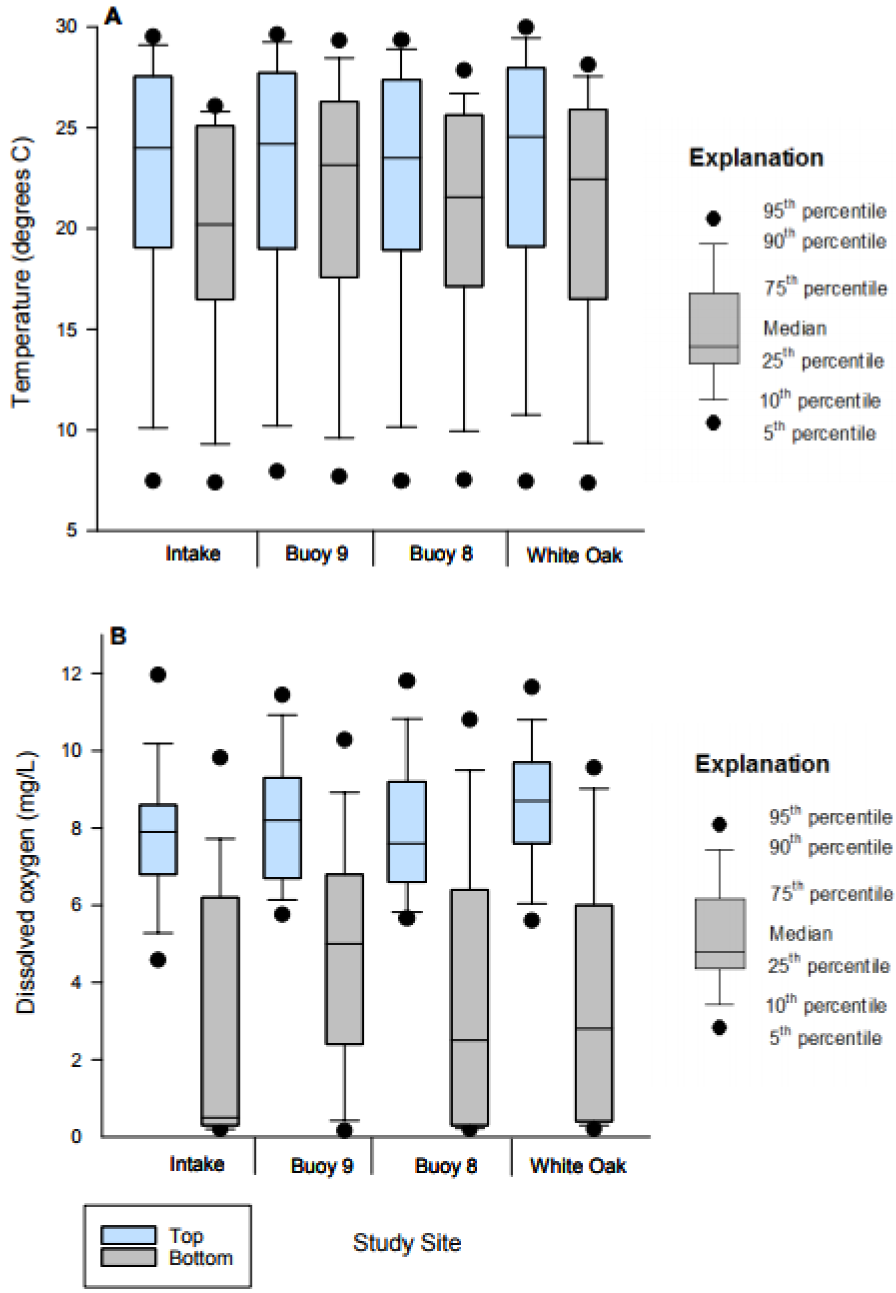


Figure 7. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Top and near-bottom observations of temperature data grouped by study site; (B) Top and near-bottom observations of dissolved oxygen data grouped by study site.

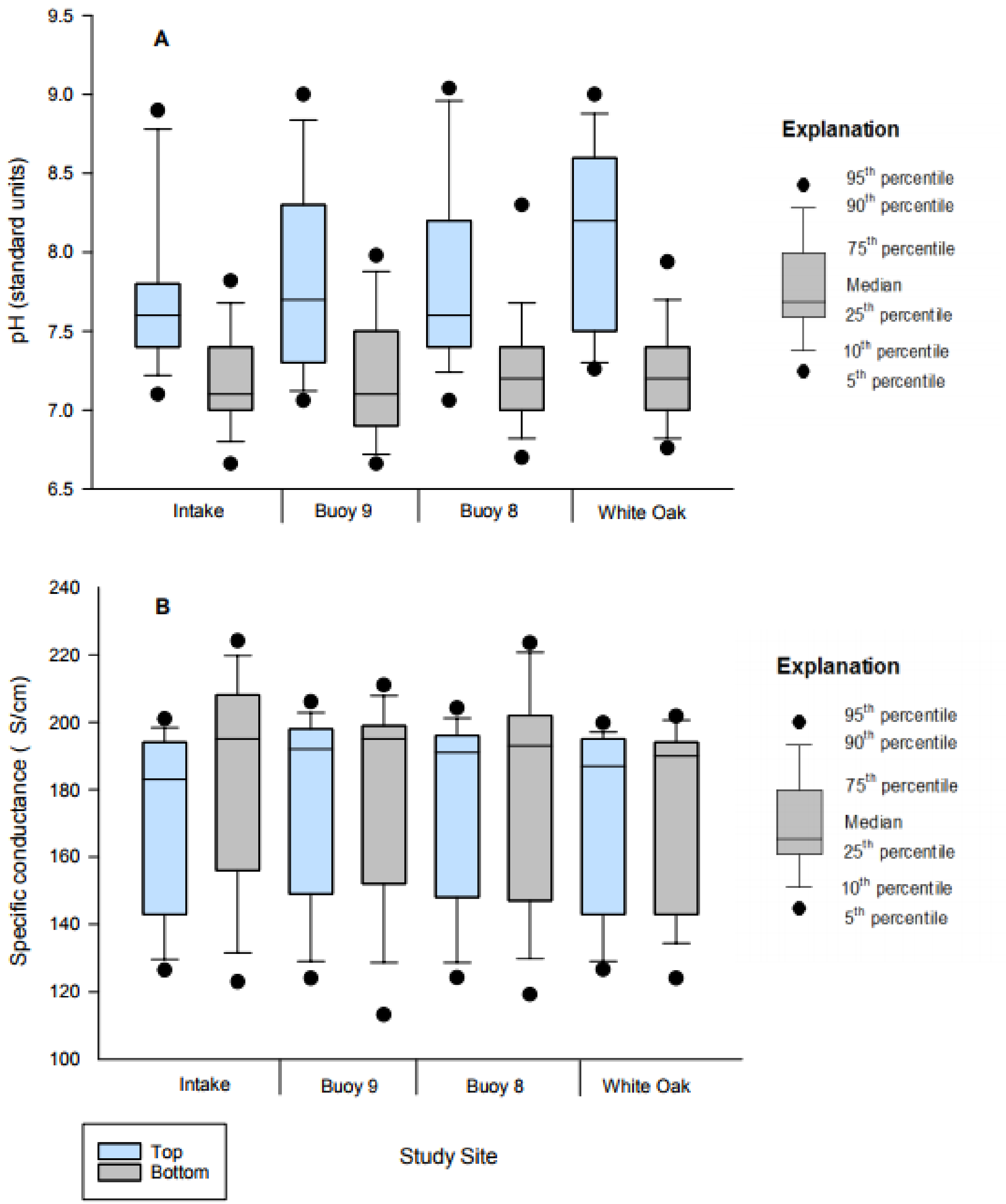


Figure 8. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Top and near-bottom observations of pH data grouped by study site; (B) Top and near-bottom observations of specific conductance data grouped by study site.

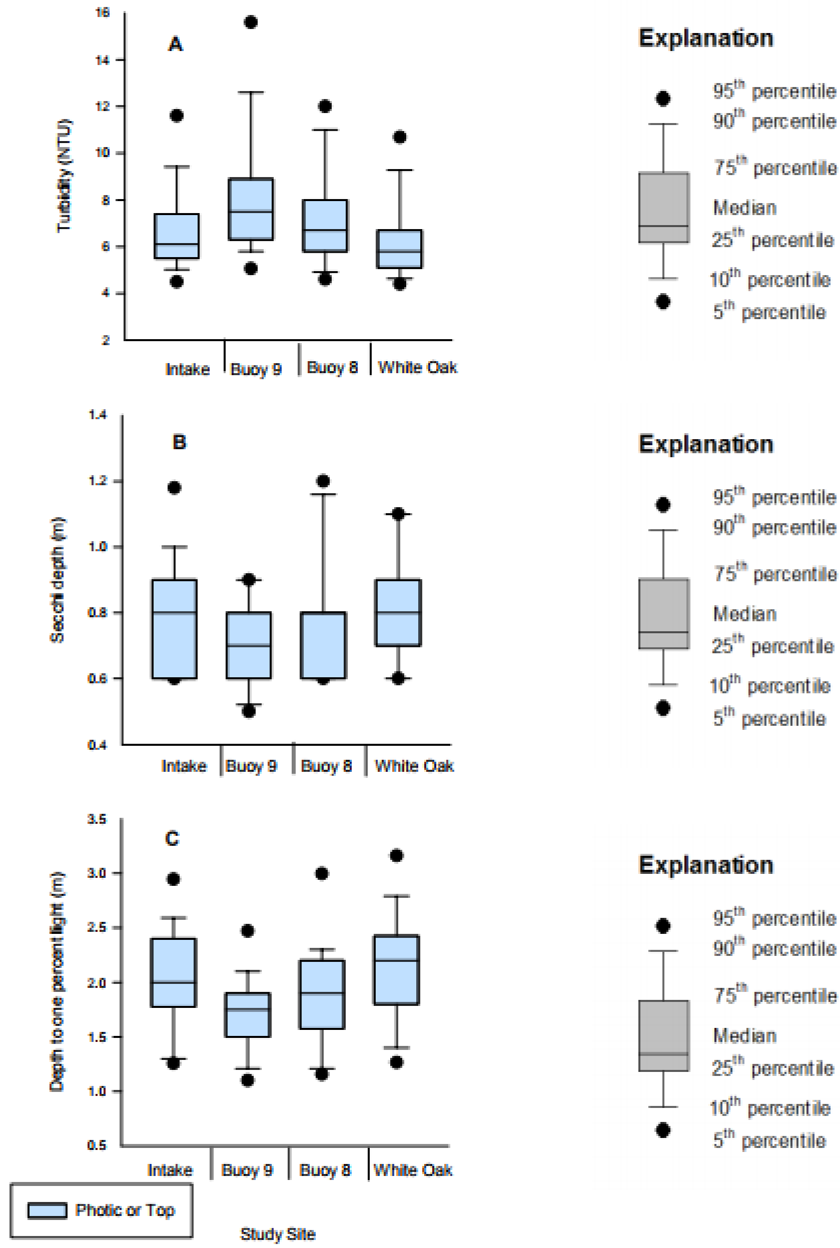


Figure 9. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Top observations of turbidity data; (B) Photic observations of secchi depth data; (C) Photic observations of depth to one percent light data.

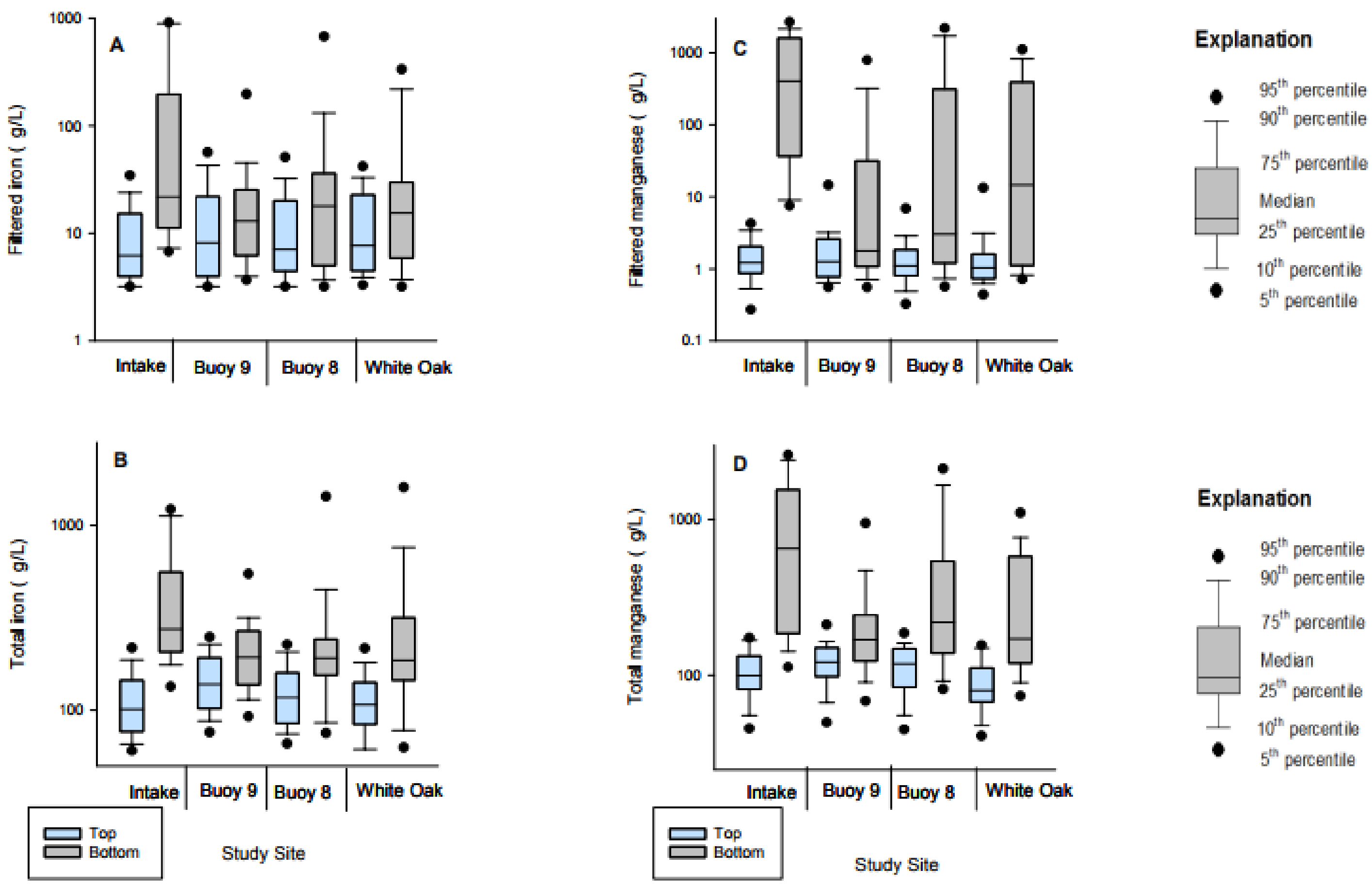


Figure 10. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Top and near-bottom observations of filtered iron data grouped by study site; (B) Top and near-bottom observations of total iron data grouped by study site; (C) Top and near-bottom observations of filtered manganese data grouped by study site; (D) Top and near-bottom observations of total manganese data grouped by study site.

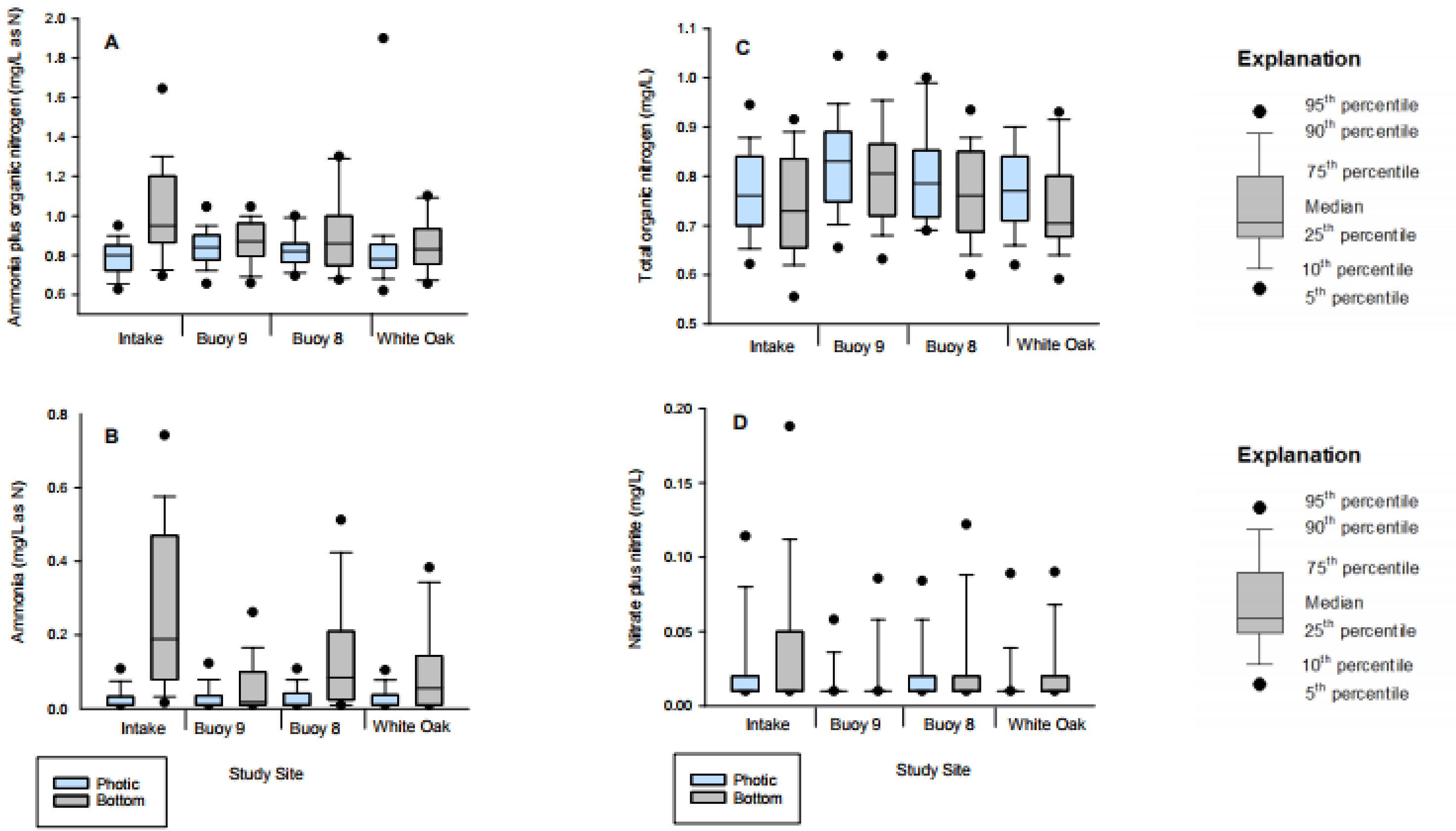


Figure 11. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Photic and near-bottom observations of ammonia plus organic nitrogen data grouped by study site; (B) Photic and near-bottom observations of ammonia data grouped by study site; (C) Photic and near-bottom observations of total organic nitrogen data grouped by study site; (D) Photic and near-bottom observations of nitrate plus nitrite data grouped by study site.

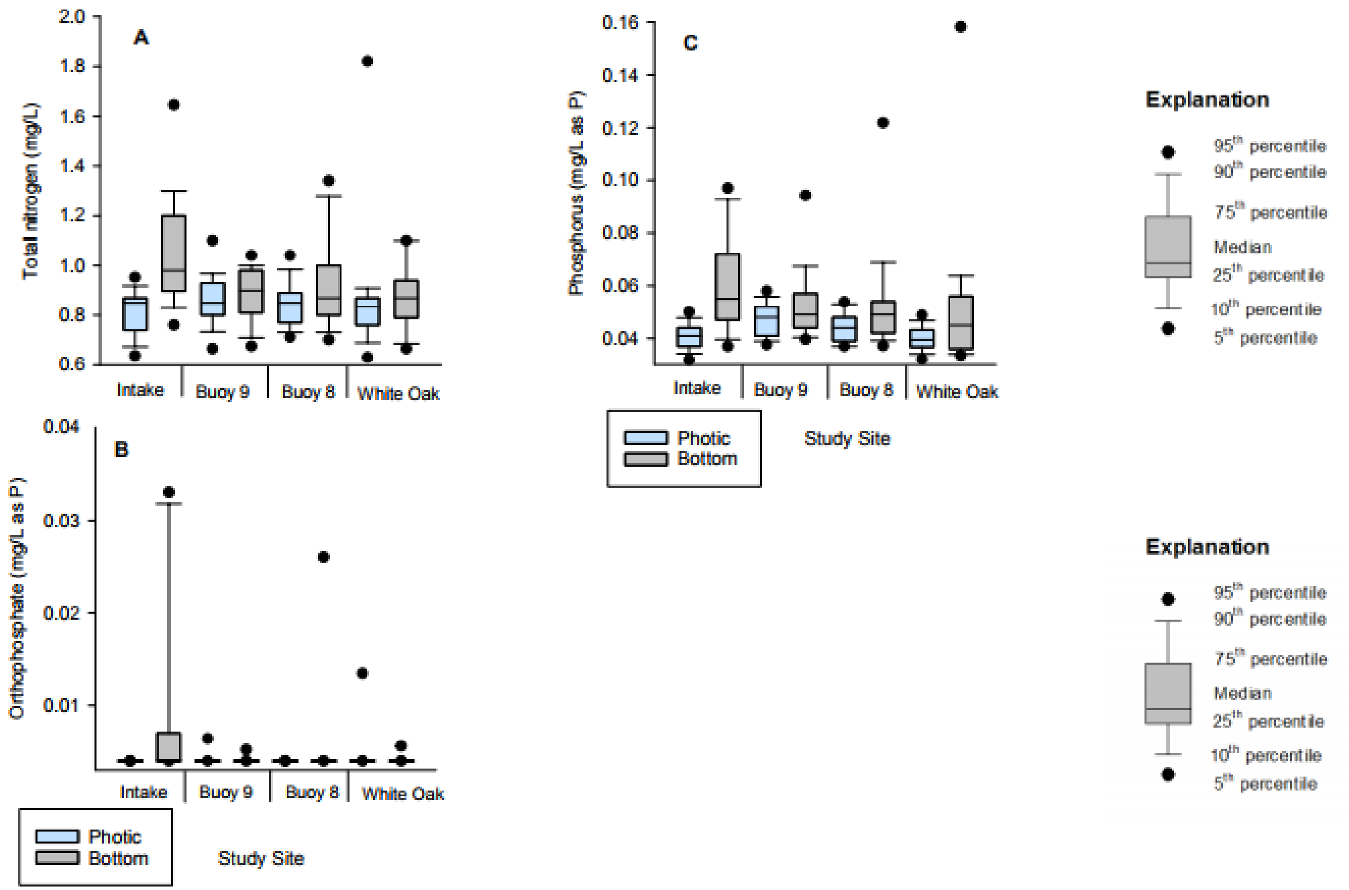


Figure 12. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Photic and near-bottom observations of total nitrogen data grouped by study site; (B) Photic and near-bottom observations of orthophosphate data grouped by study site; (C) Photic and near-bottom observations of phosphorus data grouped by study site.

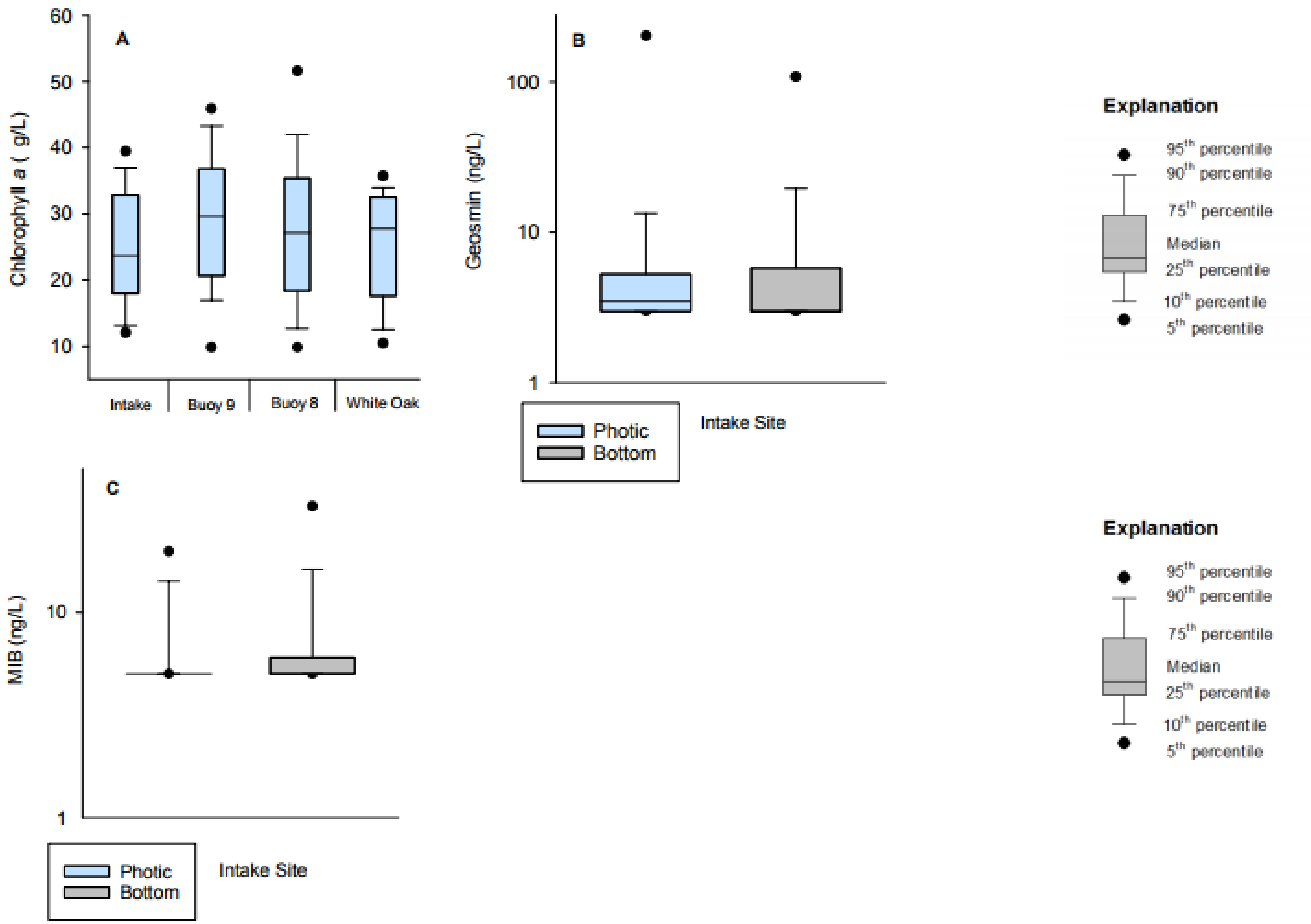


Figure 13. Box plots for the Jordan Lake study sites, April 2012 through November 2012 and April 2013 through October 2013: (A) Photic observations of chlorophyll *a* data grouped by study site; (B) Photic and near-bottom observations of geosmin data at the Intake site; (C) Photic and near-bottom observations of MIB data at the Intake site.

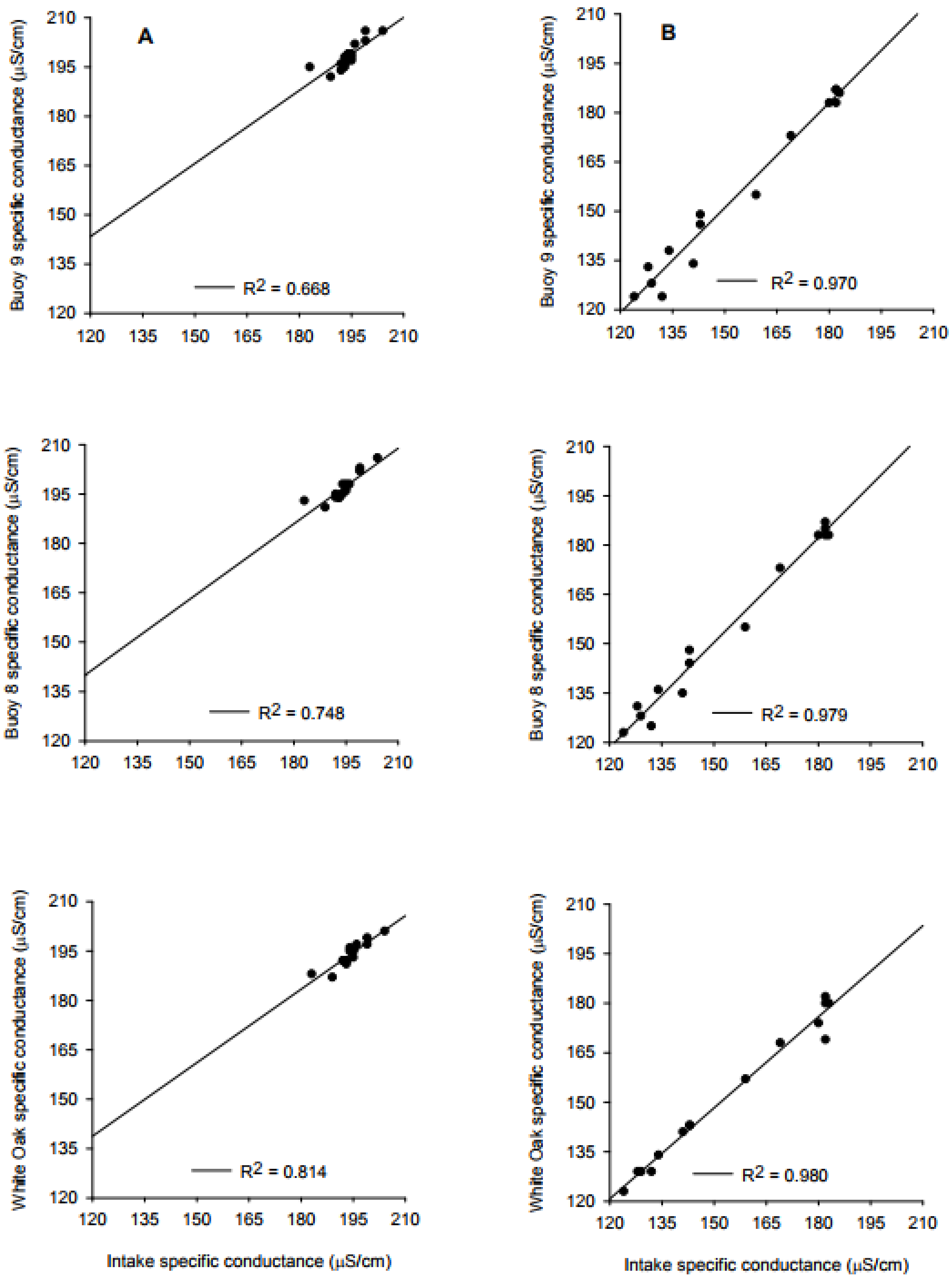


Figure 14. Regression plots for the Jordan Lake study sitescomparing the Intake site for specific conductance: (Column A) April 2012 to November 2012; (Column B) April 2013 to October 2013.

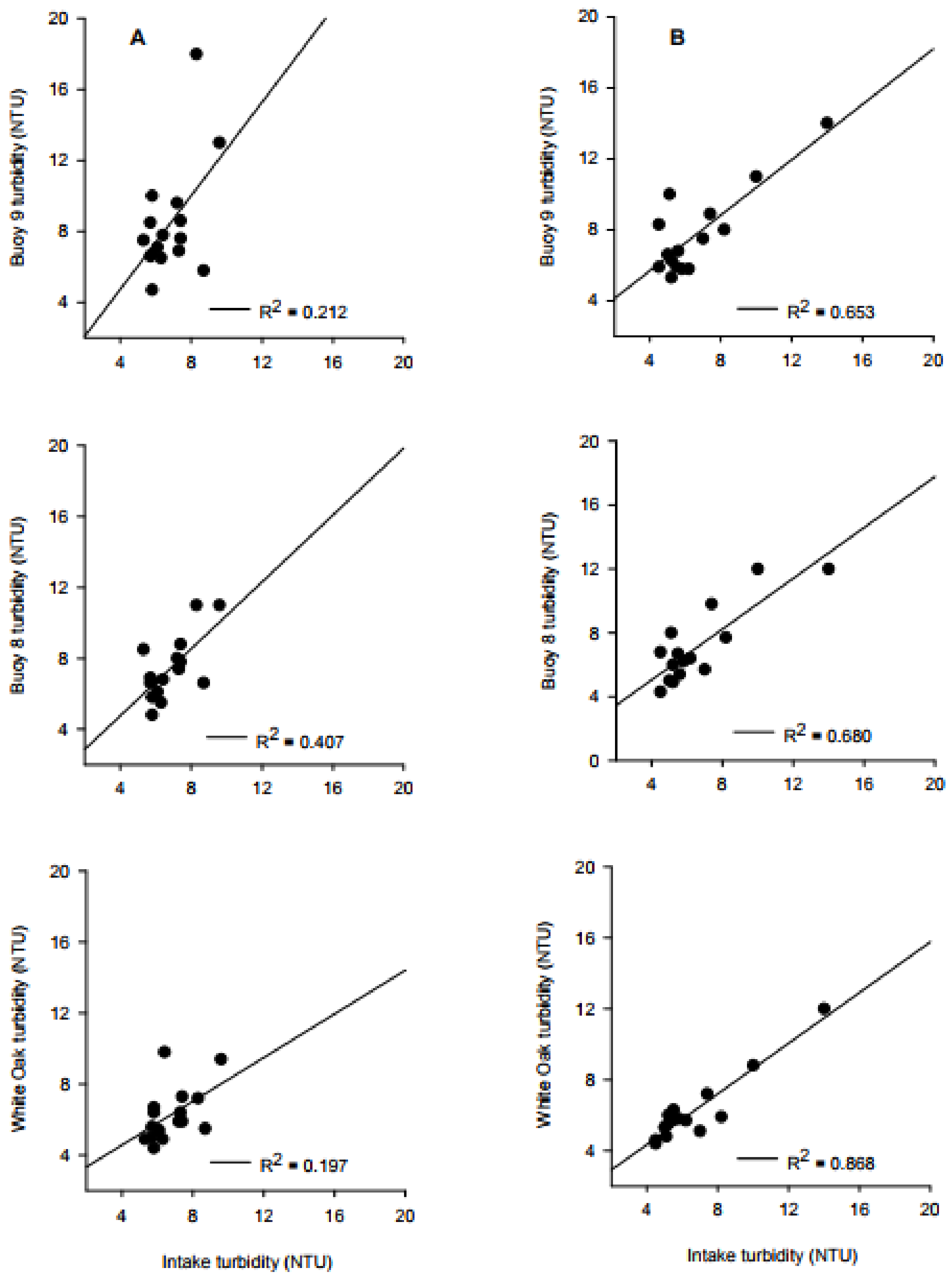


Figure 15. Regression plots for the Jordan Lake study sites comparing the Intake site for turbidity: (Column A) April 2012 to November 2012; (Column B) April 2013 to October 2013.

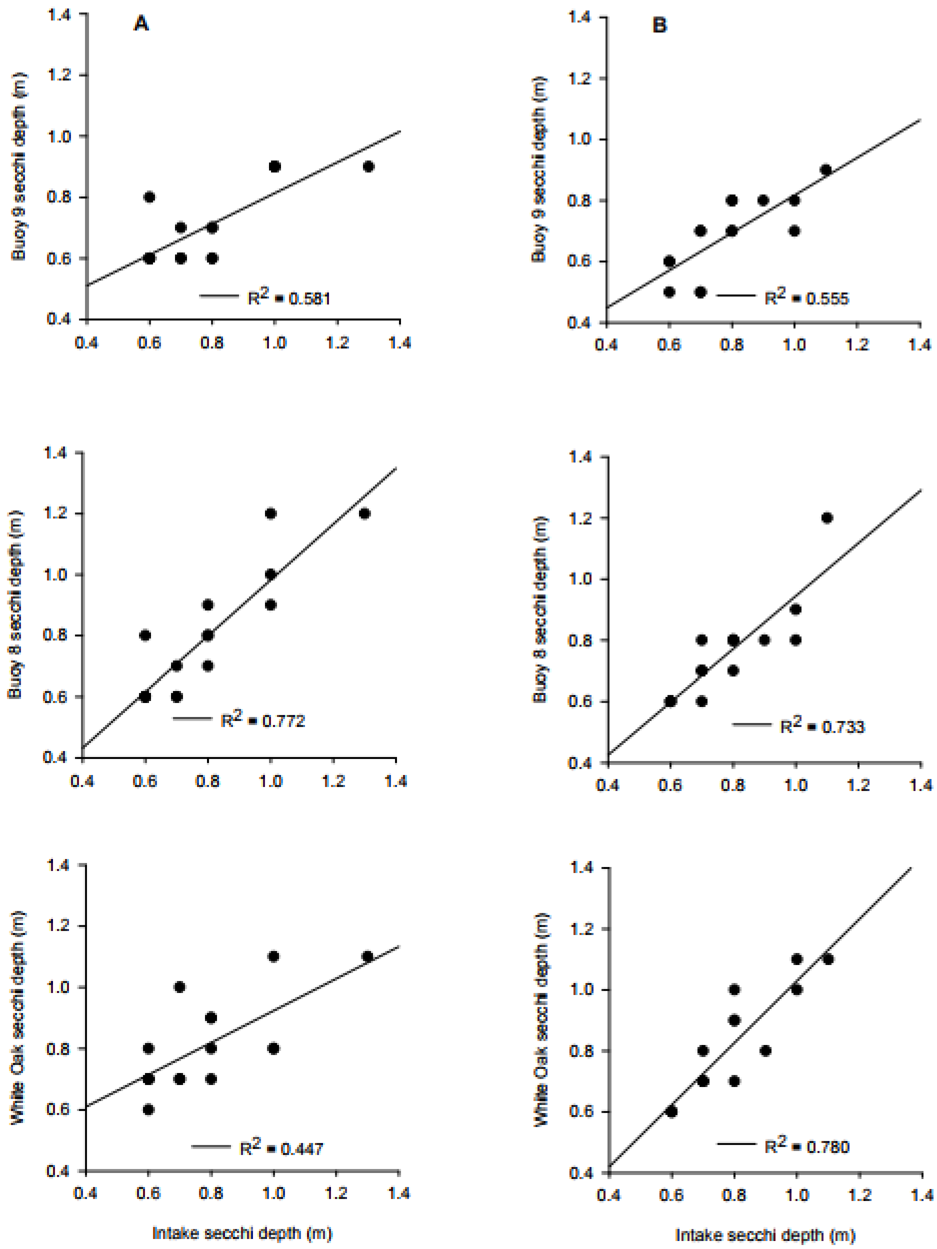


Figure 16. Regression plots for the Jordan Lake study sites comparing the Intake site for the secchi depth: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

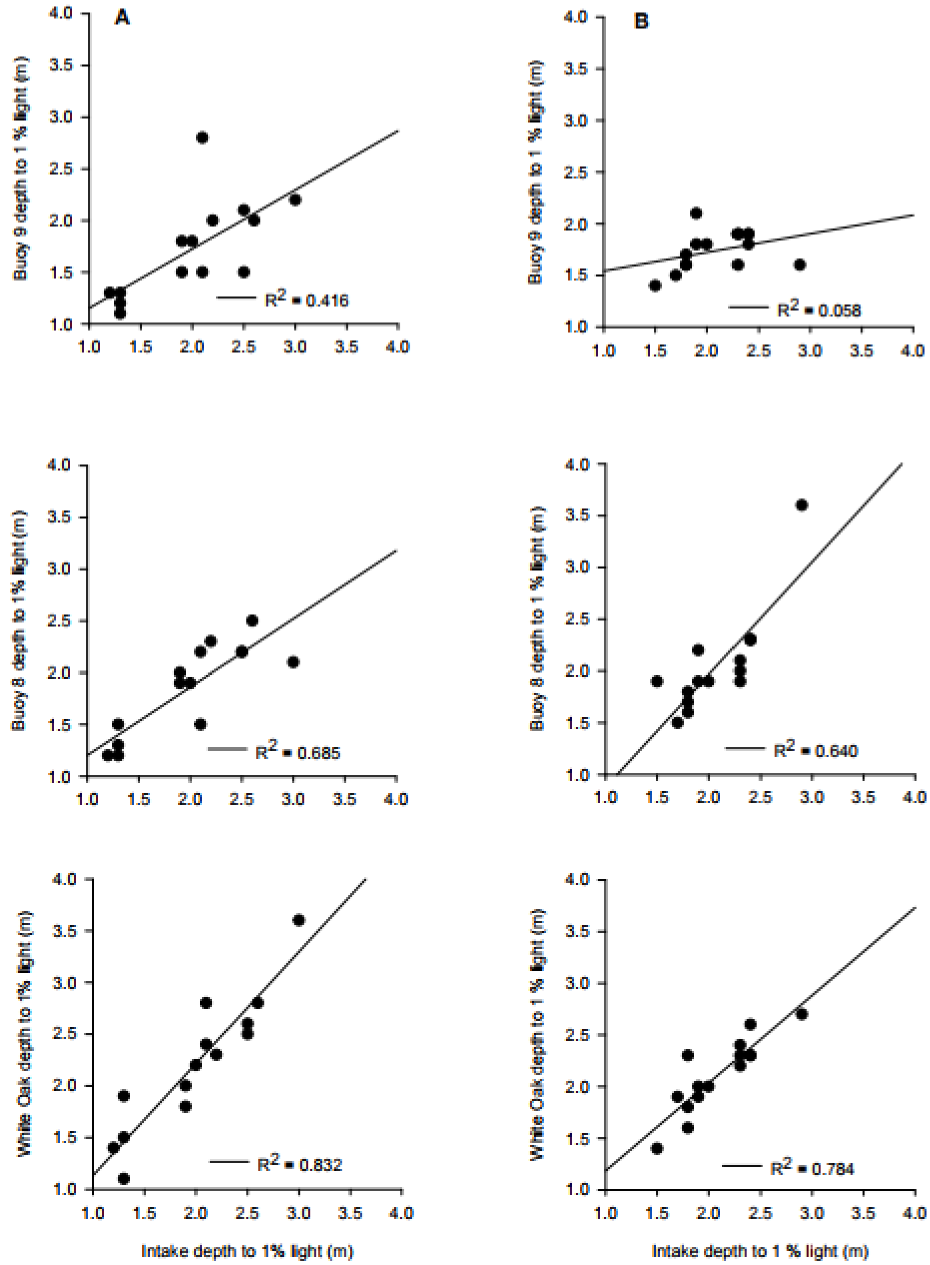


Figure 17. Regression plots for the Jordan Lake study sites comparing the Intake site for depth to one percent light: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

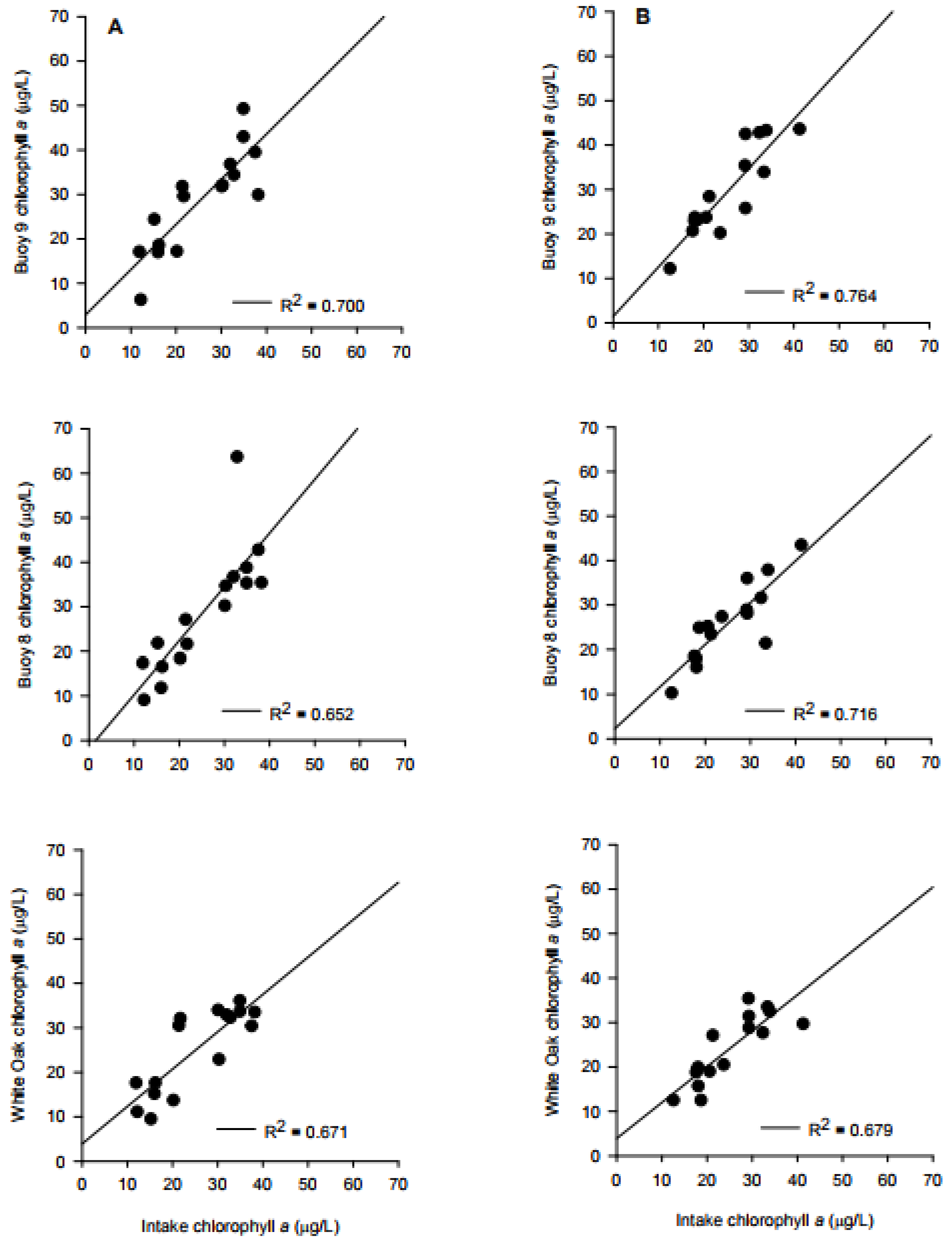


Figure 18. Regression plots for the Jordan Lake study sites comparing the Intake site for chlorophyll *a:* (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

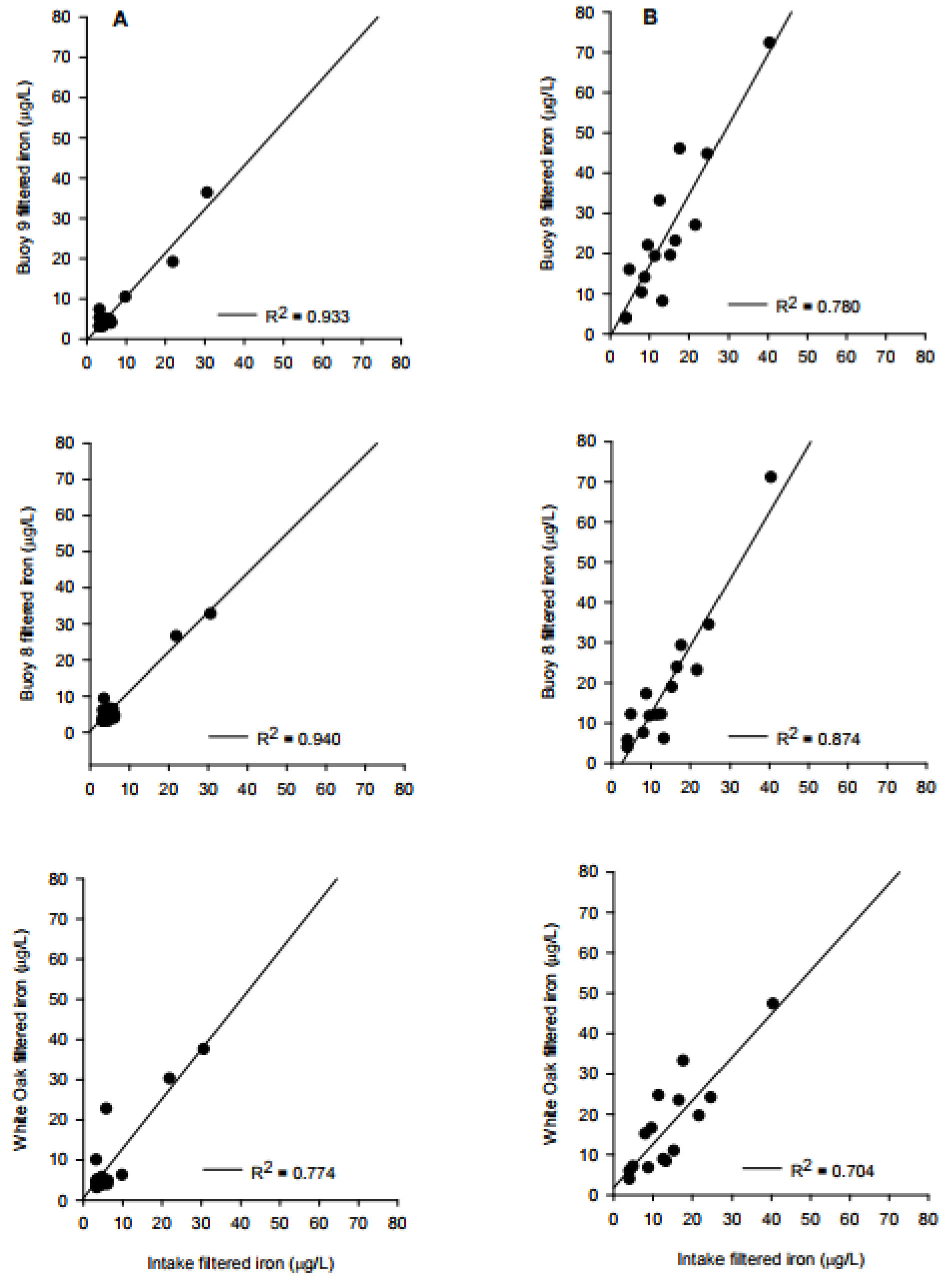


Figure 19. Regression plots for the Jordan Lake study sites comparing the Intake site for filtered iron: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

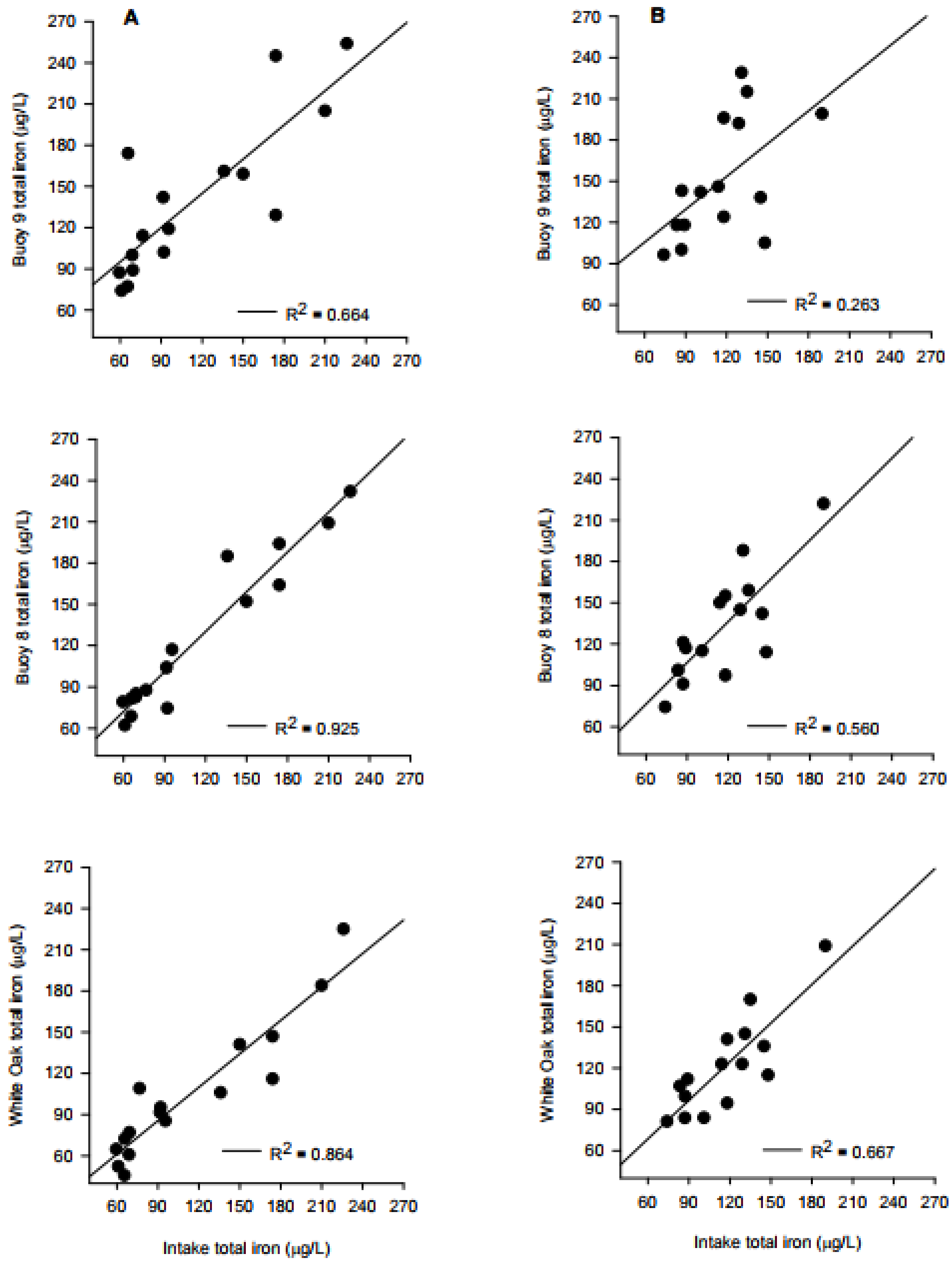


Figure 20. Regression plots for the Jordan Lake study sites comparing the Intake site for total iron: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

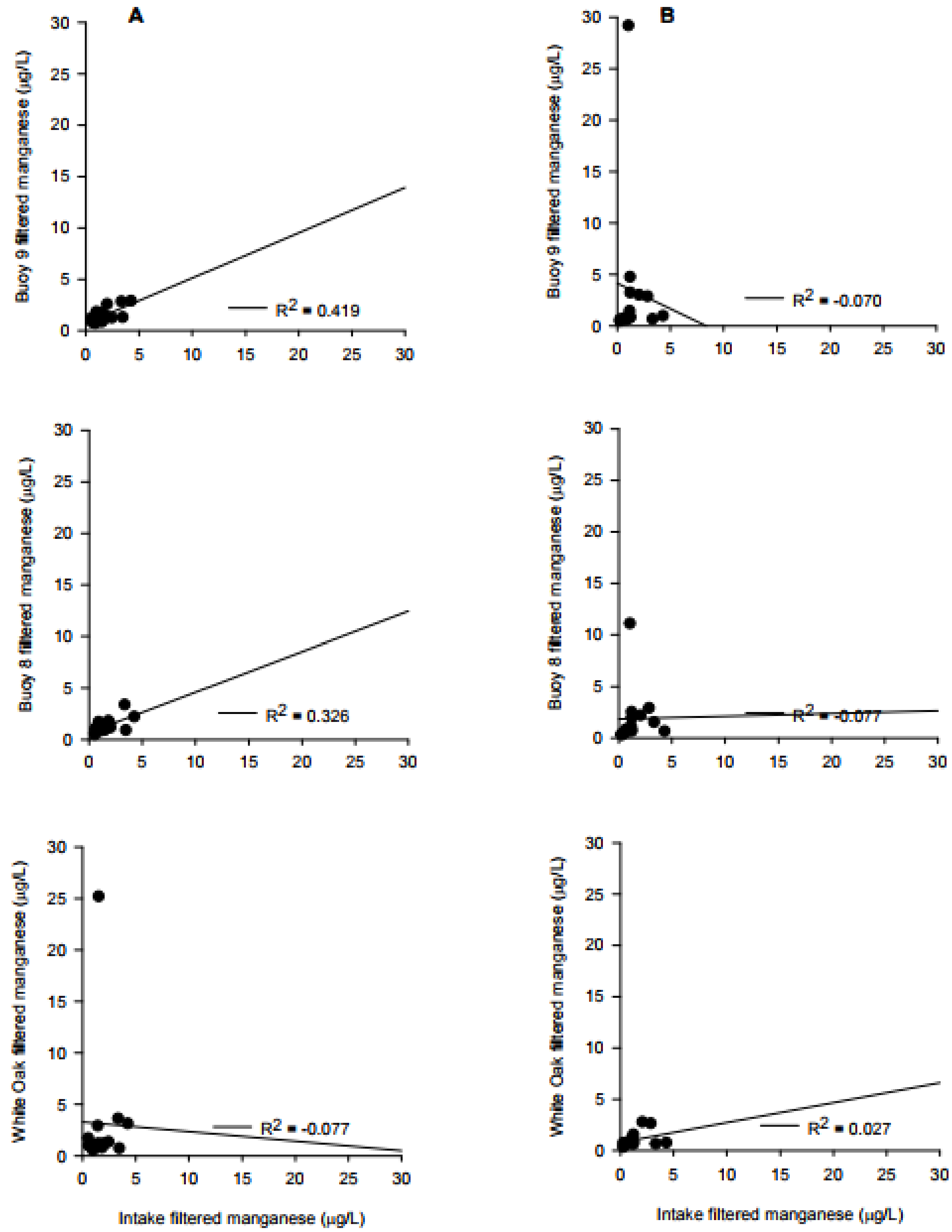


Figure 21. Regression plots for the Jordan Lake study sites comparing the Intake site for filtered manganese: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

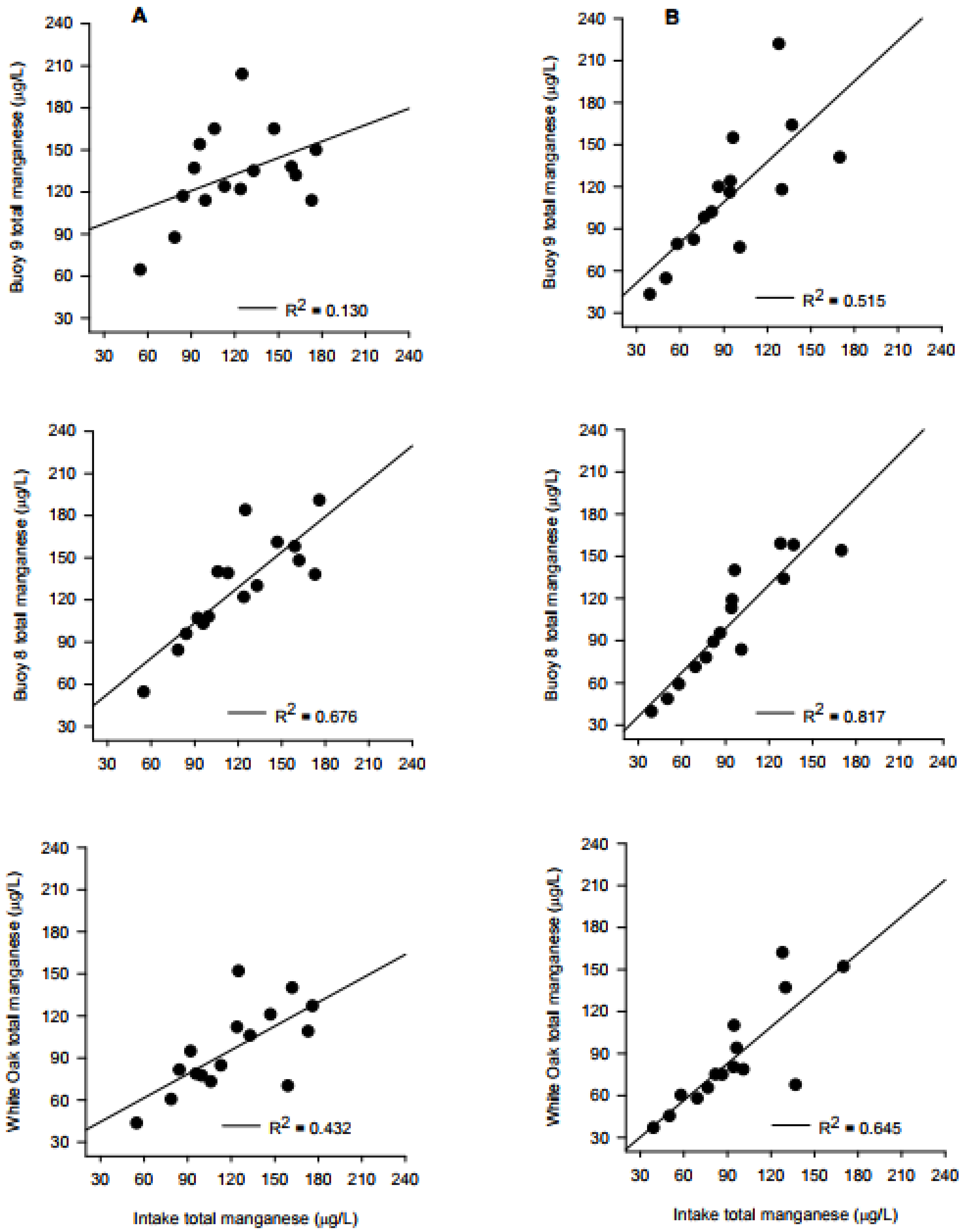


Figure 22. Regression plots for the Jordan Lake study sites comparing the Intake site for total manganese: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

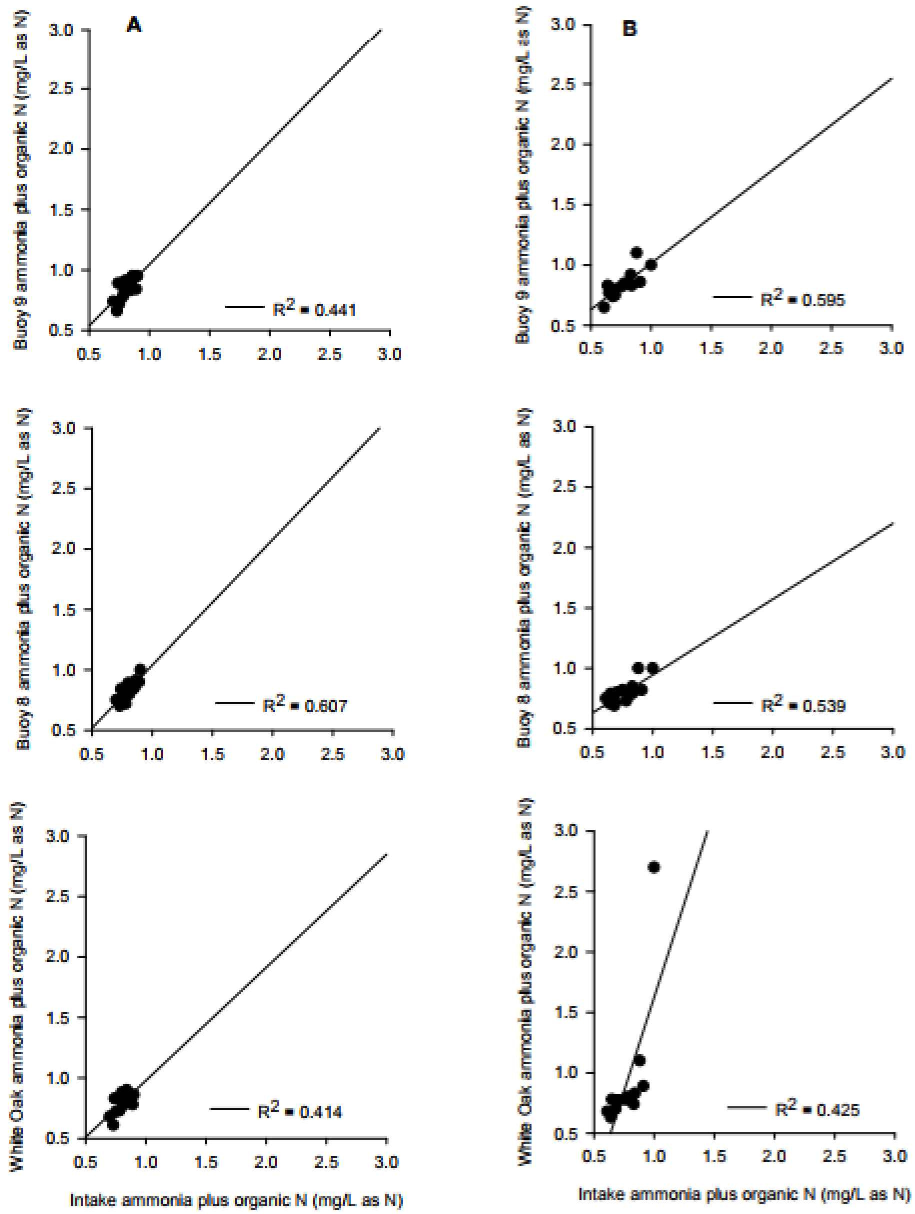


Figure 23. Regression plots for the Jordan Lake study sites comparing the Intake site for ammonia plus organic nitrogen: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

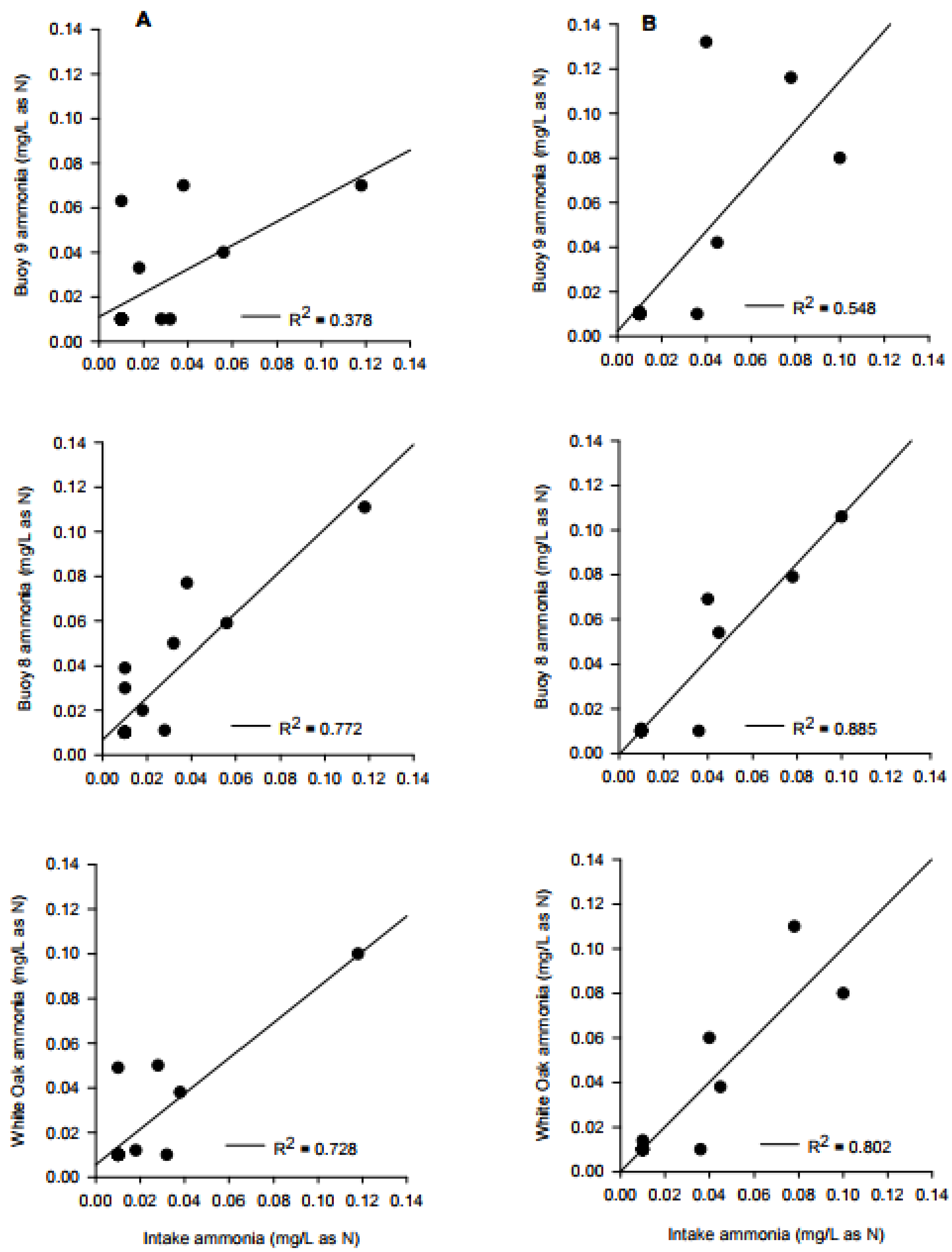


Figure 24. Regression plots for the Jordan Lake study sites comparing the Intake site for ammonia: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

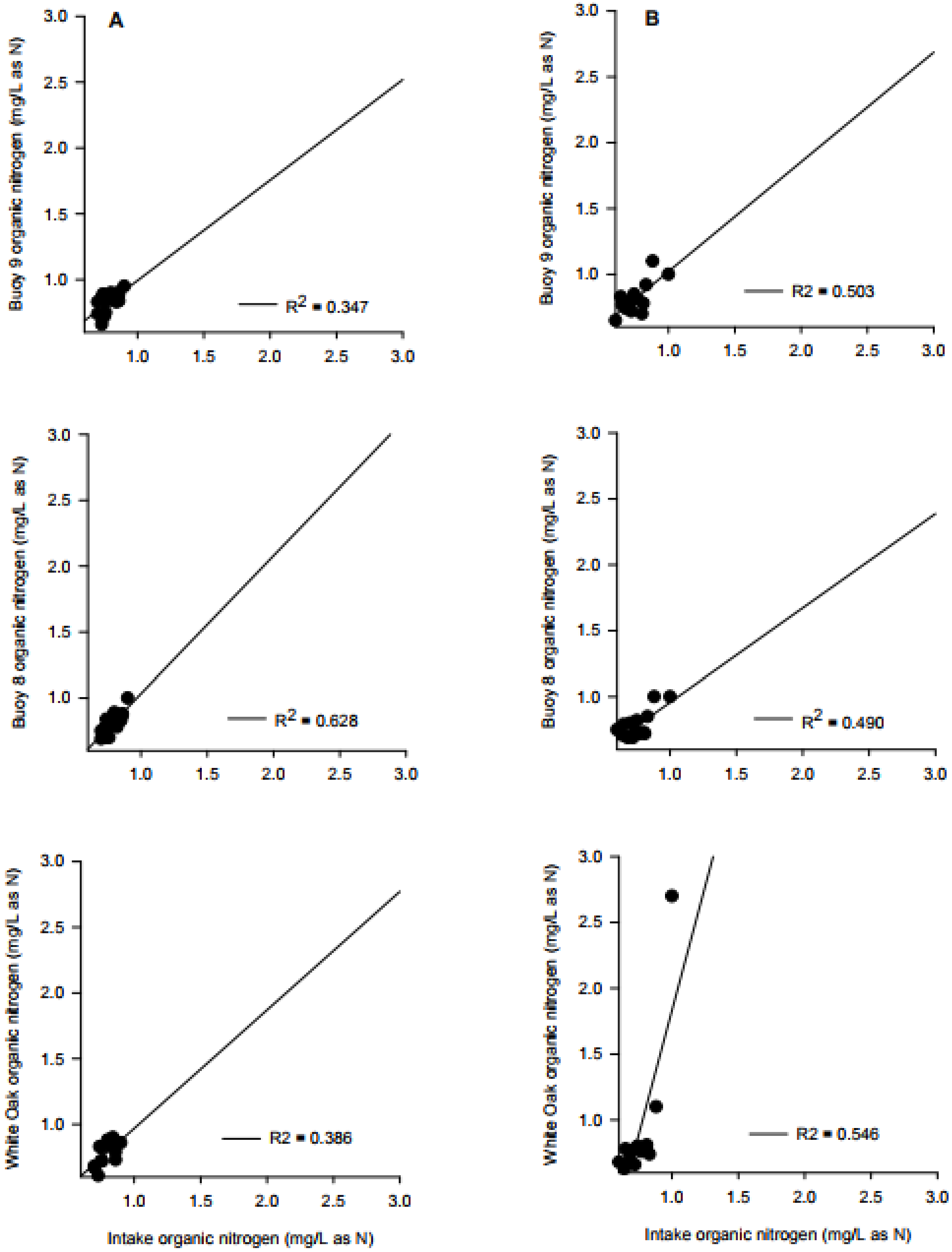


Figure 25. Regression plots for the Jordan Lake study sites comparing the Intake site for total organic nitrogen: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

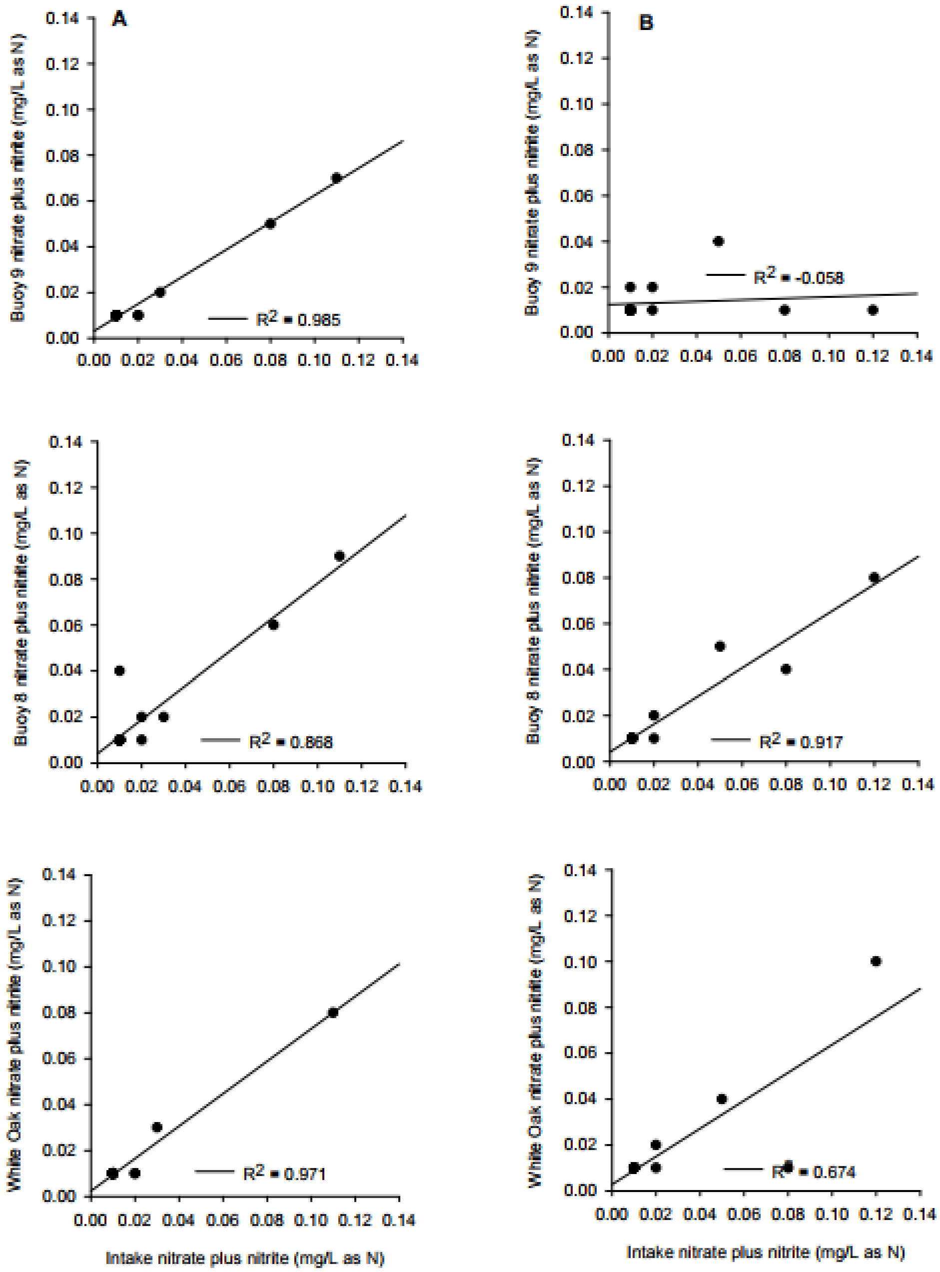


Figure 26. Regression plots for the Jordan Lake study sites comparing the Intake site for nitrate plus nitrite: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

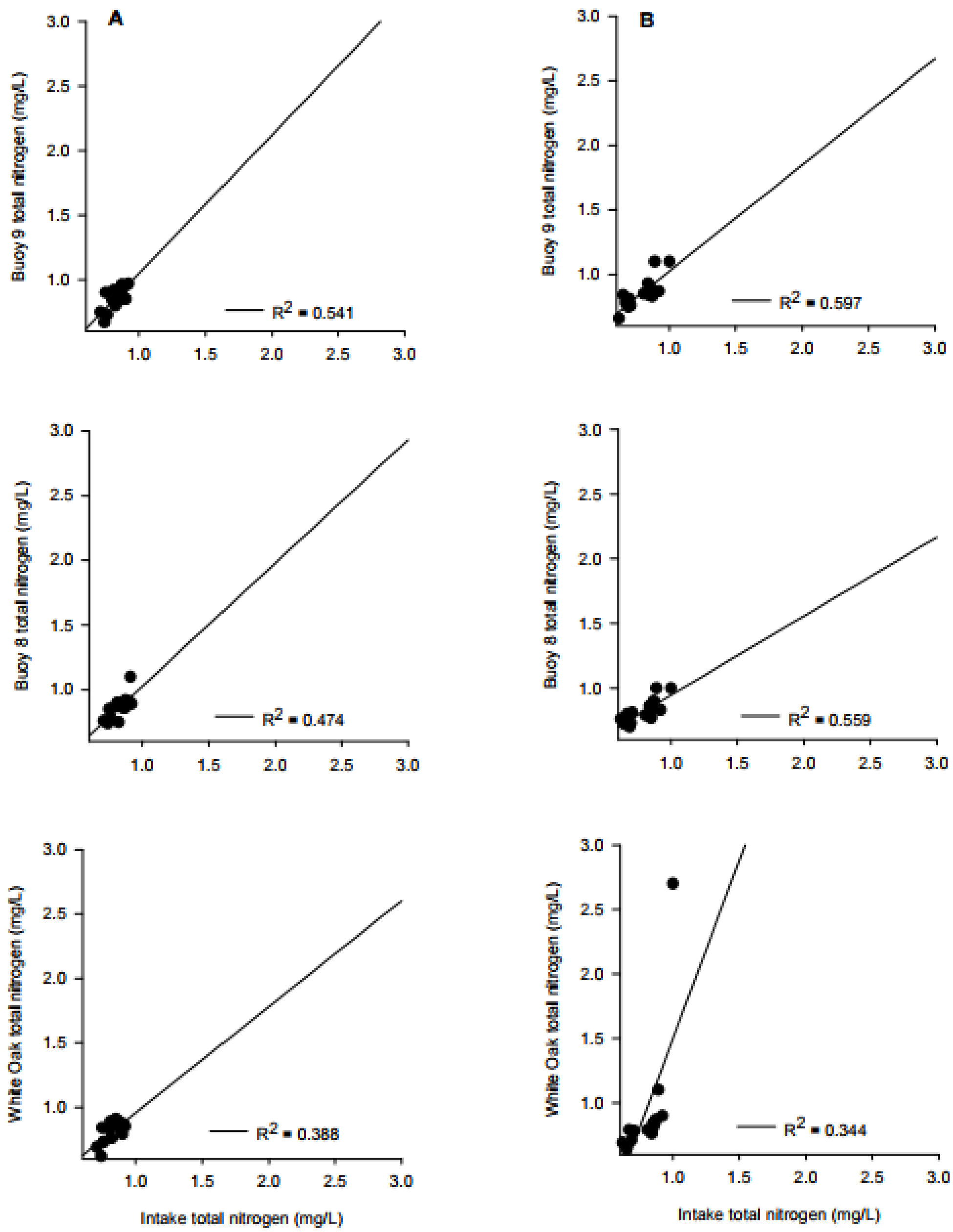


Figure 27. Regression plots for the Jordan Lake study sites comparing the Intake site for total nitrogen: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

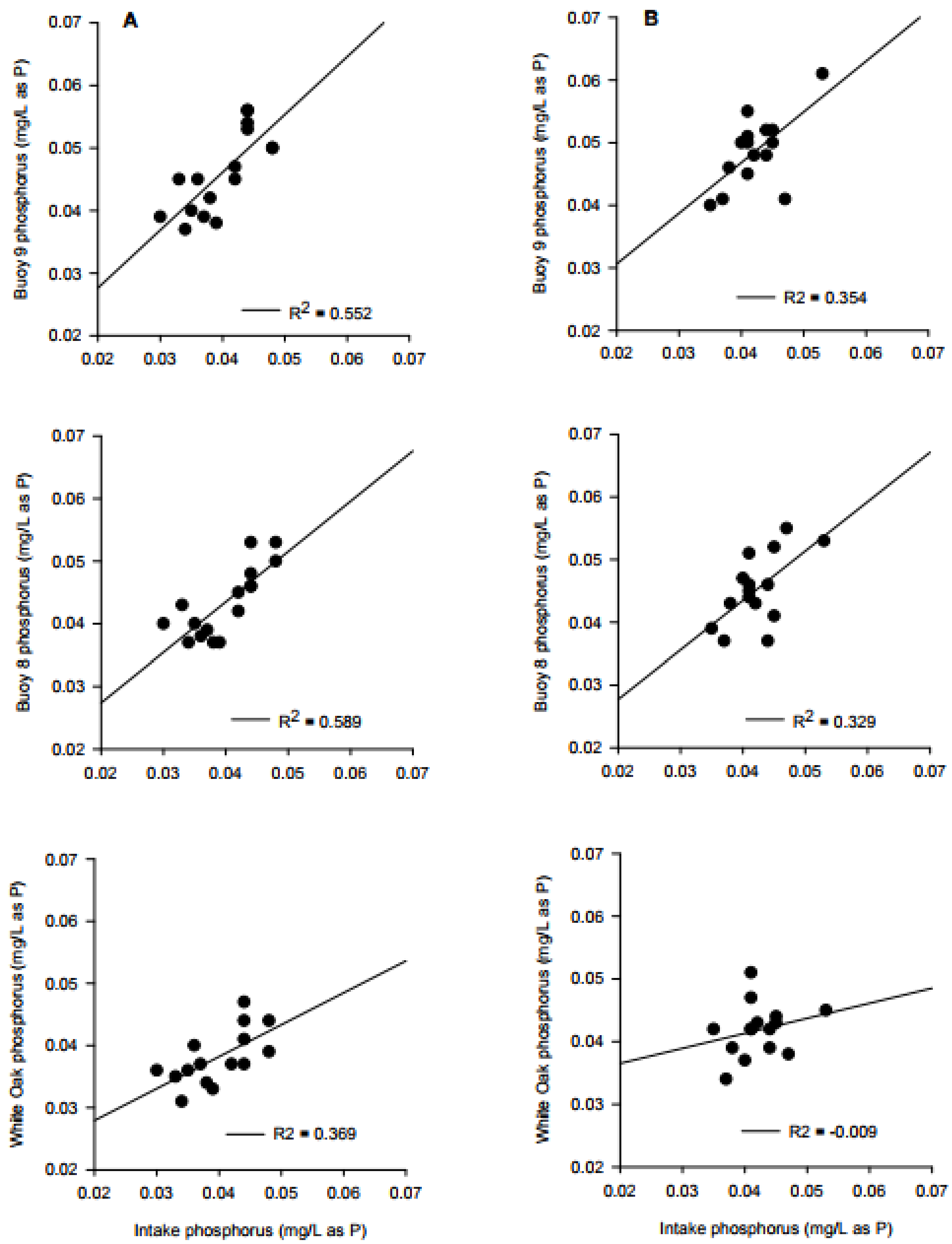


Figure 28. Regression plots for the Jordan Lake study sites comparing the Intake site for phosphorus: (Column A) April 2012 through November 2012; (Column B) April 2013 through October 2013.

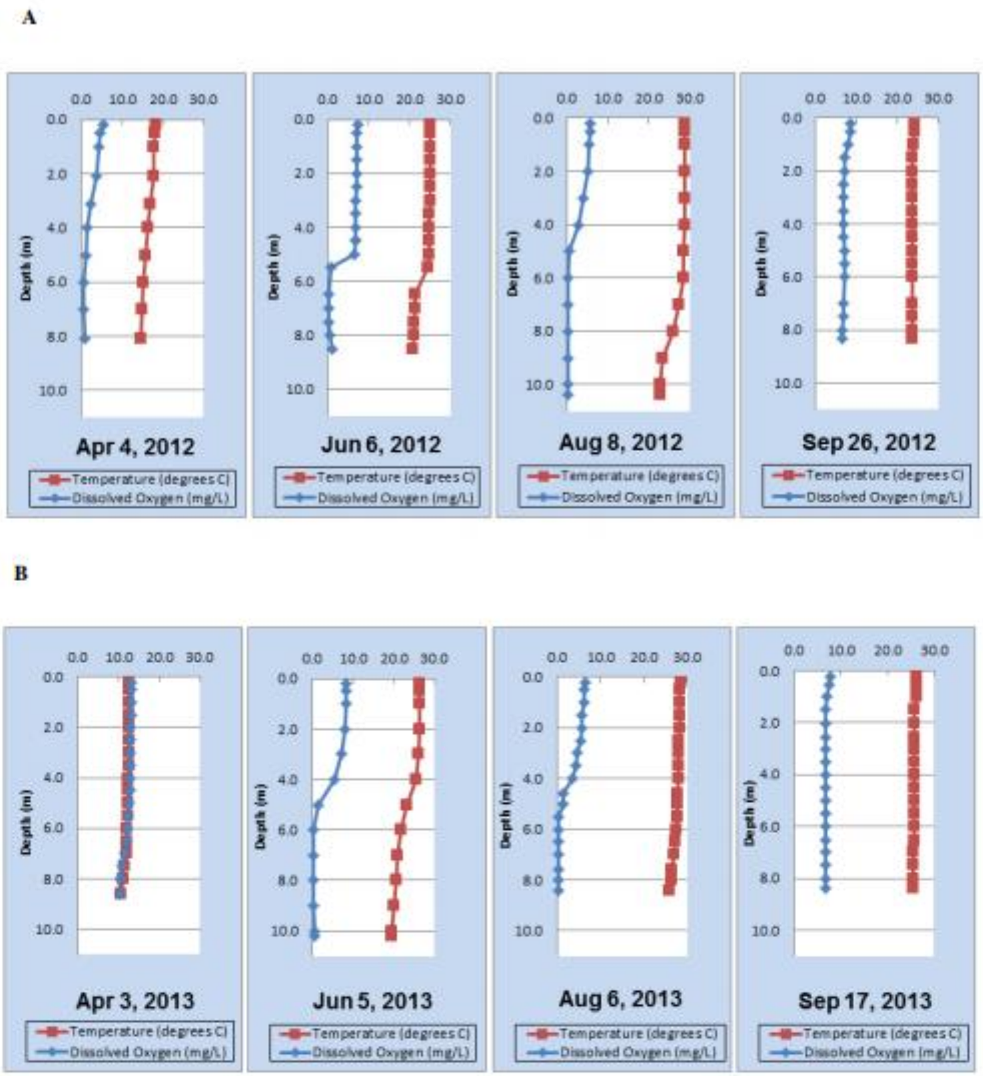


Figure 29. Vertical profile-plots illustrating water temperature and dissolved oxygen measurements during selected site visits at Jordan Lake from (A) 2012 and (B) 2013.

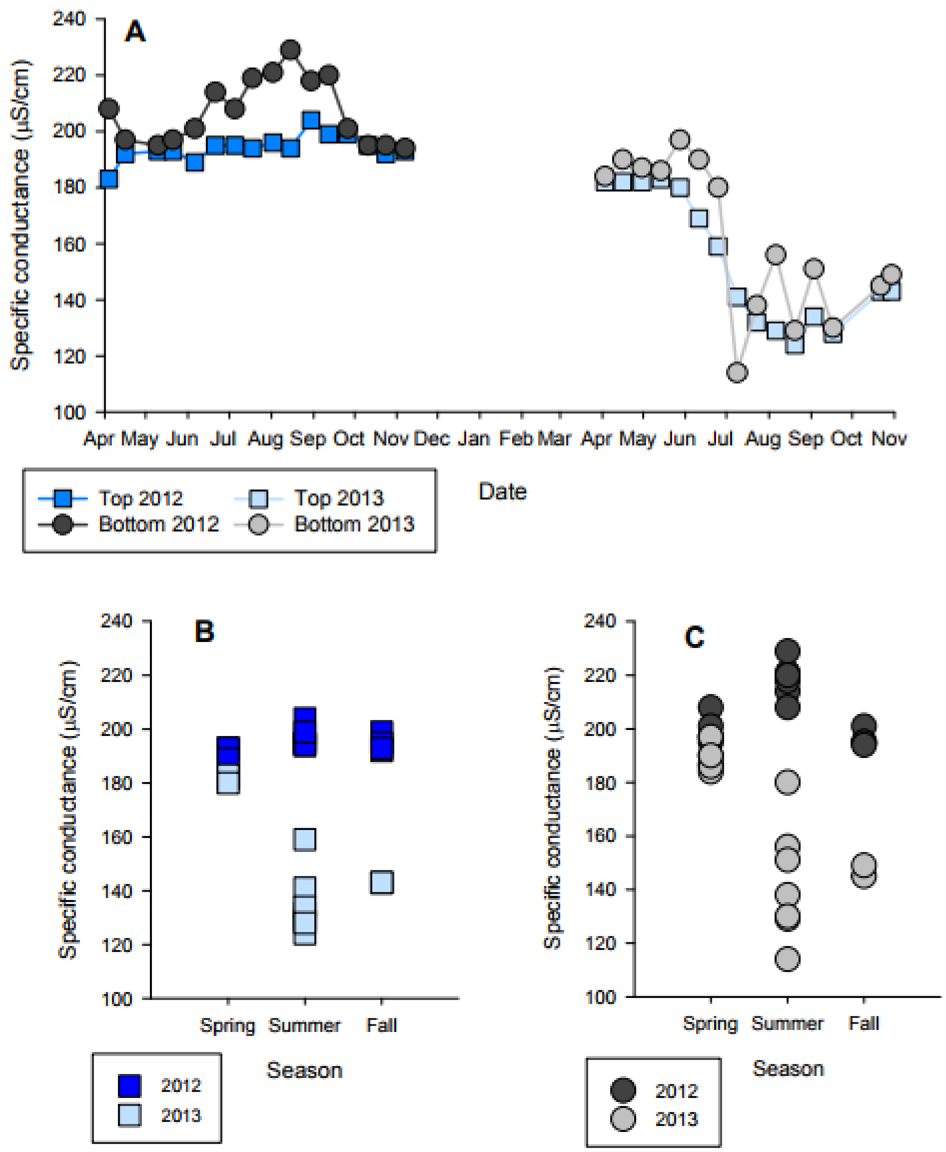


Figure 30. Plots at the Jordan Lake Intake site of specific conductance data: (A) Date plot of all observations; (B) Top observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

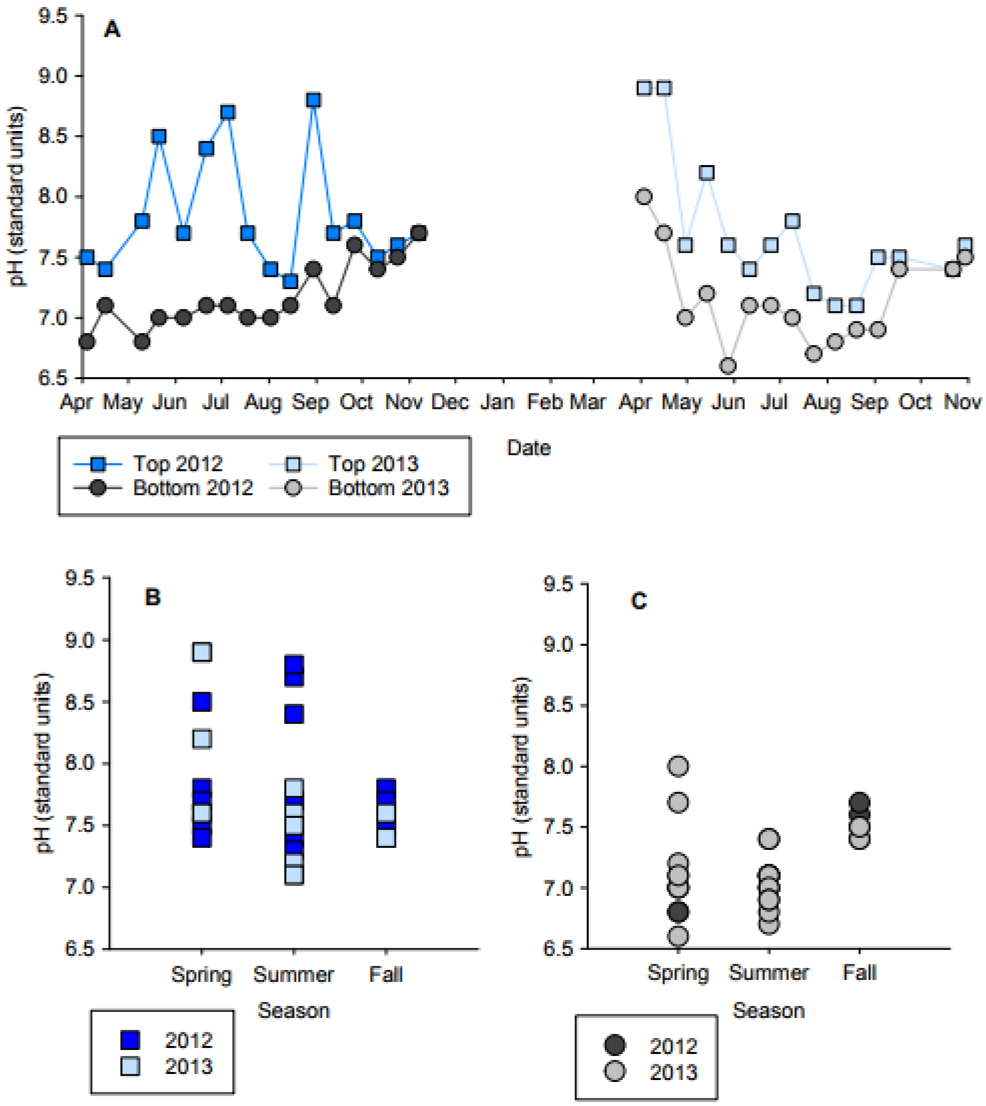


Figure 31. Plots at the Jordan Lake Intake site of pH data: (A) Date plot of all observations; (B) Top observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

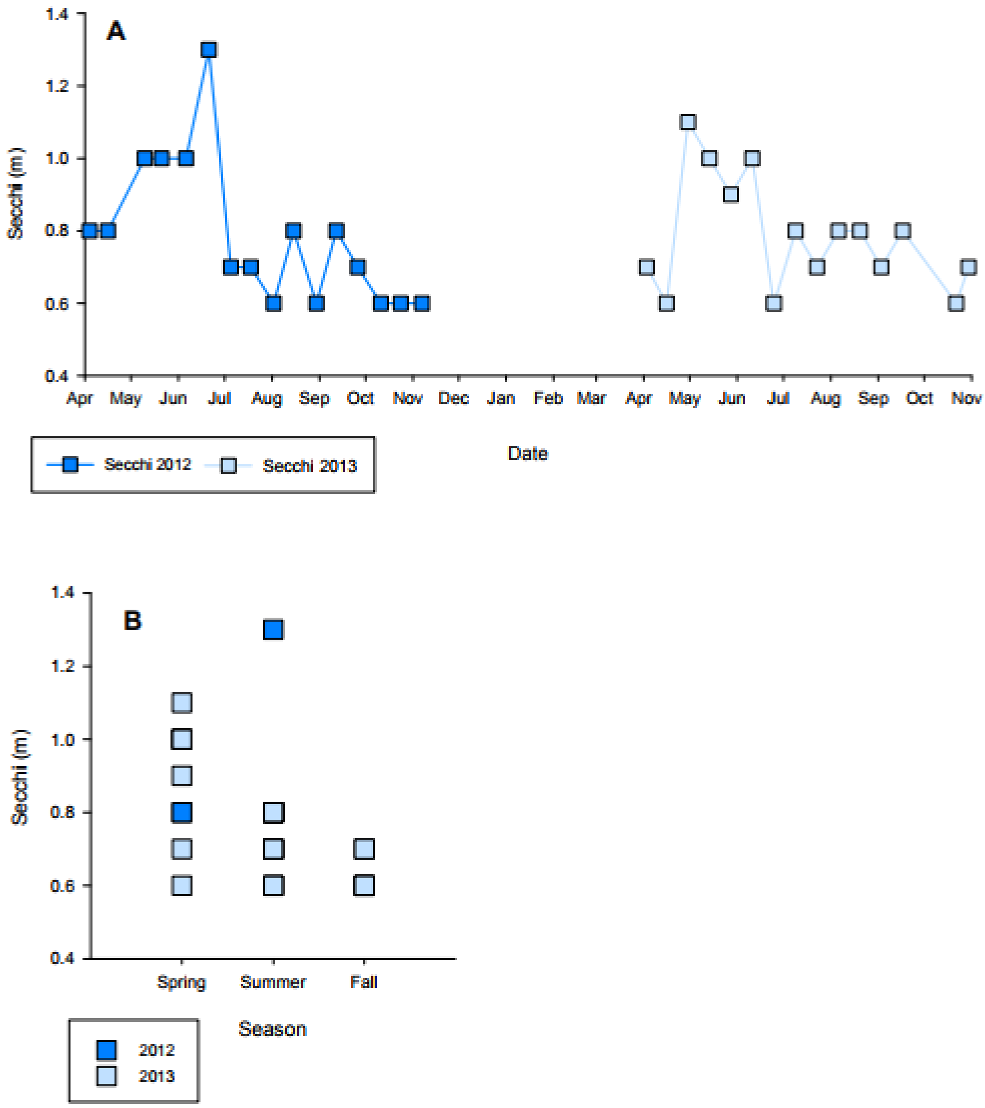


Figure 32. Plots at the Jordan Lake Intake site of secchi depth data: (A) Date plot of all observations; (B) Photic observations of secchi depth data grouped by season and year.

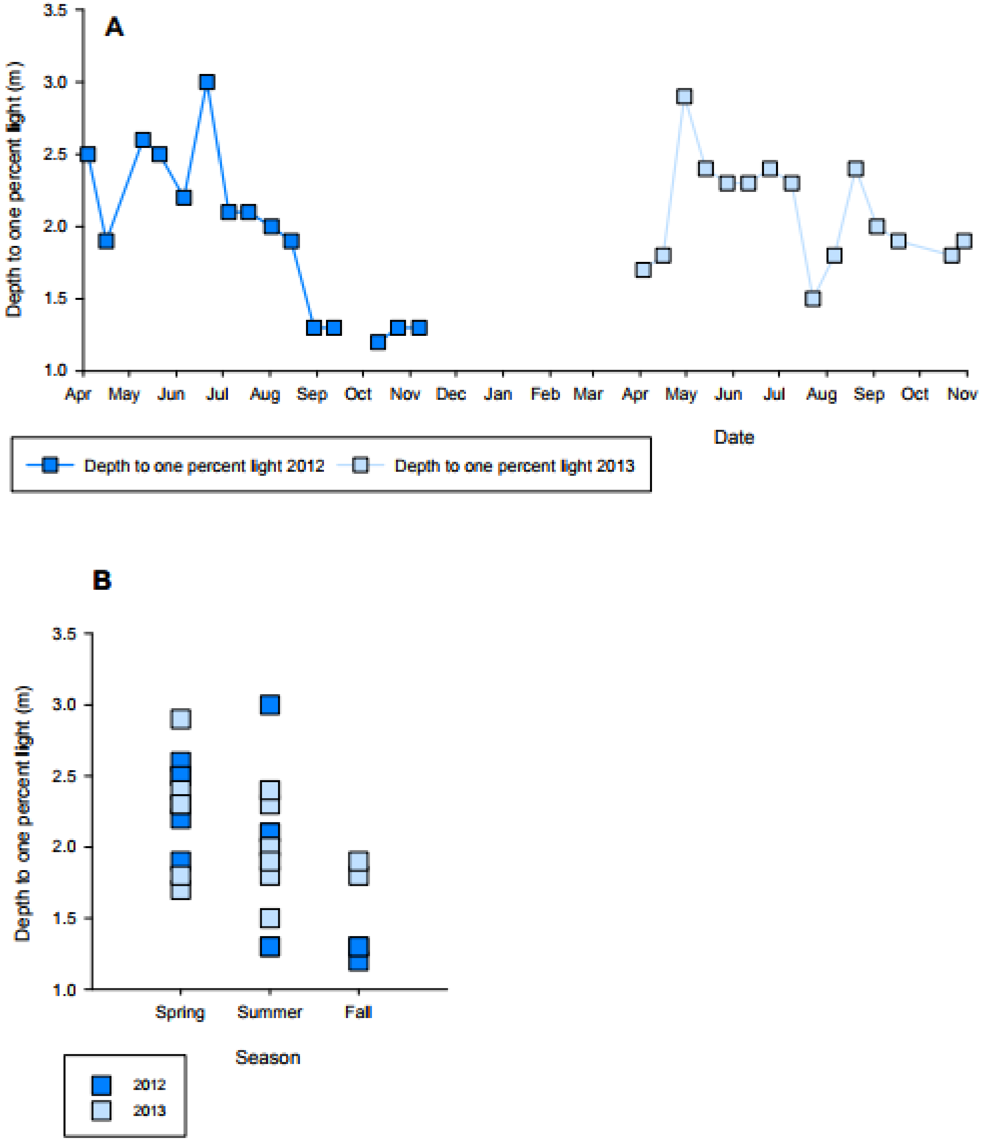


Figure 33. Plots at the Jordan Lake Intake site of depth to one percent light data: (A) Date plot of all observations; (B) Photic observations of depth to one percent light data grouped by season and year.

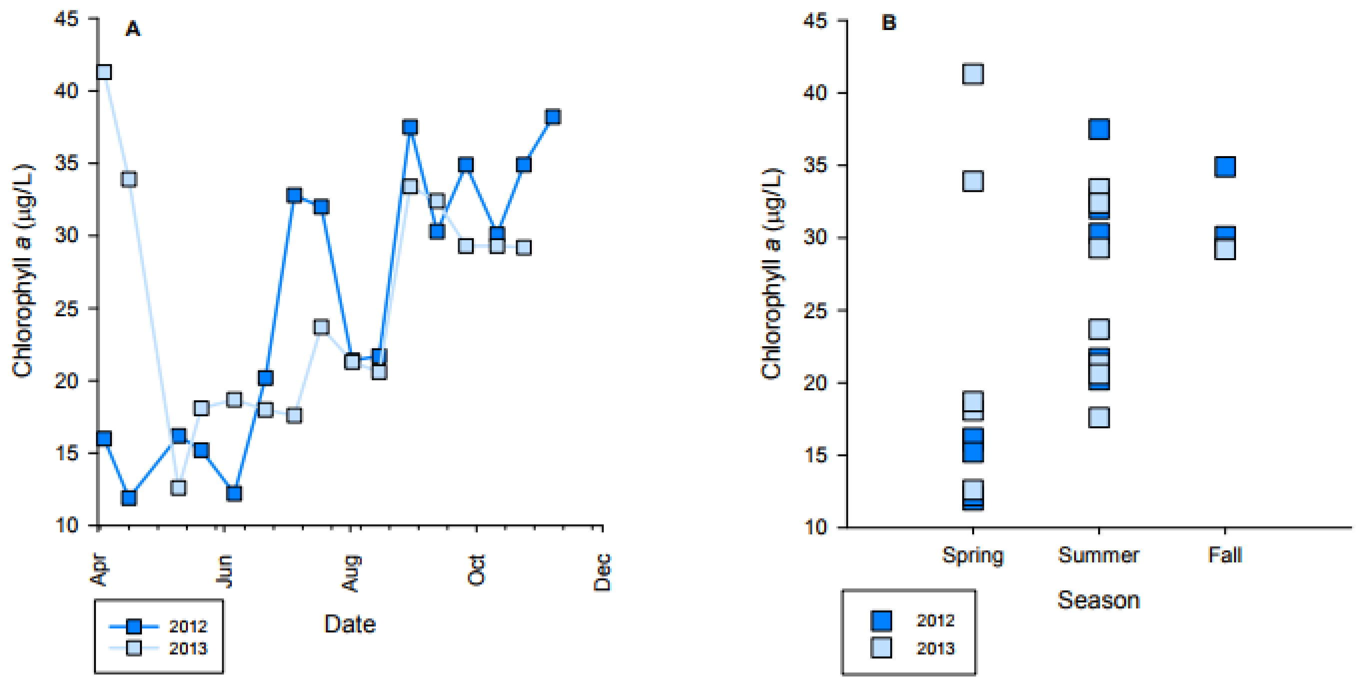


Figure 34. Plots at the Jordan Lake Intake site of chlorophyll *a* data: (A) Date plot of all observations grouped by year; (B) Photic observations grouped by season and year.

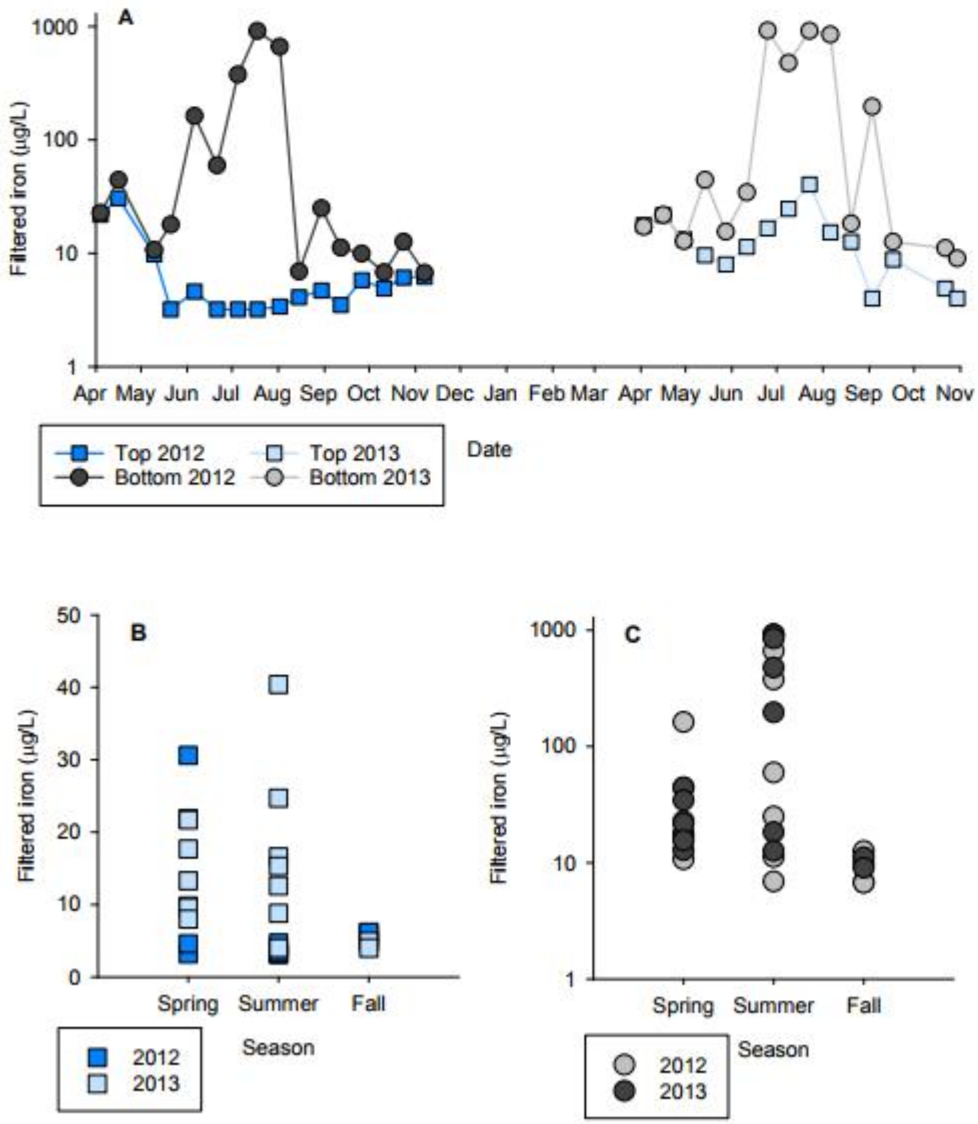


Figure 35. Plots at the Jordan Lake Intake site for filtered iron data: (A) Date plot of all observations; (B) Top observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

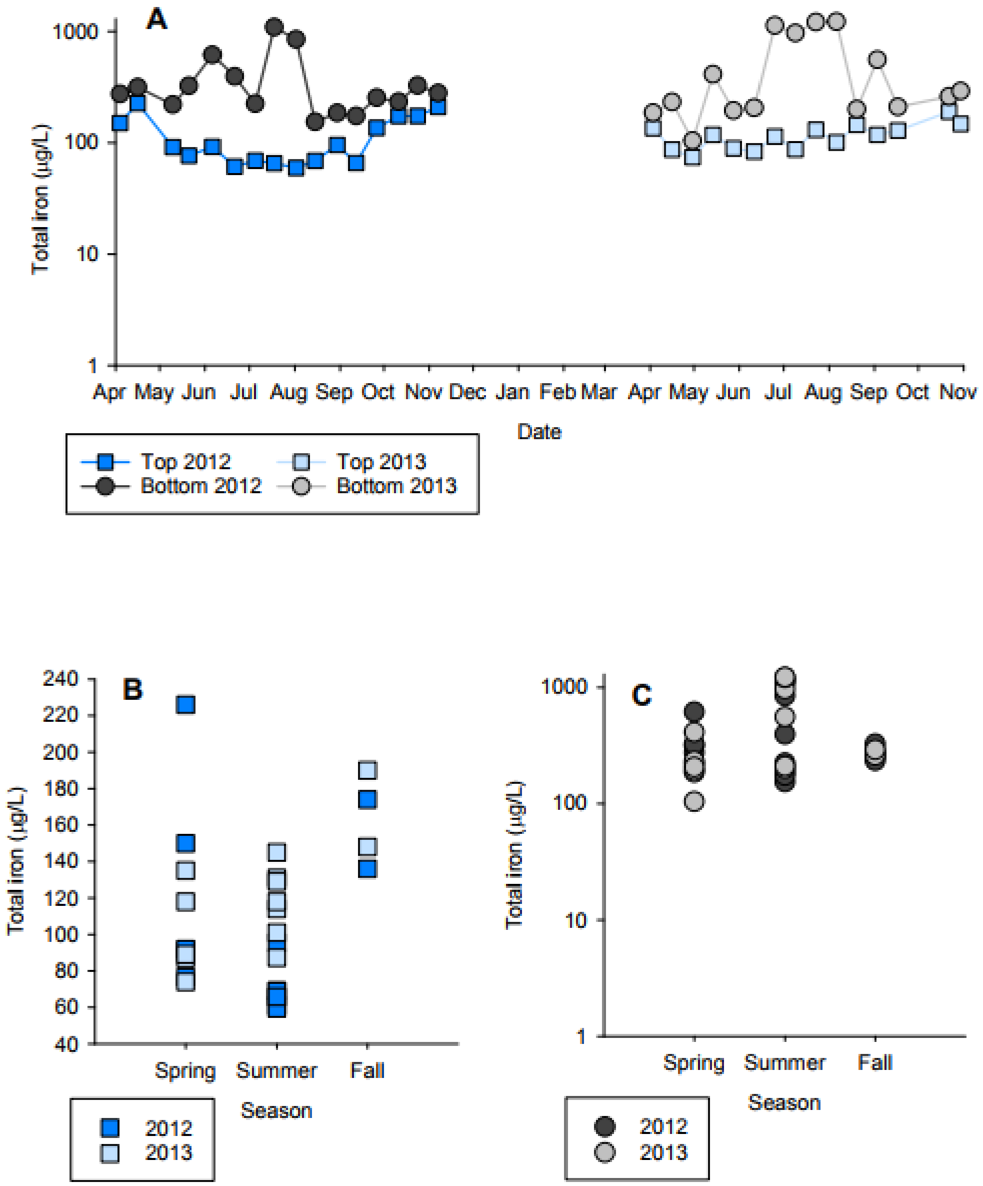


Figure 36. Plots at the Jordan Lake study site of total iron data: (A) Date plot of all observations (B) Top observations grouped by season and year; C) Near-bottom data grouped by season and year.

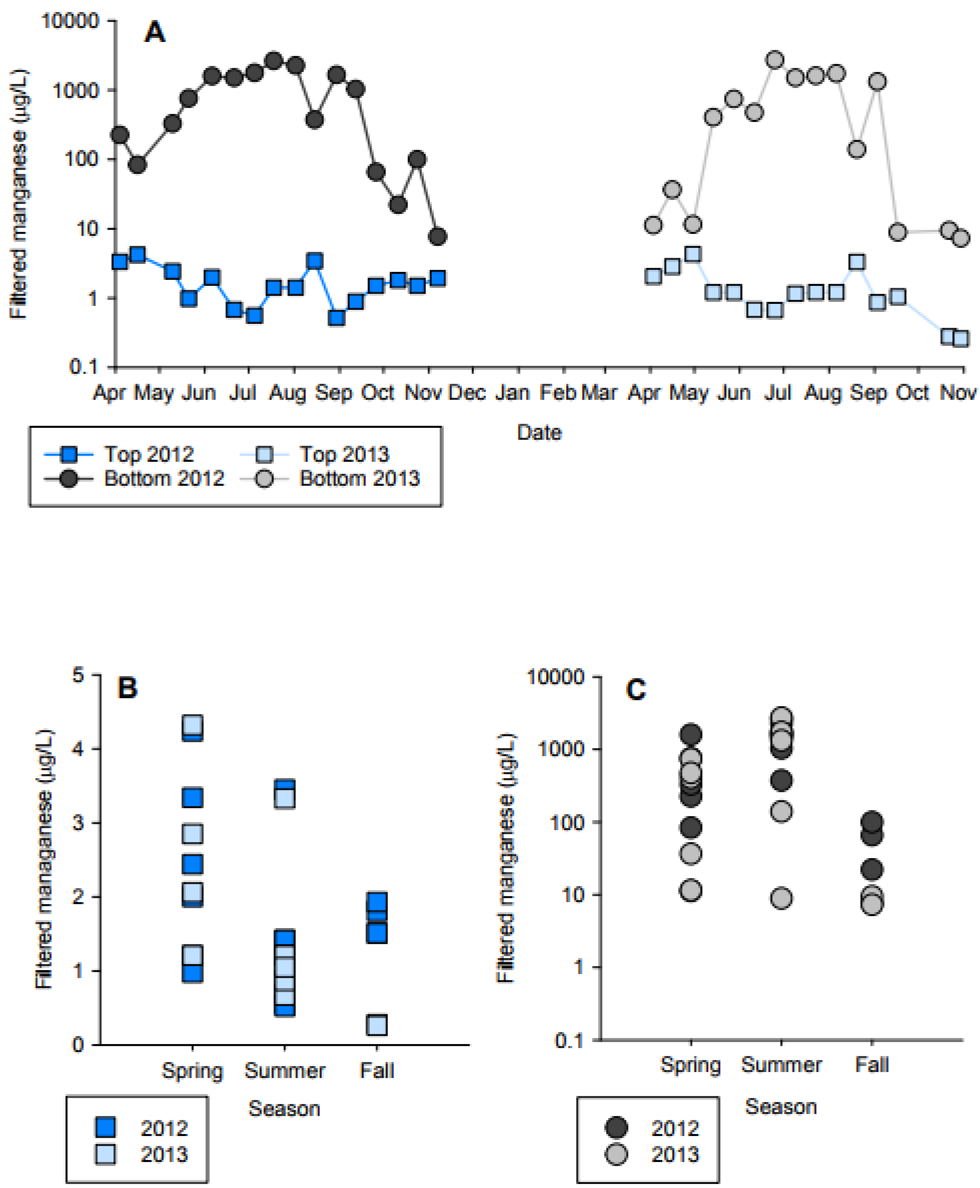


Figure 37. Plots at the Jordan Lake Intake site of filtered manganese data: (A) Date plot of all observations; (B) Top observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

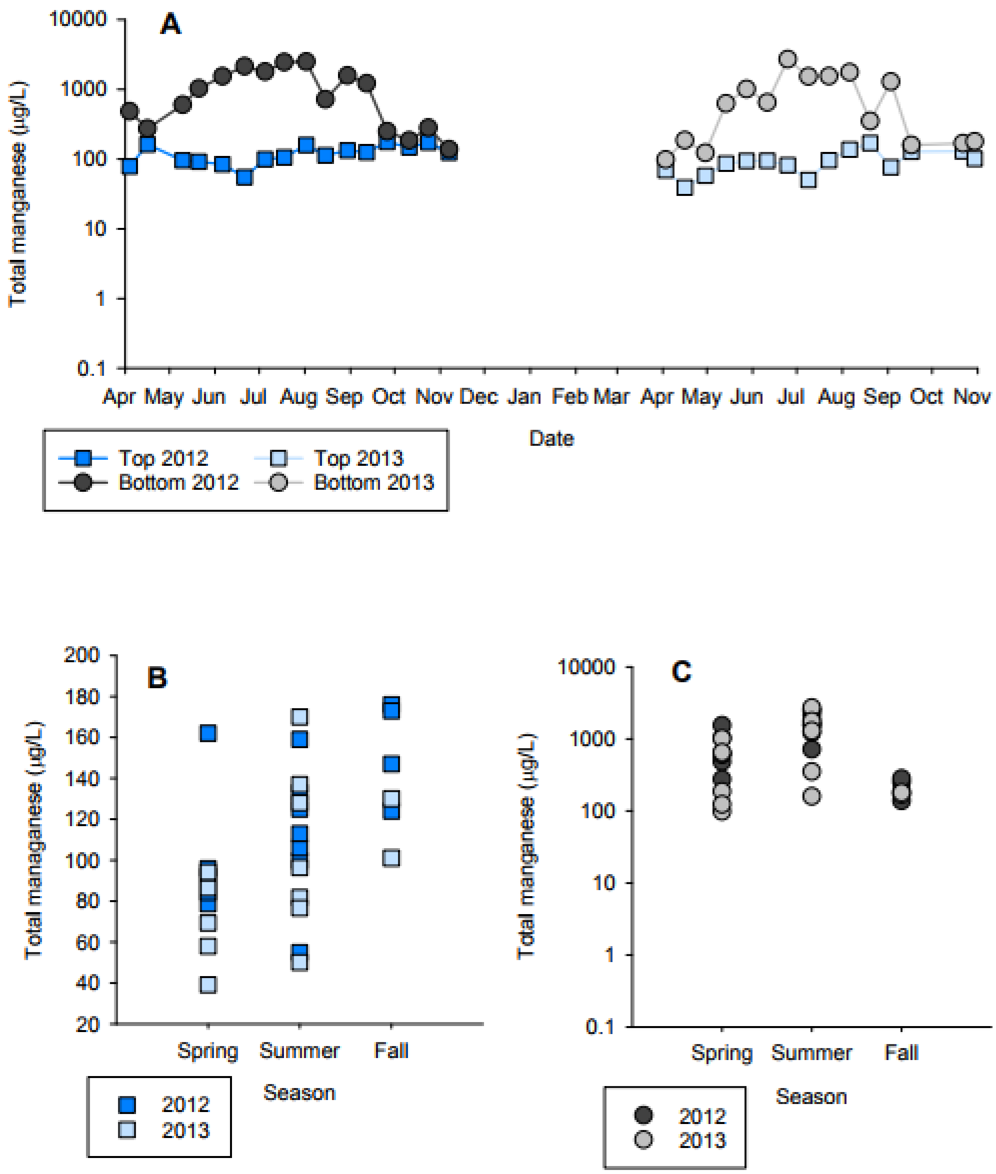


Figure 38. Plots at the Jordan Lake Intake site of total manganese data: (A) Date plot of all observations; (B) Top observations grouped by season and year; (C) Near-bottom grouped by season and year.

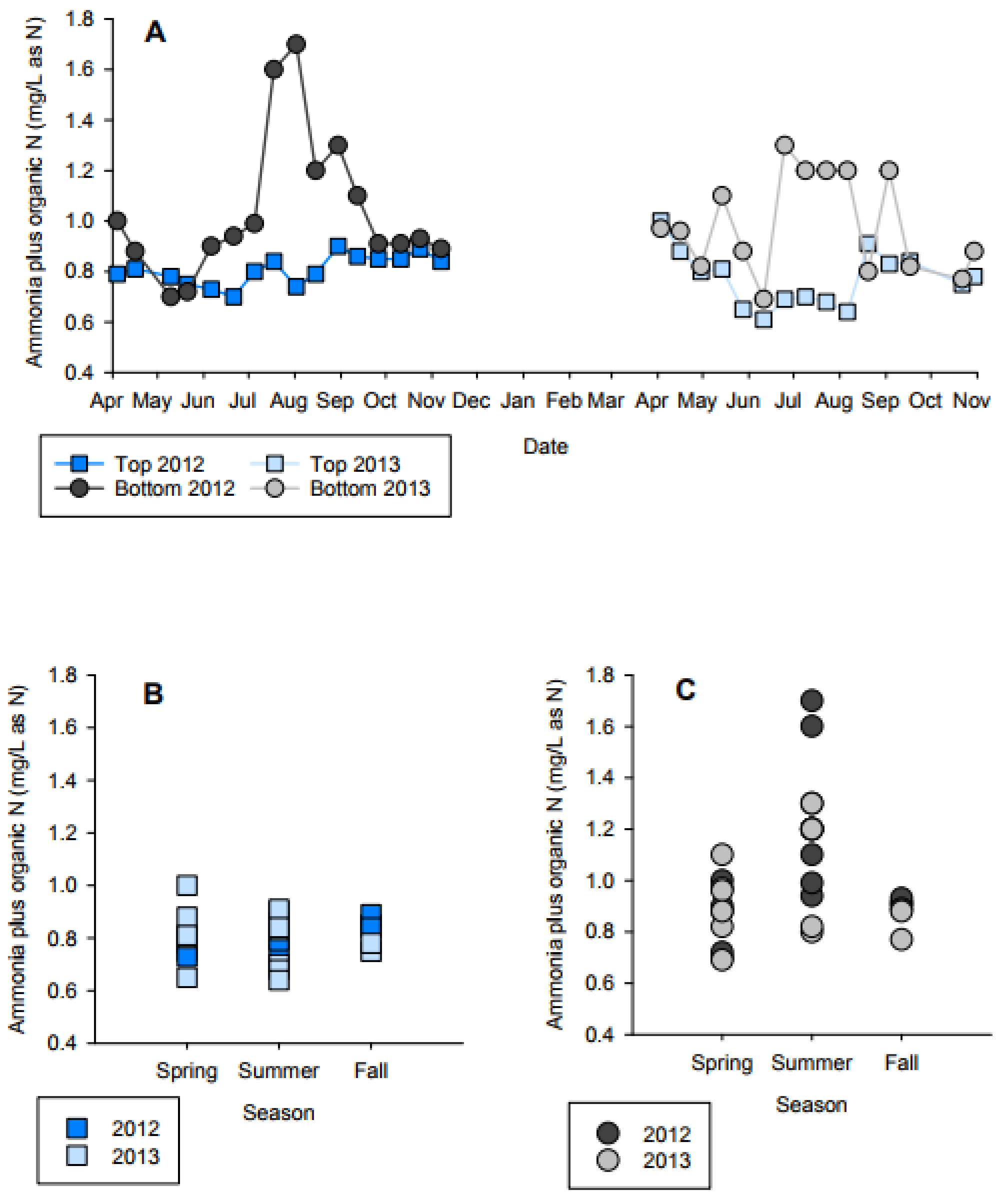


Figure 39. Plots at the Jordan Lake Intake site of ammonia plus organic N data: (A) Date plot of all observations; (B) Photic observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

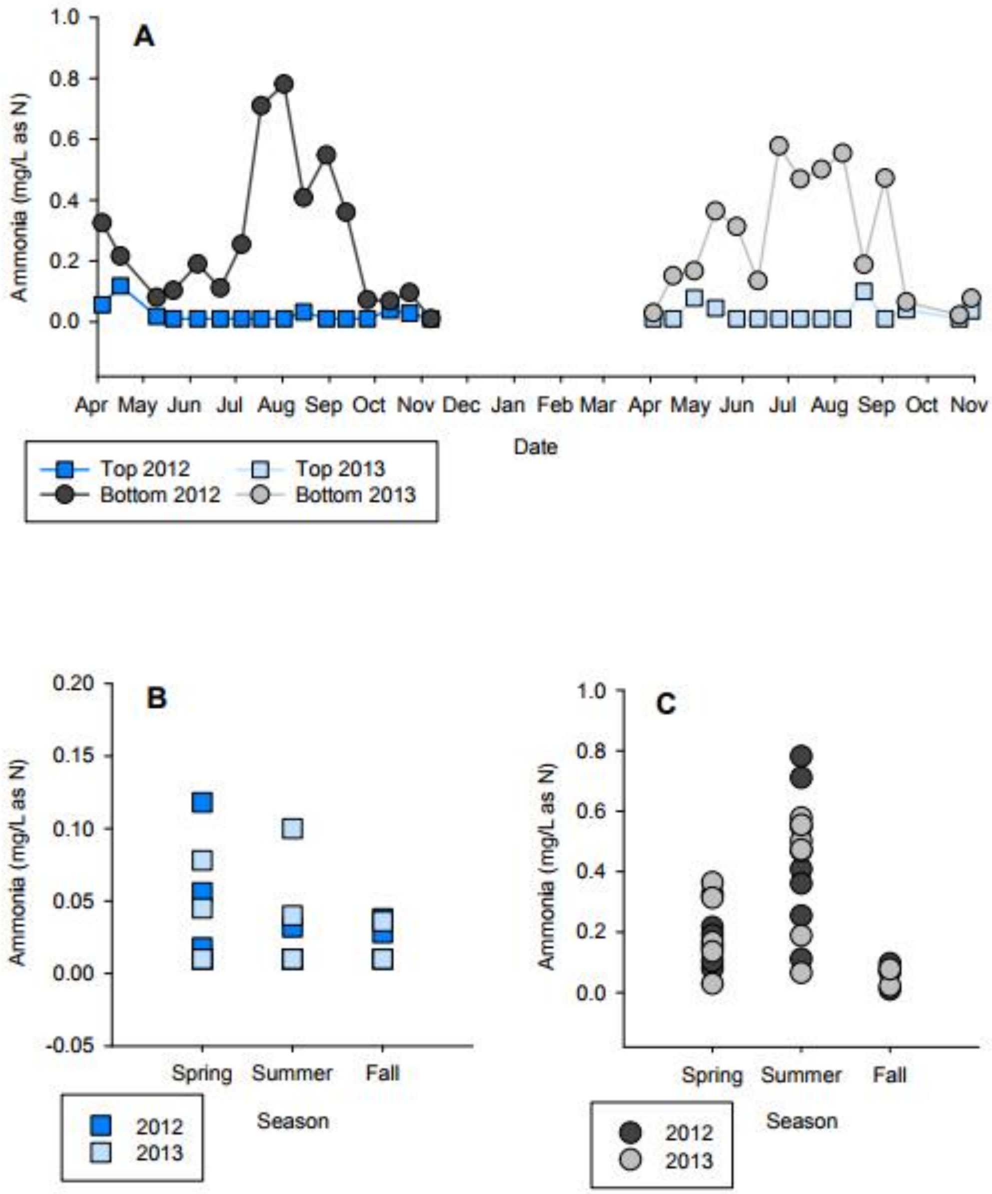


Figure 40. Plots at the Jordan Lake Intake site of ammonia data: (A) Date plot of all observations; (B) Photic observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

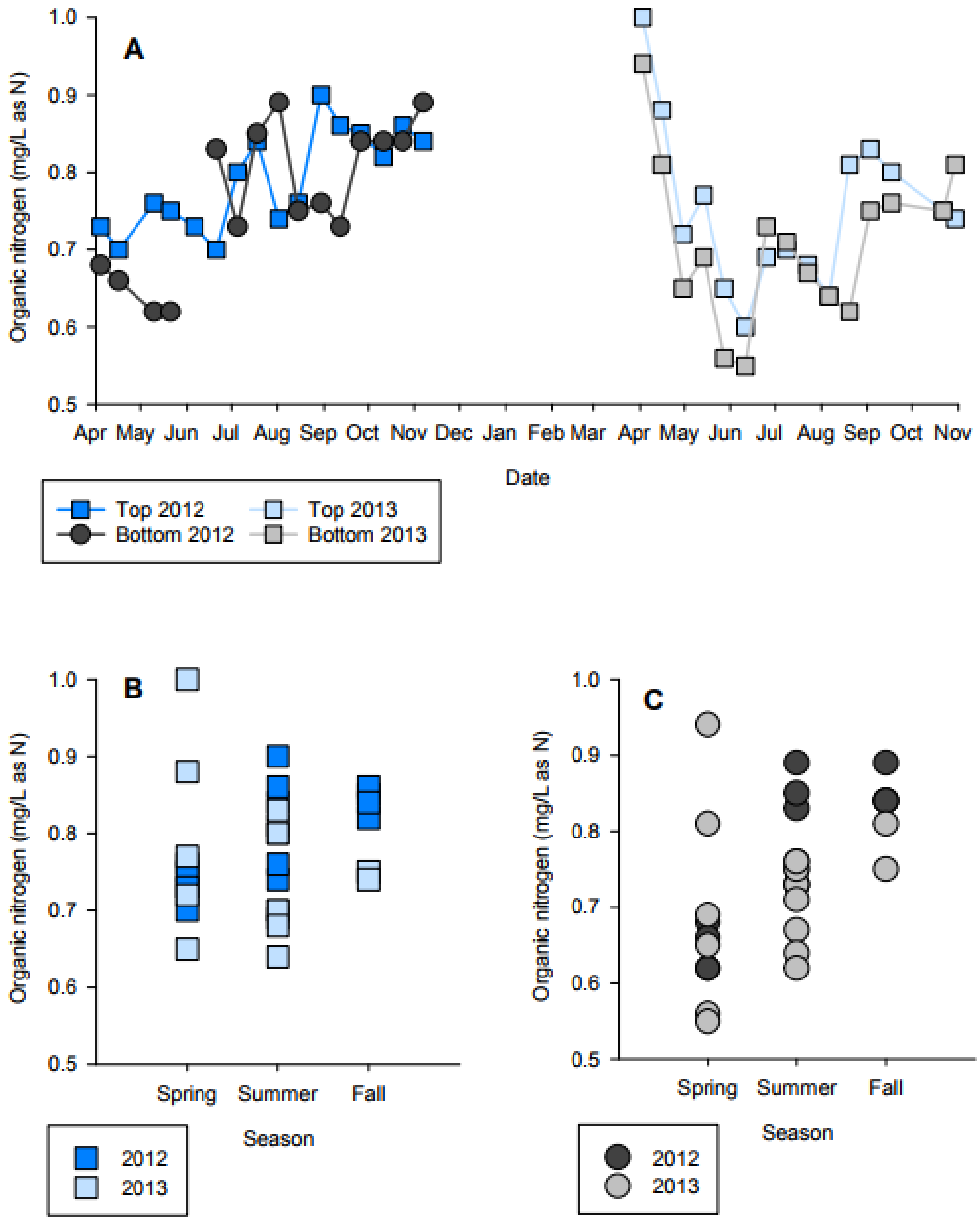


Figure 41. Plots at the Jordan Lake Intake site of organic nitrogen data: (A) Date plot of all observations; (B) Photic observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

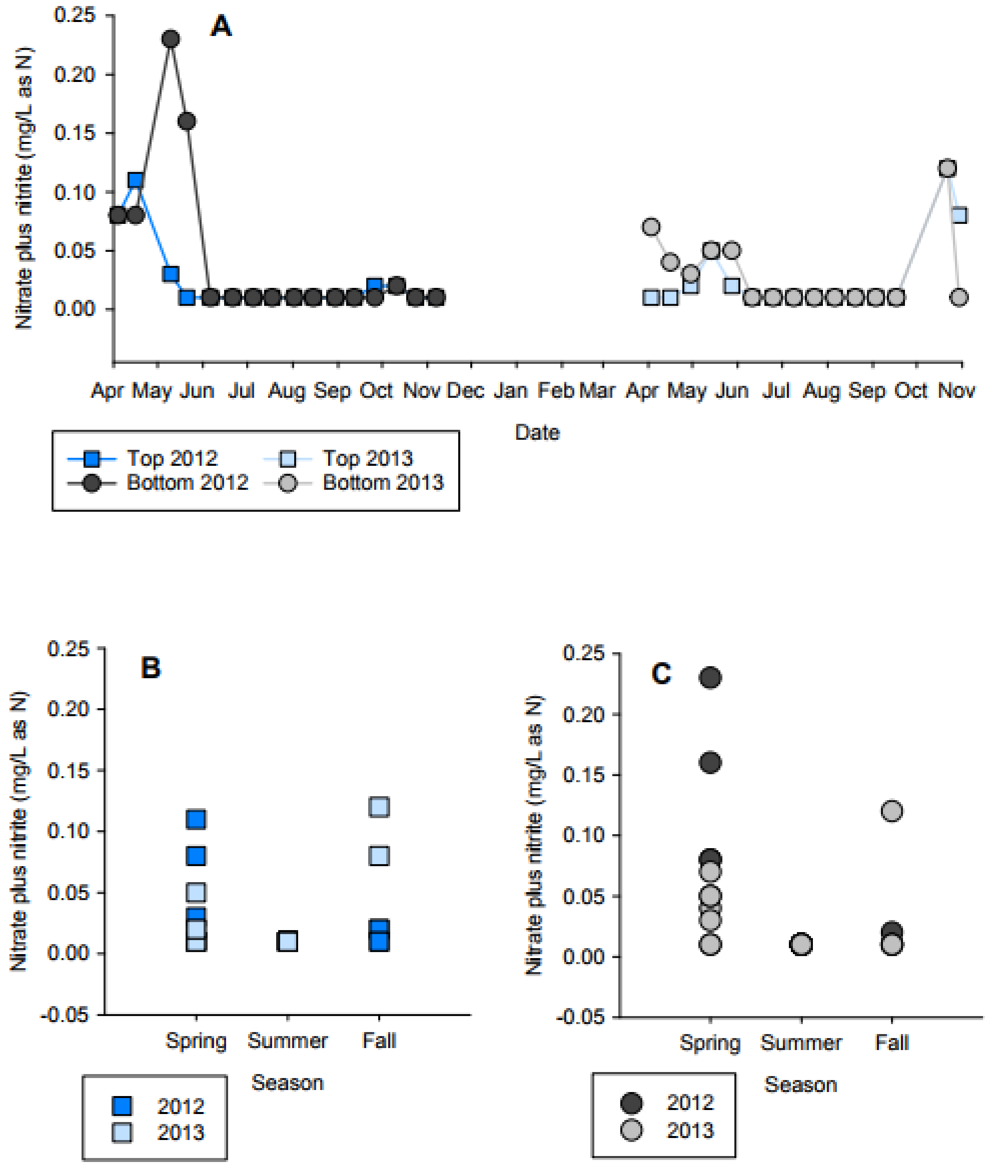


Figure 42. Plots at the Jordan Lake Intake site of nitrate plus nitrite data: (A) Date plot of all observations; (B) Photic observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

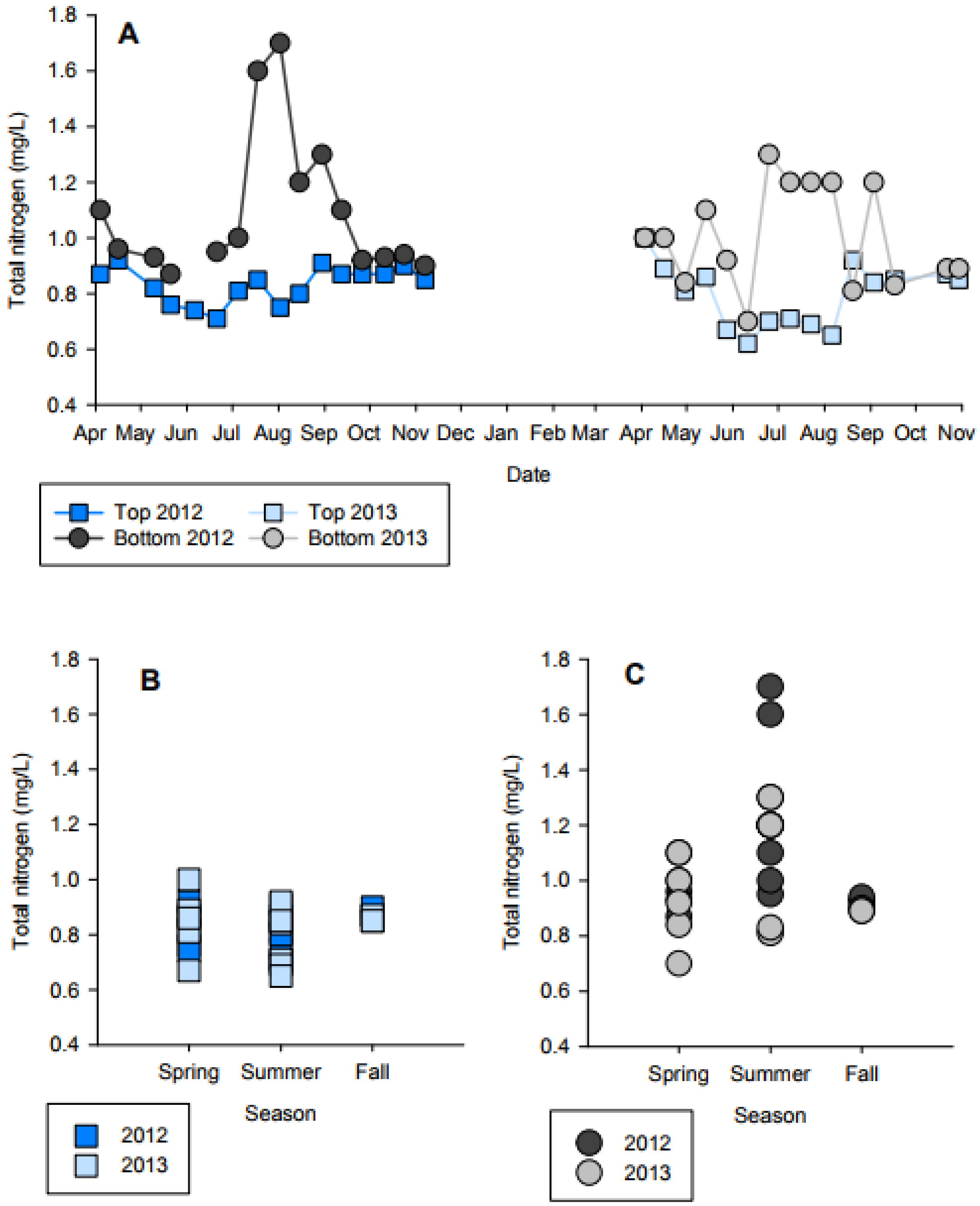


Figure 43. Plots at the Jordan Lake Intake site of total nitrogen data: (A) Date plot of all observations; (B) Photic observations grouped by season and year; (C) Near-bottom observations grouped by season and year.

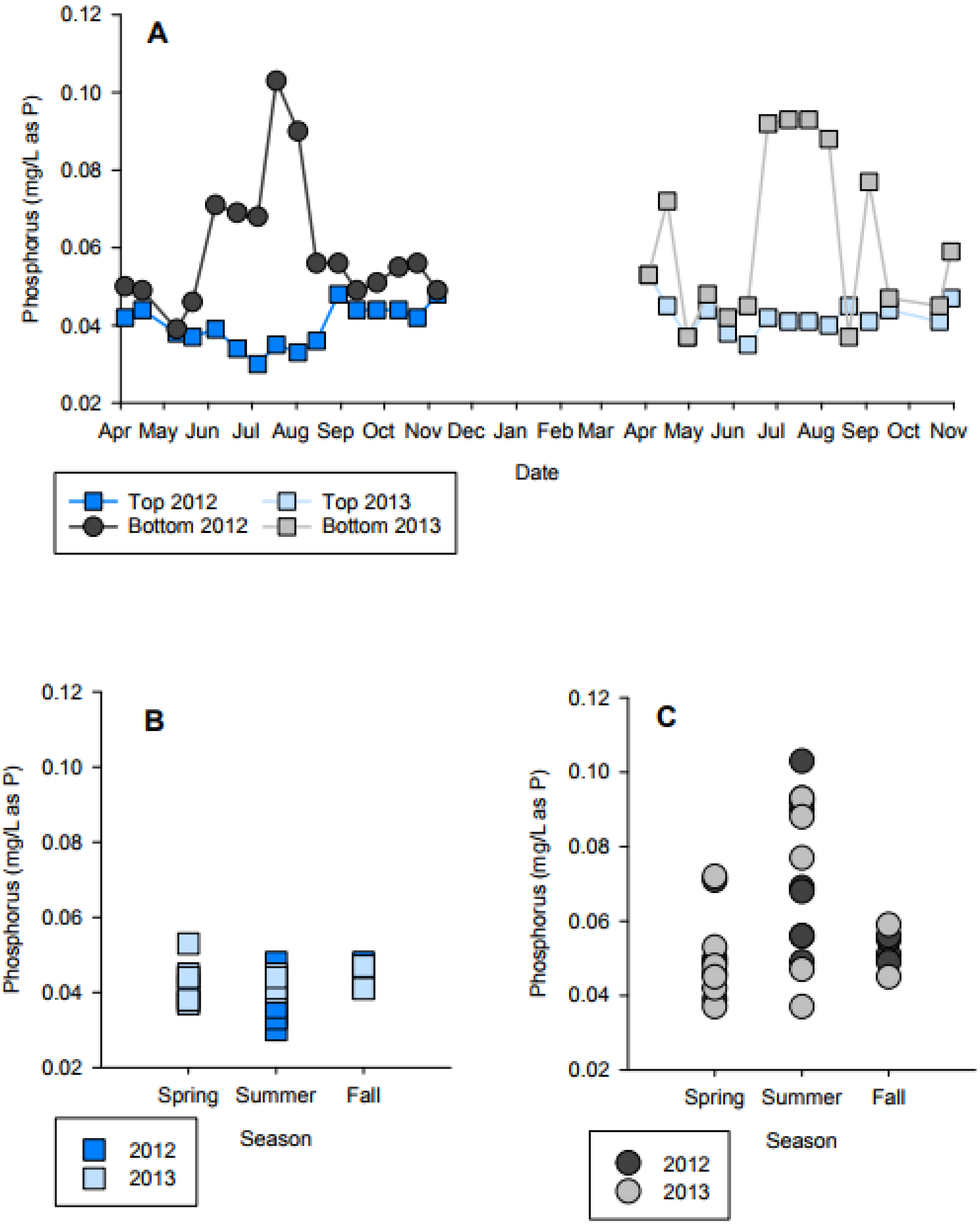


Figure 44. Plots at the Jordan Lake Intake site of phosphorus data: (A) Date plot of all observations; (B) Photic observations grouped by seaon and year; (C) Near-bottom observations grouped by season and year.

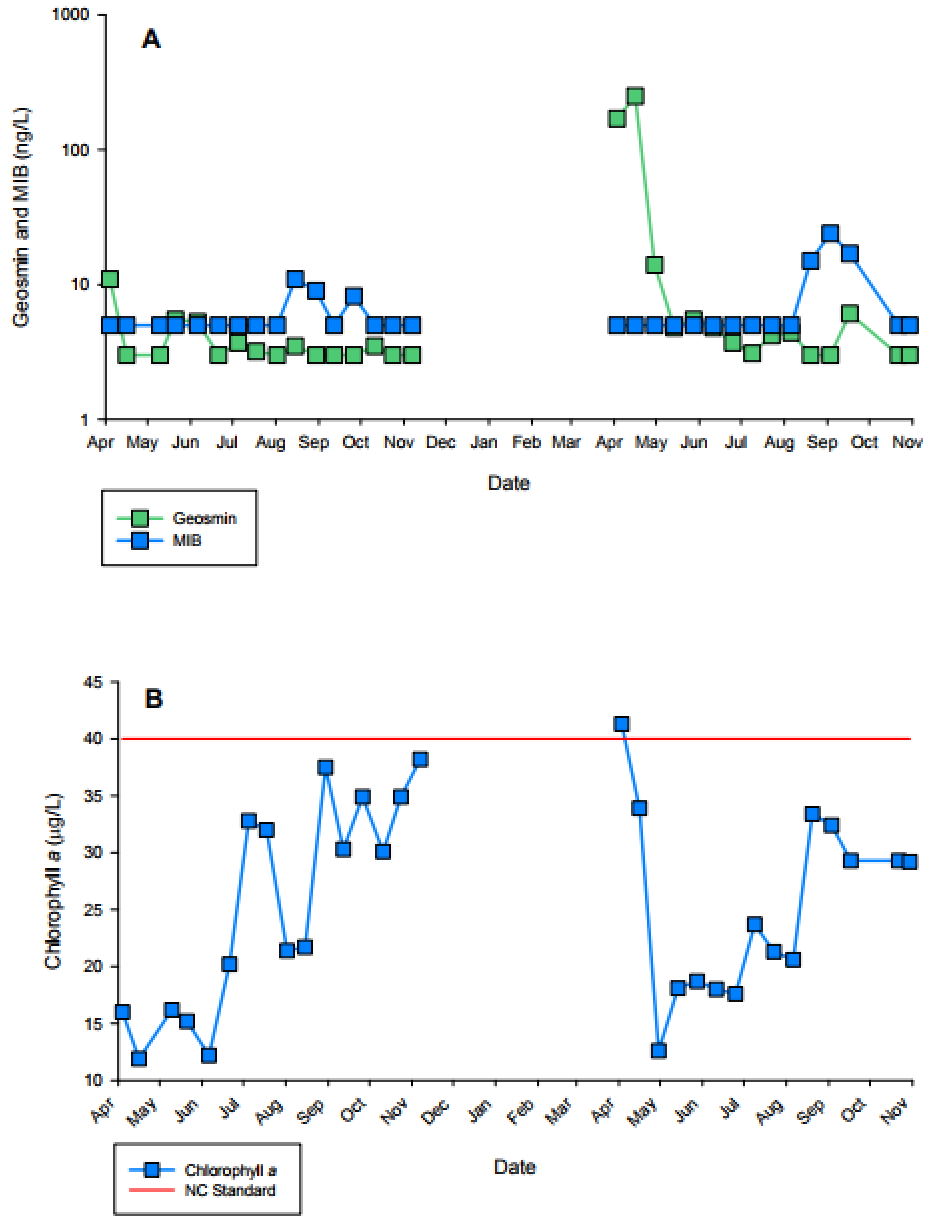


Figure 45. Date plots at the Jordan Lake Intake site, April 2012 through November 2012 and April 2013 through October 2013: (A) Photic observations of taste and odor compounds; (B) Photic observations of chlorophyll *a*.

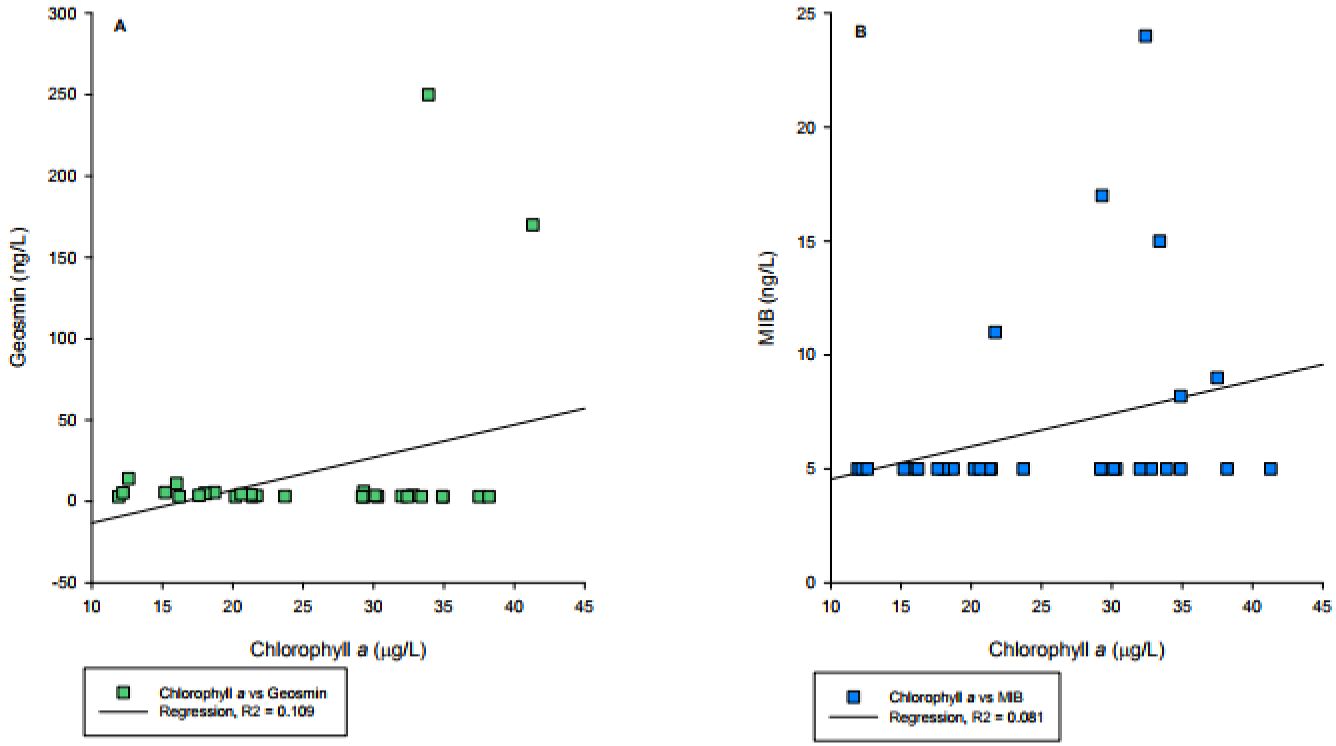


Figure 46. Correlation plots at the Jordan Lake Intake site comparing (A) Chlorophyll *a* with geosmin; (B) Chlorophyll *a* with MIB.

APPENDICES

Appendix 1. Analytical results for blanks collected during surface-water sampling at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.
[DI, deionized; mg/L, milligram per liter; µg/L, micrograms per liter; <, less than; --, not analyzed; N, nitrogen; P, phosphorus. Detections are shaded dark gray.]

Type of Blank	Sample Date	Sample Time	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
DI Water	11/15/2012	1306	--	<0.01	<0.01	<0.004	--	--	<4.0	<4.6	<0.15	<0.4	--	--
Equipment	11/15/2012	1451	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Equipment	11/15/2012	1501	--	--	--	--	--	--	--	<4.6	--	<0.4	--	--
Field	4/16/2012	1310	<0.07	0.01	<0.01	<0.004	<0.004	<1.0	--	--	--	--	<5.0	<3.0
Field	4/16/2012	1312	<0.07	0.01	<0.01	<0.004	<0.004	--	<3.2	<4.6	0.32	<0.20	--	--
Field	5/21/2012	1210	<0.07	<0.01	0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	5/21/2012	1220	<0.07	<0.01	<0.01	<0.004	<0.004	--	<3.2	<4.6	0.17	<0.20	--	--
Field	6/21/2012	1101	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	<5.0	<3.0
Field	6/21/2012	1106	--	--	--	--	--	--	<3.2	<4.6	<0.16	<0.20	--	--
Field	7/18/2012	1140	0.08	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	7/18/2012	1142	--	--	--	--	--	--	<3.2	<4.6	0.22	0.21	--	--
Field	8/15/2012	1241	<0.07	<0.01	<0.01	<0.004	<0.004	0.6	--	--	--	--	<5.0	<3.0
Field	8/15/2012	1246	<0.07	<0.01	<0.01	<0.004	<0.004	--	<3.2	<4.6	0.24	<0.20	--	--
Field	8/30/2012	1200	--	--	--	--	--	--	--	--	--	--	<5.0	<3.0
Field	9/12/2012	1056	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	9/12/2012	1101	--	--	--	--	--	--	<3.2	<4.6	0.17	<0.20	--	--
Field	11/7/2012	1111	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	<5.0	<3.0
Field	11/7/2012	1116	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	--	<0.16	--	--	--
Field	4/16/2013	1101	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	4/16/2013	1106	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	<4.6	<0.16	<0.20	--	--
Field	5/14/2013	1106	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	5/14/2013	1111	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	<4.6	<0.16	<0.20	--	--
Field	6/25/2013	1231	<0.07	<0.01	<0.01	<0.004	<0.004	<1.0	--	--	--	--	<5.0	<3.0
Field	6/25/2013	1236	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	<4.6	<0.16	<0.20	--	--
Field	7/9/2013	1236	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	7/9/2013	1241	<0.07	<0.01	<0.01	<0.004	<0.004		<4.0	<4.6	<0.16	<0.20	--	--
Field	8/20/2013	1117	<0.07	<0.01	<0.01	<0.004	<0.004	<1.0	--	--	--	--	<5.0	<3.0
Field	8/20/2013	1121	--	--	--	--	--	--	<4.0	<4.6	<0.16	<0.20	--	--
Field	9/3/2013	1201	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	9/3/2013	1206	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	<4.6	<0.16	<0.20	--	--
Field	10/30/2013	1105	<0.07	<0.01	<0.01	<0.004	<0.004	--	--	--	--	--	--	--
Field	10/30/2013	1110	<0.07	<0.01	<0.01	<0.004	<0.004	--	<4.0	<4.6	<0.20	<0.20	--	--

Appendix 2. Analytical results for the environmental and replicate sample sets collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.
Green shading indicates RPD values greater than 25 percent.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; RPD, relative percent difference if greater than 25; mg/L, milligram per liter; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample type	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/4/2012	1230	Environmental	--	--	--	--	--	16.0	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/4/2012	1231	Replicate	--	--	--	--	--	17.8	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/4/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	1230	Environmental	--	--	--	--	--	16.2	--	--	--	--	<5.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	1231	Replicate	--	--	--	--	--	13.8	--	--	--	--	<5.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	1240	Environmental	0.70	0.08	0.23	<0.004	0.04		10.70	220	328	603	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	1241	Replicate	0.69	0.09	0.27	<0.004	0.039		11.2	220	332	604	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/10/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/21/2012	1245	Environmental	--	--	--	--	--	15.2	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/21/2012	1246	Replicate	--	--	--	--	--	15.0	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/21/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/21/2012	1115	Environmental	--	--	--	--	--	20.2	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/21/2012	1116	Replicate	--	--	--	--	--	22.4	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/21/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	1200	Environmental	0.8	<0.01	<0.01	<0.004	0.03	32.8	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	1201	Replicate	0.88	<0.01	<0.01	<0.004	0.032	31.4	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	1205	Environmental	--	--	--	--	--	--	<3.2	69.2	0.56	99.7	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	1206	Replicate	--	--	--	--	--	--	<3.2	69.6	0.39	97.5	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/5/2012	--	RPD									35.8			
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/18/2012	1200	Environmental	--	--	--	--	--	32.0	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/18/2012	1201	Replicate	--	--	--	--	--	34.5	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/18/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/2/2012	1315	Environmental	--	--	--	--	--	21.4	--	--	--	--	<5.0	3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/2/2012	1316	Replicate	--	--	--	--	--	22.8	--	--	--	--	<5.0	3.4
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/2/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	1250	Environmental	0.79	0.032	0.01	<0.004	0.036	21.7	--	--	--	--	11.0	3.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	1251	Replicate	0.82	0.02	0.01	<0.004	0.038	18.8	--	--	--	--	14.0	3.4
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	--	RPD		46.2										
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	1255	Environmental	--	--	--	--	--	--	4.1	68.8	3.45	113	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	1256	Replicate	--	--	--	--	--	--	4.6	66.3	2.58	113	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/15/2012	--	RPD									28.9			
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/30/2012	1220	Environmental	--	--	--	--	--	37.5	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/30/2012	1221	Replicate	--	--	--	--	--	38.5	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/30/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/12/2012	1105	Environmental	--	--	--	--	--	30.3	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/12/2012	1106	Replicate	--	--	--	--	--	34.7	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/12/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	1120	Environmental	0.85	<0.01	0.02	<0.004	0.044	34.9	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	1121	Replicate	0.86	<0.01	0.02	<0.004	0.047	38.0	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	--	RPD												

Appendix 2. Analytical results for the environmental and replicate sample sets collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013. Green shading indicates RPD values greater than 25 percent.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; RPD, relative percent difference if greater than 25; mg/L, milligram per liter; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample type	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	1130	Environmental	0.91	0.072	0.01	<0.004	0.051	--	9.9	254	65.6	250	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	1131	Replicate	0.88	0.07	0.02	<0.004	0.055	--	11.3	276	77.5	262	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/26/2012	--	RPD			66.7									
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	1115	Environmental	0.85	0.038	0.02	<0.004	0.044	30.1	--	--	--	--	<5.0	3.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	1116	Replicate	0.84	0.04	0.02	<0.004	0.043	31.6	--	--	--	--	<5.0	4.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	1125	Environmental	0.91	0.068	0.02	0.033	0.055	--	6.8	234	22.1	185	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	1126	Replicate	0.98	0.07	0.02	0.004	0.055	--	7.4	287	21.6	204	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/11/2012	--	RPD				156.8								
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/24/2012	1115	Environmental	--	--	--	--	--	34.9	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/24/2012	1116	Replicate	--	--	--	--	--	34.6	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/24/2012	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	1100	Environmental	0.8	0.078	0.02	<0.004	0.037	12.6	--	--	--	--	<5.0	14.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	1101	Replicate	0.77	0.08	0.02	<0.004	0.038	13	--	--	--	--	<5.0	11.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	1105	Environmental	--	--	--	--	--	--	13.3	74.0	4.32	58.0	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	1106	Replicate	--	--	--	--	--	--	9.7	76.7	3.29	57.8	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	4/30/2013	--	RPD							31.3		27.1			
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	1115	Environmental	0.65	<0.01	0.02	<0.004	0.038	18.7	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	1116	Replicate	0.72	<0.01	0.02	<0.004	0.038	10.1	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	--	RPD						59.7						
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	1120	Environmental	--	--	--	--	--	--	8.0	89.1	1.21	94.2	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	1121	Replicate	--	--	--	--	--	--	8.0	89	1.25	94.1	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	5/28/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	1130	Environmental	0.61	0.01	<0.01	<0.004	0.035	18.0	--	--	--	--	<5.0	4.8
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	1131	Replicate	0.59	0.01	<0.01	<0.004	0.035	18.6	--	--	--	--	<5.0	4.9
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	1135	Environmental	--	--	--	--	--	--	11.4	83.5	0.68	94.6	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	1136	Replicate	--	--	--	--	--	--	10.3	84.2	0.63	95.5	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	6/11/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	1305	Environmental	0.68	<0.01	<0.01	<0.004	0.041	21.3	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	1306	Replicate	0.73	<0.01	<0.01	<0.004	0.043	22.5	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	1310	Environmental	--	--	--	--	--	--	40.4	131	1.22	96.4	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	1311	Replicate	--	--	--	--	--	--	52.2	138	1.29	97.2	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	7/23/2013	--	RPD							25.5					
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	1210	Environmental	0.64	<0.01	<0.01	<0.004	0.04	20.6	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	1211	Replicate	0.68	<0.01	<0.01	<0.004	0.041	23.1	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	1215	Environmental	--	--	--	--	--	--	15.3	101	1.21	137	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	1216	Replicate	--	--	--	--	--	--	14.4	104	1.87	124	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/6/2013	--	RPD									42.9			

Appendix 2. Analytical results for the environmental and replicate sample sets collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.
Green shading indicates RPD values greater than 25 percent.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; RPD, relative percent difference if greater than 25; mg/L, milligram per liter; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample type	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	1130	Environmental	0.91	0.1	<0.01	<0.004	0.045	33.4	--	--	--	--	15.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	1131	Replicate	0.88	0.1	<0.01	<0.004	0.044	29.9	--	--	--	--	20.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	--	RPD											28.6	
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	1135	Environmental	--	--	--	--	--	--	12.6	145	3.33	170	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	1136	Replicate	--	--	--	--	--	--	12.5	145	4.47	171	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	8/20/2013	--	RPD									29.2			
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	1230	Environmental	0.84	0.04	<0.01	<0.004	0.044	--	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	1231	Replicate	0.78	0.04	0.01	<0.004	0.043	--	--	--	--	--	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	1235	Environmental	--	--	--	--	--	--	8.8	129	1.05	128	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	1236	Replicate	--	--	--	--	--	--	9	123	0.93	130	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	9/17/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	1115	Environmental	0.75	<0.01	0.12	<0.004	0.041	29.3	--	--	--	--	<5.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	1116	Replicate	0.74	0.01	0.12	<0.004	0.041	29	--	--	--	--	<5.0	<3.0
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	--	RPD												
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	1120	Environmental	--	--	--	--	--	--	4.90	190	0.28	130	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	1121	Replicate	--	--	--	--	--	--	17.4	191	0.55	127	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	10/22/2013	--	RPD							112.1		65.1			

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 4 2012	1015	photic	--	--	--	--	0.6	--	1.5	1.2	0.9	0.04	0.05	0.86	<0.004	0.047	0.96	17	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 4 2012	1020	top	8.7	7.5	195	19.8	--	9.6	--	1	--	--	--	--	--	--	--	--	19.2	159	2.85	87.6	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 4 2012	1025	bottom	2.6	7.1	198	18.2	--	--	--	5	0.89	0.065	0.06	0.83	<0.004	0.047	0.95	--	26.6	193	3.8	118	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2012	1100	photic	--	--	--	--	0.7	--	1.8	1.4	0.9	0.07	0.07	0.83	<0.004	0.053	0.97	17.1	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2012	1105	top	8.8	7.7	196	19	--	13	--	1	--	--	--	--	--	--	--	--	36.4	254	2.91	132	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2012	1110	bottom	8.1	7.6	197	18.5	--	--	--	5	0.84	0.087	0.076	0.75	<0.004	0.05	0.91	--	29.8	270	1.79	139	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 10 2012	1015	photic	--	--	--	--	0.9	--	2	1.8	0.78	0.033	0.02	0.75	<0.004	0.042	0.8	18.6	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 10 2012	1020	top	6.9	7.4	198	22.2	--	8.5	--	1	--	--	--	--	--	--	--	--	10.5	142	1.26	154	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 10 2012	1025	bottom	0.5	6.8	198	19.5	--	--	--	5	0.81	0.122	0.1	0.68	<0.004	0.04	0.9	--	13.8	207	148	338	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 21 2012	1030	photic	--	--	--	--	0.9	--	2.1	1.8	0.72	<0.01	<0.01	<0.72	<0.004	0.039	<0.73	24.4	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 21 2012	1035	top	7.6	7.6	195	22.5	--	6.6	--	1	--	--	--	--	--	--	--	--	7.4	114	1.84	137	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 21 2012	1040	bottom	3.5	7.2	195	22.8	--	--	--	5	0.68	0.026	0.03	0.65	<0.004	0.042	0.71	--	4.9	164	1.22	209	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 6 2012	1015	photic	--	--	--	--	0.9	--	2	1.8	0.66	<0.01	<0.01	<0.66	<0.004	0.038	<0.67	6.3	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 6 2012	1020	top	6.1	7.3	192	24.7	--	4.7	--	1	--	--	--	--	--	--	--	--	4.3	102	2.6	117	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 6 2012	1025	bottom	3.2	7	195	24.5	--	--	--	5	0.76	0.02	<0.01	0.74	<0.004	0.057	<0.77	--	13.1	332	202	407	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 21 2012	915	photic	--	--	--	--	0.9	--	2.2	1.8	0.74	<0.01	<0.01	<0.74	<0.004	0.037	<0.75	17.2		--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 21 2012	920	top	10.1	8.9	199	27.7	--	6.5	--	1	--	--	--	--	--	--	--	--	<3.2	74.1	0.78	64.5	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 21 2012	925	bottom	0.2	6.8	206	24.9	--	--	--	5	0.94	0.062	<0.01	0.88	<0.004	0.096	<0.95	--	4.6	317	728	902	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 5 2012	945	photic	--	--	--	--	0.6	--	1.5	1.2	0.91	0.01	<0.01	0.9	<0.004	0.039	<0.92	34.4	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 5 2012	950	top	8.4	9	198	29.5	--	7.8	--	1	--	--	--	--	--	--	--	--	3.2	88.9	0.91	114	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 5 2012	955	bottom	0.1	7.1	209	26.6	--	--	--	5	0.93	0.112	<0.01	0.82	<0.004	0.068	<0.94	--	24.9	286	872	1010	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 18 2012	930	photic	--	--	--	--	0.7	--	2.8	1.4	0.88	<0.01	<0.01	<0.88	<0.004	0.04	<0.89	36.8	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 18 2012	935	top	7.1	8.3	199	29.4	--	7.5	--	1	--	--	--	--	--	--	--	--	5.3	77.1	1.77	165	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 18 2012	940	bottom	6.1	7.8	199	29.2	--	--	--	4	0.89	<0.01	0.01	<0.89	<0.004	0.042	0.9	--	7.8	98.5	25	189	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 2 2012	945	photic	--	--	--	--	0.8	--	1.8	1.6	0.89	<0.01	<0.01	<0.89	<0.004	0.045	<0.9	31.8	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 2 2012	950	top	6.7	8.3	202	30	--	6.7	--	1	--	--	--	--	--	--	--	--	<3.2	87.2	1.27	138	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 2 2012	955	bottom	4	7.7	202	29.7	--	--	--	4	0.85	<0.01	<0.01	<0.85	<0.004	0.039	<0.86	--	<3.2	83.8	1.08	129	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 15 2012	945	photic	--	--	--	--	0.7	--	1.5	1.4	0.83	<0.01	<0.01	<0.83	<0.004	0.045	<0.84	29.6	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 15 2012	950	top	8.9	8.6	197	28.8	--	5.8	--	1	--	--	--	--	--	--	--	--	<3.2	99.9	1.32	124	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 15 2012	955	bottom	0.8	7.5	214	27.9	--	--	--	5	0.99	0.166	<0.01	0.82	<0.004	0.061	<1	--	6.2	268	100	379	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 30 2012	945	photic	--	--	--	--	0.6	--	--	1.2	0.95	<0.01	<0.01	<0.95	<0.004	0.05	<0.96	39.5	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 30 2012	950	top	8.2	8.6	206	27.2	--	7.1	--	1	--	--	--	--	--	--	--	--	5.1	119	1.23	135	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 30 2012	955	bottom	1.7	7.1	207	26.2	--	--	--	5	0.94	0.162	0.01	0.78	<0.004	0.044	0.95	--	7.1	124	3.58	230	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 12 2012	930	photic	--	--	--	--	0.6	--	1.1	1.2	0.95	0.063	<0.01	0.89	<0.004	0.054	<0.96	32.1	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 12 2012	935	top	6	7.3	206	26.2	--	10	--	1	--	--	--	--	--	--	--	--	5.4	174	0.73	204	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 12 2012	940	bottom	5.8	7.1	208	26.1	--	--	--	4	0.98	0.077	<0.01	0.9	<0.004	0.052	<0.99	--	6.9	174	2.62	201	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 26 2012	940	photic	--	--	--	--	0.6	--	1.1	1.2	0.9	<0.01	0.01	<0.9	<0.004	0.056	0.91	49.3	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 26 2012	945	top	8.9	8.2	203	23.9	--	8.6	--	1	--	--	--	--	--	--	--	--	5	161	0.87	150	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 26 2012	950	bottom	5.2	7.2	205	23.5	--	--	--	5	0.97	0.01	<0.01	0.96	<0.004	0.065	<0.98	--	9.9	281	1.09	191	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 11 2012	910	photic	--	--	--	--	0.6	--	1.3	1.2	0.92	0.07	0.01	0.85	0.01	0.056	0.93	31.8	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 11 2012	915	top	6.9	7.3	197	19.6	--	18	--	1	--	--	--	--	--	--	--	--	<4	245	1.5	165	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 11 2012	920	bottom	7	7.2	199	19.6	--	--	--	5	0.96	0.073	0.01	0.89	<0.004	0.057	0.98	--	<4	255	1.27	170	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 24 2012	920	photic	--	--	--	--	0.6	--	1.3	1.2	0.84	<0.01	<0.01	<0.84	<0.004	0.045	<0.85	43	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 24 2012	925	top	9.3	8	194	19.2	--	6.9	--	1	--	--	--	--	--	--	--	--	<4	129	0.99	114	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 24 2012	930	bottom	5.8	7.4	196	18.5	--	--	--	5	0.86	<0.01	<0.01	<0.86	<0.004	0.051	<0.87	--	8.3	195	1.46	134	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Nov 7 2012	910	photic	--	--	--	--	0.6	--	1.2	1.2	0.83	<0.01	<0.01	<0.83	<0.004	0.05	<0.84	29.9	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Nov 7 2012	915	top	10.1	7.4	196	12.5	--	7.6	--	1	--	--	--	--	--	--	--	--	4.2	205	1.29	122	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Nov 7 2012	920	bottom	10	6.8	197	12.5	--	--	--	4	0.85	<0.01	<0.01	<0.85	<0.004	0.052	<0.86	--	<4	209	1.24	124	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 3 2013	900	photic	--	--	--	--	0.5	--	1.5	1	1	<0.01	0.02	<1	<0.004	0.061	1.1	43.6	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 3 2013	905	top	11.8	8.2	183	11.4	--	14	--	1	--	--	--	--	--	--	--	--	46.1	215	3.02	82.3	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 3 2013	910	bottom	10.7	7.9	184	11.3	--	--	--	4	1.1	<0.01	0.02	<1.1	<0.004	0.059	1.1	--	40.8	227	4.34	90	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2013	910	photic	--	--	--	--	0.6	--	1.6	1.2	1.1	<0.01	<0.01	<1.1	<0.004	0.052	<1.1	43.3	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2013	915	top	11.2	8.5	187	19	--	11	--	1	--	--	--	--	--	--	--	--	27.1	100	2.89	43.2	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 16 2013	920	bottom	6.8	6.6	186	16.3	--	--	--	4	1	<0.01	<0.01	<1	<0.004	0.053	<1	--	24.3	121	3	44.9	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 30 2013	915	photic	--	--	--	--	0.9	--	1.6	1.8	0.84	0.116	0.02	0.72	<0.004	0.041	0.85	12.2	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 30 2013	920	top	7.5	7.1	187	18.9	--	5.9	--	1	--	--	--	--	--	--	--	--	8.2	96.3	0.98	79.1	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Apr 30 2013	925	bottom	1.9	6.8	193	17.2	--	--	--	5	1	0.307	0.02	0.72	<0.004	0.044	1	--	22.3	178	108	331	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 14 2013	910	photic	--	--	--	--	0.7	--	1.8	1.4	0.85	0.042	0.04	0.81	<0.004	0.048	0.89	23.7	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 14 2013	915	top	9	7.6	186	19.7	--	8.3	--	1	--	--	--	--	--	--	--	--	22.1	196	4.77	120	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 14 2013	920	bottom	2.4	6.9	190	17.7	--	--	--	5	0.99	0.225	0.05	0.76	<0.004	0.049	1	--	46.7	308	31.6	244	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 28 2013	1220	photic	--	--	--	--	0.8	--	1.6	1.6	0.77	<0.01	<0.01	<0.77	<0.004	0.046	<0.78	23.2	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 28 2013	1225	top	9.7	8.5	183	24.5	--	5.8	--	1	--	--	--	--	--	--	--	--	10.4	118	0.81	116	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	May 28 2013	1230	bottom	3.6	7.3	182	22.5	--	--	--	5	0.72	<0.01	<0.01	<0.72	<0.004	0.04	<0.73	--	8.7	120	0.7	129	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 11 2013	915	photic	--	--	--	--	0.8	--	1.9	1.6	0.65	<0.01	<0.01	<0.65	<0.004	0.04	<0.66	22.9	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 11 2013	920	top	6.7	7.7	173	25.1	--	5.8	--	1	--	--	--	--	--	--	--	--	19.4	118	0.69	124	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 11 2013	925	bottom	6	8.1	174	25.1	--	--	--	5	0.63	0.017	0.01	0.61	<0.004	0.045	0.64	--	25.5	137	0.76	140	--	--

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll *a*, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methylisoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 25 2013	1045	photic	--	--	--	--	0.5	--	1.9	1	0.8	0.011	<0.01	0.79	<0.004	0.048	<0.81	20.7	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 25 2013	1050	top	8.1	7.7	155	27.5	--	6.6	--	1	--	--	--	--	--	--	--	--	23.2	146	0.75	102	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jun 25 2013	1055	bottom	7.1	7.2	157	27.1	--	--	--	4	0.78	<0.01	<0.01	<0.78	<0.004	0.047	<0.79	--	26.4	162	1.06	114	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 9 2013	1030	photic	--	--	--	--	0.8	--	1.9	1.6	0.75	<0.01	<0.01	<0.75	<0.004	0.045	<0.76	20.2	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 9 2013	1035	top	7.8	7.7	134	28.5	--	5.9	--	1	--	--	--	--	--	--	--	--	44.8	143	1.46	54.6	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 9 2013	1040	bottom	0.4	6.7	94	25.8	--	--	--	6	0.88	0.092	<0.01	0.79	0.007	0.093	<0.89	--	398	862	348	484	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 23 2013	1105	photic	--	--	--	--	0.5	--	1.4	1	0.74	<0.01	<0.01	<0.74	<0.004	0.055	<0.75	28.4	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 23 2013	1110	top	6.4	7.1	124	29.1	--	6.8	--	1	--	--	--	--	--	--	--	--	72.4	229	3.24	155	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Jul 23 2013	1115	bottom	5.7	7	128	28.8	--	--	--	4	0.7	<0.01	<0.01	<0.7	<0.004	0.047	<0.71	--	62.4	184	1.63	133	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 6 2013	1015	photic	--	--	--	--	0.7	--	1.7	1.4	0.83	<0.01	<0.01	<0.83	<0.004	0.05	<0.84	23.7	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 6 2013	1020	top	6.6	7	128	28.2	--	10	--	1	--	--	--	--	--	--	--	--	19.6	142	0.89	164	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 6 2013	1025	bottom	5	6.7	131	28.1	--	--	--	4	0.69	0.015	<0.01	0.68	<0.004	0.045	<0.7	--	24.5	152	1.79	199	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 20 2013	930	photic	--	--	--	--	0.8	--	1.9	1.6	0.86	0.08	<0.01	0.78	<0.004	0.05	<0.87	33.9	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 20 2013	935	top	6.3	7.3	124	26.2	--	7.5		1	--	--	--	--	--	--	--	--	33.2	138	0.68	141	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Aug 20 2013	940	bottom	3.6	7	126	25.7	--			5	0.8	0.096	<0.01	0.71	<0.004	0.046	<0.81	--	8.6	142	0.61	144	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 3 2013	1020	photic	--	--	--	--	0.7	--	1.8	1.4	0.92	<0.01	<0.01	<0.92	<0.004	0.051	<0.93	42.8	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 3 2013	1025	top	8.2	8	138	27.8	--	5.3	--	1	--	--	--	--	--	--	--	--	<4	124	0.61	98.1	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 3 2013	1030	bottom	3.7	7.1	144	27.3	--	--	--	4	0.83	0.01	<0.01	0.82	<0.004	0.046	<0.84	--	<4	112	0.81	92	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 17 2013	1045	photic	--	--	--	--	0.7	--	1.8	1.4	0.83	0.132	<0.01	0.7	<0.004	0.052	<0.84	25.8	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 17 2013	1050	top	5.4	7.2	133	25.6	--	8	--	1	--	--	--	--	--	--	--	--	14.1	192	29.2	222	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Sep 17 2013	1055	bottom	5.5	7.4	139	25.4	--	--	--	5	0.91	0.146	<0.01	0.76	<0.004	0.06	<0.92	--	17.1	262	21.8	243	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 22 2013	930	photic	--	--	--	--	0.6	--	1.6	1.2	0.82	<0.01	<0.01	<0.82	<0.004	0.05	<0.83	42.5	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 22 2013	935	top	10.2	8.2	149	19	--	8.9	--	1	--	--	--	--	--	--	--	--	16	199	0.63	118	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 22 2013	940	bottom	9.1	7.8	152	18.9	--	--	--	4	0.83	<0.01	<0.01	<0.83	<0.004	0.051	<0.84	--	14.8	203	1.05	123	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 30 2013	945	photic	--	--	--	--	0.7	--	2.1	1.4	0.85	<0.01	<0.01	<0.85	<0.004	0.041	<0.86	35.4	--	--	--	--	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 30 2013	950	top	11.1	9	146	17.6	--	6.3	--	1	--	--	--	--	--	--	--	--	4	105	0.48	76.8	--	--
0209771550	JORDAN LAKE AT BUOY 9 NEAR FARRINGTON, NC	Oct 30 2013	955	bottom	8.2	7.9	147	16.6	--	--	--	3	0.81	<0.01	<0.01	<0.81	<0.004	0.043	<0.82	--	5.1	122	0.47	84.3	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 4 2012	1100	photic	--	--	--	--	0.9	--	2.2	1.8	0.84	0.059	0.06	0.78	<0.004	0.042	0.89	11.8	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 4 2012	1105	top	8.3	7.4	193	19.2	--	8	--	1	--	--	--	--	--	--	--	--	26.6	152	3.39	84.2	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 4 2012	1110	bottom	2.5	6.9	202	16.9	--	--	--	6	0.83	0.112	0.06	0.72	<0.004	0.045	0.89	--	29.4	191	2.85	114	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2012	1200	photic	--	--	--	--	0.8	--	2	1.6	0.8	0.111	0.09	0.69	<0.004	0.048	0.89	17.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2012	1205	top	8	7.5	195	18.7	--	11	--	1	--	--	--	--	--	--	--	--	32.8	232	2.22	148	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2012	1210	bottom	6.5	7.3	193	17.9	--	--	--	5	0.74	0.142	0.09	0.6	<0.004	0.042	0.84	--	35.1	242	2.09	163	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 10 2012	1100	photic	--	--	--	--	1	--	2.5	2	0.72	0.02	0.02	0.7	<0.004	0.037	0.75	16.6	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 10 2012	1105	top	7.5	7.6	194	22.3	--	6.6	--	1	--	--	--	--	--	--	--	--	--	104	--	103	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 10 2012	1110	bottom	1.9	7	196	20.4	--	--	--	6	0.68	0.083	0.09	0.6	<0.004	0.044	0.77	--	--	154	--	232	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 21 2012	1115	photic	--	--	--	--	0.9	--	2.2	1.8	0.77	<0.01	<0.01	<0.77	<0.004	0.039	<0.78	21.8	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 21 2012	1120	top	8.8	8.1	194	22.9	--	6.9	--	1	--	--	--	--	--	--	--	--	6.2	87.7	0.82	107	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 21 2012	1125	bottom	0.2	7	196	19.6	--	--	--	7	0.67	0.026	0.17	0.64	<0.004	0.04	0.84	--	100	229	413	623	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 6 2012	1100	photic	--	--	--	--	1.2	--	2.3	2.4	0.7	<0.01	0.04	<0.7	<0.004	0.037	0.74	9.1	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 6 2012	1105	top	7	7.6	191	25.1	--	4.8	--	1	--	--	--	--	--	--	--	--	<3.2	74.5	1.16	95.8	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 6 2012	1110	bottom	1.9	7.1	202	22.2	--	--	--	6	0.7	<0.01	<0.01	<0.7	<0.004	0.036	<0.71	--	4.5	74.9	0.84	95.6	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 21 2012	1000	photic	--	--	--	--	1.2	--	2.1	2.4	0.75	<0.01	<0.01	<0.75	<0.004	0.037	<0.76	18.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 21 2012	1005	top	9.2	8.8	197	27.2	--	5.5	--	1	--	--	--	--	--	--	--	--	<3.2	62.1	1.16	54.6	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 21 2012	1010	bottom	0.3	7.1	226	21.4	--	--	--	8	1.3	0.425	<0.01	0.84	0.022	0.144	<1.3	--	548	1440	2590	2510	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 5 2012	1030	photic	--	--	--	--	0.6	--	1.5	1.2	0.89	<0.01	<0.01	<0.89	<0.004	0.04	<0.9	63.7	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 5 2012	1035	top	8.3	9.1	198	29.2	--	6.8	--	1	--	--	--	--	--	--	--	--	4.1	85.1	0.97	108	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 5 2012	1040	bottom	0.2	7.2	205	25.3	--	--	--	6	0.88	0.152	<0.01	0.73	<0.004	0.06	<0.89	--	68.3	229	1160	1210	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 18 2012	1030	photic	--	--	--	--	0.7	--	2.2	1.4	0.86	<0.01	<0.01	<0.86	<0.004	0.04	<0.88	36.7	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 18 2012	1035	top	7	8.4	198	29.1	--	8.5	--	1	--	--	--	--	--	--	--	--	<3.2	68.7	0.91	140	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 18 2012	1040	bottom	0.2	7	222	24.5	--	--	--	7	0.87	0.019	<0.01	0.85	<0.004	0.049	<0.88	--	3.7	75.1	85.1	303	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 2 2012	1145	photic	--	--	--	--	0.8	--	1.9	1.6	0.84	<0.01	<0.01	<0.84	<0.004	0.043	<0.85	27.1	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 2 2012	1150	top	5.7	7.7	198	29.8	--	5.8	--	1	--	--	--	--	--	--	--	--	<3.2	79.2	1.07	158	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 2 2012	1155	bottom	0.3	7.2	221	26.1	--	--	--	7	1.3	0.456	<0.01	0.85	<0.004	0.057	<1.3	--	78	242	1760	1760	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 15 2012	1100	photic	--	--	--	--	0.8	--	1.9	1.6	0.86	0.05	<0.01	0.81	<0.004	0.038	<0.87	21.6	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 15 2012	1105	top	6.3	7.5	195	28.4	--	6.6	--	1	--	--	--	--	--	--	--	--	4.6	82.5	0.91	139	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 15 2012	1110	bottom	2.9	7.4	202	28	--	--	--	6	0.85	0.11	0.01	0.74	<0.004	0.041	0.86	--	<3.2	97.5	0.71	152	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 30 2012	1045	photic	--	--	--	--	0.6	--	--	1.2	1	<0.01	<0.01	<1	<0.004	0.053	<1.1	42.8	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 30 2012	1050	top	9.7	9	206	27.6	--	6.1	--	1	--	--	--	--	--	--	--	--	6.7	117	0.48	130	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 30 2012	1055	bottom	0.3	7.1	220	25.6	--	--	--	7.5	1.2	0.386	<0.01	0.84	<0.004	0.058	<1.2	--	3.7	205	461	861	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 12 2012	1015	photic	--	--	--	--	0.7	--	1.5	1.4	0.91	0.039	<0.01	0.87	<0.004	0.046	<0.92	34.7	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 12 2012	1020	top	6.5	7.5	202	26.8	--	6.7	--	1	--	--	--	--	--	--	--	--	9.4	81.7	1.72	184	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 12 2012	1025	bottom	2.5	7.2	203	26.6	--	--	--	7	0.93	0.085	<0.01	0.85	<0.004	0.049	<0.94	--	<3.2	103	0.82	239	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 26 2012	1015	photic	--	--	--	--	0.6	--	1.1	1.2	0.86	0.03	0.02	0.83	<0.004	0.053	0.87	38.8	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 26 2012	1020	top	7.1	7.5	203	23.6	--	8.8	--	1	--	--	--	--	--	--	--	--	6.5	185	1.22	191	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 26 2012	1025	bottom	6.4	7.5	204	23.3	--	--	--	7	0.94	0.061	0.01	0.88	<0.004	0.053	0.96	--	8.3	190	1.44	196	--	--

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 11 2012	945	photic	--	--	--	--	0.6	--	1.2	1.2	0.85	0.077	0.01	0.78	<0.004	0.046	0.86	30.2	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 11 2012	950	top	7	7.4	196	20.1	--	11	--	1	--	--	--	--	--	--	--	--	6.4	194	1.82	161	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 11 2012	955	bottom	6.7	7.4	197	19.9	--	--	--	5	0.85	0.078	0.01	0.77	<0.004	0.047	0.86	--	6.2	188	1.21	152	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 24 2012	1015	photic	--	--	--	--	0.6	--	1.2	1.2	0.9	0.011	<0.01	0.88	<0.004	0.045	<0.91	35.3	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 24 2012	1020	top	7.6	7.5	194	18.6	--	7.4	--	1	--	--	--	--	--	--	--	--	<4	164	1.01	138	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 24 2012	1025	bottom	7.7	7.6	194	18.5	--	--	--	7	0.86	<0.01	<0.01	<0.86	<0.004	0.043	<0.87	--	<4	166	1.21	139	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Nov 7 2012	1000	photic	--	--	--	--	0.6	--	1.3	1.2	0.85	<0.01	<0.01	<0.85	<0.004	0.05	<0.86	35.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Nov 7 2012	1005	top	9.7	7.6	194	13	--	7.8	--	1	--	--	--	--	--	--	--	--	4.8	209	1.59	122	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Nov 7 2012	1010	bottom	9.7	7.6	195	13	--	--	--	6	0.86	<0.01	<0.01	<0.86	<0.004	0.047	<0.87	--	5.2	215	1.78	121	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 3 2013	940	photic	--	--	--	--	0.6	--	1.5	1.2	1	<0.01	<0.01	<1	<0.004	0.053	<1	43.5	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 3 2013	945	top	12.4	8.6	183	11.7	--	12	--	1	--	--	--	--	--	--	--	--	29.3	159	2.21	71.2	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 3 2013	950	bottom	11.7	8.3	187	11.6	--	--	--	6	1	<0.01	0.01	<1	<0.004	0.054	1	--	27.2	161	2.08	74.3	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2013	950	photic	--	--	--	--	0.6	--	1.7	1.2	1	<0.01	<0.01	<1	<0.004	0.052	<1	37.9	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2013	955	top	11.4	9	187	19	--	12	--	1	--	--	--	--	--	--	--	--	23.2	91.2	2.91	39.6	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 16 2013	1000	bottom	3	7.7	193	12.2	--	--	--	8	1.1	0.21	0.02	0.88	<0.004	0.071	1.1	--	29.4	297	85	270	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 30 2013	945	photic	--	--	--	--	1.2	--	3.6	2.4	0.77	0.079	0.02	0.69	<0.004	0.037	0.79	10.3	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 30 2013	950	top	9.2	7.7	185	19.2	--	4.3	--	1	--	--	--	--	--	--	--	--	6.2	74.3	0.66	59.1	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Apr 30 2013	955	bottom	4	7.1	188	18.4	--	--	--	6	0.82	0.101	0.01	0.72	<0.004	0.038	0.83	--	8.2	82.9	3.22	86.8	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 14 2013	1000	photic	--	--	--	--	0.9	--	2.3	1.8	0.78	0.054	0.05	0.72	<0.004	0.037	0.83	16.1	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 14 2013	1005	top	9.3	7.7	183	20	--	6.8	--	1	--	--	--	--	--	--	--	--	11.8	155	0.78	95.2	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 14 2013	1010	bottom	1.5	6.9	191	17.2	--	--	--	7	1.2	0.413	0.05	0.75	<0.004	0.052	1.2	--	28.8	363	213	537	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 28 2013	1300	photic	--	--	--	--	0.8	--	2.1	1.6	0.79	<0.01	<0.01	<0.79	<0.004	0.043	<0.8	24.9	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 28 2013	1305	top	8.9	8.2	183	23.4	--	6.4	--	1	--	--	--	--	--	--	--	--	7.6	117	0.67	113	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	May 28 2013	1310	bottom	3.7	7.4	183	21.7	--	--	--	5	0.75	0.104	0.04	0.65	<0.004	0.039	0.79	--	9.3	184	1.56	219	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 11 2013	1000	photic	--	--	--	--	0.8	--	2	1.6	0.75	<0.01	<0.01	<0.75	<0.004	0.039	<0.76	18	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 11 2013	1005	top	6.4	7.4	173	25.2	--	6.2	--	1	--	--	--	--	--	--	--	--	12.1	101	0.56	119	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 11 2013	1010	bottom	0.3	7.2	189	21.7	--	--	--	8	0.86	0.212	<0.01	0.65	<0.004	0.054	<0.87	--	38.8	248	1040	1240	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 25 2013	1130	photic	--	--	--	--	0.6	--	2.3	1.2	0.72	0.011	<0.01	0.7	<0.004	0.043	<0.73	18.5	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 25 2013	1135	top	6.7	7.4	155	26.8	--	5	--	1	--	--	--	--	--	--	--	--	23.9	150	0.83	89	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jun 25 2013	1140	bottom	0.4	7	157	25.6	--	--	--	5	0.73	0.026	<0.01	0.7	<0.004	0.052	<0.74	--	29.8	214	47	322	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 9 2013	1110	photic	--	--	--	--	0.7	--	1.9	1.4	0.8	<0.01	<0.01	<0.8	<0.004	0.051	<0.81	27.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 9 2013	1115	top	8.1	7.7	135	28.1	--	6.7	--	1	--	--	--	--	--	--	--	--	34.5	121	1.14	48.7	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 9 2013	1120	bottom	0.3	6.7	109	26	--	--	--	6	0.72	0.084	0.01	0.64	<0.004	0.049	0.73	--	136	297	48.9	156	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 23 2013	1145	photic	--	--	--	--	0.8	--	1.9	1.6	0.69	<0.01	<0.01	<0.69	<0.004	0.045	<0.70	23.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 23 2013	1150	top	5.7	7	125	28.7	--	5.4	--	1	--	--	--	--	--	--	--	--	71.2	188	1.97	140	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Jul 23 2013	1155	bottom	0.3	6.7	139	25.6	--	--	--	7	1.3	0.58	<0.01	0.77	0.032	0.107	<1.4	--	830	1420	1840	1850	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 6 2013	1100	photic	--	--	--	--	0.8	--	1.6	1.6	0.71	<0.01	<0.01	<0.71	<0.004	0.047	<0.72	25.2	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 6 2013	1105	top	6.5	7.1	128	28.1	--	8	--	1	--	--	--	--	--	--	--	--	19	115	2.55	158	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 6 2013	1110	bottom	3.2	6.8	129	27.8	--	--	--	5	0.68	0.03	<0.01	0.65	<0.004	0.042	<0.69	--	20.4	128	45.9	243	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 20 2013	1015	photic	--	--	--	--	0.8	--	2.3	1.6	0.82	0.106	<0.01	0.72	<0.004	0.041	<0.83	21.4	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 20 2013	1020	top	5.6	7.2	123	26	--	5.7	--	1	--	--	--	--	--	--	--	--	12.2	142	1.54	154	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Aug 20 2013	1025	bottom	1.4	7	126	25.7	--	--	--	8	1	0.248	<0.01	0.8	<0.004	0.06	<1.1	--	25.2	468	276	473	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 3 2013	1100	photic	--	--	--	--	0.7	--	1.9	1.4	0.85	<0.01	<0.01	<0.85	<0.004	0.044	<0.86	31.6	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 3 2013	1105	top	7.4	7.8	136	27.3	--	4.9	--	1	--	--	--	--	--	--	--	--	<4	97.4	0.84	77.9	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 3 2013	1110	bottom	2.3	7	138	26.8	--	--	--	5	0.86	0.075	<0.01	0.78	<0.004	0.052	<0.87	--	6.7	174	1.17	217	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 17 2013	1120	photic	--	--	--	--	0.8	--	1.9	1.6	0.8	0.069	<0.01	0.73	<0.004	0.046	<0.81	28.1	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 17 2013	1125	top	6.6	7.4	131	25.7	--	7.7	--	1	--	--	--	--	--	--	--	--	17.3	145	11.1	159	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Sep 17 2013	1130	bottom	6.2	7.3	133	25.7	--	--	--	5	0.79	0.086	<0.01	0.71	<0.004	0.048	<0.8	--	15.5	160	1.02	175	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 22 2013	1015	photic	--	--	--	--	0.6	--	1.8	1.2	0.82	<0.01	0.08	<0.82	<0.004	0.046	0.9	36	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 22 2013	1020	top	8.8	7.5	148	19	--	9.8	--	1	--	--	--	--	--	--	--	--	12.2	222	0.3	134	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 22 2013	1025	bottom	8.7	7.6	147	19	--	--	--	4	0.8	<0.01	0.08	<0.8	<0.004	0.052	0.88	--	12.1	217	0.73	132	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 30 2013	1015	photic	--	--	--	--	0.7	--	2.2	1.4	0.73	<0.01	0.04	<0.73	<0.004	0.055	0.77	28.9	--	--	--	--	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 30 2013	1020	top	11.1	8.6	144	16.8	--	6	--	1	--	--	--	--	--	--	--	--	5.8	114	0.35	83.5	--	--
0209781125	JORDAN LAKE NEAR BUOY 8 NEAR BELLS, NC	Oct 30 2013	1025	bottom	10.2	8.3	147	16.4	--	--	--	4	0.75	<0.01	<0.01	<0.75	<0.004	0.041	<0.76	--	<4	136	0.39	91.1	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 4 2012	1145	photic	--	--	--	--	0.9	--	2.6	1.8	--	--	--	--	--	--	--	15.2	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 4 2012	1150	top	9.6	7.9	188	20.5	--	5.9	--	1	--	--	--	--	--	--	--	--	30.3	141	3.62	60.5	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 4 2012	1155	bottom	1.9	6.9	199	16.5	--	--	--	5	0.95	0.266	0.07	0.68	<0.004	0.046	1	--	28.7	337	166	392	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2012	1245	photic	--	--	--	--	0.8	--	2	1.6	0.77	0.1	0.08	0.67	<0.004	0.047	0.85	17.6	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2012	1250	top	8.4	7.5	192	19.2	--	9.4	--	1	--	--	--	--	--	--	--	--	37.6	225	3.13	140	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2012	1255	bottom	7.6	7.5	192	18.7	--	--	--	5	0.76	0.12	0.09	0.64	<0.004	0.053	0.85	--	36.3	252	3.56	170	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 10 2012	1130	photic	--	--	--	--	1.1	--	2.8	2.2	0.73	0.012	0.03	0.72	<0.004	0.034	0.76	17.6	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 10 2012	1135	top	7.8	7.8	192	22.7	--	5	--	1	--	--	--	--	--	--	--	--	6.3	91.6	1.35	78.7	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 10 2012	1140	bottom	5	7.2	193	22.3	--	--	--	5	0.77	0.044	0.05	0.72	<0.004	0.033	0.81	--	4.6	99.8	0.89	100	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 21 2012	1145	photic	--	--	--	--	0.8	--	2.5	1.6	0.72	<0.01	0.01	<0.72	<0.004	0.037	0.73	9.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 21 2012	1150	top	8.4	8	191	23.1	--	5.6	--	1	--	--	--	--	--	--	--	--	10.1	109	0.52	94.8	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 21 2012	1155	bottom	6.3	7.4	193	22.6	--	--	--	5	0.65	<0.01	0.01	<0.65	<0.004	0.034	0.66	--	4.2	116	2.85	111	--	--

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 6 2012	1145	photic	--	--	--	--	0.8	--	2.3	1.6	0.61	<0.01	<0.01	<0.61	<0.004	0.033	<0.62	11.1	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 6 2012	1150	top	6.6	7.4	187	25	--	4.4	--	1	--	--	--	--	--	--	--	--	3.9	95.2	1.08	81.5	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 6 2012	1155	bottom	1.6	7.2	203	21.9	--	--	--	6	0.67	<0.01	<0.01	<0.67	<0.004	0.034	<0.68	--	6.4	86.2	0.73	89.6	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 21 2012	1030	photic	--	--	--	--	1.1	--	3.6	2.2	0.68	<0.01	<0.01	<0.68	<0.004	0.031	<0.69	13.7	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 21 2012	1035	top	8.3	8.8	195	28.2	--	4.9	--	1	--	--	--	--	--	--	--	--	--	52.2	--	43.6	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 21 2012	1040	bottom	2.8	7.3	193	25.2	--	--	--	6	0.66	0.024	<0.01	0.64	<0.004	0.04	<0.67	--	--	184	--	176	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 5 2012	1115	photic	--	--	--	--	0.7	--	2.8	1.4	0.88	<0.01	<0.01	<0.88	<0.004	0.036	<0.89	32.3	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 5 2012	1120	top	8.7	9	195	29.4	--	9.8	--	1	--	--	--	--	--	--	--	--	4.6	76.9	0.99	77.4	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 5 2012	1125	bottom	0.4	7.3	194	27.4	--	--	--	6	0.71	0.022	<0.01	0.69	<0.004	0.037	<0.72	--	<3.2	87.1	0.85	148	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 18 2012	1130	photic	--	--	--	--	1	--	2.4	2	0.85	<0.01	0.01	<0.85	<0.004	0.036	0.86	32.9	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 18 2012	1135	top	8.7	9	196	29.9	--	4.9	--	1	--	--	--	--	--	--	--	--	3.4	45.8	2.92	73.1	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 18 2012	1140	bottom	0.2	7.1	199	27.8	--	--	--	5	0.87	<0.01	<0.01	<0.87	<0.004	0.034	<0.88	--	5.8	52.4	1.44	76.2	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 2 2012	1230	photic	--	--	--	--	0.8	--	2.2	1.6	0.83	<0.01	<0.01	<0.83	<0.004	0.035	<0.84	30.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 2 2012	1235	top	7.4	8.6	197	30.2	--	6.4	--	1	--	--	--	--	--	--	--	--	<3.2	64.8	1.18	70.1	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 2 2012	1240	bottom	0.2	7.1	197	29.1	--	--	--	5	0.83	<0.01	<0.01	<0.83	<0.004	0.036	<0.84	--	<3.2	70.1	0.96	70.7	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 15 2012	1145	photic	--	--	--	--	0.7	--	1.8	1.4	0.82	<0.01	<0.01	<0.82	<0.004	0.04	<0.83	32.1	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 15 2012	1150	top	9.3	8.8	195	29.2	--	5.5	--	1	--	--	--	--	--	--	--	--	4.2	60.8	0.73	84.7	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 15 2012	1155	bottom	0.5	7.2	201	27.7	--	--	--	6	1.1	0.38	<0.01	0.71	<0.004	0.055	<1.1	--	7.4	203	501	711	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 30 2012	1130	photic	--	--	--	--	0.7	--	--	1.4	0.86	<0.01	<0.01	<0.86	<0.004	0.039	<0.87	30.4	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 30 2012	1135	top	9.7	8.9	201	27.7	--	5.4	--	1	--	--	--	--	--	--	--	--	5.8	85.5	1.71	106	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 30 2012	1140	bottom	0.3	7.2	201	25.9	--	--	--	6	0.86	0.178	<0.01	0.68	<0.004	0.045	<0.87	--	5.9	152	2.54	298	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 12 2012	1030	photic	--	--	--	--	0.9	--	1.9	1.8	0.84	0.049	<0.01	0.79	<0.004	0.037	<0.85	22.9	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 12 2012	1035	top	5.6	7.4	197	26.7	--	6.7	--	1	--	--	--	--	--	--	--	--	5.2	72.4	1.09	152	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 12 2012	1040	bottom	5.4	7.4	197	26.5	--	--	--	5	0.79	0.048	<0.01	0.74	<0.004	0.035	<0.8	--	3.7	75.5	1.22	152	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 26 2012	1050	photic	--	--	--	--	0.7	--	1.4	1.4	0.84	<0.01	0.01	<0.84	0.025	0.044	0.85	36.1	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 26 2012	1055	top	9.8	8.6	199	24.2	--	5.9	--	1	--	--	--	--	--	--	--	--	22.8	106	25.2	127	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 26 2012	1100	bottom	6.5	7.7	192	23.7	--	--	--	7	0.93	0.057	<0.01	0.87	<0.004	0.286	<0.94	--	20.7	2570	391	718	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 11 2012	1020	photic	--	--	--	--	0.7	--	1.4	1.4	0.88	0.038	0.01	0.84	<0.004	0.041	0.89	34	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 11 2012	1025	top	7.8	7.5	193	20.5	--	7.2	--	1	--	--	--	--	--	--	--	--	<4	147	0.8	121	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 11 2012	1030	bottom	6	7.2	181	19.7	--	--	--	6	0.93	<0.01	<0.01	<0.93	<0.004	0.046	<0.94	--	14.5	303	25.7	162	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 24 2012	1040	photic	--	--	--	--	0.7	--	1.5	1.4	0.78	0.05	<0.01	0.73	<0.004	0.037	<0.79	33.7	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 24 2012	1045	top	9.7	8.2	192	19.3	--	6.4	--	1	--	--	--	--	--	--	--	--	<4	116	1.13	109	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 24 2012	1050	bottom	6	7.4	193	18.8	--	--	--	6	0.87	0.08	<0.01	0.79	<0.004	0.056	<0.88	--	12.4	315	98.8	276	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Nov 7 2012	1030	photic	--	--	--	--	0.6	--	1.1	1.2	0.9	<0.01	<0.01	<0.9	<0.004	0.044	<0.91	33.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Nov 7 2012	1035	top	9.4	7.6	192	13.3	--	7.3	--	1	--	--	--	--	--	--	--	--	4.9	184	1.2	112	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Nov 7 2012	1040	bottom	9.8	7.7	190	12.8	--	--	--	6	0.8	<0.01	<0.01	<0.8	<0.004	0.044	<0.81	--	<4	186	1.17	110	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 3 2013	1015	photic	--	--	--	--	0.7	--	1.9	1.4	2.7	0.014	<0.01	2.7	<0.004	0.045	<2.7	29.7	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 3 2013	1020	top	12.6	8.6	169	12.9	--	12	--	1	--	--	--	--	--	--	--	--	33.3	170	2.77	57.9	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 3 2013	1025	bottom	9.2	8	176	10.8	--	--	--	6	0.95	0.018	0.04	0.93	<0.004	0.054	0.99	--	23.1	181	3	91.7	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2013	1025	photic	--	--	--	--	0.6	--	1.6	1.2	1.1	<0.01	<0.01	<1.1	<0.004	0.044	<1.1	32.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2013	1030	top	10.9	8.8	182	18.6	--	8.8	--	1	--	--	--	--	--	--	--	--	19.7	83.8	2.65	37	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 16 2013	1035	bottom	4	7.7	180	13.9	--	--	--	6	0.97	0.051	<0.01	0.92	<0.004	0.057	<0.98	--	25.7	205	34.4	143	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 30 2013	1020	photic	--	--	--	--	1.1	--	2.7	2.2	0.77	0.11	0.02	0.66	<0.004	0.034	0.79	12.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 30 2013	1025	top	7.7	7.3	180	18.8	--	4.6	--	1	--	--	--	--	--	--	--	--	8.4	81.2	0.75	60.2	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Apr 30 2013	1030	bottom	0.8	7.2	194	16.1	--	--	--	7	1	0.353	0.02	0.68	<0.004	0.044	1.1	--	19.1	216	395	579	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 14 2013	1045	photic	--	--	--	--	1	--	2.6	2	0.8	0.038	0.04	0.76	<0.004	0.039	0.84	15.7	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 14 2013	1050	top	10	8.2	180	20.6	--	4.4	--	1	--	--	--	--	--	--	--	--	16.6	141	0.79	74.9	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 14 2013	1055	bottom	0.9	7	175	17.5	--	--	--	6	0.83	0.131	0.04	0.7	<0.004	0.042	0.87	--	28.4	216	2	164	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 28 2013	1340	photic	--	--	--	--	0.8	--	2.2	1.6	0.78	<0.01	<0.01	<0.78	<0.004	0.039	<0.79	12.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 28 2013	1345	top	10.4	8.8	174	24.9	--	5.7	--	1	--	--	--	--	--	--	--	--	15.2	112	0.83	80.3	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	May 28 2013	1350	bottom	0.4	7.2	185	20.7	--	--	--	6	0.72	0.145	0.06	0.58	<0.004	0.036	0.79	--	11.6	177	72.1	318	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 11 2013	1100	photic	--	--	--	--	1.1	--	2.4	2.2	0.68	<0.01	<0.01	<0.68	<0.004	0.042	<0.69	19.9	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 11 2013	1105	top	7	7.4	168	25.3	--	5.8	--	1	--	--	--	--	--	--	--	--	24.7	107	0.63	110	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 11 2013	1110	bottom	3.1	7.1	159	24.6	--	--	--	7	0.74	0.055	0.01	0.68	<0.004	0.059	0.75	--	246	642	222	386	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 25 2013	1200	photic	--	--	--	--	0.6	--	2.3	1.2	0.77	<0.01	<0.01	<0.77	<0.004	0.043	<0.78	18.8	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 25 2013	1205	top	8.4	8.2	157	27.8	--	5.3	--	1	--	--	--	--	--	--	--	--	23.5	123	0.77	75.1	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jun 25 2013	1210	bottom	0.4	7	167	25.2	--	--	--	6	0.89	0.143	<0.01	0.74	<0.004	0.059	<0.9	--	233	760	859	775	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 9 2013	1200	photic	--	--	--	--	0.7	--	2.3	1.4	0.77	0.01	<0.01	0.76	<0.004	0.051	<0.78	20.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 9 2013	1205	top	8.9	8.5	141	28.8	--	6.3	--	1	--	--	--	--	--	--	--	--	24.2	99.5	1.25	45.3	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 9 2013	1210	bottom	0.3	6.9	124	25.3	--	--	--	8	1.1	0.386	<0.01	0.7	0.008	0.073	<1.1	--	442	953	1350	1350	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 23 2013	1230	photic	--	--	--	--	0.7	--	1.4	1.4	0.7	<0.01	<0.01	<0.7	<0.004	0.047	<0.71	27.1	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 23 2013	1235	top	7.5	7.5	129	29.5	--	5.8	--	1	--	--	--	--	--	--	--	--	47.4	145	1.56	93.9	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Jul 23 2013	1240	bottom	0.3	6.7	143	26.8	--	--	--	6	0.82	0.098	<0.01	0.72	<0.004	0.064	<0.83	--	88.4	745	908	931	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 6 2013	1125	photic	--	--	--	--	1	--	2.3	2	0.63	<0.01	<0.01	<0.63	<0.004	0.037	<0.64	19	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 6 2013	1130	top	7.6	7.3	129	28.6	--	4.8	--	1	--	--	--	--	--	--	--	--	11	83.9	0.62	67.6	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 6 2013	1135	bottom	0.4	6.8	143	27.3	--	--	--	6	0.7	0.101	<0.01	0.6	<0.004	0.049	<0.71	--	33.3	164	544	629	--	--

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 20 2013	1100	photic	--	--	--	--	0.9	--	2.3	1.8	0.89	0.08	<0.01	0.81	<0.004	0.043	<0.9	33.5	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 20 2013	1105	top	5.6	7.2	123	26.2	--	5.1	--	1	--	--	--	--	--	--	--	--	8.9	136	0.65	152	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Aug 20 2013	1110	bottom	3	6.9	124	25.9	--	--	--	6	0.78	0.121	<0.01	0.66	<0.004	0.034	<0.79	--	11.9	145	0.7	172	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 3 2013	1125	photic	--	--	--	--	0.8	--	2	1.6	0.74	<0.01	<0.01	<0.74	<0.004	0.042	<0.76	27.7	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 3 2013	1130	top	8.8	8.4	134	27.9	--	5.5	--	1	--	--	--	--	--	--	--	--	<4	94.5	0.92	65.5	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 3 2013	1135	bottom	0.3	6.8	140	25.9	--	--	--	6	0.91	0.231	<0.01	0.68	<0.004	0.048	<0.92	--	23.4	182	431	493	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 17 2013	1200	photic	--	--	--	--	0.9	--	1.9	1.8	0.83	0.06	<0.01	0.77	<0.004	0.042	<0.84	28.8	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 17 2013	1205	top	5.9	7.3	129	26	--	5.9	--	1	--	--	--	--	--	--	--	--	6.8	123	0.72	162	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Sep 17 2013	1210	bottom	2.9	7	133	25.7	--	--	--	6	1.1	0.254	<0.01	0.8	<0.004	0.063	<1.1	--	16.5	318	341	710	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 22 2013	1045	photic	--	--	--	--	0.6	--	1.8	1.2	0.78	<0.01	0.1	<0.78	<0.004	0.042	0.87	31.4	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 22 2013	1050	top	8.7	7.5	143	19.2	--	7.2	--	1	--	--	--	--	--	--	--	--	7.1	209	0.74	137	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 22 2013	1055	bottom	8.3	7.5	143	19.2	--	--	--	5	0.79	<0.01	0.09	<0.79	<0.004	0.044	0.87	--	8.1	214	0.82	137	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 30 2013	1040	photic	--	--	--	--	0.7	--	2	1.4	0.8	<0.01	<0.01	<0.8	<0.004	0.038	<0.81	35.4	--	--	--	--	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 30 2013	1045	top	11	8.6	143	16.9	--	6	--	1	--	--	--	--	--	--	--	--	6	115	0.34	78.6	--	--
0209791010	JORDAN LK, WHITE OAK CR ARM BL SR1008 AT BELLS, NC	Oct 30 2013	1050	bottom	9.4	7.9	142	16.5	--	--	--	5	0.81	<0.01	0.01	<0.81	<0.004	0.037	0.82	--	39.7	183	0.85	120	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 4 2012	1230	photic	--	--	--	--	0.8	--	2.5	1.6	0.79	0.056	0.08	0.73	<0.004	0.042	0.87	16	--	--	--	--	<5	11
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 4 2012	1235	top	8.3	7.5	183	19.3	--	7.2	--	1	--	--	--	--	--	--	--	--	21.9	150	3.34	78.6	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 4 2012	1240	bottom	0.6	6.8	208	14.9	--	--	--	8	1	0.325	0.08	0.68	<0.004	0.05	1.1	--	22.7	274	225	483	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2012	1345	photic	--	--	--	--	0.8	--	1.9	1.6	0.81	0.118	0.11	0.7	<0.004	0.044	0.92	11.9	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2012	1350	top	7.6	7.4	192	18.9	--	9.6	--	1	--	--	--	--	--	--	--	--	30.6	226	4.24	162	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2012	1355	bottom	3.4	7.1	197	17.2	--	--	--	8	0.88	0.216	0.08	0.66	<0.004	0.049	0.96	--	44.2	315	83.5	274	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 10 2012	1230	photic	--	--	--	--	1	--	2.6	2	0.78	0.018	0.03	0.76	<0.004	0.038	0.82	16.2	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 10 2012	1235	top	7.9	7.8	193	22.5	--	5.7	--	1	--	--	--	--	--	--	--	--	9.8	91.5	2.44	95.9	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 10 2012	1240	bottom	0.3	6.8	195	18.5	--	--	--	8	0.7	0.08	0.23	0.62	<0.004	0.039	0.93	--	10.7	220	328	603	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 21 2012	1245	photic	--	--	--	--	1	--	2.5	2	0.75	<0.01	0.01	<0.75	<0.004	0.037	0.76	15.2	--	--	--	--	<5	5.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 21 2012	1250	top	9.3	8.5	193	23.9	--	5.7	--	1	--	--	--	--	--	--	--	--	<3.2	76.5	0.98	92.1	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 21 2012	1255	bottom	0.2	7	197	19.2	--	--	--	8	0.72	0.103	0.16	0.62	<0.004	0.046	0.87	--	17.9	324	756	1030	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 6 2012	1215	photic	--	--	--	--	1	--	2.2	2	0.73	<0.01	<0.01	<0.73	<0.004	0.039	<0.74	12.2	--	--	--	--	<5	5.3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 6 2012	1220	top	7.2	7.7	189	25.1	--	5.8	--	1	--	--	--	--	--	--	--	--	4.6	92	2	84.3	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 6 2012	1225	bottom	0.4	7	201	21	--	--	--	8	0.9	0.19	<0.01	0.71	<0.004	0.071	<0.91	--	162	615	1590	1540	<5	5.8
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 21 2012	1115	photic	--	--	--	--	1.3	--	3	2.6	0.7	<0.01	<0.01	<0.7	<0.004	0.034	<0.71	20.2	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 21 2012	1120	top	8.6	8.4	195	27.3	--	6.3	--	1	--	--	--	--	--	--	--	--	<3.2	61	0.68	54.9	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 21 2012	1125	bottom	0.2	7.1	214	21.9	--	--	--	8	0.94	0.111	<0.01	0.83	<0.004	0.069	<0.95	--	59.6	394	1500	2140	<5	3.8
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 5 2012	1200	photic	--	--	--	--	0.7	--	2.1	1.4	0.8	<0.01	<0.01	<0.8	<0.004	0.03	<0.81	32.8	--	--	--	--	<5	3.7
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 5 2012	1205	top	8	8.7	195	28.9	--	6.4	--	1	--	--	--	--	--	--	--	--	<3.2	69.2	0.56	99.7	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 5 2012	1210	bottom	0.3	7.1	208	24.3	--	--	--	7	0.99	0.254	<0.01	0.73	<0.004	0.068	<1	--	376	224	1770	1790	<5	3.9
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 18 2012	1200	photic	--	--	--	--	0.7	--	2.1	1.4	0.84	<0.01	<0.01	<0.84	<0.004	0.035	<0.85	32	--	--	--	--	<5	3.2
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 18 2012	1205	top	5.2	7.7	194	29.3	--	5.3	--	1	--	--	--	--	--	--	--	--	<3.2	65.5	1.42	106	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 18 2012	1210	bottom	0.2	7	219	24.7	--	--	--	7.5	1.6	0.71	<0.01	0.85	0.033	0.103	<1.6	--	908	1090	2630	2460	<5	14
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 2 2012	1315	photic	--	--	--	--	0.6	--	2	1.2	0.74	<0.01	<0.01	<0.74	<0.004	0.033	<0.75	21.4	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 2 2012	1320	top	4.7	7.4	196	29.6	--	5.8	--	1	--	--	--	--	--	--	--	--	3.4	59.5	1.42	159	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 2 2012	1325	bottom	0.2	7	221	24.3	--	--	--	5	1.7	0.781	<0.01	0.89	0.027	0.09	<1.7	--	662	848	2260	2490	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 15 2012	1250	photic	--	--	--	--	0.8	--	1.9	1.6	0.79	0.032	0.01	0.76	<0.004	0.036	0.8	21.7	--	--	--	--	11	3.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 15 2012	1255	top	5.6	7.3	194	28.4	--	8.7	--	1	--	--	--	--	--	--	--	--	4.1	68.8	3.45	113	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 15 2012	1300	bottom	0.5	7.1	229	26	--	--	--	8	1.2	0.408	<0.01	0.75	<0.004	0.056	<1.2	--	6.9	154	372	717	8.8	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 30 2012	1220	photic	--	--	--	--	0.6	--	1.3	1.2	0.9	<0.01	<0.01	<0.9	<0.004	0.048	<0.91	37.5	--	--	--	--	9	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 30 2012	1225	top	9.1	8.8	204	27.7	--	6.1	--	1	--	--	--	--	--	--	--	--	4.7	95.5	0.52	133	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 30 2012	1230	bottom	6.2	7.4	218	25.6	--	--	--	8	1.3	0.548	<0.01	0.76	<0.004	0.056	<1.3	--	24.9	185	1650	1580	6.6	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 12 2012	1105	photic	--	--	--	--	0.8	--	1.3	1.6	0.86	<0.01	<0.01	<0.86	<0.004	0.044	<0.87	30.3	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 12 2012	1110	top	7.1	7.7	199	26.9	--	5.8	--	1	--	--	--	--	--	--	--	--	3.5	65.8	0.89	125	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 12 2012	1115	bottom	0.3	7.1	220	25.8	--	--	--	5	1.1	0.36	<0.01	0.73	<0.004	0.049	<1.1	--	11.2	174	1030	1220	8.7	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 26 2012	1120	photic	--	--	--	--	0.7	--	--	1.4	0.85	<0.01	0.02	<0.85	<0.004	0.044	0.87	34.9	--	--	--	--	8.2	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 26 2012	1125	top	7.9	7.8	199	24.1	--	7.4	--	1	--	--	--	--	--	--	--	--	5.8	136	1.51	176	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 26 2012	1130	bottom	6.4	7.6	201	23.7	--	--	--	8	0.91	0.072	0.01	0.84	<0.004	0.051	0.92	--	9.9	254	65.6	250	8.2	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 11 2012	1115	photic	--	--	--	--	0.6	--	1.2	1.2	0.85	0.038	0.02	0.82	<0.004	0.044	0.87	30.1	--	--	--	--	<5	3.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 11 2012	1120	top	7.5	7.5	195	20.2	--	8.3	--	1	--	--	--	--	--	--	--	--	4.9	174	1.81	147	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 11 2012	1125	bottom	7	7.4	195	20.1	--	--	--	8	0.91	0.068	0.02	0.84	0.033	0.055	0.93	--	6.8	234	22.1	185	<5	4.6
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 24 2012	1115	photic	--	--	--	--	0.6	--	1.3	1.2	0.89	0.028	<0.01	0.86	<0.004	0.042	<0.9	34.9	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 24 2012	1120	top	8.4	7.6	192	19.3	--	7.3	--	1	--	--	--	--	--	--	--	--	6.1	174	1.51	173	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 24 2012	1125	bottom	5.8	7.5	195	18.6	--	--	--	8	0.93	0.096	<0.01	0.84	<0.004	0.056	<0.94	--	12.6	326	99.6	281	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Nov 7 2012	1120	photic	--	--	--	--	0.6	--	1.3	1.2	0.84	<0.01	<0.01	<0.84	<0.004	0.048	<0.85	38.2	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Nov 7 2012	1125	top	9.7	7.7	193	13.2	--	7.4	--	1	--	--	--	--	--	--	--	--	6.2	210	1.93	124	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Nov 7 2012	1130	bottom	9.5	7.7	194	13.1	--	--	--	8	0.89	<0.01	<0.01	<0.89	<0.004	0.049	<0.9	--	6.7	279	7.67	138	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 3 2013	1045	photic	--	--	--	--	0.7	--	1.7	1.4	1	<0.01	<0.01	<1	<0.004	0.053	<1	41.3	--	--	--	--	<5	170
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 3 2013	1050	top	13.1	8.9	182	12.6	--	14	--	1	--	--	--	--	--	--	--	--	17.7	135	2.06	69.3	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 3 2013	1055	bottom	10.3	8	184	11.1	--	--	--	8	0.97	0.029	0.07	0.94	<0.004	0.053	1	--	17.1	186	11.2	98	<5	120

Appendix 3. Analytical results for the environmental samples collected at the Jordan Lake study sites, North Carolina, April 2012 through November 2012 and April 2013 through October 2013.

[B.E., Benjamin Everett; AB, above; US, United States; HWY, Highway; NC, North Carolina; mg/L, milligram per liter; µS/cm, microSiemens per centimeter; C, Celsius; m, meters; %, percent; µg/L, microgram per liter; ng/L, nanograms per liter; <, less than; --, not analyzed for replicate pair; N, nitrogen; P, phosphorus]

Station number	Station name	Date	Sample start time	Sample depth	Dissolved oxygen, mg/L	pH, standard units	Specific Conductance at 25 degrees C, µS/cm	Temperature, water, degrees C	Transparency, Secchi Disc, m	Turbidity, NRTU	Depth to 1% Light, m	Measurement Depth, m	Ammonia + organic N, unfiltered, mg/L as N	Ammonia, filtered, mg/L as N	Nitrate + Nitrite, filtered, mg/L as N	Organic Nitrogen, unfiltered, mg/L as N	Ortho-phosphate, filtered, mg/L as P	Phosphorus, unfiltered, mg/L as P	Total Nitrogen, mg/L	Chlorophyll a, µg/L	Iron, filtered, µg/L	Iron, unfiltered, µg/L	Manganese, filtered, µg/L	Manganese, unfiltered, µg/L	2-Methyl-isoborneol, unfiltered, ng/L	Geosmin, unfiltered, ng/L
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2013	1110	photic	--	--	--	--	0.6	--	1.8	1.2	0.88	<0.01	<0.01	<0.88	<0.004	0.045	<0.89	33.9	--	--	--	--	<5	250
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2013	1115	top	11.2	8.9	182	18.7	--	10	--	1	--	--	--	--	--	--	--	--	21.7	87	2.85	39.1	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 16 2013	1120	bottom	3.9	7.7	190	12.1	--	--	--	8	0.96	0.151	0.04	0.81	<0.004	0.072	1	--	21.8	232	36.5	186	<5	100
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 30 2013	1100	photic	--	--	--	--	1.1	--	2.9	2.2	0.8	0.078	0.02	0.72	<0.004	0.037	0.81	12.6	--	--	--	--	<5	14
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 30 2013	1105	top	9	7.6	182	19.1	--	4.5	--	1	--	--	--	--	--	--	--	--	13.3	74	4.32	58	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Apr 30 2013	1110	bottom	2.5	7	187	16.4	--	--	--	8	0.82	0.167	0.03	0.65	<0.004	0.037	0.84	--	12.8	104	11.5	123	<5	21
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 14 2013	1115	photic	--	--	--	--	1	--	2.4	2	0.81	0.045	0.05	0.77	<0.004	0.044	0.86	18.1	--	--	--	--	<5	4.8
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 14 2013	1120	top	10.3	8.2	183	20.4	--	4.5	--	1	--	--	--	--	--	--	--	--	9.6	118	1.21	86.4	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 14 2013	1125	bottom	2.2	7.2	186	17.2	--	--	--	8	1.1	0.364	0.05	0.69	<0.004	0.048	1.1	--	44.2	412	405	625	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 28 2013	1115	photic	--	--	--	--	0.9	--	2.3	1.8	0.65	<0.01	0.02	<0.65	<0.004	0.038	0.67	18.7	--	--	--	--	<5	5.5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 28 2013	1120	top	8.3	7.6	180	23.1	--	6.2	--	1	--	--	--	--	--	--	--	--	8	89.1	1.21	94.2	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	May 28 2013	1125	bottom	0.4	6.6	197	18.5	--	--	--	8	0.88	0.313	0.05	0.56	<0.004	0.042	0.92	--	15.5	194	740	1010	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 11 2013	1130	photic	--	--	--	--	1	--	2.3	2	0.61	0.01	<0.01	0.6	<0.004	0.035	<0.62	18	--	--	--	--	<5	4.8
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 11 2013	1135	top	6.6	7.4	169	25.2	--	5.8	--	1	--	--	--	--	--	--	--	--	11.4	83.5	0.68	94.6	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 11 2013	1140	bottom	0.4	7.1	190	20.3	--	--	--	9	0.69	0.135	0.01	0.55	<0.004	0.045	0.7	--	34.4	206	473	650	<5	5
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 25 2013	1240	photic	--	--	--	--	0.6	--	2.4	1.2	0.69	<0.01	<0.01	<0.69	<0.004	0.042	<0.7	17.6	--	--	--	--	<5	3.7
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 25 2013	1245	top	7.3	7.6	159	27.3	--	5	--	1	--	--	--	--	--	--	--	--	16.6	114	0.67	81.8	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jun 25 2013	1250	bottom	0.3	7.1	180	23.2	--	--	--	8	1.3	0.578	<0.01	0.73	0.024	0.092	<1.3	--	918	1130	2710	2710	<5	7.4
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 9 2013	1250	photic	--	--	--	--	0.8	--	2.3	1.6	0.7	<0.01	<0.01	<0.7	<0.004	0.041	<0.71	23.7	--	--	--	--	<5	3.1
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 9 2013	1255	top	8	7.8	141	28.3	--	5.5	--	1	--	--	--	--	--	--	--	--	24.7	87.2	1.16	50.1	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 9 2013	1300	bottom	0.3	7	114	25	--	--	--	9	1.2	0.469	<0.01	0.71	0.017	0.093	<1.2	--	477	966	1500	1530	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 23 2013	1305	photic	--	--	--	--	0.7	--	1.5	1.4	0.68	<0.01	<0.01	<0.68	<0.004	0.041	<0.69	21.3	--	--	--	--	<5	4.2
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 23 2013	1310	top	6.8	7.2	132	29.5	--	5.6	--	1	--	--	--	--	--	--	--	--	40.4	131	1.22	96.4	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Jul 23 2013	1315	bottom	0.3	6.7	138	25.6	--	--	--	8	1.2	0.501	<0.01	0.67	0.033	0.093	<1.2	--	913	1210	1600	1550	6	5.3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 6 2013	1210	photic	--	--	--	--	0.8	--	1.8	1.6	0.64	<0.01	<0.01	<0.64	<0.004	0.04	<0.65	20.6	--	--	--	--	<5	4.4
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 6 2013	1215	top	6.1	7.1	129	28.3	--	5.1	--	1	--	--	--	--	--	--	--	--	15.3	101	1.21	137	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 6 2013	1220	bottom	0.3	6.8	156	26.3	--	--	--	8	1.2	0.554	<0.01	0.64	0.027	0.088	<1.2	--	847	1220	1730	1760	<5	10
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 20 2013	1130	photic	--	--	--	--	0.8	--	2.4	1.6	0.91	0.1	<0.01	0.81	<0.004	0.045	<0.92	33.4	--	--	--	--	15	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 20 2013	1135	top	4.4	7.1	124	26.1	--	7	--	1	--	--	--	--	--	--	--	--	12.6	145	3.33	170	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Aug 20 2013	1140	bottom	2.6	6.9	129	25.8	--	--	--	8	0.8	0.188	<0.01	0.62	<0.004	0.037	<0.81	--	18.3	200	139	351	22	6
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 3 2013	1210	photic	--	--	--	--	0.7	--	2	1.4	0.83	<0.01	<0.01	<0.83	<0.004	0.041	<0.84	32.4	--	--	--	--	24	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 3 2013	1215	top	6.8	7.5	134	27.5	--	5.2	--	1	--	--	--	--	--	--	--	--	<4	118	0.87	76.6	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 3 2013	1220	bottom	0.4	6.9	151	25.4	--	--	--	8	1.2	0.472	<0.01	0.75	0.007	0.077	<1.2	--	196	557	1320	1290	49	3.9
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 17 2013	1230	photic	--	--	--	--	0.8	--	1.9	1.6	0.84	0.04	<0.01	0.8	<0.004	0.044	<0.85	29.3	--	--	--	--	17	6.1
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 17 2013	1235	top	7.1	7.5	128	26.2	--	8.2	--	1	--	--	--	--	--	--	--	--	8.8	129	1.05	128	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Sep 17 2013	1240	bottom	6.7	7.4	130	25.5	--	--	--	8	0.82	0.065	<0.01	0.76	<0.004	0.047	<0.83	--	12.6	210	8.85	159	18	4.2
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 22 2013	1115	photic	--	--	--	--	0.6	--	1.8	1.2	0.75	<0.01	0.12	<0.75	<0.004	0.041	0.87	29.3	--	--	--	--	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 22 2013	1120	top	8.6	7.4	143	19.2	--	7.4	--	1	--	--	--	--	--	--	--	--	4.9	190	0.28	130	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 22 2013	1125	bottom	7.9	7.4	145	19.1	--	--	--	7	0.77	0.022	0.12	0.75	<0.004	0.045	0.89	--	11.1	260	9.44	168	<5	<3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 30 2013	1115	photic	--	--	--	--	0.7	--	1.9	1.4	0.78	0.036	0.08	0.74	<0.004	0.047	0.85	29.2	--	--	--	--	<5	3
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 30 2013	1120	top	8.5	7.6	143	17.2	--	5.2	--	1	--	--	--	--	--	--	--	--	<4	148	0.26	101	--	--
0209799150	B.E. JORDAN LAKE AB US HWY 64 AT WILSONVILLE, NC	Oct 30 2013	1125	bottom	7	7.5	149	16.5	--	--	--	7	0.88	0.077	0.01	0.81	<0.004	0.059	0.89	--	9	291	7.27	179	<5	<3