LAKE & RESERVOIR ASSESSMENTS
BROAD RIVER BASIN

Lake Adger

Intensive Survey Branch
Water Sciences Section
Division of Environmental Quality
February 18, 2022

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GLOSSARY

Algae	Small aquatic plants that occur as single cells, colonies, or filaments. May also be referred to as phytoplankton, although phytoplankton are a subset of algae.
Algal biovolume	The volume of all living algae in a unit area at a given point in time. To determine biovolume, individual cells in a known amount of sample are counted. Cells are measured to obtain their cell volume, which is used in calculating biovolume.
Algal density	The density of algae based on the number of units (single cells, filaments and/or colonies) present in a milliliter of water. The severity of an algae bloom is determined by the algal density as follows: Mild bloom = 10,000 to 20,000 units/ml Moderate bloom = 20,000 to 30,000 units/ml Severe bloom = 30,000 to 100,000 units/ml Extreme bloom = Greater than 100,000 units/ml
Algal Growth Potential Test (AGPT)	A test to determine the nutrient that is the most limiting to the growth of algae in a body of water. The sample water is split such that one sub-sample is given additional nitrogen, another is given phosphorus, a third may be given a combination of nitrogen and phosphorus, and one sub-sample is not treated and acts as the control. A specific species of algae is added to each sub-sample and is allowed to grow for a given period of time. The dry weights of algae in each sub-sample and the control are then measured to determine the rate of productivity in each treatment. The treatment (nitrogen or phosphorus) with the greatest algal productivity is said to be the limiting nutrient of the sample source. If the control sample has an algal dry weight greater than 5 mg/L, the source water is considered to be unlimited for either nitrogen or phosphorus.
Centric diatom	Diatoms are photosynthetic algae that have a siliceous skeleton (frustule) and are found in almost every aquatic environment including fresh and marine waters, soils, in fact almost anywhere moist. Centric diatoms are circular in shape and are often found in the water column.
Chlorophyll *a*	Chlorophyll *a* is an algal pigment that is used as an approximate measure of algal biomass. The concentration of chlorophyll *a* is used in the calculation of the NCTSI, and the value listed is a lake-wide average from all sampling locations.
Clinograde	In productive lakes where oxygen levels drop to zero in the lower waters near the bottom, the graphed changes in oxygen concentration from the surface to the lake bottom produces a curve known as clinograde curve.
Coccoid	Round or spherical shaped cell.
Conductivity	This is a measure of the ability of water to conduct an electrical current. This measure increases as water becomes more mineralized.
Dissolved oxygen	The range of surface concentrations found at the sampling locations.
Dissolved oxygen saturation	The capacity of water to absorb oxygen gas. Often expressed as a percentage, the amount of oxygen that can dissolved into water will change depending on a number of parameters, the most important being temperature. Dissolved oxygen saturation is inversely proportion to temperature, that is, as temperature increases, water's capacity for oxygen will decrease, and vice versa.
Eutrophic	Describes a lake with elevated biological productivity and low water transparency.

Eutrophication	The process of physical, chemical, and biological changes in a lake associated with the presence of one or more of the following: excessive nutrients, organic matter, silt enrichment and sedimentation.
Limiting nutrient	The plant nutrient present in lowest concentration relative to need limits growth such that addition of the limiting nutrient will stimulate additional growth. In north temperate lakes, phosphorus (P) is commonly the limiting nutrient for algal growth.
Manganese	A naturally occurring metal commonly found in soils and organic matter. As a trace nutrient, manganese is essential to all forms of biological life. Manganese in lakes is released from bottom sediments and enters the water column when the oxygen concentration in the water near the lake bottom is extremely low or absent. Manganese in lake water may cause taste and odor problems in drinking water and require additional treatment of the raw water at water treatment facilities to alleviate this problem.
Mesotrophic	Describes a lake with moderate biological productivity and water transparency.
NCTSI	North Carolina Trophic State Index was specifically developed for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NRCD 1982). Values for total organic nitrogen, total phosphorus, chlorophyll *a* and Secchi depth are used to calculate a numeric score representing the lake's degree of biological productivity.
Oligotrophic	Describes a lake with low biological productivity and high water transparency.
pH	The range of surface pH readings found at the sampling locations. This value is used to express the relative acidity or alkalinity of water.
Photic zone	The portion of the water column in which there is sufficient light for algal growth. DWQ considers 2 times the Secchi depth as depicting the photic zone.
Secchi depth	This is a measure of water transparency expressed in meters. This parameter is used in the calculation of the NCTSI value for the lake. The depth listed is an average value from all sampling locations in the lake.
Temperature	The range of surface temperatures found at the sampling locations.
Total Kjeldahl nitrogen	The sum of organic nitrogen and ammonia in a water body. High measurements of TKN typically results from sewage and manure discharges in water bodies.
Total organic Nitrogen (TON)	Total Organic Nitrogen (TON) can represent a major reservoir of nitrogen in aquatic systems during summer months. Similar to phosphorus, this concentration can be related to lake productivity and is used in the calculation of the NCTSI. The concentration listed is a lake-wide average from all sampling stations and is calculated by subtracting Ammonia concentrations from TKN concentrations.
Total phosphorus (TP)	Total phosphorus (TP) includes all forms of phosphorus that occur in water. This nutrient is essential for the growth of aquatic plants and is often the nutrient that limits the growth of phytoplankton. It is used to calculate the NCTSI. The concentration listed is a lake-wide average from all sampling stations.
Trophic state	This is a relative description of the biological productivity of a lake based on the calculated NCTSI value. Trophic states may range from extremely productive (Hypereutrophic) to very low productivity (Oligotrophic).
Turbidity	A measure of the ability of light to pass through a volume of water. Turbidity may be influenced by suspended sediment and/or algae in the water.
Watershed	A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Overview

The Broad River Basin encompasses a 1,506 square mile watershed drained by 1,452 miles of streams. The three major tributaries to the Broad River are the Green, the Second Broad, and the First Broad Rivers. The headwaters of the Broad River and its major tributaries are located within the Mountains and flow towards the Foothills before entering the Piedmont ecoregion southeast and east of Lake Lure. From there, the Broad River flows through Rutherford and Cleveland counties, then into South Carolina. The basin encompasses most of Cleveland, Polk and Rutherford counties, and small portions of Buncombe, Henderson, Lincoln, and Gaston counties. Larger municipalities include the towns and cities of Forest City, Kings Mountain, Lake Lure, Rutherfordton, Shelby and Spindale. Many of these municipalities are concentrated along the US 74 corridor between the cities of Lake Lure and King's Mountain. Approximately one-half of the basin consists of forests and widespread agriculture while the other half is urbanized.

The Broad River (Rocky Broad River) originates upstream of Lake Lure. Flat, Hickory, and Reedypatch Creeks are the largest tributaries above the lake. Buffalo Creek forms a major arm of the lake and Cove Creek is a large tributary to the Broad River below the lake. Land use within the lake's watershed is predominantly forested with some urban and agricultural uses. The headwater reaches of the Green River are in Henderson County. The Green has been impounded at two locations to form Lakes Summit and Adger. Tributary streams are often high gradient and are capable of supporting trout populations. Apple orchards are a significant land use in upper reaches of many tributary catchments, including the Hungry River. As the topography flattens, the lower reaches of many catchments are farmed. The First Broad River originates in Rutherford County and flows into the Broad River in Cleveland County, just above the South Carolina border. This geographic area is a transitional zone between ecoregions, with some streams exhibiting Mountain characteristics while other streams are more Piedmont in nature.

A statewide fish consumption advisory from the North Carolina Department of Health and Human Resources, Division of Public Health is in place due to mercury contamination (http://epi.publichealth.nc.gov/oee/programs/fish.html) Fish such as blackfish (bowfin), largemouth bass and chained pickerel (jack fish) have been found to have high mercury levels.

Assessment Methodology

For this report, data from January 1, 2017 through December 31, 2021 were reviewed. Lake monitoring and sample collection activities performed by DWR field staff are in accordance with the Intensive Survey Unit Standard Operating Procedures Manual (http://portal.ncdenr.org/c/document_library/get_file?uuid=522a90a4-b593-426f-8c11-21a35569dfd8&groupId=38364) An interactive map of the state showing the locations of lake sites sampled by DWR may be found at http://www.arcgis.com/home/webmap/viewer.html?webmap=9dbc8edafb7743a9b7ef3f6fed5c4db0&extent=-87.8069,29.9342,-71.5801,38.7611.

All lakes were sampled during the growing season from May through September. Data were assessed for excursions of the state's Class C water quality standards for chlorophyll *a*, pH, dissolved oxygen, water temperature, turbidity, and surface metals. Other parameters discussed in this report include secchi depth and percent dissolved oxygen saturation. Secchi depth provides a measure of water clarity and is used in calculating the trophic or nutrient enriched status of a lake. Percent dissolved oxygen saturation gives information on the amount of dissolved oxygen in the water column and may be increased by photosynthesis or depressed by oxygen-consuming decomposition.

For algae collection and assessment, water samples are collected from the photic zone, preserved in the field and taken concurrently with chemical and physical parameters. Samples were quantitatively analyzed to determine assemblage structure, density (units/ml) and biovolume (m^3/mm^3). Results of algae analysis for the lakes sampled in the Broad River Basin are provided in Appendix B. Brief discussions on the ecological implications of each dominant lake algal group is provided in Appendix C.

For the purpose of reporting, algal blooms were determined by the measurement of unit density (units/ml). Unit density is a quantitative measurement of the number of filaments, colonies or single celled taxa in a waterbody. Blooms are considered mild if they are between 10,000 and 20,000 units/ml. Moderate blooms are those between 20,000 and 30,000 units/ml. Severe blooms are between 30,000 and 100,000 units/ml and extreme blooms are those 100,000 units/ml or greater.

An algal group is considered dominant when it comprises 40% or more of the total unit density or total biovolume. A genus is considered dominant when it comprises 30% or more of the total unit density or total biovolume.

Quality Assurance of Field and Laboratory Lakes Data

Data collected in the field via multiparameter water quality meters are uploaded into the Labworks® Database within five days of the sampling date.

Chemistry data from the DWR Water Quality Laboratory are uploaded into Labworks®. If there are data entry mistakes, possible equipment, sampling, and/or analysis errors, these are investigated and corrected, if possible. Chemistry results received from the laboratory that are given a qualification code are entered along with the assigned laboratory code.

Information regarding the WSS Chemistry Laboratory Quality Assurance Program is available on the ISB website (https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/microbiology-inorganics-branch/methods-pqls-qa).

Weather Overview for Summer 2021

Limited rainfall resulted in one of the driest Mays in recent years. The National Centers for Environmental Information (NCEI) rated the month at the state's 13th driest Mays since 1895. Preliminary rainfall totals for the state was 2.19 inches, or just 55% of the long-term state average rainfall for May. A cold front crossed the state during the Memorial Day weekend and brought hit-or-miss rainfall. The statewide average temperature was 65.9°F which was seasonable for May.

While May, statewide, was dry, June turned out to be the 20th wettest out of the past 127 years with an average state measurement of 6.04 inches of rain... However, the rain fall pattern across the state exhibited extremes from east to west. The first two weeks of June had heavy rains across the eastern half of the state. More rain came to the eastern North Carolina in the form of the tropical storm strength remnants of Hurricane Claudette on June 20-21. The Broad River Basin in the southwestern portion of the state remained dry in June with approximately 50% of its normal June rainfall. The statewide average temperature in June was 73.6°F, which was seasonable for June.

Seasonable summer temperatures continued through July, with a statewide average at 76.8°F. Tropical Storm Elsa tracked through the Coastal Plain region of the state on July 8, 2021. Dry conditions continued in the southern Yadkin-Pee Dee River Basin in July. Scattered thunder storms brought rain to the southern Broad River Basin in July. The warmest weather of the summer arrived in August with the statewide temperature average for the month at 77.8°F. The statewide precipitation for August was 5.94 inches. In the middle of the month, the remnants of Tropical Storm Fred crossed the Mountains and brought significant rain to parts of the Broad River Basin.

September was slightly warmer than usual, with three weeks of warm weather followed by a late month cooldown. The state average temperature for this month was 71.0°F. September was generally dry with the statewide average precipitation at 2.99 inches, or the 39th driest September since 1895. Rain returned on September 21st due to a cold front from the west and a stalled boundary to the south.

LAKE & RESERVOIR ASSESSMENTS

HUC 03050105

Lake Lure

Ambient Lakes Program Name	Lake Lure		
Trophic Status (NC TSI)	No Score		
Mean Depth (meters)	20.0		
Volume ($10^6 m^3$)	12.14		
Watershed Area (mi^2)	89.6		
Classification	B; Tr		
Stations	BRD001C	BRD001D1	BRD001F
Number of Times Sampled	5	5	5

DWR field staff monitored Lake Lure five times in 2021. Secchi depths were greater than a meter, ranging from 1.7 to 3.5 meters (Appendix A). Surface dissolved oxygen ranged from 8.3 to 10.3 mg/L and surface pH values ranged from 5.7 to 7.9 s.u. Surface conductivity in Lake Lure ranged from 32 to 38 μmhos/cm.

In 2021, total phosphorus concentrations in Lake Lure ranged from <0.02 to 0.02 mg/L and NH_3 ranged from <0.02 to 0.03 mg/L. The concentration of NO_2+NO_3 ranged from <0.02 to 0.04 mg/L. Chlorophyll *a* in Lake Lure (nine values) ranged from 5.2 to 21.0 μg/L. Turbidity values were low, ranging from 1.1 to 4.6 NTUs.

Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake in 2021. Based on previous DWR lake monitoring, the NCTSI scores for Lake Lure determined that Lake Lure has been oligotrophic (exhibited low biological productivity) since 1981 when it was first monitored by DWR field staff.

Lake Adger

Ambient Lakes Program Name	Lake Adger		
Trophic Status (NC TSI)	No Score		
Mean Depth (meters)	8.0		
Volume ($10^6 m^3$)	14.40		
Watershed Area (mi^2)	906.5		
Classification	C		
Stations	BRD007J	BRD007L	BRD007P
Number of Times Sampled	5	5	5

Lake Adger dam constructed in 1925 created a 460-acre impoundment located in the mountains of southwestern North Carolina. The maximum depth of Lake Adger is 22 meters and the average retention time is 21 days. The Green River is the primary tributary to this reservoir. Fishing and boating are common recreational activities at Lake Adger. In June 2008, Polk County agreed to purchase the reservoir, water and dam from Duke Energy, the previous owner. Northbrook Power Management will continue to operate the hydropower facility as a part of this purchase agreement.

Lake Adger was sampled five times from May through September 2021by DWR field staff. Secchi depths ranged from 0.9 to 2.8 meters and surface dissolved oxygen ranged from 8.3 to 10.3 mg/L (Appendix A). Surface pH in Lake Adger ranged from 6.8 to 8.1 s.u. and surface conductivity ranged from 34 to 38 µmhos/cm.

Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake in 2021. Historically, Lake Adger has been oligotrophic (exhibited low biological productivity) since it was first monitored by DWR in 1989.

Kings Mountain Reservoir

Ambient Lakes Program Name	Kings Mountain Reservoir			
Trophic Status (NC TSI)	No Score			
Mean Depth (meters)	14.0			
Volume ($10^6 m^3$)	56.80			
Watershed Area (mi^2)	65.3			
Classification	WS-III; CA			
Stations	BRD056C	BRD056E	BRD056G	BRD056J
Number of Times Sampled	5	5	5	5

Kings Mountain Reservoir (also known as Moss Lake) is the water supply for the City of Kings Mountain. The reservoir, built in 1963, has a maximum depth of 24 meters. Major tributaries include Buffalo Creek and White Oak Creek. The watershed consists of rolling hills and rural land with approximately 50 to 70 percent of the shoreline developed.

This reservoir was monitored by DWR staff monthly from May through September 2021. Secchi depths ranged from 0.8 to 2.2 meters and surface dissolved oxygen ranged from 7.7 to 10.0 mg/L (Appendix A). Surface pH values in this reservoir ranged from 7.2 to 8.6 s.u. and surface conductivity ranged from 55 to 66 μmhos/cm.

Total phosphorus concentrations in Kings Mountain Reservoir were low, ranging from <0.02 to 0.02 mg/L. The values for NH_3 were consistently below the DWR laboratory detection level of <0.02 mg/L and NO_2+NO_3 ranged from <0.02 to 0.50 mg/L. Chlorophyll *a* values ranged from 7.1 to 16.0 μg/L and turbidity ranged from 1.6 to 3.9 NTUs,

Water samples collected on September 8, 2021 from each of the two lake sampling sites were sent to the EPA Region IV chemistry laboratory in Athens, GA for an Algal Growth Potential Test. The results of that test determined that nuisance algal growth in Kings Mountain Reservoir was limited by the nutrient, phosphorus (Table 1).

Table 1. Algal Growth Potential Test Results for Kings Mountain Reservoir, September 8, 2021.

Algal Growth Potential Test Results

Kings Mountain Reservoir

September 8, 2021

Station	Maximum Standing Crop, Dry Weight (mg/L) Control	C+N	C+P	Limiting Nutrient
BRD056C	0.67	0.32	1.05	Phosphorus
BRD056E	0.58	0.23	1.79	Phosphorus
BRD056G	0.61	0.27	0.91	Phosphorus
BRD056J	0.26	0.19	0.74	Phosphorus

Freshwater AGPT using *Selenastrum capricornutum* as test alga

C+N = Control + 1.0 mg/L Nitrate-N

C+P = Control + 0.05 mg/L Phosphate-P

Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake in 2021. Based on previous DWR lake monitoring, the NCTSI scores for Kings Mountain Reservoir indicated that the lake ranged from oligotrophic to eutrophic (elevated biological productivity) since monitoring began in 1981.

Appendix A - Broad River Basin Lakes Data
October 1, 2011 through September 31, 2015

Lake	Date	Sampling Station	DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Secchi Depth meters	Percent SAT	TP mg/L	TKN mg/L	NH3 mg/L	NOx mg/L	TN mg/L	TON mg/L	TIN mg/L	Chla µg/L	Total Solids mg/L	Total Suspended Solids mg/L	Turbidity NTU	Hardness mg/L
SURFACE PHYSICAL DATA									PHOTIC ZONE DATA											
HUC 03050105																				
LAKE LURE	May 12, 2015	BRD001C	9.8	23.8	7.9	35	2.0	116.0%	0.02	0.27	0.02	0.03	0.30	0.25	0.05		40	<6.2	7.4	
	May 12, 2015	BRD001D1	9.3	24.4	7.7	35	3.3	111.3%	<0.02	0.27	0.02	<0.02	0.28	0.25	0.03		36	<6.2	3.3	
	May 12, 2015	BRD001F	9.1	24.7	7.7	34	2.4	109.6%	<0.02	0.24	0.02	<0.02	0.25	0.22	0.03		34	<6.2	2.2	
	June 16, 2015	BRD001C	8.3	26.9	7.2	38	2.0	104.0%	0.02	0.26	0.02	<0.02	0.27	0.24	0.03	7.2	50	<6.2	2.5	
	June 16, 2015	BRD001D1	8.1	27.7	7.5	37	3.0	103.0%	<0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	5.5	49	<6.2	1.6	
	June 16, 2015	BRD001F	7.7	28.3	7.4	37	3.0	98.9%	<0.02	0.20	0.02	<0.02	0.21	0.18	0.03	4.4	51	<6.2	1.2	
	July 21, 2015	BRD001C	7.8	28.3	7.5	39	1.9	100.2%	0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	9.8	52	<6.2	1.3	
	July 21, 2015	BRD001D1	7.8	28.4	7.3	38	3.1	100.4%	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	5.2	50	<6.2	1.2	
	July 21, 2015	BRD001F	7.7	28.5	7.3	38	3.0	99.3%	0.02	<0.20	0.02	<0.02	0.11	0.08	0.03	4.8	49	<6.2	<1.0	
	August 19, 2015	BRD001C	8.1	27.1	7.4	40	2.0	101.9%	0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	11.0	36	<6.2	1.9	
	August 19, 2015	BRD001D1					2.4		<0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	6.2	34	<6.2	1.9	
	August 19, 2015	BRD001F	8.0	27.2	7.7	39	2.2	100.8%	<0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	5.7	33	<6.2	1.7	
	September 16, 2015	BRD001C	8.6	23.2	7.7	39	1.9	100.7%	0.01	0.31	<0.02	<0.02	0.32	0.30	0.02	10.0	46	<6.2	1.1	
	September 16, 2015	BRD001D1	8.4	23.5	7.7	39	1.9	98.9%	0.02	0.28	<0.02	<0.02	0.29	0.27	0.02	9.1	45	<6.2	<1.0	
	September 16, 2015	BRD001F	8.6	23.5	7.9	40	1.9	101.2%	0.02	0.27	<0.02	<0.02	0.28	0.26	0.02	8.6	40	<6.2	1.1	
LAKE ADGER	May 12, 2015	BRD007J	9.8	24.8	7.7	35	1.2	118.2%	<0.02	0.22	0.03	0.09	0.31	0.19	0.12		39	<6.2	6.2	
	May 12, 2015	BRD007L	9.4	25.5	7.6	34	2.0	114.8%	<0.02	0.20	0.02	0.09	0.29	0.18	0.11		32	<6.2	4.2	
	May 12, 2015	BRD007P	8.7	24.6	7.5	34	2.8	104.5%	<0.02	0.20	0.02	0.08	0.28	0.18	0.10		28	<6.2	2.0	
	June 16, 2015	BRD007J	8.4	27.2	7.3	36	1.2	105.8%	<0.02	0.26	0.02	0.09	0.35	0.24	0.11	4.2	53	6.3	4.2	
	June 16, 2015	BRD007L	8.6	29.2	8.2	37	1.8	112.2%	0.02	0.21	0.02	0.05	0.26	0.19	0.07	6.5	50	<6.2	1.1	
	June 16, 2015	BRD007P	8.3	30.0	8.1	38	2.4	109.8%	<0.02	0.20	0.02	0.04	0.24	0.18	0.06	5.3	50	<6.2	1.5	
	July 21, 2015	BRD007J	8.2	27.8	7.5	40	0.8	104.4%	0.04	0.29	0.02	<0.02	0.30	0.27	0.03	12.0	54	<6.2	3.2	
	July 21, 2015	BRD007L	8.8	29.4	8.7	39	1.4	115.3%	0.02	0.27	<0.02	<0.02	0.28	0.26	0.02	9.3	54	<6.2	2.7	
	July 21, 2015	BRD007P	8.5	29.5	8.6	38	1.6	111.5%	0.02	0.25	<0.02	<0.02	0.26	0.24	0.02	6.9	52	<6.2	1.8	
	August 19, 2015	BRD007J	7.1	27.5	7.0	40	1.3	89.9%	0.03	0.32	0.02	<0.02	0.33	0.31	0.02	8.0	44	<6.2	5.1	
	August 19, 2015	BRD007L	6.9	27.7	7.1	40	1.8	87.7%	0.02	0.27	<0.02	<0.02	0.28	0.26	0.02	8.8	35	<6.2	2.4	
	August 19, 2015	BRD007P	6.6	27.7	7.0	40	1.9	83.9%	<0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	7.9	33	<6.2	1.8	
	September 16, 2015	BRD007J	8.2	24.0	7.0	41	0.9	97.4%	0.03	0.31	0.01	0.01	0.32	0.30	0.02	13.0	50	8.0	2.7	
	September 16, 2015	BRD007L	7.2	24.1	6.8	41	1.5	85.7%	0.02	0.29	0.01	0.01	0.30	0.28	0.02	9.3	43	<6.2	2.2	
	September 16, 2015	BRD007P	5.9	24.3	6.6	41	1.5	70.5%	<0.02	0.30	0.04	0.01	0.31	0.26	0.05	8.5	39	<6.2	1.3	
KINGS MOUNTAIN RESERVOIR	May 13, 2015	BRD056C	10.7	25.3	9.2	64	1.1	130.2%	0.02	0.45	0.02	0.44	0.89	0.43	0.46	19.0	54	<6.2	5.5	
	May 13, 2015	BRD056E	10.1	25.3	9.1	63	1.0	122.9%	0.02	0.44	0.02	0.41	0.85	0.42	0.43	14.0	48	<6.2	5.8	
	May 13, 2015	BRD056G	10.1	25.0	9.1	62	1.1	122.3%	0.02	0.43	0.02	0.41	0.84	0.41	0.43	15.0	53		5.4	
	May 13, 2015	BRD056J	10.2	24.5	9.1	62	1.1	122.3%	0.02	0.62	0.02	0.40	1.02	0.60	0.42	15.0	47	<6.2	5.2	38.0
	June 15, 2015	BRD056C	8.1	30.4	8.5	63	1.7	107.9%	<0.02	0.30	0.02	0.33	0.63	0.28	0.35	3.9	69	<6.2	2.5	
	June 15, 2015	BRD056E	7.7	31.1	8.3	63	1.2	103.8%	0.02	0.36	0.02	0.29	0.65	0.34	0.31	4.1	65	<6.2	2.0	
	June 15, 2015	BRD056G	7.7	30.2	8.1	63	1.6	102.3%	<0.02	0.28	0.02	0.34	0.62	0.26	0.36	3.1	61	<6.2	2.4	
	June 15, 2015	BRD056J	7.9	30.2	8.1	62	1.8	104.9%	<0.02	0.32	0.02	0.36	0.68	0.30	0.38	2.1	67	<6.2	<1.0	17.0
	July 20, 2015	BRD056C	8.6	30.9	9.2	65	1.2	115.6%	0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	13.0	68	<6.2	1.6	
	July 20, 2015	BRD056E	8.6	31.3	9.2	65	1.1	116.4%	0.02	0.40	0.02	<0.02	0.41	0.38	0.03	13.0	69	<6.2	1.8	
	July 20, 2015	BRD056G					1.3		0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	11.0	67	<6.2	2.3	
	July 20, 2015	BRD056J					1.4		0.02	0.42	0.02	<0.02	0.45	0.40	0.05	9.6	67	<6.2	1.6	20.0
	August 18, 2015	BRD056C	7.9	29.0	8.4	66	1.5	102.7%	<0.02	0.35	<0.02	<0.02	0.36	0.34	0.02	9.4	46	<6.2	3.0	
	August 18, 2015	BRD056E	7.4	29.2	8.1	65	1.5	96.6%	0.02	0.37	<0.02	<0.02	0.38	0.36	0.02	9.9	50	<6.2	3.7	
	August 18, 2015	BRD056G	7.5	28.8	8.1	65	1.5	97.2%	<0.02	0.33	<0.02	<0.02	0.34	0.32	0.02	12.0	46	<6.2	3.1	
	August 18, 2015	BRD056J	7.5	28.5	8.2	65	1.5	96.7%	0.02	0.35	<0.02	<0.02	0.36	0.34	0.02	9.2	50	<6.2	3.0	19.0
	September 15, 2015	BRD056C	6.7	25.8	7.3	65	1.7	82.3%	0.02	0.34	0.01	0.03	0.37	0.33	0.04	9.6	53	<6.2	2.0	
	September 15, 2015	BRD056E	7.2	25.5	7.4	64	1.4	88.0%	0.02	0.39	0.01	0.01	0.40	0.38	0.02	5.8	53	<6.2	2.3	
	September 15, 2015	BRD056G	7.4	25.5	7.6	64	1.7	90.4%	0.02	0.40	0.01	0.01	0.41	0.39	0.02	6.8	55	<6.2	1.3	
	September 15, 2015	BRD056J	7.2	25.6	7.4	64	1.8	88.1%	0.02	0.43	0.01	0.01	0.44	0.42	0.02	7.8	56	<6.2	<1.0	20.0

Appendix A - Broad River Basin Lakes Data
January 1, 2016 through December 31, 2021

Lake	Date	Sampling Station	DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Secchi Depth meters	Percent SAT	TP mg/L	TKN mg/L	NH3 mg/L	NOx mg/L	TN mg/L	TON mg/L	TIN mg/L	Chla µg/L	Total Solids mg/L	Total Suspended Solids mg/L	Turbidity NTU	Hardness mg/L
	SURFACE PHYSICAL DATA								PHOTIC ZONE DATA											
LAKE LURE	Septembert 29, 2021	BRD001C	8.4	21.8	6.7	35	2.4	98.8%	<0.02		<0.02	<0.02			0.02	6.6	38		1,5	
	Septembert 29, 2021	BRD001D1	8.3	21.9	6.8	35	3.5	97.3%	<0.02		<0.02	<0.02			0.02	6.3	43		1.4	
	Septembert 29, 2021	BRD001F	8.3	22.4	6.5	35	3.5	98.3%	<0.02		<0.02	<0.02			0.02	5.2	39		1.6	
	September 9, 2021	BRD001C	8.7	26.0	7.6	34	1.7	111.7%	0.02		<0.02	<0.02			0.02	14.0	40		2.8	
	September 9, 2021	BRD001D1	8.7	26.0	7.8	32	2.7	111.3%	<0.02		<0.02	<0.02			0.02	11.0	39		1.9	
	September 9, 2021	BRD001F	8.8	26.0	7.9	32	2.7	112.3%	<0.02		<0.02	<0.02			0.02	21.0	33		1.9	
	July 21, 2021	BRD001C	8.6	26.7	7.1	38	1.4	111.1%	0.02		<0.02	<0.02			0.02	15.0	43	<6.2	3.2	
	July 21, 2021	BRD001D1	8.7	27.2	7.2	38	1.9	113.4%	<0.02		<0.02	<0.02			0.02	9.4	41	<6.2	1.9	
	July 21, 2021	BRD001F	8.7	27.2	7.2	38	2.0	113.2%	<0.02		<0.02	<0.02			0.02	8.0	28		1.9	
	June 10, 2021	BRD001C	8.5	25.6	5.7	35	2.3	107.0%	0.02	<0.30	0.03	0.04	0.19	0.12	0.07		37	<6.2	4.6	
	June 10, 2021	BRD001D1	8.3	26.1	6.7	35	3.2	106.1%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02		31	<6.2	2.2	
	June 10, 2021	BRD001F	8.3	26.1	6.9	35	2.9	106.1%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02		31	<6.2	1.5	
	May 19, 2021	BRD001C	10.3	20.2	7.6	33	2.0	116.2%	<0.02	<0.30	<0.02	0.02	0.17	0.14	0.03		38	<6.2	2.2	
	May 19, 2021	BRD001D1	9.9	20.4	7.4	33	3.0	112.3%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02		34	<6.2	1.1	
	May 19, 2021	BRD001F	10.0	20.6	7.4	32	3.0	113.7%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02		34	<12.0	1.4	
LAKE ADGER	September 29, 2021	BRD007J	9.2	23.8	6.9	38	1.2	111.9%	<0.02		<0.02	0.03			0.04	6.8	44		3.2	
	September 29, 2021	BRD007L	9.1	24.0	7.0	38	2.0	111.4%	<0.02		<0.02	<0.02			0.02	9.3	37		2.2	
	September 29, 2021	BRD007P	9.2	24.1	6.8	38	2.2	113.2%	<0.02		<0.02	<0.02			0.02	10.0	37		1.8	
	September 9, 2021	BRD007J	8.4	26.2	7.4	34	1.7	107.2%	<0.02		<0.02	<0.02			0.02	7.3	36		3.5	
	September 9, 2021	BRD007L	8.9	26.8	8.1	34	2.0	115.3%	<0.02		<0.02	<0.02			0.02	8.5	29		2.8	
	September 9, 2021	BRD007P	8.3	25.8	8.0	34	2.4	104.8%	<0.02		<0.02	<0.02			0.02	8.6	33		1.9	
	July 20, 2021	BRD007J	8.5	27.0	7.2	37	1.2	110.2%	<0.02		<0.02	<0.02			0.02	8.4	41		3.0	
	July 20, 2021	BRD007L	8.9	27.4	7.6	37	1.8	116.5%	<0.02		<0.02	0.02			0.03	8.4	41	<6.2	3.2	
	July 20, 2021	BRD007P	8.7	27.8	7.4	38	2.3	114.7%	<0.02		<0.02	0.03			0.04	6.4	40	<6.2	2.4	
	June 10. 2021	BRD007J	8.7	25.4	7.0	37	1.9	109.7%	<0.02	<0.30	0.02	0.06	0.21	0.13	0.08		38	6.5	5.1	
	June 10. 2021	BRD007L	8.8	26.6	7.0	36	2.5	113.0%	<0.02	<0.30	0.02	0.08	0.23	0.13	0.10		37	<6.2	3.2	
	June 10. 2021	BRD007P	8.6	26.7	6.5	36	2.8	111.0%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07		36	<6.2	2.5	
	May 19, 2021	BRD007J	9.5	20.7	7.3	34	0.9	108.2%	<0.02	<0.30	<0.02	0.11	0.26	0.14	0.12		36	<6.2	2.6	
	May 19, 2021	BRD007L	9.7	21.5	8.0	34	1.9	111.6%	<0.02	<0.30	<0.02	0.09	0.24	0.14	0.10		51	<6.2	3.3	
	May 19, 2021	BRD007P	10.3	21.6	7.9	34	2.4	118.1%	<0.02	<0.30	<0.02	0.07	0.22	0.14	0.08		47	<6.2	2.2	
KINGS MOUNTAIN RESERVOIR	September 28, 2021	BRD056C	8.8	25.8	7.2	66	1.6	111.0%	0.02		<0.02	<0.02			0.02	11.0	47		2.1	
	September 28, 2021	BRD056E	8.6	26.3	7.2	66	1.8	109.1%	0.02		<0.02	<0.02			0.02	11.0	44		2.7	
	September 28, 2021	BRD056G	8.5	25.5	7.2	65	2.2	106.5%	<0.02		<0.02	<0.02			0.02	10.0	44		2.2	
	September 28, 2021	BRD056J	8.3	25.7	7.2	65	1.6	104.6%	<0.02		<0.02	<0.02			0.02	8.0	48		2.8	19.0
	September 8, 2021	BRD056C	8.1	28.4	7.9	64	1.9	106.9%	<0.02		<0.02	<0.02			0.02	10.0	45		2.2	
	September 8, 2021	BRD056E	7.7	28.5	7.9	61	1.9	102.0%	<0.02		<0.02	<0.02			0.02	9.7	46		2.3	
	September 8, 2021	BRD056G	7.7	28.3	7.9	61	1.9	102.3%	<0.02		<0.02	<0.02			0.02	7.6	43		1.8	
	September 8, 2021	BRD056J	7.8	28.3	8.0	61	2.1	103.5%	<0.02		<0.02	<0.02			0.02	7.1	45		1.6	20.0
	July 21, 2021	BRD056C	8.6	30.3	8.4	66	0.8	117.3%	<0.02		<0.02	<0.02			0.02	13.0	50	<6.2	3.9	
	July 21, 2021	BRD056E	8.4	30.2	8.1	65	1.1	113.6%	<0.02		<0.02	<0.02			0.02	16.0	50	<6.2	3.6	
	July 21, 2021	BRD056G	8.4	30.1	8.2	65	1.2	113.3%	<0.02		<0.02	<0.02			0.02	12.0	44	<6.2	2.9	
	July 21, 2021	BRD056J	8.5	30.0	8.4	63	1.2	115.4%	<0.02		<0.02	<0.02			0.02	11.0	45	<6.2	3.1	19.0
	June 9, 2021	BRD056C	8.9	27.6	8.2	61	1.4	114.8%	<0.02	0.39	<0.02	0.29	0.68	0.38	0.30		45	6.2	3.2	
	June 9, 2021	BRD056E	8.8	27.8	8.6	60	1.4	113.9%	<0.02	0.36	<0.02	0.24	0.60	0.35	0.25		44	6.2	3.2	
	June 9, 2021	BRD056G	8.9	27.0	8.6	60	1.5	114.5%	<0.02	0.37	<0.02	0.28	0.65	0.36	0.29		43	<6.2	2.8	
	June 9, 2021	BRD056J	9.2	26.8	8.6	60	1.6	117.1%	<0.02	0.38	<0.02	0.28	0.66	0.37	0.29		43	<12.0	2.9	18.0
	May 18, 2021	BRD056C	9.9	22.8	8.3	59	1.6	116.2%	<0.02	0.35	<0.02	0.50	0.85	0.34	0.51		46	<6.2	2.9	
	May 18, 2021	BRD056E	10.0	22.5	8.3	59	1.5	117.0%	<0.02	0.42	<0.02	0.47	0.89	0.41	0.48		43	<6.2	2.9	
	May 18, 2021	BRD056G	9.9	22.2	8.3	58	1.5	115.2%	<0.02	0.40	<0.02	0.48	0.88	0.39	0.49		43	<6.2	2.6	
	May 18, 2021	BRD056J	9.6	22.5	8.3	55	1.5	112.0%	<0.02	0.41	<0.02	0.48	0.89	0.40	0.49		49	<6.2	2.3	16.0

Appendix B - Broad River Basin Lakes
Phytoplankton Analysis for 2021

Algal densities and dominance at Station BRD001D1 at **Lake Lure**

Date	Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/19/21	17,900	mild	Chrysophytes	78%	*Ochromonas*	49%
6/10/21	5,600	n/a	Greens	46%	no dominant	n/a
7/21/21	12,700	mild	Cyanobacteria	70%	*Planktolyngbya*	61%
9/9/21	19,800	mild	Cyanobacteria	47%	*Planktolyngbya*	42%
9/29/21	12,500	mild	Chrysophytes	58%	no dominant	n/a

Algal biovolumes and dominance at Station BRD001D1 at **Lake Lure**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/19/21	1,600	Chrysophytes	61%	*Ochromonas*	32%
6/10/21	1,400	Euglenoids	52%	*Trachelomonas*	52%
7/21/21	700	Cyanobacteria	55%	*Aphanizomenon*	41%
9/9/21	2,100	Chrysophytes	41%	no dominant	n/a
9/29/21	2,600	Chrysophytes	47%	*Synura*	31%

Algal densities and dominance at Station BRD007L at **Lake Adger**

Date	Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/19/21	7,500	n/a	Chrysophytes	90%	*Ochromonas*	69%
6/10/21	7,000	n/a	Chrysophytes	52%	*Dinobryon*	39%
7/20/21	8,800	n/a	Chrysophytes	70%	*Dinobryon*	45%
9/9/21	9,300	n/a	Chrysophytes	42%	no dominant	n/a
9/29/21	13,000	mild	Chrysophytes	45%	no dominant	n/a

Algal biovolumes and dominance at Station BRD007L at **Lake Adger**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/19/21	1,900	Chrysophytes	69%	*Synura*	35%
6/10/21	2,100	no dominant	n/a	no dominant	n/a
7/20/21	1,000	Chrysophytes	67%	*Dinobryon*	30%
9/9/21	1,900	no dominant	n/a	no dominant	n/a
9/29/21	3,900	no dominant	n/a	*Asterionella*	32%

Algal densities and dominance at Station BRD056J at **Kings Mountain Reservoir**

Date	Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/18/21	16,000	mild	Cyanobacteria	53%	*Cylindrospermopsis*	30%
6/9/21	14,700	mild	no dominant	n/a	no dominant	n/a
7/21/21	26,400	moderate	Cyanobacteria	58%	*Cylindrospermopsis*	54%
9/8/21	25,000	moderate	Cyanobacteria	56%	*Cylindrospermopsis*	46%

Algal biovolumes and dominance at Station BRD056J at **Kings Mountain Reservoir**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/18/21	1,500	no dominant	n/a	no dominant	n/a
6/9/21	2,500	no dominant	n/a	*Trachelomonas*	30%
7/21/21	1,600	Cyanobacteria	49%	*Cylindrospermopsis*	43%
9/8/21	1,500	no dominant	n/a	*Cylindrospermopsis*	37%

Appendix C – Ecological Implications of Dominant Lake Algal Groups

Cyanobacteria (Blue-greens):
Cyanobacteria (also known as blue-green algae) are common indicators of nutrient enrichment. Cyanobacteria blooms can cause unsightly water discoloration, surface films, flecks, mats, taste and odor problems, and some, such as *Cylindrospermopsis*, are known to produce toxins (Wehr and Sheath 2003). Historically, there have been no documented cases of health problems caused by cyanobacteria in North Carolina.

Diatoms:
Diatoms are generally considered beneficial as a food source for small crustaceans, fish, and other aquatic life. They are well adapted to lower light intensities and tend to be more prevalent in freshwater systems during cooler months. Diatom blooms are known to cause taste and odor problems, and their silica cell walls are notorious for clogging water treatment plant intake filters (Wehr and Sheath 2003).

Euglenoids:
Euglenoids tend to be found in waters rich in organic matter and frequently associated with animal wastes. Euglenoid blooms can discolor water, ranging from red or brown to green (Wehr and Sheath 2003).

Greens:
Green algae are generally beneficial and provide food and shelter for many aquatic insects and fish. They may bloom when environmental conditions are conducive for excessive growth. Blooms are usually an indication of elevated nutrients. Some algal blooms can discolor the water and cause changes in the amount of oxygen in the water. This in turn can affect fish and other aquatic life. Filamentous greens can form large unsightly mats which can hamper boating, fishing, and swimming (Wehr and Sheath 2003).

Cryptomonads:
Cryptomonads are some of the most common algae in North Carolina. They are an important food source for many aquatic organisms (Wehr and Sheath 2003).

Dinoflagellates:
Dinoflagellates are known to form blooms which are generally a response to nutrient enrichment (Wehr and Sheath 2003).

Prymnesiophytes and Chrysochromulina:
Several species of the prymnesiophyte *Chrysochromulina* are common in North Carolina. They are known to form blooms and are common in eutrophic waters (Wehr and Sheath 2003). These blooms are more likely to occur during summer and fall. Blooms may discolor the water and are often associated with elevated levels of chlorophyll *a*.

Gonyostomum is common in bogs, lakes, and ponds that are generally of low pH (< 6). It is indicative of dystrophic and eutrophic conditions (Wehr and Sheath 2003). Although usually in low numbers, *Gonyostomum* is known to form nuisance blooms in the summer.

Chrysophytes:
Chrysophytes are generally an indicator of clean, low nutrient, waters (Wehr and Sheath 2003). They can be found throughout North Carolina but are rarely abundant. Some chrysophytes can cause tastes and odors in drinking water (Palmer, C. M. 1977).

Palmer, C. M. 1977. Algae and water pollution. EPA-600/9-77-036. National Technical Information Service, Sprinfield, VA).

Wehr, J. D. and R. G. Sheath (Eds). 2003. Freshwater algae of North America: ecology and classification. Academic Press, San Diego, CA.