LAKE & RESERVOIR ASSESSMENTS
LUMBER RIVER BASIN

Pages Lake

Intensive Survey Branch
Water Sciences Section
Division of Environmental Quality
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TABLE OF CONTENTS

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 may be determined by the algal density as follows:

Mild 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) found in almost every aquatic environment including fresh and marine waters, as well as moist soils. 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 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. The concentrations listed are the range of values observed in surface readings from the sampling locations.

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 dissolve 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 high plant productivity and low water transparency.

Eutrophication The process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a lake.

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 northern 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 plant 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). It takes the nutrients present along with chlorophyll *a* and Secchi depth to calculate a lake's biological productivity.
Oligotrophic	Describes a lake with low plant 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. DEQ 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 Lumber River Basin, located along the North Carolina-South Carolina state border at the southeast corner of the state, consists of 2,283 miles of freshwater streams and rivers. The basin extends approximately 150 miles from the Sand Hills region of the state in southern Moore and Montgomery Counties to the Atlantic Ocean coastline in Brunswick County. Streams and rivers in the Lumber River Basin (with the exception of Lockwoods Folly and Shallotte Rivers) flows southwest into South Carolina and are tributaries of the Great Pee Dee River, which flow into the Atlantic Ocean near Georgetown, South Carolina.

Three lakes were sampled in this river basin by DWR staff in 2021. These lakes were Pages Lake, Lake Waccamaw and Lake Tabor. Lake Waccamaw is part of Lake Waccamaw State Park and has an Outstanding Resource Water (ORW) designation. This unique Carolina Bay Lake supports populations of endemic fish, mussels, clams, and snails.

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 (https://epi.dph.ncdhhs.gov/oee/fish/advisories.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 Lumber River Basin are provided in Appendix B. Brief discussions on the ecological implications of dominant lake algal groups 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. Severe Drought (D2) emerged in parts of the southern Coastal Plain with Lumberton recording their second driest spring on record having received less than half their normal 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 Lumber River Basin experienced 150% to 200% 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. Precipitation in the Lumber River Basin ranged from normal to below normal in July. The warmest weather of the summer arrived in August with the statewide temperature average for the month at 77.8°F. In the Lumber River Basin, the Laurinburg-Maxton airport reported 102°F on August 13th. The statewide precipitation for August was 5.94 inches. In the final two weeks of the month, precipitation tapered off, bringing drier conditions to the northwestern Lumber 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. On September 8th, a temperature of 96°F was recorded at the Laurinburg-Maxton Airport. This was the hottest temperature reported for the state in September. 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 03040203

Pages Lake

Ambient Lakes Program Name	Pages Lake	
Trophic Status (NC TSI)	No Score	
Mean Depth (meters)	2.0	
Volume (10^6 m^3)	0.03	
Watershed Area (mi^2)	13.9	
Classification	B	
Stations	LBR027D	LBR027E
Number of Times Sampled	5	5

Pages Lake (Aberdeen Town Lake) is located on Aberdeen Creek west of US Hwy 1 in the Town of Aberdeen. The lake was built in the 1930's and is used for recreation, bank fishing, and canoeing, however, swimming is not allowed in Pages Lake. There is a town park adjacent to the lake and a wooden footbridge that crosses the center of the lake. Pages Lake is under a fish consumption advisory for high levels of mercury found in fish taken from this lake (https://epi.dph.ncdhhs.gov/oee/fish/advisories.html).

DWR field staff monitored Pages Lake six times in 2021. Secchi depths in this lake in this lake were greater than a meter, ranging from 1.1 to 1.7 meters (Appendix A). Surface dissolved oxygen ranged from 6.3 to 8.7 mg/L and surface pH values ranged from 6.0 to 7.8 s.u. Surface conductivity in Pages Lake ranged from 36 to 44 μmhos/cm.

The concentration of total phosphorus in 2021 ranged from <0.02 to 0.03 mg/L. The concentrations of NH_3 ranged from <0.02 to 0.05 mg/L and NO_2+NO_3 ranged from <0.02 to 0.13 mg/L. Chlorophyll *a* ranged from 4.6 to 16.0 μg/ and turbidity in Pages Lake ranged from 1.8 to 6.8 NTUs.

Based on the calculated NCTSI score for May, the trophic status of Pages Lake was determined to be mesotrophic or moderately biologically productive. Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake from June through September to be calculated, and the overall trophic state of this reservoir in 2021 could not be accurately determined. Historically, the trophic state of this lake has ranged between mesotrophic and eutrophic beginning in 1981 when monitoring efforts by DWR staff began.

LAKE & RESERVOIR ASSESSMENTS

HUC 03040206

Lake Waccamaw

Ambient Lakes Program Name	Lake Waccamaw		
Trophic Status (NC TSI)	No Score		
Mean Depth (meters)	2.3		
Volume ($10^6 m^3$)	54.30		
Watershed Area (mi^2)	96.9		
Classification	B Sw ORW		
Stations	LBR076A	LBR076K	LBR076P
Number of Times Sampled	5	5	5

Lake Waccamaw is one of the few natural lakes in North Carolina. Located in Columbus County, this is a shallow, elliptical lake owned by the State of North Carolina as part of Lake Waccamaw State Park. Recreational uses include swimming, boating and fishing. Lake Waccamaw, a Carolina Bay Lake, is an Outstanding Resource Water (ORW). Waters designated as ORW have outstanding state or national recreational or ecological significance. The term 'Bay' comes from the presence of bay trees commonly found growing in swampy oval depressions that may have been lakes at one time. Unlike the majority of Carolina Bay Lakes that have an acidic pH, Lake Waccamaw is unique for its neutral pH, which is important in the support of numerous endemic species including the Waccamaw Silverside (*Menidia extensa*), Waccamaw Darter (*Etheostema perlongum*), and Waccamaw Killifish (*Fundulus waccamensis*). This lake also has 15 species of mussels and clams including the endemic Waccamaw Fatmucket (*Lampsilis fullerkati)* and Waccamaw Spike (*Elliptio waccamawensis*). Two species of snails, the Waccamaw Amnicola (*Amnicola* sp.1) and the Waccamaw Siltsnail (*Cincinnatia* sp. 1) are also endemic to this lake. Lake Waccamaw provides high recreational and scenic value and is an important component of the Lake Waccamaw State Park. Lake Waccamaw is currently under a fish consumption advisory due to elevated mercury (https://epi.dph.ncdhhs.gov/oee/fish/advisories.html).

DWR field staff monitored Lake Waccamaw five times in 2021. Secchi depths ranged from 1.0 to 1.7 meters and was often measured down to the bottom of this shallow lake. Surface dissolved oxygen ranged from 7.3 to 8.8 mg/L and surface pH ranged from 6.3 to 7.2 s.u. Surface conductivity in Lake Waccamaw ranged from 48 to 53 μmhos/cm.

The concentrations of total phosphorus were low, ranging from <0.02 to 0.02 mg/L. The concentrations of NH_3 ranged from <0.02 to 0.03 mg/L and NO_2+NO_3 was consistently below the DWR laboratory detection limit of <0.02 mg/L. Chlorophyll *a* values in this lake were low and ranged from 2.6 to 5.7 μg/L. Turbidity ranged from 1.6 to 3.5 NTUs. Water samples collected on August 24, 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 Lake Waccamaw was limited by the nutrient phosphorus (Table 1).

Table 1. Algal Growth Potential Test Results for Lake Waccamaw, August 24, 2021.

Algal Growth Potential Test Results

Lake Waccamaw
August 24, 2021

Station	Maximum Standing Crop, Dry Weight (mg/L)			Limiting Nutrient
	Control	C+N	C+P	
LBR076A	0.17	0.09	0.54	Phosphorus
LBR076K	0.03	0.04	0.12	Phosphorus
LBR076P	0.17	0.08	0.70	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

Based on the calculated NCTSI score for May, the trophic status of Lake Waccamaw was determined to be mesotrophic or moderately biologically productive. Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake from June through September to be calculated, and the overall trophic state of this reservoir in 2021 could not be accurately determined. Historically, the trophic state of Lake Waccamaw has varied between mesotrophic and eutrophic since monitoring by DWR began in 1981.

Lake Tabor

Ambient Lakes Program Name	Lake Tabor	
Trophic Status (NC TSI)	No Score	
Mean Depth (meters)	1.0	
Volume (10^6 m^3)	0.03	
Watershed Area (mi^2)	9.7	
Classification	B Sw	
Stations	LBR091B	LBR091C
Number of Times Sampled	5	5

Lake Tabor is a shallow 69.2-acre lake located northeast of Tabor City at the US Hwy 701 Business/Bypass split. Recreational facilities at the lake include a bait and tackle shop, piers, boat launches, picnic areas, and ball fields. The lake, built in 1952 from what had been an old millpond at the confluence of Grissett Swamp (a cypress gum swamp), Simmons Branch and Black Creek, contains tannic swamp waters. The dam was breached in 1996 during Hurricane Fran and rebuilt in 2000. There are houses around the lake with a residential area on the northwest; shoreline development is 50% to 75%. Lake Tabor is under a fish consumption advisory for high levels of mercury found in fish taken from this lake (https://epi.dph.ncdhhs.gov/oee/fish/advisories.html).

Total phosphorus ranged from 0.08 to 0.11 mg/L while both NH_3 and NO_2+NO_3 values were below the DWR laboratory detection limit of <0.02 mg/L. Chlorophyll *a* ranged from 25 to 55 µg/L with the latter value greater than the state water quality standard of 40 µg/L. This lake is listed in the 2020 303(d) List of Impaired Waters for chlorophyll a values greater than the state standard (https://files.nc.gov/ncdeq/Water%20Quality/Planning/TMDL/303d/2020/NC_2020_Category5_303dlist.pdf). Turbidity measurements in Lake Tabor ranged from 7.5 to 24.0 NTUs.

Issues with nutrient and chlorophyll *a* analysis by the DWR Chemistry Laboratory prevented the NCTSI scores for this lake from May through September to be calculated, and the overall trophic state of this reservoir in 2021 could not be accurately determined. Previous sampling efforts by DWR of Lake Tabor indicated that this lake exhibited elevated to extremely elevated biological productivity (eutrophic to hypereutrophic conditions) since 1981 when monitoring began.

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

Lake	Date	SURFACE PHYSICAL DATA							PHOTIC ZONE DATA									
		Sampling Station	DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Depth Secchi 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	Solids Total mg/L	Total Solids Suspended mg/L	Turbidity NTU
PAGES LAKE	September 30, 2021	LBR027D	8.7	25	6.5	36	1.4	105.4%	0.03		<0.02	<0.02			0.02	8.5	39		3.1
	September 30, 2021	LBR027E	8.6	24.5	6.5	37	1.2	103.8%	0.03		0.02	<0.02			0.03	13.0	46	6.8	3.3
	August 30, 2021	LBR027D	6.3	30.7	6.4	37	1.7	84.4%	<0.02		0.05	<0.02			0.06	14.0	44	<6.2	3.1
	August 30, 2021	LBR027E	6.4	30.9	6.5	38	1.5	87.2%	<0.02		<0.02	<0.02			0.02	16.0	40	<6.2	2.8
	July 28, 2021	LBR027D	7.9	31.4	6.3	41	1.2	107.5%	0.03		0.03	<0.02			0.04	10.0	43	<6.2	6.8
	July 28, 2021	LBR027E	8.0	30.7	6.6	40	1.1	107.7%	0.02		<0.02	<0.02			0.02		41	<6.2	4.0
	June 2, 2021	LBR027D	7.8	25.1	6.0	43	1.2	94.7%	0.02	0.48	0.03	0.04	0.52	0.45	0.07		44	6.5	5.4
	June 2, 2021	LBR027E	7.8	24.5	7.8	44	1.2	94.3%	0.02	0.53	0.04	<0.02	0.54	0.49	0.05		44	<6.2	3.2
	May 4, 2021	LBR027D	7.6	22.9	6.5	43	1.3	89.1%	<0.02	0.40	<0.02	0.13	0.53	0.39	0.14	6.8	29	<6.2	1.8
	May 4, 2021	LBR027E	8.3	22.4	7.2	43	1.5	97.1%	<0.02	0.41	<0.02	0.13	0.54	0.40	0.14	4.6	34	<6.2	2.1
LAKE WACCAMAW	September 16, 2021	LBR076A	7.6	27.7	6.3	49	1.4	96.2%	<0.02		<0.02	<0.02			0.02	3.0	57		2.0
	September 16, 2021	LBR076K	7.8	28.0	6.3	50	1.7	99.6%	<0.02		<0.02	<0.02			0.02	2.6	57		1.6
	September 16, 2021	LBR076P	7.6	27.8	6.3	50	1.7	96.8%	<0.02		<0.02	<0.02			0.02	3.4	55		2.2
	August 24, 2021	LBR076A	7.3	32.8	6.7	48	1.4	101.7%	<0.02		0.03	<0.02			0.04	5.7	66	<6.2	1.8
	August 24, 2021	LBR076K	7.8	31.5	6.8	48	1.6	105.3%	<0.02		0.01	<0.02			0.02	3.1	53	<6.2	2.0
	August 24, 2021	LBR076P	7.6	31.1	6.6	48	1.4	101.7%	<0.02		0.01	<0.02			0.02	5.7	54	<6.2	2.6
	July 12, 2021	LBR076A	7.7	29.3	7.1	50	1.5	100.2%	<0.02		<0.02	<0.02			0.02	3.3	52	<6.2	2.5
	July 12, 2021	LBR076K	7.6	29.2	7.0	50	1.1	98.3%	<0.02		<0.02	<0.02			0.02	3.6	52	<6.2	2.9
	July 12, 2021	LBR076P	7.5	29.1	6.9	50	1.1	97.3%	<0.02		<0.02	<0.02			0.02	3.4	55	<6.2	3.4
	June 16, 2021	LBR076A	7.6	31.0	7.2	49	1.3	102.5%	<0.02	0.48	<0.02	<0.02	0.49	0.47	0.02		58		2.2
	June 16, 2021	LBR076K	7.6	30.8	7.0	53	1.3	102.1%	<0.02	0.48	<0.02	<0.02	0.49	0.47	0.02		55	<6.2	2.4
	June 16, 2021	LBR076P	7.6	31.2	7.1	52	1.3	102.0%	<0.02	0.43	<0.02	<0.02	0.44	0.42	0.02			<6.2	3.1
	May 18, 2021	LBR076A	8.7	23.4	7.1	48	1.0	100.6%	0.02	0.60	<0.02	<0.02	0.61	0.59	0.02	3.2	55	<6.2	3.1
	May 18, 2021	LBR076K	8.7	24.3	6.9	48	1.0	102.1%	<0.02	0.57	<0.02	<0.02	0.58	0.56	0.02	3.8	89	<6.2	3.0
	May 18, 2021	LBR076P	8.8	22.8	6.9	48	1.0	100.7%	<0.02	0.56	<0.02	<0.02	0.57	0.55	0.02	4.0	103	<6.2	3.5
LAKE TABOR	September 16, 2021	LBR091B	8.5	27.2	6.9	108	0.4	107.2%	0.08		<0.02	<0.02			0.02		110	9.8	22.0
	September 16, 2021	LBR091C	8.7	27.4	6.6	108	0.4	109.7%	0.08		<0.02	<0.02			0.02		125	9.8	24.0
	August 24, 2021	LBR091B	10.2	30.2	7.0	97	0.7	134.7%	0.08		<0.02	<0.02			0.02	55.0	94	7.2	7.8
	August 24, 2021	LBR091C	9.3	29.7	7.2	99	0.7	121.7%	0.08		<0.02	<0.02			0.02	25.0	96	6.8	7.6
	July 12, 2021	LBR091B	7.6	29.7	7.0	102	0.7	98.7%	0.08		<0.02					28.0	88	8.0	7.5
	July 12, 2021	LBR091C	7.2	29.4	7.4	103	0.7	93.1%	0.11		<0.02						108	12.0	7.9
	June 16, 2021	LBR091B	8.6	28.4	7.7	107	0.4	110.6%	0.09	1.30	<0.02			1.29				13.0	16.0
	June 16, 2021	LBR091C	10.3	28.5	8.4	107	0.4	132.4%	0.08	1.30	<0.02			1.29				11.0	18.0
	May 18, 2021	LBR091B	9.2	23.7	7.2	98	0.6	107.8%	0.08	1.00	<0.02			0.99		36	93	8.5	12.0
	May 18, 2021	LBR091C	9.1	22.9	7.3	98	0.5	104.7%	0.10	1.30	<0.02			1.29		38	93	7.5	13.0

Appendix B - Lumber River Basin Lakes
Phytoplankton Analysis for 2021

Algal densities and dominance at Station LBR027E at **Pages Lake**

Date	Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/4/21	11,800	mild	Chrysophytes	60%	*Ochromonas*	53%
6/2/21	6,500	n/a	Chrysophytes	71%	*Synura*	64%
7/28/21	16,800	mild	Prymnesiophytes	50%	*Chrysochromulina*	50%
8/30/21	9,500	n/a	Chrysophytes	44%	no dominant	n/a
9/30/21	10,400	mild	Chrysophytes	62%	*Synura*	42%

Algal biovolumes and dominance at Station LBR027E at **Pages Lake**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/4/21	800	Chrysophytes	56%	*Ochromonas*	47%
6/2/21	5,900	Chrysophytes	93%	*Synura*	91%
7/28/21	6,000	Prymnesiophytes	72%	*Chrysochromulina*	72%
8/30/21	5,900	Dinoflagellates	44%	*Peridinium*	44%
9/30/21	2,800	Chrysophytes	76%	*Synura*	66%

Algal densities and dominance at Station LBR076P at **Lake Waccamaw**

Date	Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/18/21	4,800	n/a	Cyanobacteria/ Chrysophytes	50%/41%	no dominant	n/a
6/16/21	7,100	n/a	Cyanobacteria	43%	*Choococcus*	34%
7/12/21	4,900	n/a	Chrysophytes	53%	*Ochromonas*	42%
8/24/21	6,100	n/a	Chrysophytes	51%	no dominant	n/a
9/16/21	3,300	n/a	no dominant	n/a	no dominant	n/a

Algal biovolumes and dominance at Station LBR076P at **Lake Waccamaw**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/18/21	600	Cyanobacteria	58%	*Microcystis*	56%
6/16/21	1,000	Greens	53%	*Dictyosphaerium*	46%
7/12/21	1,000	Greens	61%	*Coelastrum*	57%
8/24/21	900	no dominant	n/a	no dominant	n/a
9/16/21	2,600	Greens	65%	*Eudorina*	62%

Algal densities and dominance at Station LBR091C at **Lake Tabor**

Density (units/ml)	Bloom magnitude	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
11,800	mild	Cyanobacteria	52%	*Aphanizomenon*	34%
67,200	severe	Cyanobacteria	76%	*Aphanizomenon*	71%
23,800	moderate	Cyanobacteria	53%	*Cylindrospermopsis*	49%
20,000	mild	Greens	41%	no dominant	n/a
9,700	n/a	Cyanobacteria	93%	*Aphanizomenon*	81%

Algal biovolumes and dominance at Station LBR091C at **Lake Tabor**

Date	Biovolume (mm^3/m^3)	Dominant Group	Group % Dominance	Dominant Taxa	Taxa % Dominance
5/18/21	3,500	Cyanobacteria	41%	*Aphanizomenon*	37%
6/16/21	39,400	Cyanobacteria	76%	*Aphanizomenon*	67%
7/12/21	5,500	Euglenoids	47%	*Trachelomonas*	47%
8/24/21	4,500	no dominant	n/a	no dominant	n/a
9/16/21	4,200	Cyanobacteria	91%	*Aphanizomenon*	84%

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.