Total Maximum Daily Load

Evaluation

for

Carters Lake

in the

Coosa River Basin

for

Chlorophyll *a*

Submitted to:
The U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

Submitted by:
The Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

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Table of Contents

Section | Page

List of Tables

List of Figures

List of Appendices

EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use or assessment pending, depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* (Draft GA EPD, 2012 – 2013). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

The subset of the water bodies that do not meet designated uses on the 305(b) list are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Although the 305(b) and 303(d) lists are two distinct requirements under the CWA, Georgia reports both lists in one combined format called the Integrated 305(b)/303(d) List, which is found in Appendix A of *Water Quality in Georgia*. Water bodies on the 303(d) list are denoted by Category 5, and are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDLs in this document are based on the Draft 2014 303(d) listing, which is available on the GA EPD website. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. This allows water quality-based controls to be developed to reduce pollution and restore and maintain water quality.

A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

The State of Georgia has identified two segments of Carters Lake located in the Coosa River Basin as not supporting their designated use (Coosawattee River Embayment and Upstream of Woodring Branch/Midlake). The lake is currently impaired for Total Phosphorus and chlorophyll *a*. The following site-specific lake criteria are not being met: the Major Lake Tributary Annual Total Phosphorus Loading at Mountaintown Creek at US Highway 76 and the chlorophyll *a* criteria at the Woodring Branch/Midlake. A lake is placed on the not support list if during the last five-year assessment period, the average of the annual total phosphorous loadings exceeded the site-specific criteria and/or the chlorophyll *a* growing season (April through October) average exceeded the site-specific criteria two or more times. A segment is placed on the assessment pending list if during the last five-year assessment period the site-specific criteria are exceeded one time. Water quality samples collected monthly during the growing season are used to determine the growing season average. Chlorophyll *a* is a pigment in algae. It is used as an indicator of the potential presence of nutrients in a waterbody that causes excess algal growth. Carters Lake's water use classifications are Recreation and Drinking Water.

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulated nutrients that wash off land surfaces as a result of storm events.

The process of developing the chlorophyll *a* TMDLs for the Carters Lake listed segments includes using three computer models to determine the following:

- The current nutrient loads to the lake under existing conditions;
- The critical nutrient load to the lake under NPDES permits at full capacity;
- The TMDL for similar meteorological conditions to those under which the current critical load was determined; and
- The percent reduction in the current critical nutrient load necessary to achieve the TMDL.

A watershed model for Carters Lake was developed using the Loading Simulation Program in C++ (LSPC). The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to available data. The model also included all major point sources of nutrients. The results of this model were used as tributary flow inputs to the lake hydrodynamic and lake water quality model Environmental Fluid Dynamics Code (EFDC). The hydrodynamic model simulates the transport of water into and out of the lake and the water quality model simulates the fate and transport of nutrients into and out of the lake and the uptake of nutrients by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter chlorophyll *a*. The nutrient loads and required reductions are summarized in the table below.

Total Daily Nutrient Loads and Required Load Reductions

<table>
<tr><th colspan="2" rowspan="2">Stream Segment</th><th colspan="2">Carters Lake Coosawattee River Embayment</th><th colspan="2">Carters Lake Woodring Branch</th><th colspan="2">Total Carters Lake</th></tr>
<tr><th>Total Nitrogen (lbs/day)</th><th>Total Phosphorus (lbs/day)</th><th>Total Nitrogen (lbs/day)</th><th>Total Phosphorus (lbs/day)</th><th>Total Nitrogen (lbs/day)</th><th>Total Phosphorus (lbs/day)</th></tr>
<tr><td colspan="2">Critical Load (lbs/day)</td><td>2,738</td><td>346</td><td>2,778</td><td>350</td><td>2,791</td><td>349</td></tr>
<tr><td rowspan="4">TMDL Components</td><td>WLA (lbs/day)</td><td>979</td><td>26</td><td>979</td><td>26</td><td>980</td><td>26</td></tr>
<tr><td>LA (lbs/day)</td><td>1,558</td><td>113</td><td>1598</td><td>118</td><td>1,610</td><td>119</td></tr>
<tr><td>MOS (lbs/day)</td><td>Implicit</td><td>Implicit</td><td>Implicit</td><td>Implicit</td><td>Implicit</td><td>Implicit</td></tr>
<tr><td>TMDL (lbs/day)</td><td>2,537</td><td>139</td><td>2,577</td><td>144</td><td>2,590</td><td>145</td></tr>
<tr><td colspan="2">Percent Reduction</td><td>7%</td><td>60%</td><td>7%</td><td>59%</td><td>7%</td><td>58%</td></tr>
</table>

Management practices that may be used to help reduce nutrient source loads include:

- Compliance with NPDES permit limits and requirements;
- Adoption of NRCS Conservation Practices; and
- Application of Best Management Practices (BMPs) appropriate to reduce nonpoint sources.

The amount of nutrients delivered to a stream is difficult to determine; however, by requiring monitoring, the implementation of these management practices can be measured. The effects of the management practices will improve stream water quality and will represent a beneficial measure of TMDL implementation.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use, or assessment pending, depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* (GA EPD, 2012 – 2013). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

The subset of the water bodies that do not meet designated uses on the 305(b) list are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Although the 305(b) and 303(d) lists are two distinct requirements under the CWA, Georgia reports both lists in one combined format called the Integrated 305(b)/303(d) List, which is found in Appendix A of *Water Quality in Georgia*. Water bodies on the 303(d) list are denoted by Category 5, and are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

Chlorophyll *a* is a pigment in algae. It is used as an indicator of the potential presence of nutrients in a waterbody that cause excess algal growth. In 2006, the two segments of Carters Lake were listed as impaired for chlorophyll *a.* These segments remained on the 2008 impaired list and in 2010 these two segments were also listed as impaired for Total Phosphorus based on violations of the Major Lake Tributary Annual Total Phosphorus Loading at Mountaintown Creek at US Highway 76. In 2014, the Coosawattee River Embayment segment was moved to assessment pending for chlorophyll *a*, since during the last five-year assessment period only one year of data exceeded the site-specific growing season average chlorophyll *a* criteria. Table 1 presents the segments of the Carters Lake included on the Draft 2014 303(d) list.

Table 1. Waterbodies Listed on the Draft 2014 303(d) List for Carters Lake

Lake Segment	Category	Criterion Violated	Segment Area (acres)	Designated Use
Coosawattee River Embayment (Gilmer County)	5	Total P	1,280	Recreation/ Drinking Water
Upstream Woodring Branch/Midlake (Gilmer County)	5	Total P Chlorophyll *a*	1,472	Recreation/ Drinking Water

1.2 Watershed Description

Carters Lake lies in the Coosawattee Watershed in Northwest Georgia, approximately 70 miles northwest of the City of Atlanta. The Ellijay River originates in Fannin County in the north Georgia Mountains. The Ellijay River flows southwest to Ellijay where it merges with the Cartecay River to form the Coosawattee River. The Cartecay River begins in east Gilmer County and flows west to join the Ellijay River. The Coosawattee River continues to flow west to Carters Lake. The Carters Lake watershed lies within the Coosa River Basin, and is part of the Alabama-Coosa-Tallapoosa (ACT) River Basin that drains into Alabama and down to Mobile Bay.

Carters Lake is a US Army Corps of Engineers (USACE) lake, and Carters Dam and the Reregulation Dam were completed and have been operational since 1977. Carters Lake is the deepest manmade reservoir east of the Mississippi River and has 62 miles of shoreline with no development or private docks. The reservoir was developed as a multipurpose project for flood control, hydropower, navigation, water quality, fish and wildlife enhancement, and recreation. It spans an area of about 3,220 acres. The City of Chatsworth has an intake in the upper end of the Wurley Creek arm and depends on the reservoir to meet its water usage needs. Five counties are located either completely or partially in the Carters Lake Watershed, therefore making the watershed very important to a wide range of communities.

USACE generates power at Carters Dam only when demand for electricity is greatest. When demand for electricity is low, water is pumped back from a reregulation pool, via turbines, thus maintaining Carters Lake at its optimal power generation level. The Reregulation Dam stores water in the reregulation pool for the pumped storage operation, and regulates peak flows from Carters Dam to provide stable downstream flows to the Coosa River. Carters Lake and the reregulation pool both experience frequent elevation changes as expected with a pump back/storage system. The minimum Carters Lake pool elevation for power production is 1,022 feet above mean sea level, and a maximum of 1,074 and 1072 feet above mean sea level in summer and winter respectively. The reregulation pool year round elevation operating range is 677 to 696 feet above mean sea level, and provides a minimum of 240 cubic feet per second to the Coosa River. Carters Dam has a drainage area of 372 square miles and the reregulation pool has a drainage area of 148 square miles for a total drainage area at the Reregulation Dam of 520 square miles.

The Carters Lake watershed contains parts of the Blue Ridge and Piedmont physiographic provinces that extend throughout the south-eastern United States. The United States Geologic Survey (USGS) has divided the Coosa basin into five sub-basins, or Hydrologic Unit Codes

(HUCs) numbered 03150101 to 03150105. Figure 1 shows the locations of these sub-basins. Carters Lake is located in the upper half of HUC 03150102. Figure 2 shows the impaired segments within the Lake.

The land use characteristics of Carters Lake watersheds were determined using data from the Georgia Land Use Trends (GLUT) for Year 2005. This raster land use trend product was developed by the University of Georgia – Natural Resources Spatial Analysis Laboratory (NARSAL) and follows land use trends for years 1974, 1985, 1991, 1998, 2001, 2005 and 2008. The raster data sets were developed from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+). Some of the NARSAL land use types were reclassified, aggregated into similar land use types, and used in the final watershed characterization. Table 2 lists the watershed land coverage distribution of the two segments.

1.3 Water Quality Standard

The water use classifications for the listed segments in Carters Lake are Recreation and Drinking Water. The criteria violated are listed as Total P and chlorophyll *a*. The potential causes listed include urban runoff, nonpoint sources, and municipal and industrial facilities. The site-specific criteria for Carters Lake, as stated in the *State of Georgia's Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(17)(5)(i) (GA EPD, 2009), are:

(f) Carters Lake: Those waters impounded by Carters Dam and upstream on the Coosawattee River as well as other impounded tributaries to an elevation of 1072 feet mean sea level corresponding to the normal pool elevation of Carters Lake.

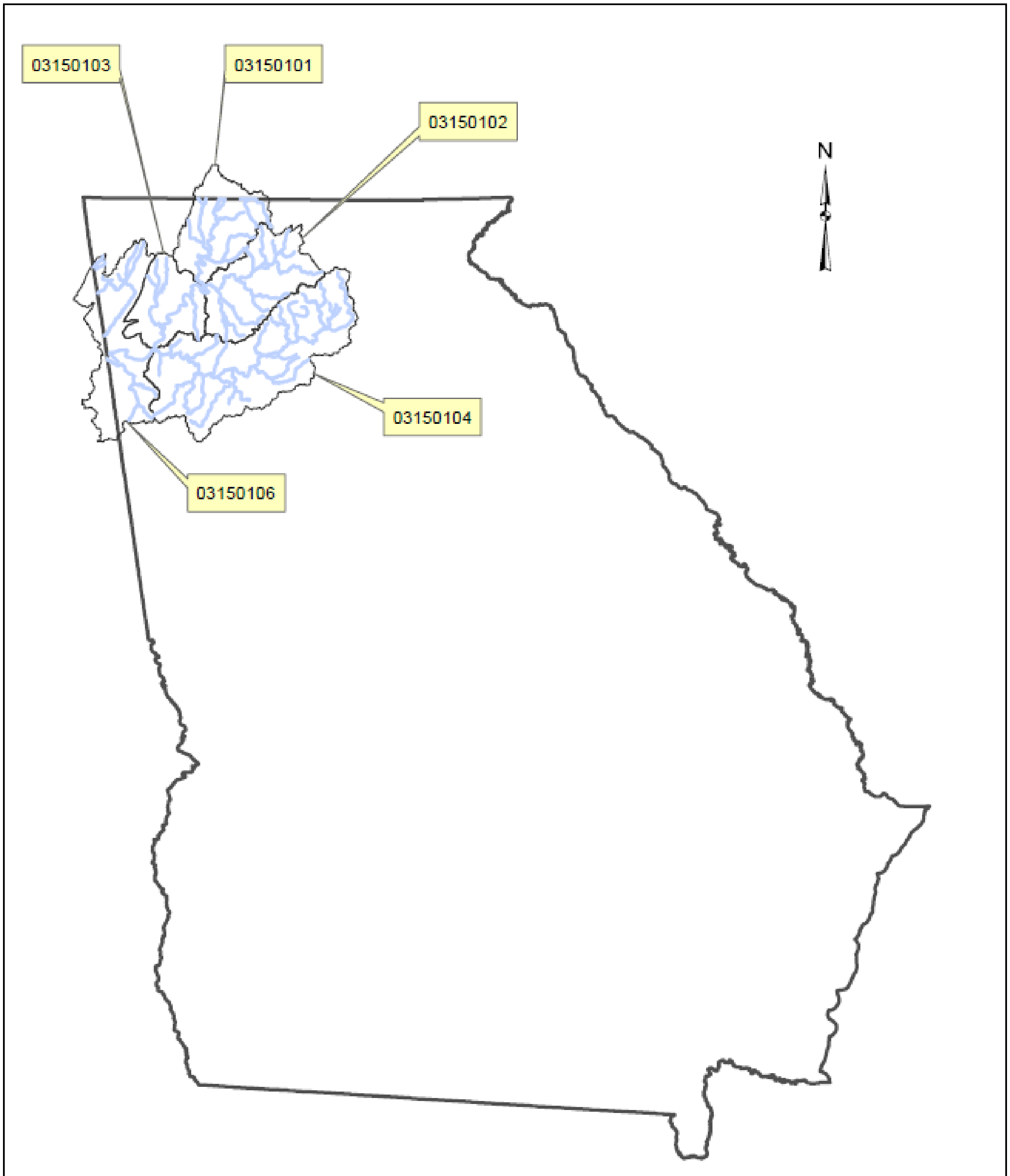
(i) Chlorophyll *a*: For the months of April through October, the average of monthly mid-channel photic zone composite samples shall not exceed the chlorophyll a concentrations at the locations listed below more than once in a five-year period:

1.	Carters Lake upstream from Woodring Branch	10 μg/L
2.	Carters Lake at Coosawattee River embayment mouth	10 μg/L

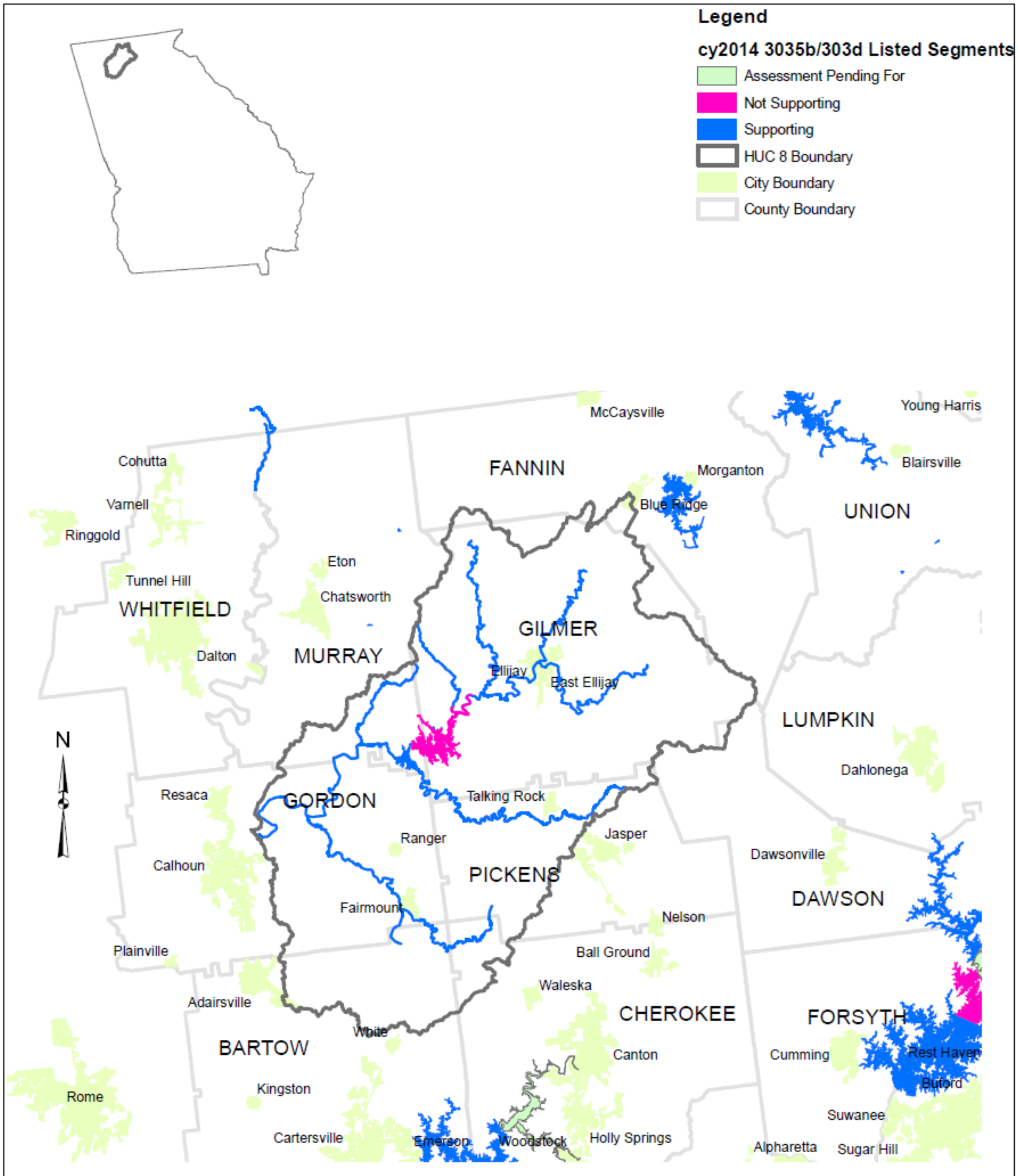
(ii) pH: within the range of 6.0 – 9.5 standard units.
(iii) Total Nitrogen: Not to exceed 4.0 mg/L as nitrogen in the photic zone.
(iv) Phosphorous: Total lake loading shall not exceed 172,500 pounds or 0.46 pounds per acre-foot of lake volume per year.
(v) Fecal Coliform: Fecal coliform bacteria shall not exceed the Recreation criterion as presented in 391-3-6-.03(6)(b)(i).
(vi) Dissolved Oxygen: A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times at the depth specified in 391-3-6-.03(5)(g).
(vii) Temperature: Water temperature shall not exceed the Recreation criterion as presented in 391-3-6-.03(6)(b)(iv).
(viii) Major Lake Tributaries: For the following major tributaries, the annual total phosphorous loading at the compliance monitoring location shall not exceed the following:

1.	Coosawattee River at Old Highway 5	151,500 pounds
2.	Mountaintown Creek at U.S. Highway 76	16,000 pounds

Figure 1. USGS 8-Digit HUCs for Coosa River Basin



TMDL Evaluation – Total P and Chlorophyll *a* Coosa River Basin	Figure 1. USGS 8-digit HUCS for Coosa River Basin



TMDL Evaluation - Total P and Chlorophyll a Coosa River Basin

Figure 2. 303d Listed Segments in Carters Lake

Table 2. Carters Lake Watershed Land Coverage

Stream/Segment	Land use Categories - Acres (Percent)														
	Open Water	Developed Open Space	Low Intensity Residential	Medium Intensity Residential	High Intensity Residential	Barren	Deciduous Forest	Evergreen Forest	Mixed Forest	Golf Couse	Pasture	Row Crops	Forested Wetland	Non-Forested Wetland	Total
Carters Lake - Coosawattee River Embayment	1,962 (0.9%)	11,647 (5.1%)	2,258 (1.0%)	620 (0.3%)	208 (0.1%)	3,689 (1.6%)	149,535 (65.4%)	39,284 (17.2%)	7,872 (3.4%)	95 (0.0%)	10,152 (4.4%)	1,145 (0.5%)	162 (0.1%)	0 (0.0%)	228,630
Carters Lake - US Woodring Branch/Midlake	3,919 (1.6%)	12,016 (5.0%)	2,312 (1.0%)	627 (0.3%)	209 (0.1%)	4,112 (1.7%)	155,523 (65.1%)	40,657 (17.0%)	8,009 (3.4%)	95 (0.0%)	10,177 (4.3%)	1,145 (0.5%)	170 (0.1%)	0 (0.0%)	238,972
Reregulation Reservoir Watershed	1,054 (1.1%)	5,218 (5.6%)	1,141 (1.2%)	148 (0.2%)	32 (0.0%)	6,679 (7.1%)	48,410 (51.6%)	19,905 (21.2%)	1,887 (2.0%)	0 (0.0%)	9,013 (9.6%)	226 (0.2%)	120 (0.1%)	0 (0.0%)	93,833
Carters Lake System Entire Watershed	4,973 (1.5%)	17,234 (5.2%)	3,453 (1.0%)	775 (0.2%)	241 (0.1%)	10,792 (3.2%)	203,933 (61.3%)	60,563 (18.2%)	9,896 (3.0%)	95 (0.0%)	19,190 (5.8%)	1,371 (0.4%)	290 (0.1%)	0 (0.0%)	332,805

2.0 WATER QUALITY ASSESSMENT

In lakes with nutrient and chlorophyll *a* standards, GA EPD collects water quality samples monthly during the growing season, which is from April through October. Carters Lake is sampled at two locations. Figure 3 shows the locations of the Carters Lake water quality stations. These data are used to assess water quality standards, see trends in nutrients and chlorophyll *a* levels, and to assist in developing NPDES permits.

Stream segments are placed on the 303(d) list as not supporting their water use classification based on water quality sampling data. A lake segment is placed on the not support list if during the last five-year assessment period, the chlorophyll *a* growing season average exceeded the site-specific criteria two or more times or the average of the annual total phosphorous loadings for the last five years exceeded the site-specific Major Lake Tributary Annual Total Phosphorus Loading criteria.

The data used to develop these TMDLs were collected during calendar years 2000 through 2007. Appendix A present these data along with other water quality data collected as part of the lake standard monitoring program for calendar years 2000-2013. Appendix B shows plots of the average annual growing season chlorophyll *a* levels at the five monitoring stations.

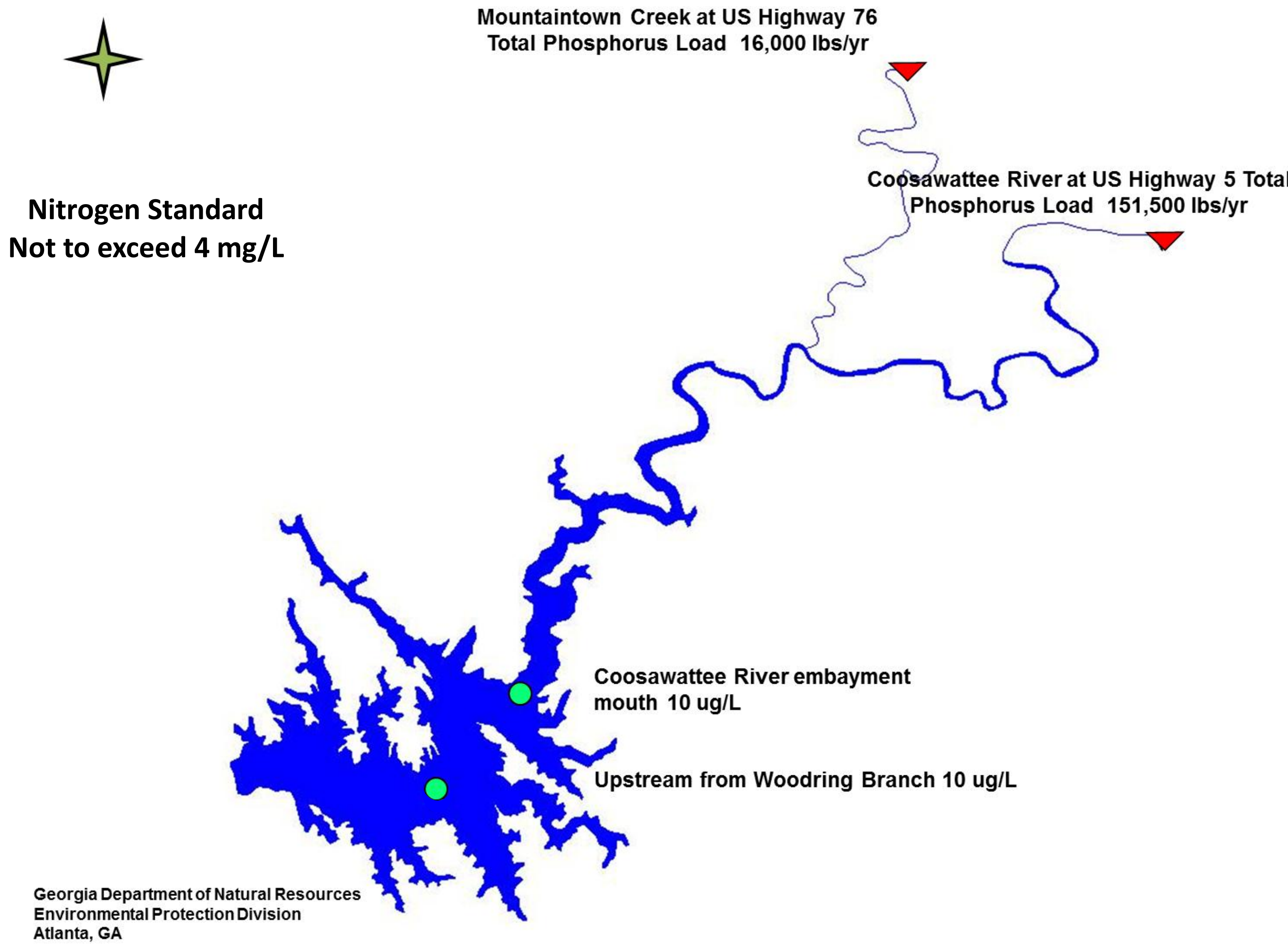


Figure 3. Carters Lake Water Quality Stations - Chlorophyll *a* and Major Total Phosphorus Tributary Monitoring Locations

3.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are, or may be, discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of nutrients on land surfaces that wash off as a result of storm events.

3.1 Point Source Assessment

Title IV of the Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES) permit program. There are two basic kinds of NPDES permits: 1) municipal and industrial wastewater treatment facilities, and 2) regulated storm water discharges.

3.1.1 Wastewater Treatment Facilities

In general, industrial and municipal wastewater treatment facilities have NPDES permits with effluent limits. These permit limits are either based on federal and state effluent guidelines (technology-based limits) or on water quality standards (water quality-based limits).

The United States Environmental Protection Agency (US EPA) has developed technology-based guidelines, which establish a minimum standard of pollution control for municipal and industrial discharges without regard for the quality of the receiving waters. These are based on Best Practical Control Technology Currently Available (BPT), Best Conventional Control Technology (BCT), and Best Available Technology Economically Achievable (BAT). The level of control required by each facility depends on the type of discharge and the pollutant.

The US EPA and the states have also developed numeric and narrative water quality standards. Typically, these standards are based on the results of aquatic toxicity tests and/or human health criteria and include a margin of safety. Water quality-based effluent limits are set to protect the receiving stream. These limits are based on water quality standards that have been established for a stream based on its intended use and the prescribed biological and chemical conditions that must be met to sustain that use.

Discharges from municipal and industrial wastewater treatment facilities can contribute nutrients to receiving waters. There are 4 point source discharges located in the Carters Lake watershed (Figure 4). Of these point sources, one is a major municipal facility, two are rock quarries, and one is a minor Public Institutional Discharger. The two rock quarries should not be a source of nutrients. Table 3 provides the monthly average discharge flows and nutrient concentrations (total phosphorus [Total P], ortho-phosphate [PO_4], ammonia [NH_3], and nitrate-nitrite [NO_2/NO_3]) for the municipal and industrial treatment facilities with permitted flows greater than 0.1 MGD. These data were obtained from 2000-2009 Discharge Monitoring Reports (DMRs). The permitted flow and nutrient concentrations for these facilities are also included in this table. It should be noted that the City of Ellijay was issued a permit in 2011 with a Total P limit of 1 mg/L. Prior to this permit, the level of Total P discharged from this facility was not regulated and this facility could discharge Total P concentrations in the range of 10-20 mg/L.

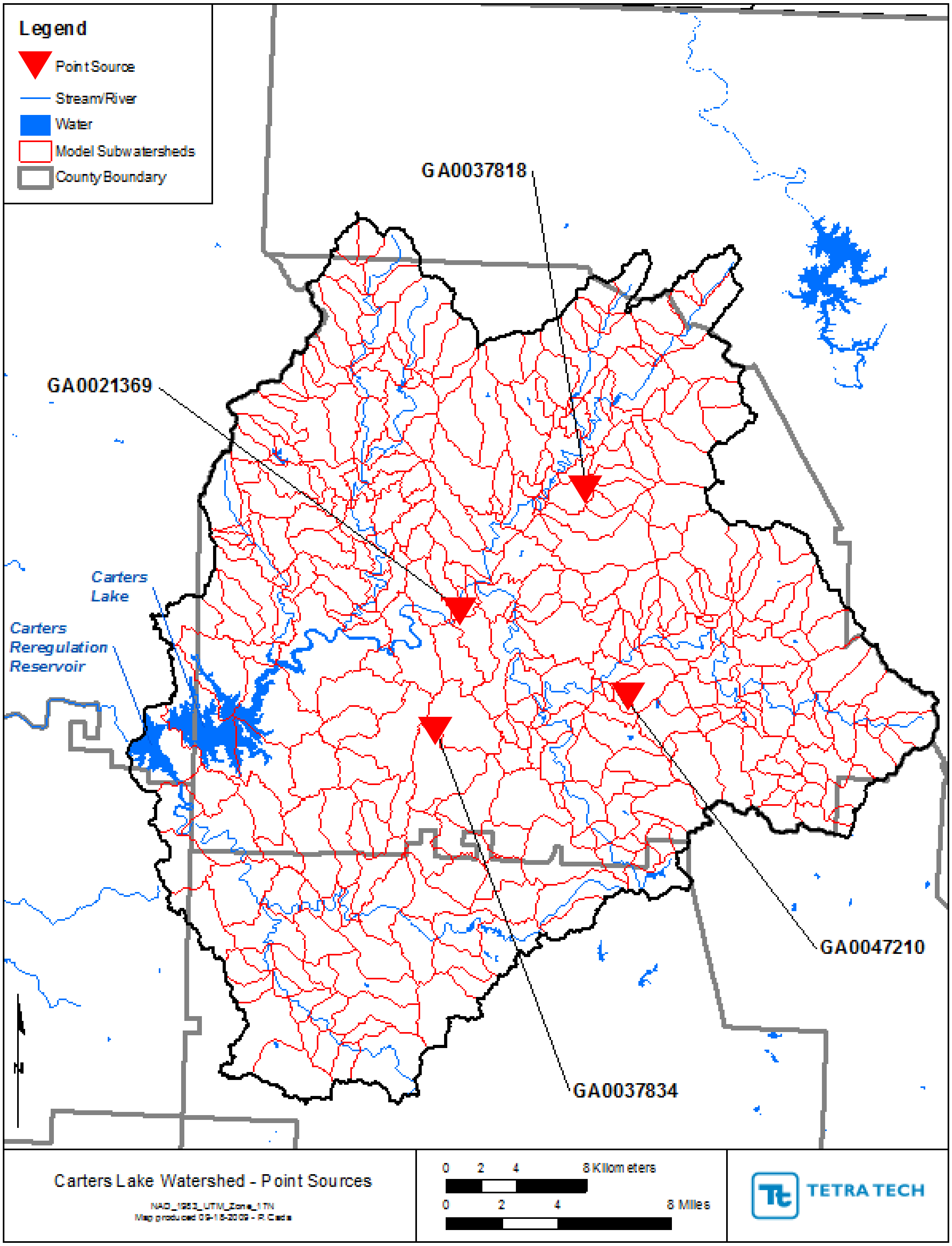


Figure 4. Location of Point Source Discharges in the Carters Lake Watershed

Table 3. NPDES Facilities Discharging to the Carters Lake Watershed

Facility Name	NPDES Permit No.	Receiving Stream	NPDES Permit Limits					Average Discharge prior to 2011				
			Average Monthly Flow (MGD)	BOD_5 (mg/L)	TP (mg/L)	NH_3 (mg/L)	TSS (mg/L)	Average Monthly Flow (MGD)	BOD_5 (mg/L)	TP (mg/L)	PO_4 (mg/L)	NH_3 (mg/L)
Ellijay WPCP (issued 9/01/2006)	GA0021369	Coosawattee River	2.5	30	Report	17.4	30	1.9	8.09	13.1	11.64	7.35
			4.0	30	Report	17.4	30					
Ellijay WPCP (issued 8/30/2011)	GA0021369	Coosawattee River	2.5	30	1.0	17.4	30					
			4.0	30	0.75	17.4	30					
Vulcan Construction Materials (issued 12/27/2012)	GA0037818	Tributary to White Path Creek	Report	-	-	-	55	0.89	-	-	-	-
O-N Minerals Chemstone Co	GA0037834	Tributary to Talona Creek	Report	-	-	-	55	1.375	-	-	-	-
Oakland Elementary School	GA0047210	Lick Log Creek	0.004	30	-	-	30	0.001	9.9	-	-	-

Source: GA EPD GAPDES

Combined sewer systems convey a mixture of raw sewage and storm water in the same conveyance structure to the wastewater treatment plant. These are considered a component of municipal wastewater treatment facilities. When the combined sewage exceeds the capacity of the wastewater treatment plant, the excess is diverted to a combined sewage overflow (CSO) discharge point. There are no permitted CSO outfalls in the Coosa River Basin.

3.1.2 Regulated Storm Water Discharges

Some stormwater runoff is covered under the NPDES Permit Program as a point source. Some industrial facilities included under the program will have limits similar to traditional NPDES-permitted dischargers, whereas others establish controls: "to the maximum extent practicable" (MEP). Currently, regulated stormwater discharges that may contain nutrients consist of those associated with industrial activities including construction sites disturbing one acre or greater, and large, medium, and small municipal separate storm sewer systems (MS4s) that serve populations of 50,000 or more.

3.1.2.1 Industrial General Stormwater NPDES Permit

Storm water discharges associated with industrial activities are currently covered under the 2012 General Storm Water NPDES Permit (GAR050000) also called the Industrial General Permit (IGP). This permit requires visual monitoring of storm water discharges, site inspections, implementation of Best Management Practices (BMPs), and record keeping. The IGP requires that stormwater discharging into an impaired stream segment or within one linear mile upstream of, and within the same watershed as, any portion of an impaired stream segment identified as "not supporting" its designated use(s), must satisfy the requirements of Appendix C of the 2012 IGP if the pollutant(s) of concern for which the impaired stream segment has been listed may be exposed to stormwater as a result of industrial activity at the site. If a facility is covered under Appendix C of the IGP, then benchmark monitoring for the pollutant(s) of concern is required.

3.1.2.2 MS4 NPDES Permits

Storm water discharges from MS4s are very diverse in pollutant loadings and frequency of discharge. At present, all cities and counties within the state of Georgia that had a population of greater than 100,000 at the time of the 1990 Census are permitted for their storm water discharge under Phase I. This includes 58 permittees in Georgia.

Phase I MS4 permits require the prohibition of non-storm water discharges (i.e., illicit discharges) into the storm sewer systems and controls to reduce the discharge of pollutants to the maximum extent practicable, including the use of management practices, control techniques and systems, as well as design and engineering methods (Federal Register, 1990). A site-specific Storm Water Management Plan (SWMP) outlining appropriate controls is required by and referenced in the permit. There are no Phase I MS4s in the Carters Lake watershed.

Small MS4s serving urbanized areas are required to obtain a storm water permit under the Phase II storm water regulations. An urbanized area is defined as an area with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. There are two Phase II MS4s in the Caters lake watershed (Table 4).

Table 4. Phase II Permitted MS4s in the Carters Lake Watershed

Name	Watershed
Murray County	Chattahoochee, Coosa
Dawson County	Coosa

Source: Nonpoint Source Permitting Program, GA DNR, 2015

There is no urbanized area (cities) in the Carters Lake watershed.

3.1.3 Concentrated Animal Feeding Operations

Under the Clean Water Act, Concentrated Animal Feeding Operations (CAFOs) are defined as point sources of pollution and are therefore subject to NPDES permit regulations. From 1999 through 2001, Georgia adopted rules for permitting swine and non-swine liquid manure animal feeding operations (AFOs). Georgia rules required medium size AFOs with more than 300 animal units (AU) but less than 1000 AU to apply for a non-discharge State land application system (LAS) waste disposal permit. Large operations with more than 1000 AU were required to apply for an NPDES permit (also non-discharge) as a CAFO. The US EPA CAFO regulations were successfully appealed in 2005. They were revised to comply with the court’s decision that NPDES permits only be required for actual discharges. Georgia’s rules were amended on August 7, 2012 to reflect the US EPA revisions. The revised state rules will continue LAS permitting of medium size liquid manure AFOs and extend LAS permitting to large liquid manure AFOs with more than 1000 AU, unless they elect to obtain an NPDES permit. There are no known swine and non-swine liquid manure CAFOs located upstream of the listed segments in the Carters Lake watershed.

In 2002, the US EPA promulgated expanded NPDES permit regulations for CAFOs that added dry manure poultry operations larger than 125,000 broilers or 82,000 layers. In accordance with the Georgia rule amendment discussed above, the general permit covering these facilities has been terminated and they are no longer covered under any permit. Georgia is consistently among the top three states in the U.S. in terms of poultry operations. The majority of poultry farms are dry manure operations where the manure is stored for a time and then land applied. Freshly stored litter can be a nonpoint source of nutrients. Table 5 lists the dry manure poultry operations in the Carters Lake watershed.

Table 5. Registered Dry Manure Poultry Operations in the Carters Lake Watershed

Name	County	Number of Animals (thousands)
Curtis Davis	Gilmer	170.0
David Pierce	Gilmer	355.0
Double K Poultry	Gilmer	39.0
Drumstick Ridge Farm	Pickens	175.0
F.D. Whitaker	Gilmer	196.0
Frady Farms	Habersham	137.2
Greg K. Wright Farm	Gilmer	300.0
Hy-View Farm	Gilmer	146.4

Name	County	Number of Animals (thousands)
James Gene	Gilmer	132.0
John Reece	Gilmer	125.0
K Dee Farm	Pickens	168.0
Kenny McClure	Gilmer	138.0
Little Brook Farms #1 & #2	Gilmer	199.0
Little C and H & D Farms	Pickens	165.0
Lofton Farms	Gilmer	138.0
Mack Logan #1 & #2	Gilmer	158.2
Patsy Sandford	Gilmer	142.0
Ralston Creek Farm	Gilmer	138.8
Ray Reece Farm Cartecay Poultry	Gilmer	154.1
Rich Mountain/North Cutt #2	Gilmer	131.0
Robin Sanford Farms	Gilmer	180.0
Ronald West Farm	Gilmer	95.6
Ruth Ann T Reece Farm	Gilmer	52.2
Sam West Farm	Gilmer	58.5
South Point Farms, Inc. - Talking Rock	Pickens	150.0
South Point Farms, Inc. - Ellijay	Gilmer	250.0
Steelman Poultry	Gilmer	176.0
Stillwell Farm	Gilmer	150.0
Triple A Farms	Gilmer	138.0
Triple F Farm	Gilmer	Not Available
Triple G Farms	Pickens	125.0
Valley Creek, Green Meadows, D&B, W&R, Dasrew Broswell Farm	Gilmer	188.1
Wendell Teague	Gilmer	140.0

Source: GA Dept. of Agriculture, 2014
NA= Not Available

3.2 Nonpoint Source Assessment

In general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Typical nonpoint sources of nutrients come from materials being washed into the rivers and streams during storm events. Constituents that have washed off of land surfaces in previous months or years have either flushed out of the system along with the water column flow or settled out and became part of the lake bottom. In this manner, settleable material accumulates and may release nutrients into the water column over time. Constituents of concern from surface washoff include the fractions of phosphorus and nitrogen that become an integral part of channel bottom sediments, thus becoming a potential source of nutrients for algae.

Typical nonpoint sources of nutrients include:

- Wildlife
- Agricultural Livestock
  - Application of manure to pastureland and cropland
  - Application of fertilizers
- Urban Development
  - Application of fertilizers
  - Septic systems
  - Land Application Systems
  - Landfills

In urban areas, a large portion of storm water runoff may be collected in storm sewer systems and discharged through distinct outlet structures. For large urban areas, these storm sewer discharge points may be regulated as described in Section 3.1.2.

3.2.1 Wildlife

The significance of wildlife as a source of nutrients in streams varies considerably, depending on the animal species present in the watersheds. Based on information provided by the Wildlife Resources Division (WRD) of GA DNR, the greatest wildlife sources of nutrients are the animals that spend a large portion of their time in or around aquatic habitats. Of these, waterfowl, (especially ducks and geese), are considered to potentially be the most significant source of nutrients, because when present, they are typically found in large numbers on the water surface, they deposit their waste directly into the water and their feces contain high levels of nutrients. Other animals regularly found around aquatic environments include racoons, beavers, muskrats, and to a lesser extent, river otters and minks. Recently, rapidly-expanding feral swine populations have become a significant presence in the floodplain areas of all the major rivers in Georgia.

White-tailed deer populations are significant throughout the Coosa River Basin. Nutrient contributions from deer to water bodies are generally considered less significant than that of waterfowl, racoons, and beavers. This is because a greater portion of their time is spent in terrestrial habitats. This also holds true for other terrestrial mammals such as squirrels and rabbits, and for terrestrial birds (GA WRD, 2007). However, waste deposited on the land surface that contains nutrients can result in additional nutrient loads to streams during runoff events.

3.2.2 Agricultural Livestock

Manure from agricultural livestock is a potential source of nutrients to streams in the Carters Lake watershed. The animals grazing on pastureland deposit their feces, which contain nutrients, onto land surfaces, where it can be transported during storm events to nearby streams. Animal access to pastureland varies monthly, resulting in varying nutrient loading rates throughout the year. Beef cattle spend all of their time in pastures, while dairy cattle and hogs are periodically confined. In addition, agricultural livestock will often have direct access to streams that pass through their pastures, and can thus impact water quality in a more direct manner (USDA, 2002).

Table 6 provides the annual estimated number of beef cattle, dairy cattle, goats, horse, swine, sheep, and chickens reported by county in the Coosa River Basin. The Natural Resources Conservation Service (NRCS) provided these data.

Table 6. Estimated Agricultural Livestock Populations in the Carters Lake Watershed

County	Livestock							
	Beef Cattle	Dairy Cattle	Swine	Sheep	Horses	Goats	Chickens Layers	Chickens-Broilers Sold
Dawson	2,600	-	-	90	650	175	-	14,784,000
Fannin	1,800	-	-	25	30	300	160,000	6,476,800
Gilmer	3,300	300	-	20	35	350	460,000	59,136,000
Gordon	13,500	-	960	130	100	1,500	300,000	44,759,000
Murray	2,549	-	-	82	20	158	200,000	10,137,600
Pickens	2,300	-	50	250	234	400	-	18,900,000

Source: NRCS, 2013

3.2.3 Urban Development

Nutrients from urban areas are attributable to multiple sources, including: domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges, leaking septic systems, runoff from lawns where fertilizers have been applied, and leachate from both operational and closed landfills.

Urban runoff can contain high concentrations of nutrients from domestic animals and urban wildlife. Nutrients enter streams by direct washoff from the land surface, or the runoff may be diverted to a storm water collection system and discharged through a discrete outlet structure. For large, medium, and small urban areas (populations greater than 50,000), the storm water outlets are regulated under MS4 permits (see Section 3.1.2). For smaller urban areas, the storm water discharge outlets currently remain unregulated.

In addition to urban animal sources of nutrients, there may be illicit connections to the storm sewer system. As part of the MS4 permitting program, municipalities are required to conduct dry-weather monitoring to identify and then eliminate these illicit discharges. Nutrients may also enter streams from leaky sewer pipes, or during storm events when sanitary sewer overflows discharge.

3.2.3.1 Leaking Septic Systems

A portion of the nutrient contributions in the Carters Lake watershed may be attributed to septic systems failures and illicit discharges of raw sewage. Table 7 presents the number of septic systems in each county of the Coosa River Basin existing in 2007 and the number existing in 2012 based in part on U.S. Census data, and on the Georgia Department of Human Resources, Division of Public Health data. In addition, an estimate of the number of septic systems installed and repaired during the five-year period from 2008 through 2012 is given. These data show an increase in the number of septic systems in all of counties. Often, this is a reflection of population increases outpacing the expansion of sewage collection systems.

Table 7. Number of Septic Systems in the Carters Lake Watershed

County	Existing Septic Systems (2007)[1]	Existing Septic Systems (2012)	Number of Septic Systems Installed (2008 to 2012)	Number of Septic Systems Repaired (2008 to 2012)
Dawson	9,196	9,416	220	162
Fannin	16,674	17,443	769	111
Gilmer	17,062	17,641	579	128
Gordon	16,685	16,992	307	371
Murray	12,813	12,994	181	209
Pickens	12,325	12,571	246	128

Source: The Georgia Dept. of Human Resources, Division of Public Health, 2013
Notes: [1] Adjusted from State Water Plan values

3.2.3.2 Land Application Systems

Many smaller communities use land application systems (LAS) for treatment and disposal of their sanitary wastewater. These facilities are required through LAS permits to treat all their wastewater by land application and are to be properly operated as non-discharging systems that contribute no runoff to nearby surface waters. However, runoff during storm events may carry surface residual containing nutrients to nearby surface waters. Some of these facilities may also exceed the ground percolation rate when applying the wastewater, resulting in surface runoff from the field. If not properly bermed, this runoff, which probably contains nutrients, may be discharged to nearby surface waters. There are no permitted LAS systems located in the Carters Lake watershed).

3.2.3.3 Landfills

Leachate from landfills might contain nutrients that may at some point reach surface waters. Sanitary (or municipal) landfills are the most likely to be a source of nutrients. These types of landfills receive household wastes, animal manure, offal, hatchery and poultry processing plant wastes, dead animals, and other types of wastes. Older sanitary landfills were not lined and most have been closed. Those that remain active and have not been lined operate as construction/demolition landfills. Currently active sanitary landfills are lined and have leachate collection systems. All landfills, excluding inert landfills, are now required to install environmental monitoring systems for groundwater and methane sampling. There are 109 known landfills in the Coosa River Basin. Of these, 19 are active landfills, 3 are in closure and 87 are inactive or closed. There are eight landfills in the Carters Lake watershed (Table 8).

Table 8. Landfills in the Carters Lake Watershed

Name	County	Permit No.	Type	Status
Garland Lumber	Gilmer	-	NA	Inactive
Gilmer Co. - US 76 N, TV Tower Ph	Gilmer	061-003D(SL)	NA	Inactive
Jones Mtn. Rd. PH3	Pickens	112-006D(SL)	Sanitary Landfill	Closed
Jones Mtn. Rd. Westside	Pickens	112-007D(SL)	Sanitary Landfill	Closed
Pickens Co. - Long Branch	Pickens	-	NA	Inactive
Pickens Co.- Jones Mountain Rd. PH 2 (SL)	Pickens	112-005D(SL)	Sanitary Landfill	Closed
SR 52N / TV Tower PH1-5	Gilmer	061-010D(SL)	Sanitary Landfill	Closed
SR 52N / TV Tower PH1-5	Gilmer	061-010D(SL)	Sanitary Landfill	Closed

Source: Land Protection Branch, GA DNR, 2014

4.0 ANALYTICAL APPROACH

The process of developing the chlorophyll *a* TMDLs for Carters Lake included developing two computer models for the Lake and its embayments. The models were run for calendar years 2001 through 2009, when water quality data were collected in the Lake. A watershed model of the Carters Lake watershed was developed, using LSPC that included all major point sources of nutrients. The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to available data. The results of this model were used as tributary flow inputs to the hydrodynamic model EFDC, which simulated the transport of water into and out of the lake. The EFDC water quality model was used to simulate the fate and transport of nutrients into and out of the lake and the uptake by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter chlorophyll *a*. Figure 5 shows how the two models interact with one another and what outputs each model provides. The computer models used to develop this TMDL are described in the following sections.

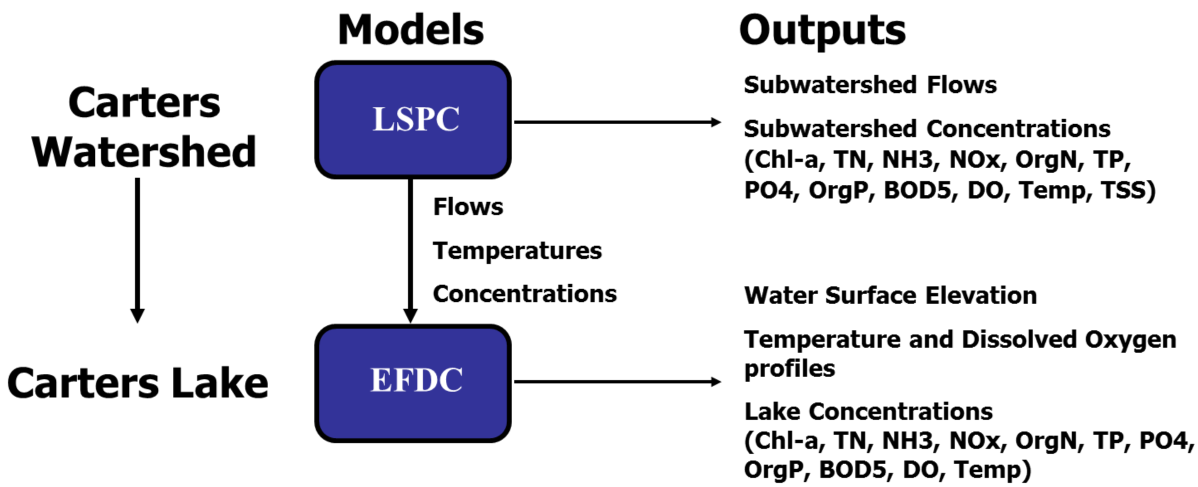


Figure 5. Linkage between LSPC and EFDC

4.1 Watershed Modeling (LSPC)

LSPC is a system designed to support TMDL development for areas impacted by both point and nonpoint sources. It is capable of simulating land-to-stream transport of flow, sediment, metals, nutrients, and other conventional pollutants, as well as temperature and pH. LSPC is a comprehensive data management and modeling system that simulates pollutant loading from nonpoint sources. LSPC utilizes the hydrologic core program of the Hydrological Simulation Program Fortran (HSPF, EPA 1996b), with a custom interface of the Mining Data Analysis System (MDAS), and modifications for non-mining applications such as nutrient and pathogen modeling.

LSPC was used to calculate runoff and hydrologic transport of pollutants based on historic precipitation data. LSPC was configured for the Carters Lake watershed to simulate the watershed as a series of hydrologically connected sub-watersheds. Configuration of the model involved sub-dividing the Carters Lake watershed into 366 modeling sub-watersheds, which are shown in Figure 6. Sub-basin delineations were based on elevation data (30 meter National Elevation Dataset from USGS), and stream connectivity from the National Hydrography Dataset.

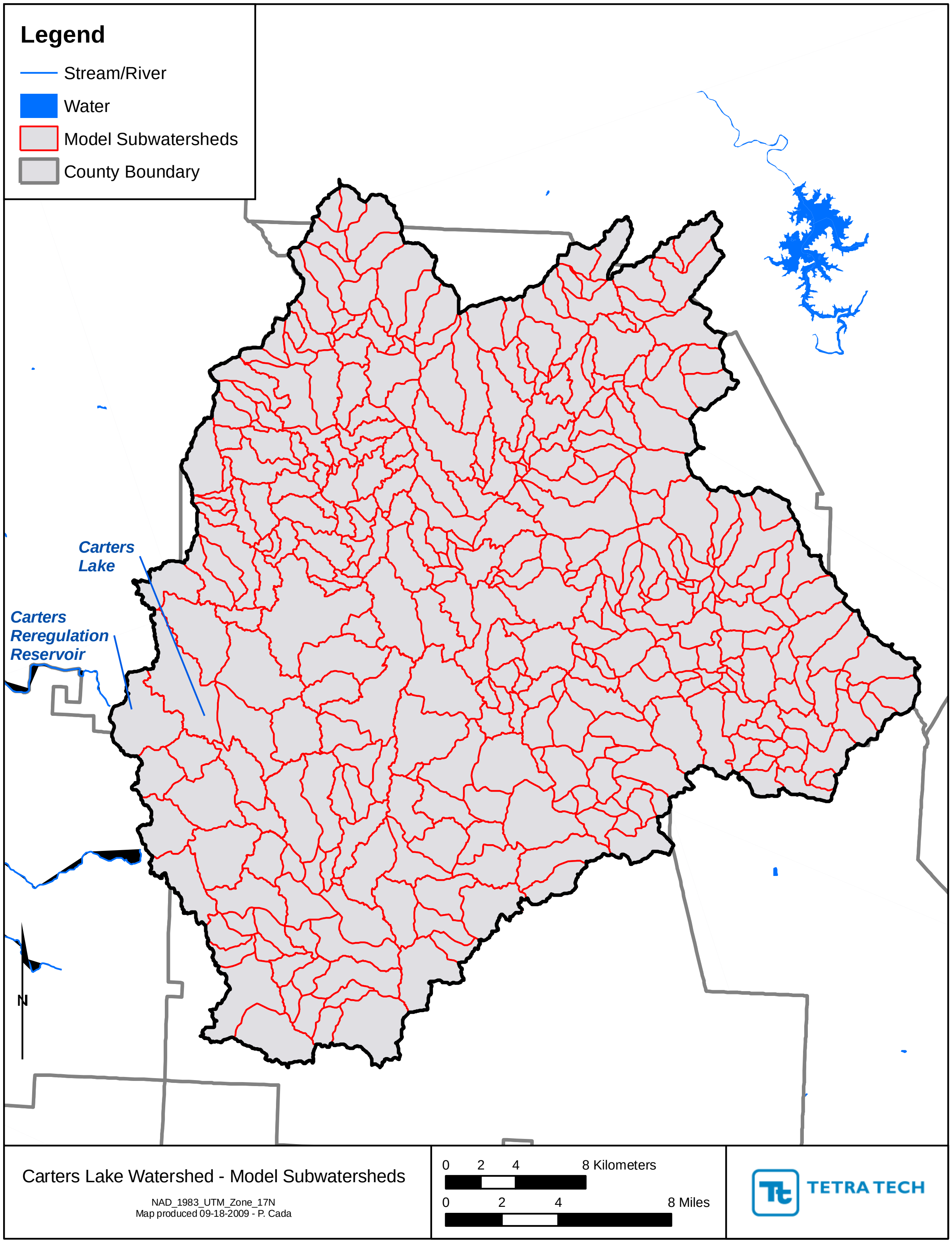


Figure 6. Sub-delineated 12-Digit HUC Coverage for the Carters Lake Watershed

Potential pollutant loadings were determined from mass-balance predictions of available pollutants on the land surface for the land cover distribution in each sub-watershed.

The Carters Lake watershed LSPC model performed a continuous simulation of flow and water quality for these sub-watersheds using the following data:

- Meteorological data
- Land cover
- Soils
- Stream lengths and slopes
- Point source discharge data
- Water withdrawal data
- USGS flow data
- Water quality data

Meteorological Data

Nonpoint source loadings and hydrological conditions are dependent on weather conditions. Hourly data from weather stations within the boundaries of, or in close proximity to, the sub-watersheds were applied to the watershed model. An ASCII file was generated for each meteorological station used in the hydrological evaluations in LSPC. Each meteorological station file contains atmospheric data used in modeling the hydrological processes. These data include precipitation, air temperature, dew point temperature, wind speed, cloud cover, evaporation, and solar radiation. These data are used directly, or calculated from the observed data. The six meteorological stations used for the Carters Lake models are listed in Table 9 and shown in Figure 7.

Table 9. Available Meteorological Stations in the Carters Lake Watershed

Station ID	Station Name	Elevation (ft)	County	Latitude	Longitude
091863	Chatsworth 2	709	Murray	34.759	-84.765
093115	Ellijay	1287	Gilmer	34.695	-84.484
094648	Jasper 1 NW	1465	Pickens	34.495	-84.459
02380500	Coosawattee River near Ellijay	1247	Pickens	34.675	-84.509
02382200	Talking Rock Creek near Hilton	960	Gilmer	34.523	-84.611
GEMN355	Hillcrest Orchards/Ellijay	1676	Gilmer	34.62	-84.374

The Carters Lake watershed was subdivided into Thiessen polygons, using the meteorological stations as centers, to determine the meteorological station that would be used for each sub-watershed.

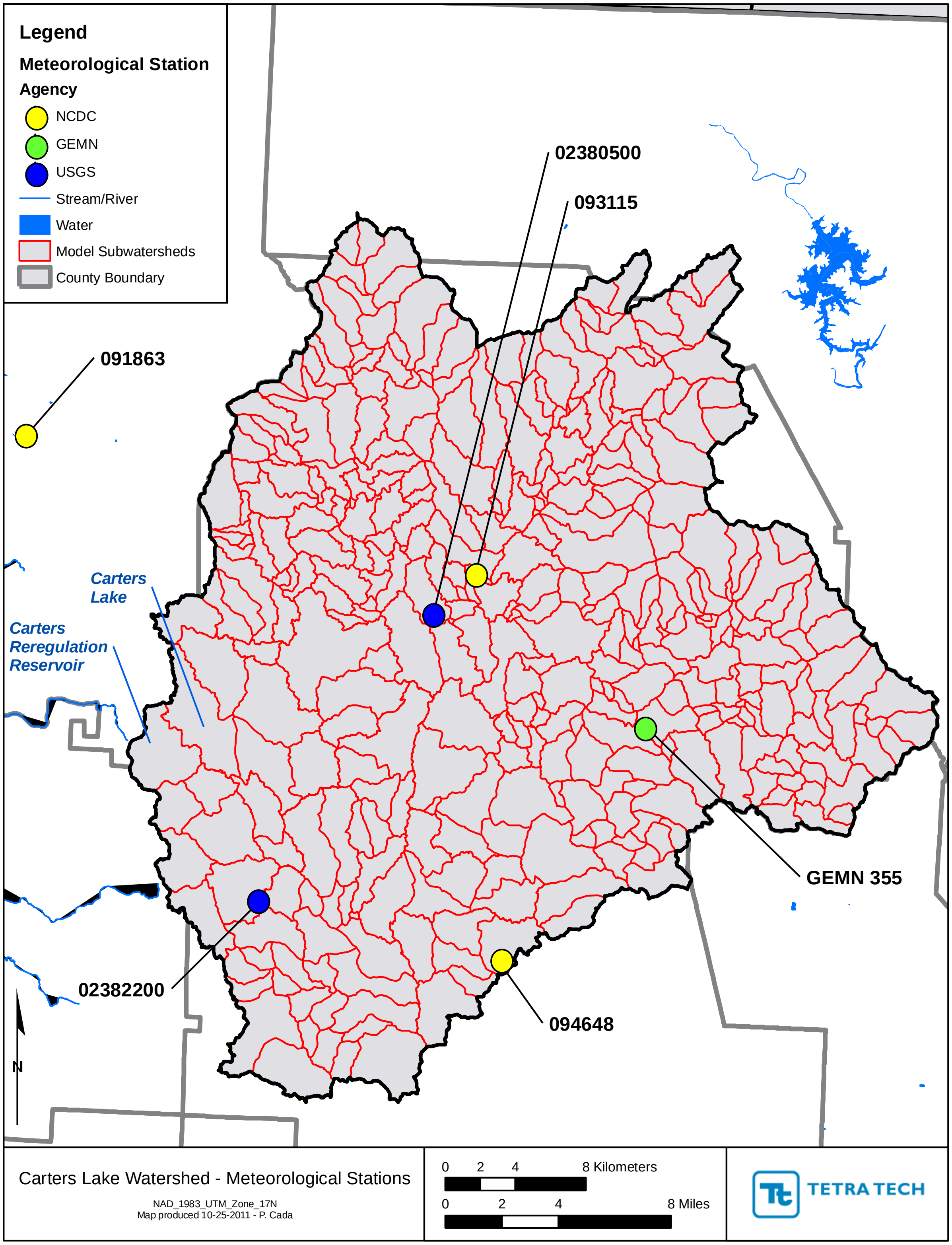


Figure 7. Precipitation Stations Used in the Carters Lake Watershed Model

Land Cover

The watershed model uses land cover data as the basis for representing hydrology and nonpoint source loading. The land use data used was the 2005 GLUT coverage. Figure 8 presents the distribution of land cover within the Carters Lake watershed, and a breakdown of the watershed by land use is given in Table 2.

The LSPC model requires division of land cover into pervious and impervious land units. For this, the GLUT impervious cover, Figure 9, was intersected with the GLUT land use cover. Any impervious areas associated with utility swaths, developed open space, and developed low intensity, were grouped together into low intensity development impervious. Impervious areas associated with medium intensity development and high intensity development, were kept separate in medium intensity development impervious and high intensity development impervious, respectively. Finally, all impervious areas not already accounted for in the three developed impervious classes were grouped together into a remaining impervious class called catch all for remaining impervious (Table 10). The catch all for remaining impervious class is made up of small bits of imperviousness associated with Clearcut/Sparse (Transitional), Quarries/Strip Mines/Gravel Pits, Bare Rock/Sand/Clay, Deciduous Forest, Evergreen Forest, Mixed Forest, Golf Courses, Pasture/Hay, and Row Crops.

Table 10. Land Cover Percent Impervious and Pervious

Land Categories Represented in the Model	Land Use Code	GLUT Land use Category	% Impervious	% Pervious
Water	11	Open Water	0	100
Urban	20,21,22	Developed Low Intensity	4	96
Urban	23	Developed Medium Intensity	48	52
Urban	24	Developed High Intensity	83	17
Barren & Mining	31	Clearcut/Sparse (Transitional)	0	100
Barren & Mining	33	Quarries/Strip Mines/Gravel Pits	0	100
Barren & Mining	34	Bare Rock/Sand/Clay	0	100
Forest	41	Deciduous Forest	0	100
Forest	42	Evergreen Forest	0	100
Forest	43	Mixed Forest	0	100
Golf	73	Golf Courses	0	100
Pasture	80	Pasture/Hay	0	100
Cropland	83	Row Crops	0	100
Wetland	91	Forested Wetland	0	100
Wetland	93	Non-forested Wetlands	0	100
Failing Septic	888	Failing Septics	0	100
Pasture Chicken	1000	Chicken Pasture	0	100
Remaining Impervious	332	Catch All for Remaining Impervious	100	0

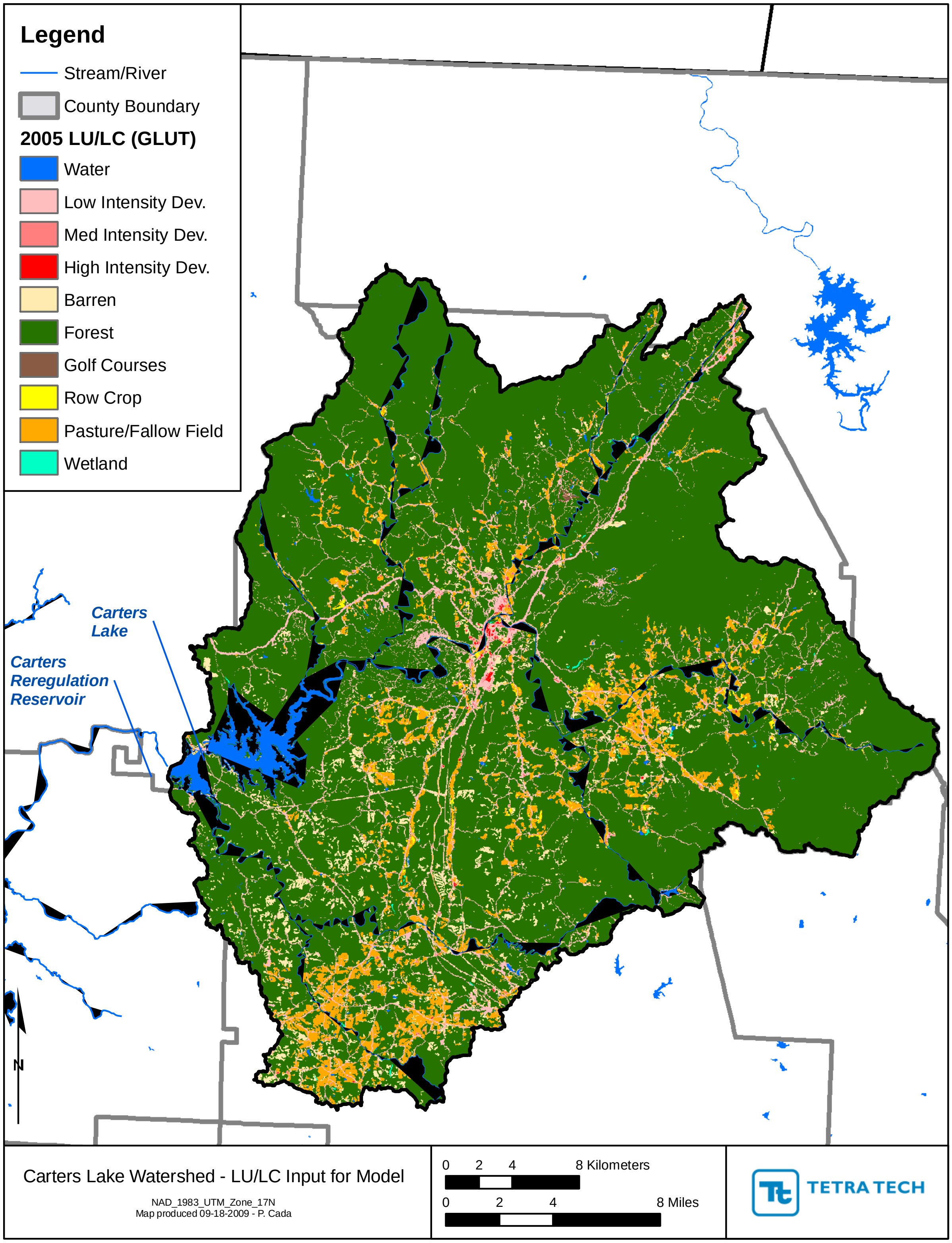


Figure 8. Carters Lake Watershed Land Cover from 2005 GLUT

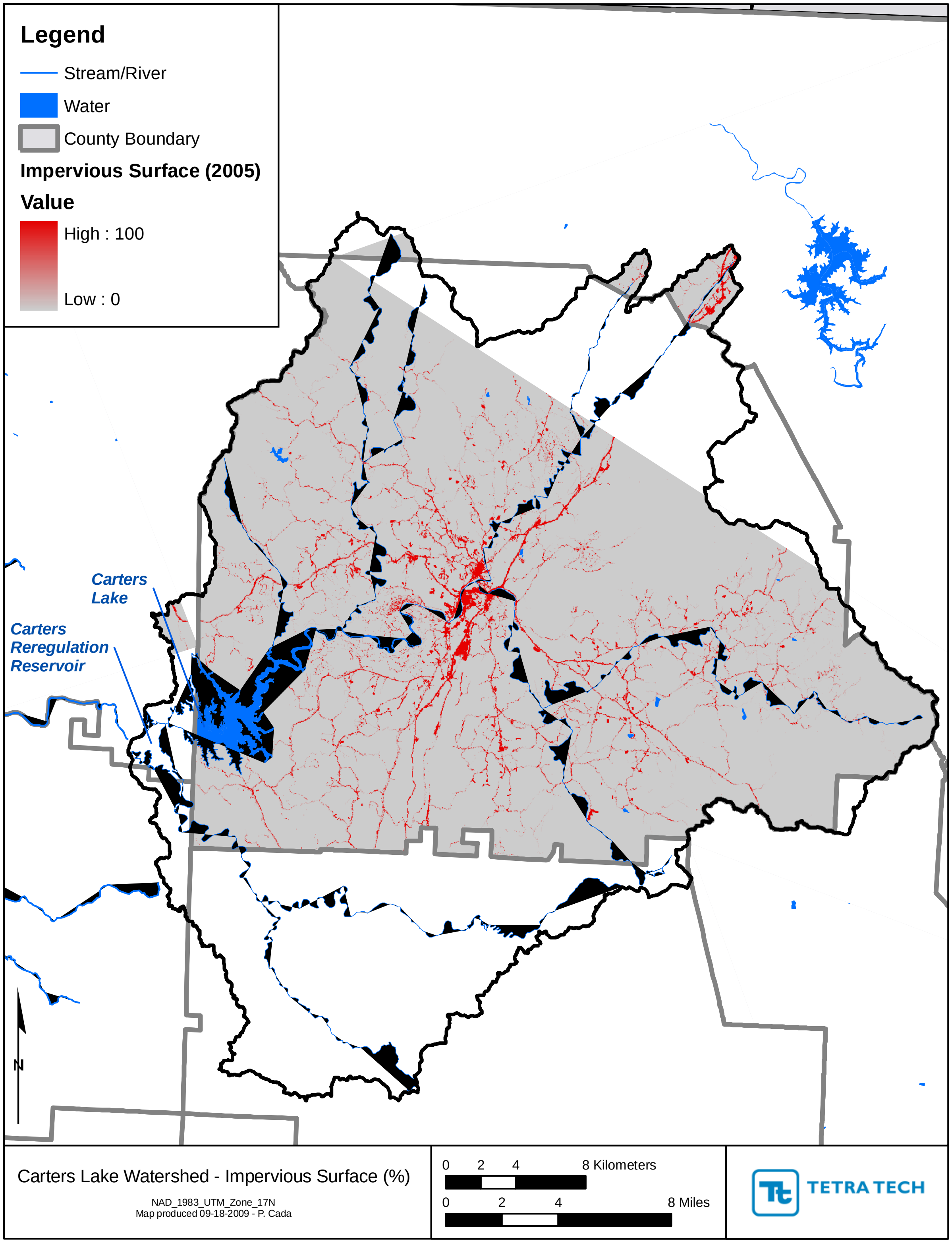


Figure 9. Carters Lake Watershed Impervious Coverage from 2005 GLUT

Chicken Houses

In the Carters Lake watershed, an amendment to the land use coverage was made to account for broiler chicken houses. Google Earth imagery was used to map locations and create a Geographic Information System (GIS) point coverage of broiler chicken houses. There are 791 broiler houses identified in the Carters Lake watershed. These broiler chicken houses are buildings that currently house, or in the past housed, a large number of birds. It is common for chicken manure to be applied to pasture land. A study conducted by the University of Georgia (UGA) showed pasture land within a 0.75-km radius of a chicken house typically received applications of broiler manure (Lin, 2008). To distinguish regular pasture land from pasture land that receives or has received broiler manure, a 0.75-km radius was drawn around each broiler chicken house, and all pasture land contained within this buffer area was converted to a new land use type known as “Pasture-Chicken” (Figure 10).

It is well known that chicken manure is very high in phosphorus and nitrogen. It was assumed that the pasture land within the buffer area receives 6.73 mg per hectares per year of broiler litter (Lin, 2008), which translates to an average of 16.45 pounds of broiler litter per day. Of the 16.45 lbs per day of broiler litter, 1.3% (Radcliffe, 2008a) was assumed to be total phosphorus (0.214 lbs per day). It was assumed that 0.214 pounds per day was the accumulation rate and the maximum storage was 0.214 pounds, indicating an “instant build-up.” To calculate the amount of nitrogen applied to the pasture land used by poultry, it was assumed that of the 16.45 pounds per acre per day of broiler litter, total nitrogen makes up 3.13% (0.515 lbs per day) (Radcliffe 2008). Similar to total phosphorous, it was assumed that the load of total nitrogen, the accumulation rate and the maximum storage value, indicating an “instant build-up”.

During the water quality calibration process, several water quality stations simulated too low Total Nitrogen concentrations for 2008. These stations were identified as having a higher percentage of Pasture-Chicken land. A series of scenarios were set up using different percentages of the buffer area for receiving applications of broiler manure. Each simulation was compared to the observed Total Nitrogen concentrations and a statistical technique called sum of least square errors was used to determine which scenario best fit the observed data. After this analysis was completed, the pasture-chicken land was reprocessed. The total chicken house buffer area in each sub-watershed was increased by 25%. In order to preserve each sub-watersheds area, the Pasture-Chicken area was subtracted from 1) Pasture, if this created a negative number for Pasture then Pasture area was set to zero and the remaining area was subtracted from 2) Barren, if this still resulted in a negative number for Barren then Barren was set to zero and the remaining was taken from 3) Deciduous Forest.

It is acknowledged that the estimation of chicken houses based on aerial photography includes facilities that are no longer active. Thus, the number of active houses in the watershed and the corresponding pasture land within buffer area that receives manure, is currently applied, has most likely been overestimated. Additionally, the model does not account for the significant amount of manure that is transferred out of the watershed for use as a fertilizer in other parts of the State.

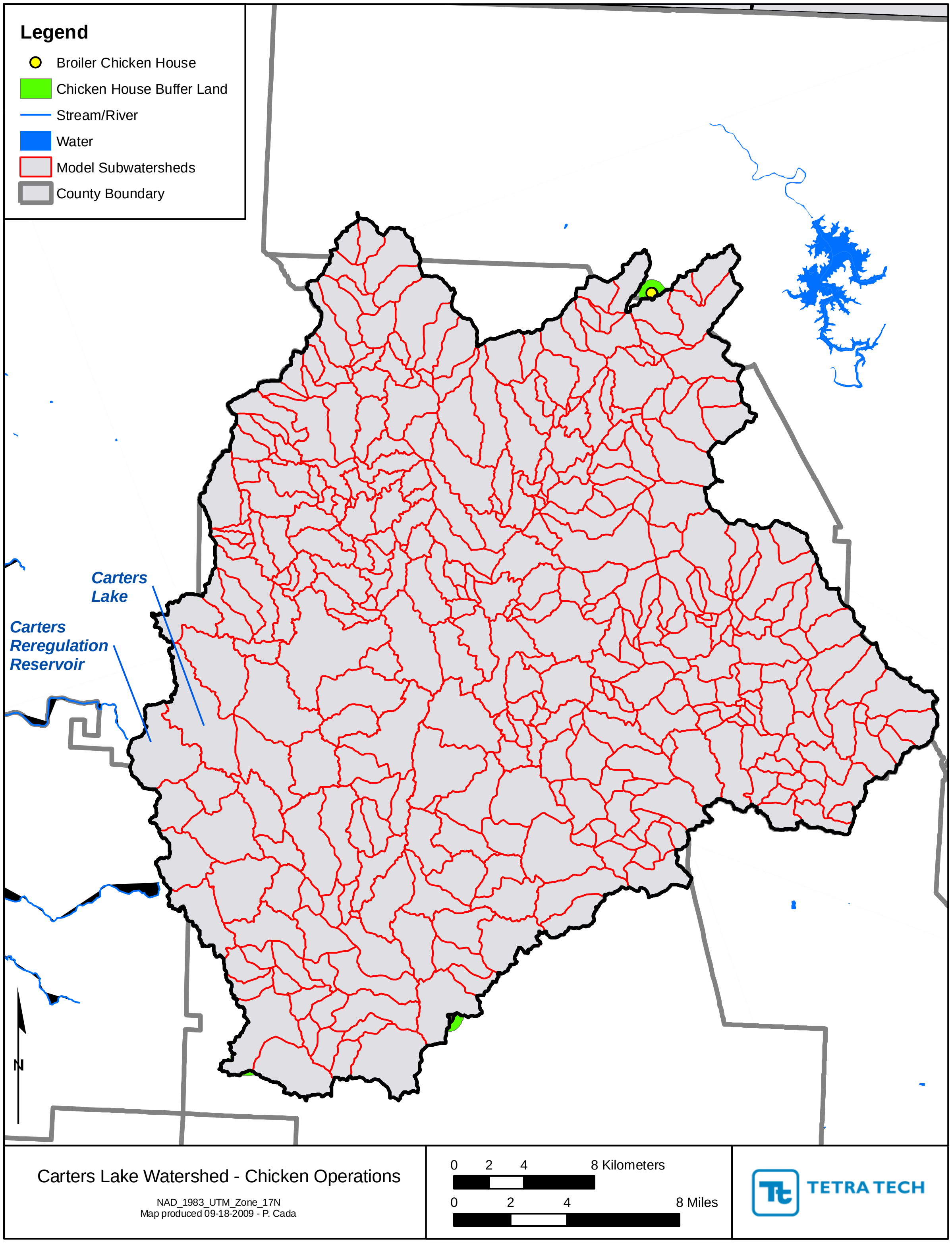


Figure 10. Pasture Chicken Land around Chicken Houses in the Carters Lake Watershed

Soils

Soils are classified by the Natural Resources Conservation Service (NRCS) into four Hydrologic Soil Groups based on the soil's runoff potential. The four basic Hydrologic Soil Groups are A, B, C, and D The different soil groups range from soils that have a low runoff potential to soils that have a high runoff potential. The four soils groups are described below:

> Group A Soils Low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well to excessively drained.
> Group B Soils Moderate infiltration rates when wet and consist chiefly of soils that are moderately deep to deep, moderately to well drained, and moderately to moderately course textures.
> Group C Soils Low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately fine to fine texture.
> Group D Soils High runoff potential, very low infiltration rates and consist chiefly of clay soils.

Soil data for the Carters Lake Watershed was obtained from the U.S General Soil Map (STATSGO2). The NRCS – National Cartography and Geospatial Center (NCGC) previously archived and distributed the State Soil Geographic (STATSGO) Database. The STATSGO spatial and tabular data were revised and updated in 2006 and STATSGO has been renamed to the U.S. General Soil Map (STATSGO2). There are two main Hydrologic Soil Groups, Groups B and C, in the Carters Lake watershed. Figure 11 shows the soil groups coverage for the watershed. The total area that each hydrologic soil group covered within each sub-watershed was determined. The hydrologic soil group that had the highest percent of coverage within each sub-watershed represented that sub-watershed in LSPC.

Reach Characteristics - Stream Lengths and Slopes

Each sub-watershed must have a representative reach defined for it. The characteristics for each reach include the length and slope of the reach, the channel geometry, and the connectivity between the sub-watersheds. Length and slope data for each reach was obtained using the Digital Elevation Maps (DEM) and the National Hydrography Dataset (NHD). The channel geometry is described by a bank full width and depth (the main channel), a bottom width factor, a flood plain width factor, and the slope of the flood plain.

Point Source Discharge Data

There are four point source discharges located in the Carters Lake watershed that have NPDES permits. Of the four point sources, one is a major municipal facility, two are rock quarries, and one is a minor Public Institutional Discharger (PID). Flows and water data for these point source discharges were obtained from either the Discharge Monitoring Reports (DMR) or Operating Monitoring Reports (OMR). Data obtained from these reports were input directly into the LSPC model. The sub-watershed that each facility was assigned are given in Table 11.

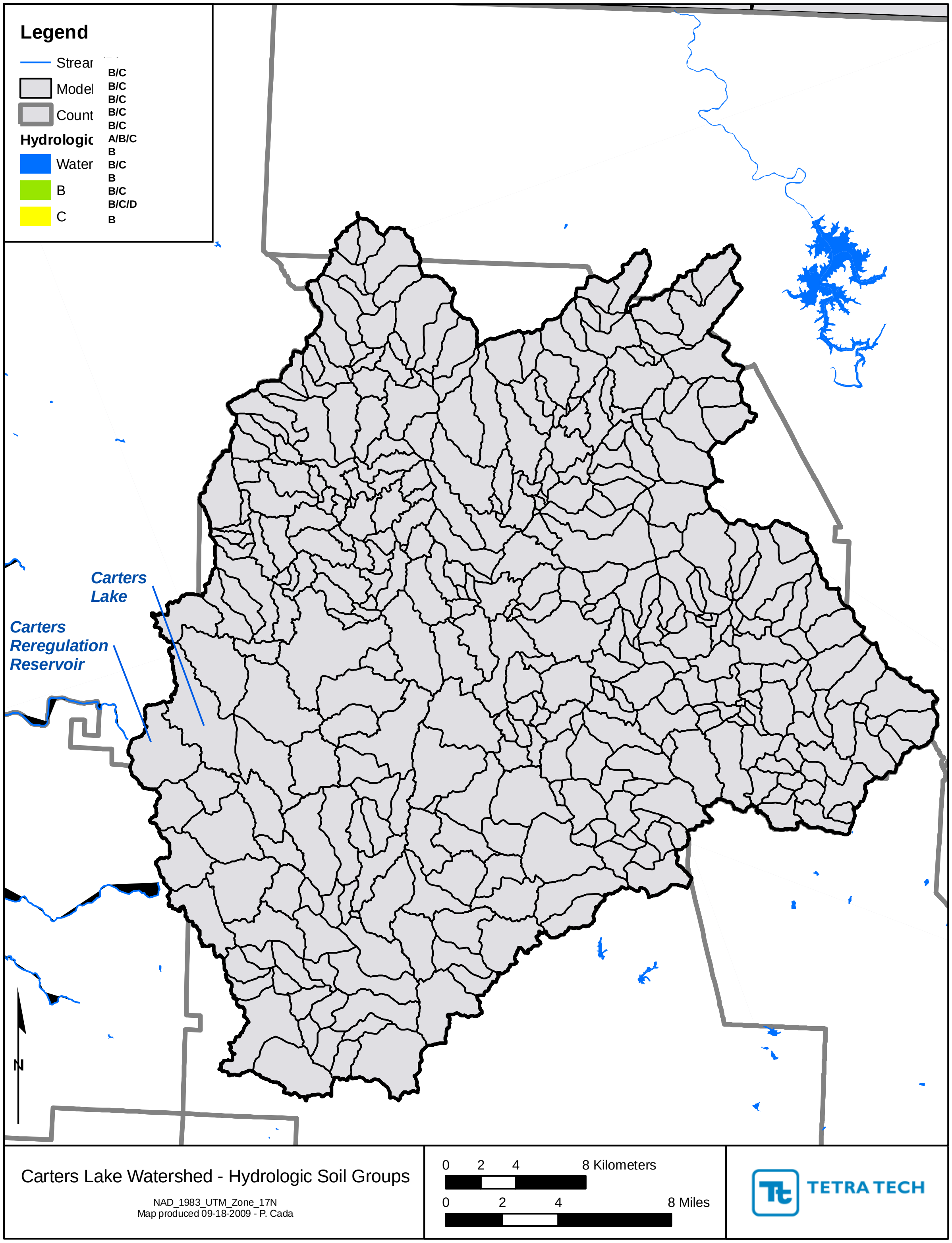


Figure 11. Carters Lake Watershed Soil Hydrologic Groups

Table 11. Summary of Point Source Discharges to the Carters Lake Watershed

Permit Number	Facility Name	Facility Type	Receiving Water	Permitted Flow (MGD)	Sub-Watershed
GA0021369	Ellijay WPCP	MUN	Coosawattee River	2.5	101
GA0037818	Vulcan Construction Materials	IND-RQ	White Path Creek	NA	127
GA0037834	O-N Minerals Chemstone Co	IND-RQ	Talona Creek Tributary	NA	333
GA0047210	Oakland Elementary School	PID	Lick Log Creek	0.004	271

Compliance Sampling Inspection (CSI) reports data were used to determine values for particular constituents needed for model input that were not reported on the DMR and OMR sheets. The CSI was either used directly or based on the average speciation was used to calculate constituent values (Table 12). For example, ammonia is a measured value and the other nitrogen species are default, so speciation from the CSI reports are utilized to calculate the other nitrogen constituents from the measured ammonia values.

Table 12. Compliance Sampling Inspection Data

Permit Number	Facility Name	Date Sampled	Flow (MGD)	BOD_5 (mg/L)	TP (mg/L)	Ortho P (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_2/NO_3 (mg/L)	TSS (mg/L)
GA0021369	Ellijay WPCP	4/17/2008	2.297	<2.0	15	15	17	17	6.6	4.8
		5/19/2009	2.29	<2.0	18	18	3.6	2.4	9.4	<1.0
GA0037818	Vulcan Construction Materials	5/28/2009	-	-	0.03	-	1.1	-	3.7	4.2
GA0037834	O-N Minerals Chemstone Co	5/28/2009	-	-	0.04	-	<0.20	<0.03	2.1	6
GA0047210	Oakland Elementary School	4/17/2008	-	3	9.6	8.9	47	39	19	9.1

The two rock quarries did not report loads or concentrations for all constituents utilized in the LSPC model input time series (Flow, DO, BOD5, TN, Org-N, NH3, NOx, TP, Org-P, Ortho-P, TSS, and Temperature). Default concentrations adopted for the missing constituents were DO 5 mg/L and TSS 30 mg/L. Flow was the maximum reported flow from 1997 through 2009 or the design flow. All other constituents were 0 mg/L unless otherwise noted. In addition, none of the facilities had effluent temperature, so an assumed temperature of 15°C was utilized for October-March and 25°C was utilized for April-September.

Septic Tanks

Septic tanks were also considered in the watershed model. The number of septic tanks in each sub-watershed was determined through an area-weighting method. Each sub-watershed was assigned to a county based on where the outlet of the watershed lies. The ratio of the area of the sub-watershed to the area of the county was determined, and this ratio was applied to the total number of septic tanks in the county to determine a number for each sub-watershed.

Septic tanks contribute to water quality whether they are functioning properly or failing. It was assumed that 85% of the septic tanks were non-failing and 15% of the septic tanks were failing. For the non-failing septic tanks, these were treated as a source of nutrients through subsurface flow. This was represented as a direct input into the stream, assuming a first order decay rate and an average 60-day travel time from the septic tank to the stream. To represent the non-failing septic tank flow, it was assumed that each septic tank serves a household of 2.8 people and that each person accounts for 70 gallons/day of flow in the septic tank and 15% of the water used in the house never makes it to the septic tank. The non-failing septic tanks were modeled as very small individual point sources for each sub-watershed. Table 13 presents the concentration of septic tank effluent, decay rates for each constituent, and the concentration after 60 days of decay. For phosphorus, it was also assumed that 90% was sorbed to sediment; therefore only 10% of the effluent concentration was used to calculate decay after 60-days.

Table 13. Septic Tank Water Quality Concentrations

Parameter	Effluent Concentration (mg/L)	Decay Rate (1/day)	Concentration at Stream (mg/L)**
BOD_5	105.0	0.16	0.003
Total Nitrogen	70.268	0.1	0.01263
Organic Nitrogen	0.458	0.1	0.0008
Ammonia	10.5	0.1	0.0189
Nitrate+Nitrite	59.3	0.1	0.01066
Total Phosphorus*	0.3	0.014	0.1287
Organic Phosphorus*	0.3	0.014	0.1287
Ortho-Phosphate*	0.0	0.014	0
TSS	10.0	0	10
Dissolved Oxygen			4
Fecal coliform	--	--	10000***

* It was assumed that 90% of phosphorus is sorbed to sediment.
** Assumes Septic Flow takes an average of 60 days to reach stream
*** Fecal coliform concentration obtained from US EPA (2001) "Protocol for Developing Pathogen TMDLs"

The portion of the septic tanks that were considered failing were modeled as a “Failing Septic Tank“ land use because it was assumed that no decay occurs and raw effluent is directly applied to the land. It was determined that the average area of a septic field is 6,750 ft^2 (Inspectapedia 2009). The land use that was represented as “Failing Septic Tanks” was subtracted from the Low Intensity Urban Pervious land use for each sub-watershed. For a few of the sub-watersheds subtracting Failing Septic from Low Intensity Urban Pervious resulted in negative values. For these watersheds, all of the Failing Septic Tank area was subtracted from Developed Open Space.

<u>Water Withdrawal Data</u>

There are two water withdrawals located in the Carters Lake watershed that were represented in the LSPC model. Average monthly water withdrawal data were obtained. The withdrawal volume data were developed into a time-series from 1997 to 2009 for inclusion in the model. For data gaps less than three months, the before and after volumes were averaged and used to fill the data gap. For longer than three month data gaps, it was verified that the facility was operational and the long-term monthly average withdrawal volume was used to fill the data gap.

The source water, sub-watershed, and permitted withdrawal for each withdrawal are given in Table 14.

Table 14. Summary of Water Withdrawals in the Carters Lake Watershed

Permit Number	Withdrawal	Source Water	Sub-Watershed	Permitted Withdrawal 24-Hour Limit (MGD)	Permitted Withdrawal Monthly Average (MGD)
061-1407-01	City of Ellijay	Ellijay River	109	0.55	0.45
061-1408-01	Ellijay-Gilmer County Water and Sewer Authority	Cartecay River	108	4.00	4.00

Modeling Parameters

Pollutants simulated by LSPC were biochemical oxygen demand (BOD), total nitrogen (Total N), and total phosphorus (Total P). LSPC requires land cover specific accumulation and washoff rates for each of the modeled water quality parameters. Table 15 provides the rates developed during model calibration for BOD, total nitrogen, and total phosphorus for each land cover type.

Table 15. LSPC Modeling Parameters

Land use	Water Quality Parameter	Rate of Accumulation (lb/acre/day)	Maximum Storage (lb/acre)	Rate Of Surface Runoff Which Will Remove 90% (in/hr)	Concentration In Interflow Outflow (mg/L)	Concentration In Active Groundwater Outflow (mg/L)
Beach	BOD	0.12 - 0.37	0.48 - 1.48	0.70	1.4 - 1.55	1.3 - 1.45
	Total N	0.06 - 0.2	0.24 - 0.8	0.70	0.44 - 0.59	0.34 - 0.49
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0168 - 0.0186	0.0129 - 0.0145
Water	BOD	0.00	0.00	0.00	0.00	0.00
	Total N	0.00	0.00	0.00	0.00	0.00
	Total P	0.00	0.00	0.00	0.00	0.00
Low Developed Pervious	BOD	0.12 - 0.37	0.48 - 1.48	0.70	3.43 - 5.55	2.33 - 3.45
	Total N	0.06 - 0.2	0.24 - 0.8	0.70	0.405 - 0.54	0.288 - 0.423
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0188 - 0.0206	0.0147 - 0.0164
Low Developed Impervious	BOD	0.06 - 0.185	0.24 - 0.74	0.35	0.00	0.00
	Total N	0.03 - 0.1	0.12 - 0.4	0.35	0.00	0.00
	Total P	0.0045 - 0.017625	0.018 - 0.0705	0.30	0.00	0.00
Medium Developed Pervious	BOD	0.12 - 0.37	0.48 - 1.48	0.70	3.43 - 5.55	2.33 - 3.45
	Total N	0.06 - 0.2	0.24 - 0.8	0.70	0.405 - 0.54	0.288 - 0.423
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0188 - 0.0206	0.0147 - 0.0164
Medium Developed Impervious	BOD	0.06 - 0.185	0.24 - 0.74	0.35	0.00	0.00
	Total N	0.03 - 0.1	0.12 - 0.4	0.35	0.00	0.00
	Total P	0.0045 - 0.017625	0.018 - 0.0705	0.30	0.00	0.00
High Developed Pervious	BOD	0.12 - 0.37	0.48 - 1.48	0.70	3.43 - 5.55	2.33 - 3.45
	Total N	0.06 - 0.2	0.24 - 0.8	0.70	0.405 - 0.54	0.288 - 0.423
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0188 - 0.0206	0.0147 - 0.0164
High Developed Impervious	BOD	0.06 - 0.185	0.24 - 0.74	0.35	0.00	0.00
	Total N	0.03 - 0.1	0.12 - 0.4	0.35	0.00	0.00
	Total P	0.0045 - 0.017625	0.018 - 0.0705	0.30	0.00	0.00

Land use	Water Quality Parameter	Rate of Accumulation (lb/acre/day)	Maximum Storage (lb/acre)	Rate Of Surface Runoff Which Will Remove 90% (in/hr)	Concentration In Interflow Outflow (mg/L)	Concentration In Active Groundwater Outflow (mg/L)
Barren	BOD	0.1 - 0.1	0.4 - 0.4	0.70	1.3 - 2.8	1.6000
	Total N	0.05 - 0.19	0.2 - 0.76	0.70	0.4 - 0.55	0.25 - 0.4
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.012 - 0.0138	0.011 - 0.0127
Forest	BOD	0.1 - 0.35	0.4 - 1.4	0.70	1.4 - 1.55	1.3 - 1.45
	Total N	0.04 - 0.15	0.16 - 0.6	0.70	0.252 - 0.387	0.171 - 0.306
	Total P	0.00325 - 0.0295	0.013 - 0.118	0.60	0.0092 - 0.011	0.0085 - 0.0103
Golf	BOD	0.12 - 0.37	0.48 - 1.48	0.70	1.45 - 1.6	1.35 - 1.5
	Total N	0.06 - 0.2	0.24 - 0.8	0.70	0.405 - 0.54	0.288 - 0.423
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0161 - 0.0179	0.0147 - 0.0164
Pasture	BOD	0.18 - 0.55	0.72 - 2.2	0.70	2.4 - 2.55	2.3 - 2.45
	Total N	0.08 - 0.61	0.32 - 2.44	0.70	1.314 - 1.485	1.017 - 1.17
	Total P	0.02075 - 0.0395	0.083 - 0.158	0.60	0.078 - 0.0798	0.0564 - 0.0591
Crop	BOD	0.18 - 1.22	0.72 - 4.88	0.70	2.45 - 2.6	2.35 - 2.5
	Total N	0.08 - 0.61	0.32 - 2.44	0.70	1.51 - 1.7	1.28 - 1.45
	Total P	0.02075 - 0.0395	0.083 - 0.158	0.60	0.1055 - 0.1073	0.0811 - 0.0832
Wetland	BOD	0.1 - 0.35	0.4 - 1.4	0.70	1.4 - 1.55	1.3 - 1.45
	Total N	0.04 - 0.19	0.16 - 0.76	0.70	0.6 - 0.75	0.47 - 0.62
	Total P	0.007 - 0.03325	0.028 - 0.133	0.60	0.0092 - 0.011	0.0085 - 0.0103
Other Impervious	BOD	0.06 - 0.185	0.24 - 0.74	0.35	0.00	0.00
	Total N	0.03 - 0.1	0.12 - 0.4	0.35	0.00	0.00
	Total P	0.0045 - 0.017625	0.018 - 0.0705	0.30	0.00	0.00
Failing Septic	BOD	0.3090	1.2360	0.70	4.2000	1.5000
	Total N	0.0701	0.2804	0.70	0.5680	0.4680
	Total P	0.0093	0.0370	0.60	0.0528	0.0473
Chicken Land	BOD	0.133333 - 0.4	0.133333 - 0.4	0.70	0.2000	1.5000
	Total N	0.5149	0.5149	0.70	5.5010	4.5010
	Total P	0.2139	0.2139	0.50	0.0974	0.0878

Model Calibration

Historical flow data collected at USGS stations located in the Carters Lake watershed (Table 16) were used to calibrate and validate the LSPC watershed hydrology model. Figure 12 shows the location of these flow gages used for the hydrologic calibrations. Three of the gages had a complete period of record for the simulation period from January 1, 1998 through December 31, 2009. These gages were used as calibration gages. The two remaining gages had short periods of record and were utilized as validation gages.

Table 16. Flow Stations Used to Calibrate LSPC Hydrology

Station Name	Station Number	USGS Stations	Drainage Area (mi^2)	Calibration/ Validation/ Verification
Cartecay River near Ellijay, GA	002	02379500	134	Validation
Coosawattee River near Ellijay, GA	003	02380500	236	Calibration
Mountaintown Creek at GA 282, near Ellijay, GA	006	02381090	62	Validation
Fausett Creek near Talking Rock, GA	007	02381600	10	Calibration
Talking Rock Creek near Hinton, GA	016	02382200	119	Calibration

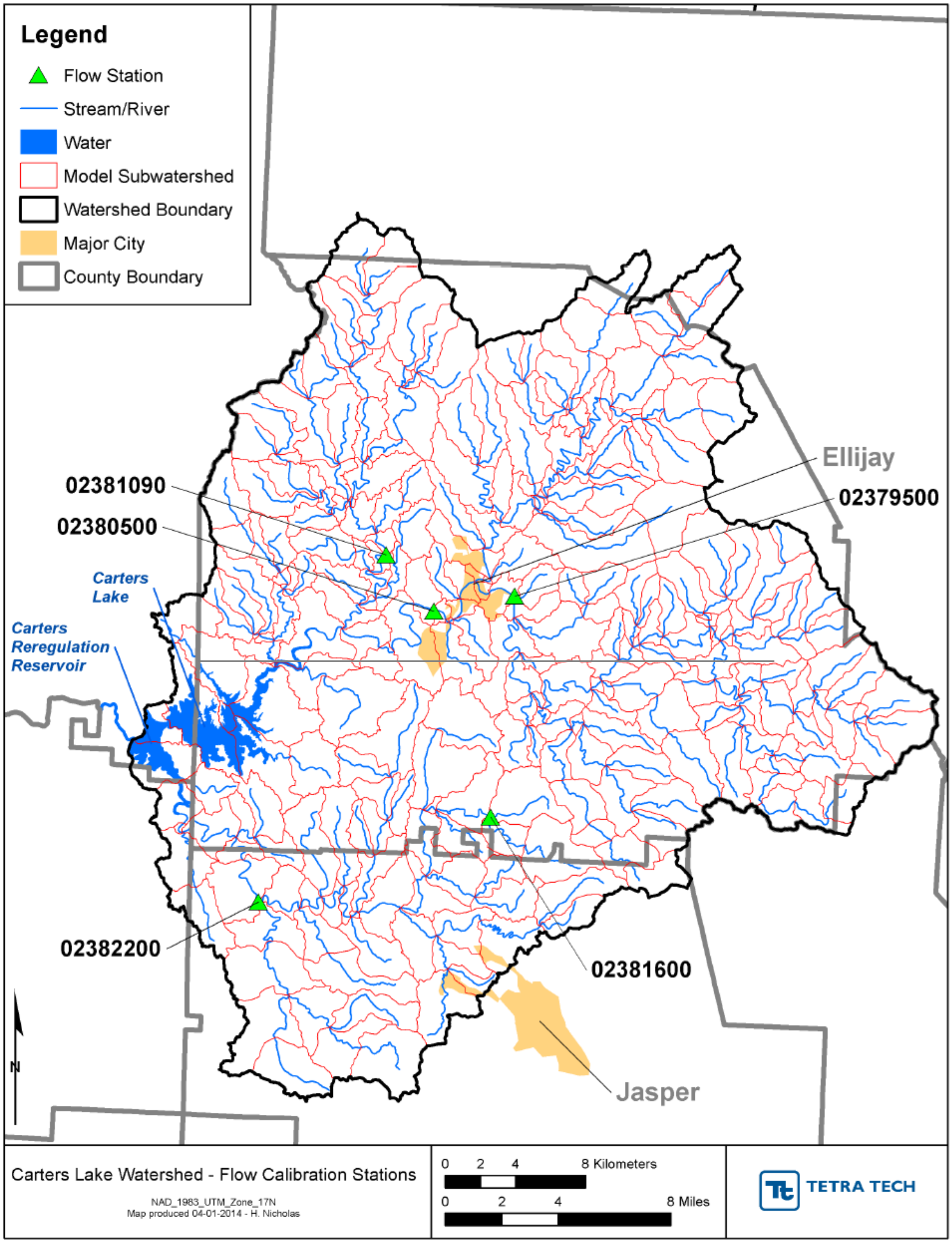


Figure 12. Flow Stations Used in the Hydrologic Calibration of LSPC

During the calibration process, model parameters were adjusted based on local knowledge of soil types and groundwater conditions, within reasonable constraints as outlined in Technical Note 6 (US EPA 2000), until an acceptable agreement was achieved between simulated and observed stream flow. Key hydrologic model parameters adjusted included: evapo-transpiration, infiltration, upper and lower zone storages, groundwater recession, and losses to the deep groundwater system.

It was observed that the USGS gages in the watershed contributing to Carters Lake (02379500, 02380500, and 02381090) had different flow regimes than the USGS gages in the watershed contributing to the Reregulation Reservoir (02381600 and 02382200). To improve calibration of the Reregulation watershed without affecting the calibration of the Carters Lake watershed, two new parameter groups were developed that represented Hydrologic Soil Groups 2 and 3 for the portion of the watershed contributing to the Reregulation Reservoir. The parameters that were changed were the groundwater recession constants and losses to deep groundwater. The addition of these two new parameter groups resulted in acceptable calibration results for the two different hydrologic regimes observed in the Carters Lake Watershed.

As previously mentioned, to represent watershed loadings and resulting pollutant concentrations in individual stream segments, the Carters Lake watershed was divided into 366 sub-watersheds. Listed reaches, tributary confluences, and the locations of water quality monitoring sites defined these sub-watersheds, representing hydrologic boundaries. Delineation at water quality monitoring sites allowed comparison of model output to measured data.

During 2008, GA EPD intensively sampled rivers and streams in the Carters Lake Watershed. This sampling was conducted at 24 key locations throughout the watershed. The Carters Lake LSPC model was calibrated and validated to discrete instream water quality measurements. The list of stations and how they were utilized is given in Table 17 and the station locations are shown in Figure 13.

The water quality data included total nitrogen, nitrate+nitrite, ammonia, total Kjeldahl nitrogen (TKN), total phosphorus, orthophosphate, BOD_5, and total suspended sediment (TSS). Five of the 24 stations had more than one year of data so they were chosen to be calibration stations. The remaining 19 stations were utilized as validation stations. Figure 16 shows the total phosphorus calibration for the Coosawattee River at Georgia Highway 5 near Ellijay, Georgia during 2001 through 2009. Other calibration plots can be found in Appendix P of the LSPC Watershed Modeling Report for Carters Lake.

Table 17. Monitoring Stations Used to Calibrate LSPC Water Quality

Station Name	Station Number	Calibration / Validation / Verification
Rock Creek at Rock Creek Road	14056301	Validation
Ellijay River at Foose Island Road	14056401	Validation
Boardtown Creek at Whitepath Road	14056501	Validation
Big Turniptown Creek at Northcutt Road	04056701	Validation
Kells Creek at Kells Ridge Drive	14056821	Validation
Ellijay River at SR 52 (River Street)near Ellijay, GA	14056901	Calibration
Tickanetly Creek at Macedonia Road	14063901	Validation
Royston Creek at Big Creek Road	14064901	Validation
Cartecay River at Lower Cartecay Road	14070001	Validation
Clear Creek at Blackberry Mountain Road	14095511	Calibration
Cartecay River At SR 2 Connector near Ellijay, GA	14079011	Calibration
Coosawattee River at GA Highway 5 near Ellijay, GA	14109901	Validation
Coosawattee River at Bridge in Coosawattee Resort	14109931	Validation
Mountaintown Creek At CR 64 (Sam Hill Road)	14114001	Validation
Mountaintown Creek at Craigtown Road	14114031	Validation
Little Mountain Creek at Hidden Valley Trail	14114101	Validation
Conasauga Creek at Mountaintown Road	14114201	Validation
Davis Creek at Private Drive off Mountaintown Road	14114301	Validation
Mountaintown Creek at SR 282 (US Hwy 76) near Ellijay, GA	14115001	Calibration
Tails Creek at SR 282/US Hwy 76 near Ellijay, GA	14116001	Calibration
Flat Creek at SR 382	14119251	Validation
Harris Creek at East Harris Branch Road	14119261	Validation
Talking Rock Creek at GA Hwy 136 near Blaine, GA	14119901	Validation
Talking Rock Creek at Talking Rock Resort Community	14119981	Validation

Table 18 gives the modeled annual total phosphorus load for the major lake tributaries compared to the calculated load based on continuous flow measured at the USGS gages and monthly total phosphorus measured at Coosawattee River at Old Highway 5 and Mountaintown Creek at U.S. Highway 76. In average to above average precipitation years, the calculated annual load is often higher than the modeled load. This may be due to the method of holding Total Phosphorus concentration constant when calculating the annual major tributary load.

Table 18. Modeled and Calculated Annual Average Total Phosphorus Load (lbs/yr) for the Major Tributaries

Station	Standard	2002	2003	2004	2005	2006	2007	2008	2009
Coosawattee River at Old Highway 5	Modeled	96,500	126,800	126,900	109,400	104,900	94,900	105,300	177,600
	Measured	93,000	106,600	156,400	277,000	85,400	127,580	127,600	265,948
Mountaintown Creek at U.S. Highway 76	Modeled	5,500	12,100	10,500	7,900	3,100	1,600	2,700	14,600
	Measured	2,700	5,000	6,800	15,900	5,700	2,710	4,700	19,658

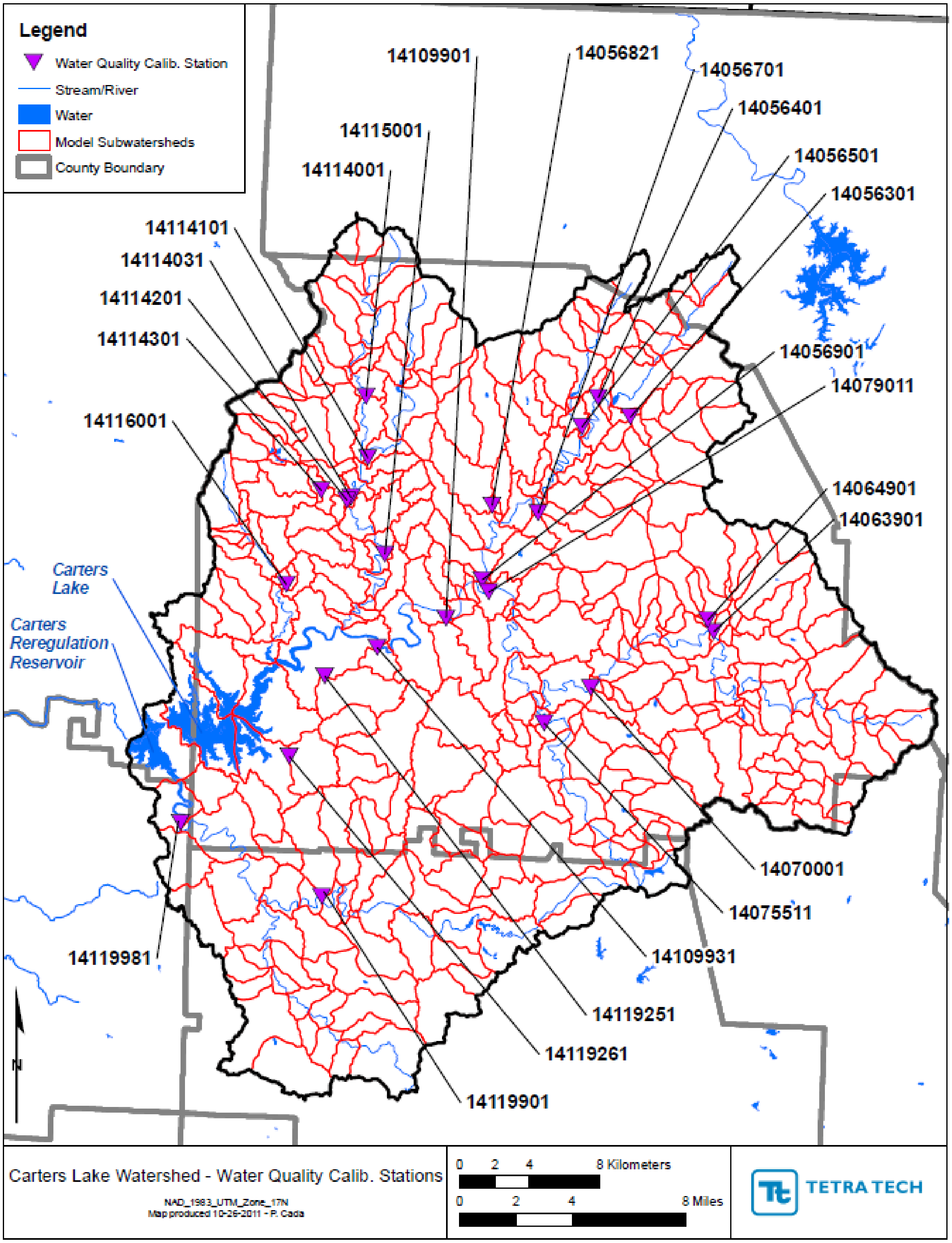


Figure 13. Monitoring Stations Used in the Water Quality Calibration of LSPC

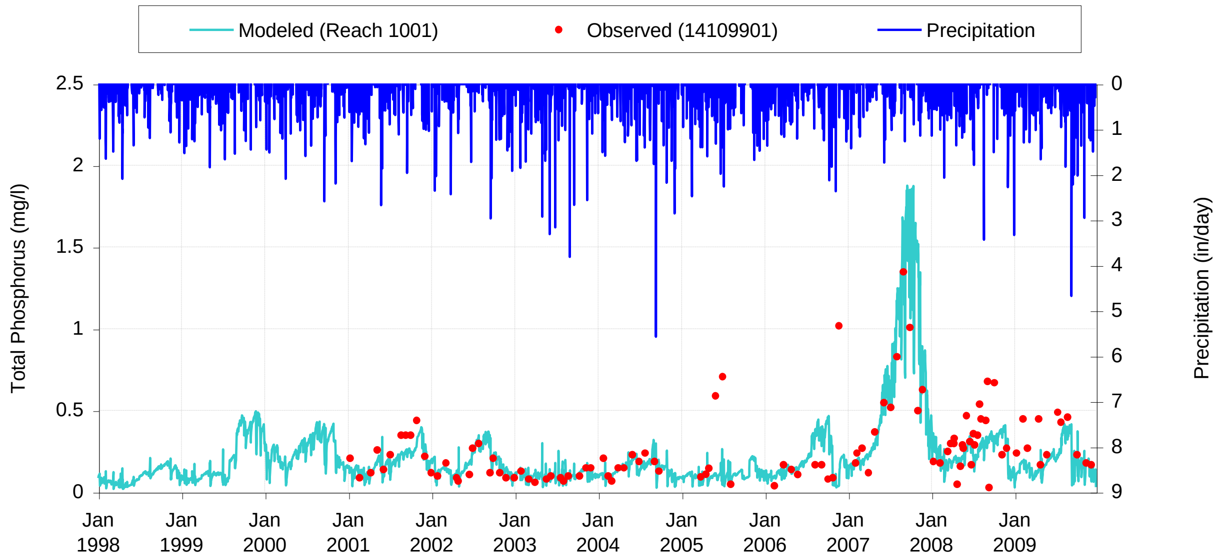


Figure 14. Total Phosphorus Calibration at GA EPD 14109901 Coosawattee River at Georgia Highway 5 near Ellijay, Ga.

4.2 Hydrodynamic Lake Modeling (EFDC)

Bottom elevations and shoreline boundaries define the EFDC model grid. The grid for Carters Lake covers the entire lake and includes the Coosawattee River up to approximately eight miles downstream from USGS station 0280500 (Coosawattee River near Ellijay, GA). The grid for Carters Reregulation Reservoir covers the entire lake and includes the lower portion of Talking Rock Creek to approximately eight miles downstream from USGS station 0238220 (Talking Rock Creek near Hinton, GA).

The bottom elevations for Carters Lake were obtained from a Kingfisher Map. Once the horizontal grid was developed, bottom elevations were interpolated for each grid cell taking into account the total pool area and volume of the reservoir. Once the bottom elevation was determined for each cell, the stage-area and stage-capacity of Carters Lake were compared. The bottom elevations for Carter Reregulation Reservoir were generated through trial and error since this information was not available from the Kingfisher Maps.

A maximum of 20 uniformly distributed (equal height) vertical layers were defined along the deepest region of the main channel of the Lake. The EFDC model determines how many layers to assign to each cell based on a given reference maximum water surface elevation and the bathymetry (bottom elevation) of each cell. The lowest elevation in the Carters Lake grid was set at 212.44 m MSL (697.0 ft MSL) and the maximum water surface elevation was set at 331.9 m MSL (1089 ft MSL). These two elevations were used to determine the maximum reference depth of 119.5 m (392 ft) and reference layer thickness of 5.97 m (19.6 ft) was determined by dividing the reference depth by the maximum number of layers. To promote the temperature induced convective circulation, both Caters Lake and Carters Reregulation Reservoir had a minimum of 2 layers.

The bottom of Carters Lake is physically above the water surface elevation of Carters Reregulation Pool. To not have the Reregulation Reservoir elevations impact layer assignments of Carters Lake, the Carters Reregulation Reservoir elevations were normalized to Carters Lake elevations. This was done by adding the average difference between the observed water surface elevations from 2001 through 2009 for both lakes (383 ft) to the observed water surface elevation and bottom elevation inputs for Carters Reregulation Reservoir.

The EFDC model requires boundary conditions to simulate circulation and transportation. These conditions include water surface elevations, lake outflows, watershed tributary inflows, and meteorological data. In addition, time series information on the Reregulation Dam releases and withdrawal/return (pump-back) operations between the lakes must be provided. Data for the operation of Carters Dam was obtained from USACE. The USACE provided a 24-hour discharge in cubic feet per second (cfs), which contained both positive and negative numbers. A positive number indicated that there was a net loss of water from Carters Lake and a gain in Carters Reregulation Reservoir. A negative number indicated that there was a net gain of water to Carters Lake and a loss in Carters Reregulation Reservoir. The interaction between the two reservoirs was simulated in EFDC through withdrawal return pairs. Withdrawal return pairs allow for a grid cell and layer in the Carters Lake grid to be linked to a grid cell and layer in the Carters Reregulation Grid. This linkage was done using the USACE 24-hour discharge and creating two flow time-series. One time-series represented flow out of Carters Lake and into Carters Reregulation Reservoir and the other time-series represented flow out of Carters Reregulation Reservoir and into Carters Lake. The benefit of using withdrawal return pairs is that the simulated water quality constituents get passed along with the flow volume. It was assumed that water leaving and returning to Carters Lake was below the surface of the lake and water entering and leaving Carters Reregulation Reservoir was doing so in the top layer.

<u>Tributary Inputs</u>

The results of the LSPC watershed model were used as tributary flow inputs to the Lake hydrodynamic model. Figure 15 shows the model grid for Carters Lake and Carters Reregulation reservoir and the location of the upstream boundaries and watershed inputs.

The watershed flows are an important input for the flow balance of the Lake. Table 19 identifies which EFDC cell each LSPC sub-watershed was input into and the flow type utilized. RO means the in-stream flow value and PERO means the total land outflow from an individual sub-watershed.

Table 19. LSPC Watershed Inputs

LSPC Sub-Watershed	EFDC Cell Flow Type		Flow Type
	I-Value	J-Value	
1	8	11	PERO
2	21	17	PERO
3	9	6	RO
4	9	2	RO
5	28	19	RO
6	34	12	PERO
7	36	6	RO
9	33	18	RO
10	33	23	RO

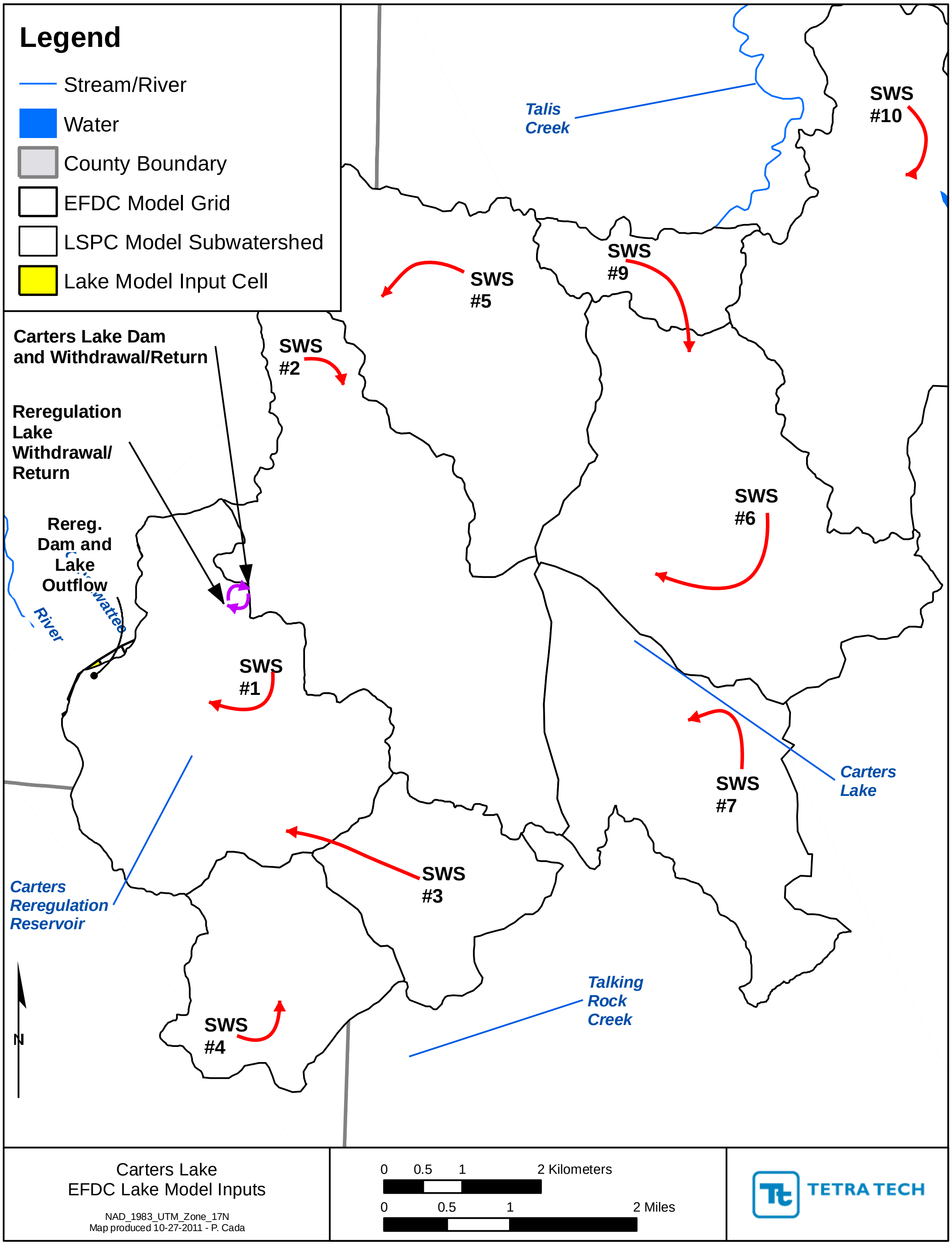


Figure 15. Model Grid for Carters Lake, Showing the Location of the Upstream Boundary and Tributary Flow Inputs

There is one water withdrawal located in Carters Lake. The City of Chatsworth has a water supply intake at the very upper end of Wurley Creek. Table 20 provides a summary of this facility's water withdrawal permit and Table 21 gives the facility's monthly water withdrawals.

Table 20. Summary of Water Withdrawals in the Carters Lake System

Withdrawal	Number Permitted	Permitted Withdrawal 24-Hour Limit (MGD)	Permitted Withdrawal Monthly Average (MGD)	EFDC Cell
City of Chatsworth	105-1409-01	2.55	2.3	(28,19)

Table 21. Monthly Water Withdrawals from the City of Chatsworth (MGD)

Month	2001	2002	2003	2004	2005	2006	2007	2008	2009	Monthly Avg
Jan	1.26	1.04	1.25	1.04	0.95	1.2	0.74	0.86	0.68	0.90
Feb	1.11	1.03	1.21	1.1	0.94	1.25	0.77	0.79	0.57	0.88
Mar	1.06	1.12	1.29	1.18	0.96	1.23	0.82	0.76	0.42	0.88
Apr	1.26	1.24	1.29	1.19	1.26	1.37	0.92	0.74	0.55	0.98
May	1.40	1.39	1.37	1.45	1.29	1.41	1.17	0.62	0.52	1.06
Jun	1.67	1.71	1.42	1.46	1.48	1.55	1.23	0.70	0.60	1.18
Jul	1.51	1.65	1.53	1.37	1.47	1.64	0.98	0.70	0.58	1.14
Aug	1.57	1.81	1.54	1.33	1.52	1.79	1.27	0.81	0.59	1.22
Sep	1.37	1.64	1.39	1.29	1.45	1.7	1.14	0.83	0.65	1.15
Oct	1.31	1.38	1.23	1.15	1.27	1.41	1.20	0.84	0.56	1.04
Nov	1.25	1.2	1.17	1.10	1.33	1.35	0.76	0.76	0.48	0.94
Dec	1.15	1.09	1.05	1.03	1.16	0.98	0.71	0.69	0.49	0.83
Annual Avg	1.33	1.36	1.31	1.22	1.26	1.41	0.98	0.76	0.56	1.02

<u>Meteorological Inputs</u>

The meteorological inputs included precipitation, evaporation, relative humidity, air pressure, air temperature, solar radiation, cloud cover, wind speed, and wind direction. Evaporation was calculated by EFDC. Cloud cover was estimated from reported sky conditions at Richard B. Russell Airport (WBAN 93801). The other meteorological inputs were obtained from the Georgia Automated Environmental Monitoring Network (GAEMN) station Ellijay (GEMN 355) due to its close proximity to the Carters Lake System.

4.3 Water Quality Lake Modeling (EFDC)

The water quality model developed for the Carters Lake System simulated different loading conditions. EFDC was also used for the water quality model. The EFDC model for the Carters Lake System was setup using the following variables:

- Organic nitrogen
- Ammonia
- Nitrate-Nitrite

- Organic phosphorus
- Orthophosphate
- Algae (2 species)
- Dissolved oxygen
- Organic carbon
- Silica

The output from the LSPC watershed model was used to represent the runoff to the Lakes. The LSPC model was calibrated for temperature, dissolved oxygen, nitrate-nitrate, ammonia, organic nitrogen, ortho-phosphorus, organic phosphorus, Total Suspended Solids, and chlorophyll *a*. LSPC Output parameters do not directly link up with the EFDC input parameters. Therefore, the LSPC outputs were "linked" to EFDC inputs through various equations. Table 22 presents what LSPC parameter is used for each EFDC parameter. Note that the LSPC outputs are in English units, whereas the EFDC inputs are in metric units. Therefore, the factor of 0.4536 was used to convert all the equation from lbs/day to kg/day.

Table 22. Parameter Linkage for LSPC to EFDC

Parameter	LSPC Parameters	EFDC Parameter
Flow	RO or PERO	Flow
Temperature	TEMP	TEMP
Dissolved Oxygen	DOx	DO
Biochemical Oxygen Demand (5-day)	BOD5	DOC, DON, LPON, DOP, LPOP
Nitrate + Nitrite	NO3 + NO2	NOx
Ammonia	TAM	NH4
Organic Nitrogen	ORN	DON, RPON. LPON
Orthophosphate	PO4	PO4
Organic Phosphorus	ORP	DOP, RPOP, LPOP
Phytoplankton	PHYTO	Total Algae = greens (Bg) + diatoms (Bd) + Cyano (Bc)

$$DON = \left[(ORN * \%\ Dissolved) + \left[fDOx * \left[(BOD_5 * fRatio)/S_{BODu\ to\ OrgN} \right] \right] \right] * flow * C$$

$$RPON = \left[ORN * \%Particulate \right] * flow * C$$

$$LPON = \left[fLPOx * \left[(BOD_5 * fRatio)/S_{BODu\ to\ OrgN} \right] \right] * flow * C$$

$$NH4 = TAM * flow * C$$

$$NOx = \left[NO3 + NO2 \right] * flow * CBOD$$

Where:

DON = Dissolved Organic Nitrogen (kg/day)
RPON = Refractory Particulate Organic Nitrogen (kg/day)
LPON = Labile Particulate Organic Nitrogen (kg/day)
NH4 = Ammonium (kg/day)
NOx = Nitrate + Nitrite (kg/day)
ORN = Dead Refractory Organic Nitrogen Concentration from LSPC (mg/L)
BOD5 = Biochemical Oxygen Demand (5-day) Concentration from LSPC (mg/L)
TAM = Total Dissolved Ammonia Concentration from LSPC (mg/l)
NO3 = Nitrate Concentration from LSPC (mg/L)
NO2 = Nitrite Concentration from LSPC (mg/L)
% Dissolved = Percent of ORN that is Dissolved = 0.80
% Particulate = Percent of ORN that is Particulate = 0.20
fDOx = Fraction of Labile Organics in BODu that is Dissolved = 0.50
fLPOx = Fraction of Labile Organics in BODu that is Particulate = 0.50
fRatio = Factor to convert BOD5 to BODu = 3.0
S(BODu to OrgN) = Stoichiometric Value to convert BODu into Labile Organic Nitrogen = 22.90
flow = Flow from LSPC (cfs)
*C = Conversion factor from lbs/day to kg/day * 5.39 = 2.44*

$$DOP = \left[(ORP * \% Dissolved) + \left[fDOx * \left[(BOD_5 * fRatio)/S_{BODu\ to\ OrgP} \right] \right] \right] * flow * C$$

$$RPOP = \left[ORP * \% Particulate \right] * flow * C$$

$$LPOP = \left[fLPOx * \left[(BOD_5 * fRatio)/S_{BODu\ to\ OrgP} \right] \right] * flow * C$$

$$PO4_{EFDC} = PO4_{LSPC} * flow * C$$

Where:

DOP = Dissolved Organic Phosphorus (kg/day)
RPOP = Refractory Particulate Organic Phosphorus (kg/day)
LPOP = Labile Particulate Organic Phosphorus (kg/day)
$PO4_{EFDC}$ *= Orthophosphorus (kg/day)*
ORP = Dead Refractory Organic Phosphorus Concentration from LSPC (mg/L)
BOD_5 *= Biochemical Oxygen Demand (5-day) Concentration from LSPC (mg/L)*
$PO4_{LSPC}$ *= Orthophosphorus Concentration from LSPC (mg/L)*
% Dissolved = Percent of ORP that is Dissolved = 0.50
% Particulate = Percent of ORP that is Particulate = 0.50
fDOx = Fraction of Labile Organics in BODu that is Dissolved = 0.50
fLPOx = Fraction of Labile Organics in BODu that is Particulate = 0.50
fRatio = Factor to convert BOD5 to BODu = 3.0
$S_{(BODu\ to\ OrgP)}$ *= Stoichiometric Value to convert BODu into Labile Organic Phosphorus = 165.80*
flow = Flow from LSPC (cfs)
*C = Conversion factor from lbs/day to kg/day * 5.39 = 2.44*

$$Flow = RO\ (Instream\ Flow)\ or\ PERO\ (Overland\ Flow)$$

$$TEMP_{EFDC} = TEMP_{LSPC}$$

$$DO = DOx * flow * C$$

$$DOC = \left((BOD_5 * fRatio)/F_{(BODu\ to\ Carbon)} \right) * flow * C$$

Algae Biomass Equations

$$Bg = \left[\left(PHYTO*cphyto*\left(Green\ Algal\ Fraction\right)\right)\right]*flow*C$$

$$Bd = \left[\left(PHYTO*cphyto*\left(Diatom\ Algal\ Fraction\right)\right)\right]*flow*C$$

$$Bc = \left[\left(PHYTO*cphyto*\left(Cynobacteria\ Algal\ Fraction\right)\right)\right]*flow*C$$

Where:

Flow = Flow into EFDC (cms)
$TEMP_{EFDC}$ *= Temperature (OC)*
DO = Dissolved Oxygen (kg/day)
DOC = Dissolved Organic Carbon (kg/day)
Bg = Green Algae (kg/day)
Bd = Diatom Algae (kg/day)
Bc = Cynobacteria Algae (kg/day)
RO = Instream Flow from LSPC (cfs)
PERO = Overland Flow from LSPC (in-acre/day)
$TEMP_{LSPC}$ *= Temperature from LSPC (OC)*
DOx = Dissolved Oxygen Concentration from LSPC (mg/l)
$_{BOD5}$ *= Biochemical Oxygen Demand (5-day) Concentration from LSPC (mg/l)*
fRatio = Factor to convert BOD5 to BODu = 3.0
$F_{(BODu\ to\ Carbon)}$ *= Stoichiometric Value to convert BODu into Carbon = 2.67*
PHYTO = Phytoplankton Concentration from LSPC (mg/l)
cphyto = Coefficient of Conversion from PHYTO Biomass to Carbon = 0.49
Green Algal Fraction = Fraction of PHYTO that is Green Algal = 0.90
Diatom Algal Fraction = Fraction of PHYTO that is Diatom Algal = 0.10
Cynobacteria Algal Fraction = Fraction of PHYTO that is Cynobacteria Algal = 0.00
flow = Flow from LSPC (cfs)
*C = Conversion factor from lbs/day to kg/day * 5.39 = 2.44*

The EFDC framework allows the user to parameterize by water quality zones. Examples of information that may be used to specify water quality zone include reaeration, sediment oxygen demand, benthic nutrient flux, and more. Due to the substantial depth of Carters Lake, benthic studies were not available, thus many parameters were assigned values and then adjusted during the calibration process. Carters Lake was divided into two zones and a third zone was created for Carters Reregulation Reservoir.

<u>Modeling Parameters</u>

Table 23 provides the reaction rates and parameters used in the EFDC water quality model for the modeled algae species.

Table 23. EFDC Modeling Parameters

Constants and Parameters - Algae	EFDC Card	Cyano	Diatoms	Greens
Nitrogen Half-Saturation (mg/L)	08	NA	0.02	0.020
Phosphorus Half-Saturation (mg/L)	08	NA	0.002	0.002
Silica Half-Saturation (mg/L)	08	NA	0.100	N/A
Carbon to Chlorophyll *a* Ratio (mg C/ug Chl a)*	09	NA	0.050-0.060**	0.030-0.060**
Optimal Depth for Growth (m)	09	NA	1.5	2.0
Lower Optimal Temperature for Growth (^oC)	11	NA	12.0	25
Upper Optimal Temperature for Growth (^oC)	11	NA	16.0	27
Suboptimal Temperature Coeff for Growth	12	NA	0.005	0.005
Superoptimal Temperature Coeff for Growth	12	NA	0.01	0.01
Reference Temperature for Metabolism (^oC)	13	NA	20	20
Temperature Coeff for Metabolism	13	NA	0.069	0.069
Carbon Dist Coeff for Metabolism	147	NA	0.000	0.000
Half Saturation Constant for DOC Excretion (gO_2/m^3)	14	NA	0.500	0.500
Phosphorus Dist Coeff of RPOP for Metabolism	18	NA	0.000	0.000
Phosphorus Dist Coeff of LPOP for Metabolism	18	NA	0.000	0.000
Phosphorus Dist Coeff of DOP for Metabolism	20	NA	1.000	1.000
Phosphorus Dist Coeff of PO4 for Metabolism	20	NA	0.000	0.000
Nitrogen Dist Coeff of RPON for Metabolism	22	NA	0.000	0.000
Nitrogen Dist Coeff of LPON for Metabolism	22	NA	0.000	0.000
Nitrogen Dist Coeff of DON for Metabolism	24	NA	0.900	0.900
Nitrogen Dist Coeff of DIN for Metabolism	24	NA	0.100	0.100
Nitrogen to Carbon Ratio (mg N/mg C)	24	NA	0.200	0.200
Maximum Growth Rate (1/day) *	45	NA	1.5-1.75	1.5-1.75
Basal Metabolism Rate (1/day)*	45	NA	0.010	0.010
Predation Rate (1/day)*	45	NA	0.050-0.100**	0.040-0.090**
Settling Velocity (m/day)	46	NA	0.15	0.10
Settling Velocity for Refractory POM (m/day)	46	0.50		

*- These variables are by Water Quality Zone and are found in the ALGAEGRO.inp file

**-These vary by year and Water Quality Zone

Constants and Parameters – Light Extinction	EFDC Card	Value
Light Extinction for TSS (1/m per g/m^3)	09	0.000
Light Extinction for Total Suspended Chlorophyll *a* $KeCHL = (0.054 * CHL^{0.6667}) + (0.0088 * CHL)$ Where CHL = Total Chlorophyll *a* Concentration (ug/L)	09	Calculated
Background Light Extinction Coeff. (1/m)*	45	0.500

Constants and Parameters – Carbon	EFDC Card	Value
Carbon Dist Coeff for Algae Predation - RPOC	14	0.0600
Carbon Dist Coeff for Algae Predation - LPOC	14	0.000
Carbon Dist Coeff for Algae Predation - DOC	14	0.400
Minimum Dissolution Rate of RPOC (1/day)	16	0.005
Minimum Dissolution Rate of LPOC (1/day)	16	0.075
Minimum Dissolution Rate of DOC (1/day)***	16	0.050
Constant Relating RPOC Dissolution Rate to Total Chl *a*	16	0.000
Constant Relating LPOC Dissolution Rate to Total Chl *a*	16	0.000
Constant Relating DOC Dissolution Rate to Total Chl *a*	16	0.000
Reference Temperature for Hydrolysis (^oC)	17	20

Reference Temperature for Mineralization (°C)	17	20
Temperature Effect Constant for Hydrolysis	17	0.069
Temperature Effect Constant for Mineralization	17	0.069
Oxic Respiration Half-Saturation Constant for DO (gO_2/m^3)	17	0.500
Half-Saturation Constant for Denitrification (gN/m^3)	17	0.100
Ratio of Denitrification Rate to Oxic DOC Respiration Rate	17	0.500
Constants and Parameters – Phosphorus	**EFDC Card**	**Value**
Phosphorus Dist Coeff for Algae Predation - RPOP	18	0.700
Phosphorus Dist Coeff for Algae Predation - LPOP	18	0.000
Phosphorus Dist Coeff for Algae Predation - DOP	18	0.200
Phosphorus Dist Coeff for Algae Predation – Inorganic DOP	18	0.100
Minimum Hydrolysis Rate of RPOP (1/day)	21	0.005
Minimum Hydrolysis Rate of LPOP (1/day)	21	0.0075
Minimum Hydrolysis Rate of DOP (1/day)	21	0.100
Constant Relating Hydrolysis Rate of RPOP to Algae	21	0.000
Constant Relating Hydrolysis Rate of LPOP to Algae	21	0.000
Constant Relating Hydrolysis Rate of DOP to Algae	21	0.200
Constant 1 in determine Phosphorus to Carbon Ratio	21	25
Constant 2 in determine Phosphorus to Carbon Ratio	21	20
Constant 2 in determine Phosphorus to Carbon Ratio	21	350
Constants and Parameters – Nitrogen	**EFDC Card**	**Value**
Nitrogen Dist Coeff for Algae Predation – RPON	22	0.500
Nitrogen Dist Coeff for Algae Predation – LPON	22	0.000
Nitrogen Dist Coeff for Algae Predation – DON	22	0.400
Nitrogen s Dist Coeff for Algae Predation – Inorganic DON	22	0.100
Maximum Nitrification Rate (gN/m^3/day)	25	0.007
Nitrification Half-Saturation Constant for DO	25	1.000
Nitrification Half-Saturation Constant for NH4	25	0.100
Reference Temperature for Nitrification (°C)	25	27
Suboptimal Temperature Effect Constant for Nitrification	25	0.0045
Superoptimal Temperature Effect Constant for Nitrification	25	0.0045
Minimum Hydrolysis Rate of RPON (1/day)	26	0.005
Minimum Hydrolysis Rate of LPON (1/day)	26	0.075
Minimum Hydrolysis Rate of DON (1/day)	26	0.100
Constant Relating Hydrolysis Rate of RPON to Algae	26	0.000
Constant Relating Hydrolysis Rate of LPON to Algae	26	0.000
Constant Relating Hydrolysis Rate of DON to Algae	26	0.000
Constants and Parameters – Silica	**EFDC Card**	**Value**
Silica Dist. Coeff. for Diatom Predation	27	1.000
Silica Dist. Coeff. for Diatom Metabolism	27	1.000
Silica to Carbon Ratio for Algae Diatoms	27	0.360
Partition Coeff. for Sorbed Dissolved SA	27	0.160
Dissolution Rate of Particulate Silica (PSi) (1/day)	27	0.050
Reference Temperature for PSi Dissolution (°C)	27	20.0
Temperature Effect on PSi Dissolution	27	0.092
Constants and Parameters – Dissolved Oxygen	**EFDC Card**	**Value**
Stoichiometric Algae Oxygen to Carbon (gO_2/gC)	28	2.670
Stoichiometric Algae Oxygen to Nitrogen (gO_2/gN)	28	4.330
Reaeration Constant ***	28	3.933
Temperature Rate Constant for Reaeration***	28	1.024

Reaeration Adjustment Factor***	46	1.000
*- These variables are by Water Quality Zone and are found in the ALGAEGRO.inp file		
*** - These variables are by Water Quality Zone and are found in the KINETICS.inp file		

4.4 Model Calibration and Verification

The simulation period for the hydrodynamic model EFDC was from January 1, 2002 through December 31, 2009. The model simulated water surface elevations at the Carters Dam forebay and the Regulation Dam forebay, and temperature. To help minimize the difference between simulated and measured water surface elevations, the corrective flow feature of EFDC was applied. This feature allows EFDC to calculate, at a given time scale, the amount of flow required to force a match between the calculated and observed water surface elevations. This "corrective flow" represents the error in volume associated with the model. This flow can be due to a combination of inaccurate readings of flow inputs or outputs, inaccurate estimates of watershed flow, spatial discrepancies in meteorological data, or unaccounted flow terms. The corrective flow feature of EFDC only works with one water surface elevation time-series. Therefore, each lake was simulated individually in order to calculate the corrective flow. Once calculated the corrected flow was entered as a time series to adjust the simulated water surface elevation. Positive corrective flows (inflows) were added to the upstream flow and negative corrective flows (outflows) were added at the dam discharge. Figures 16 and 17 show the water surface elevation calibration at the Carters Dam forebay and Reregulation Dam Forebay, respectively, for the period 2001 through 2009.

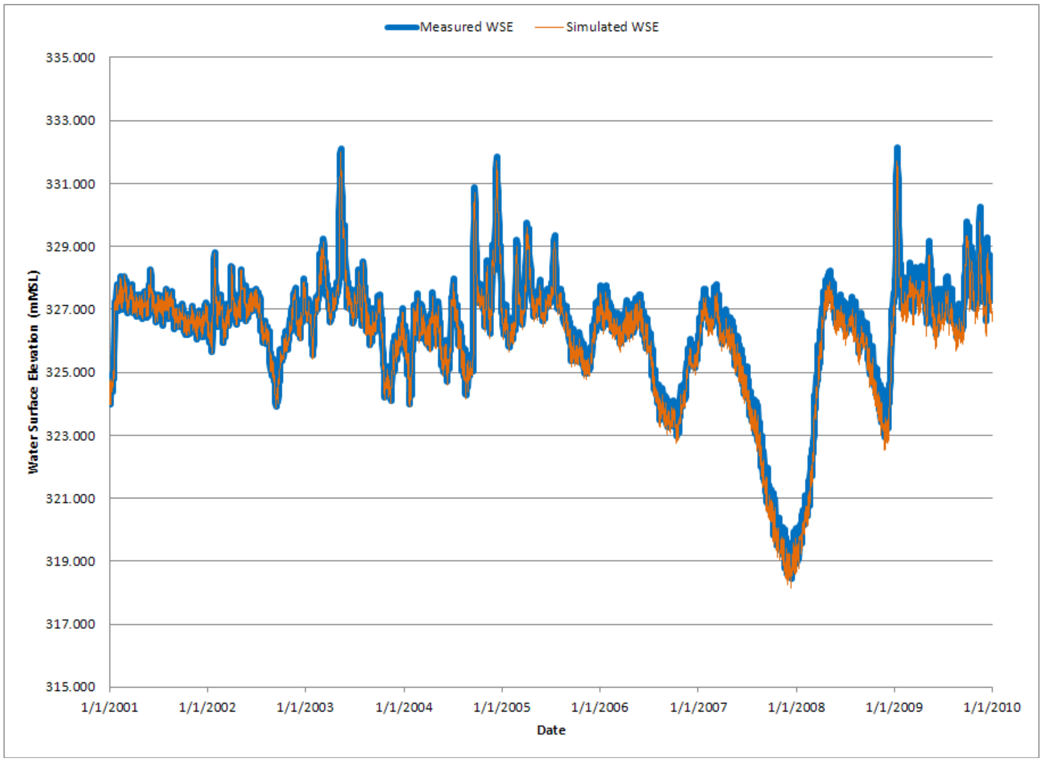


Figure 16. Water Surface Elevation Calibration at the Carters Dam Forebay for the Period 2001-2009

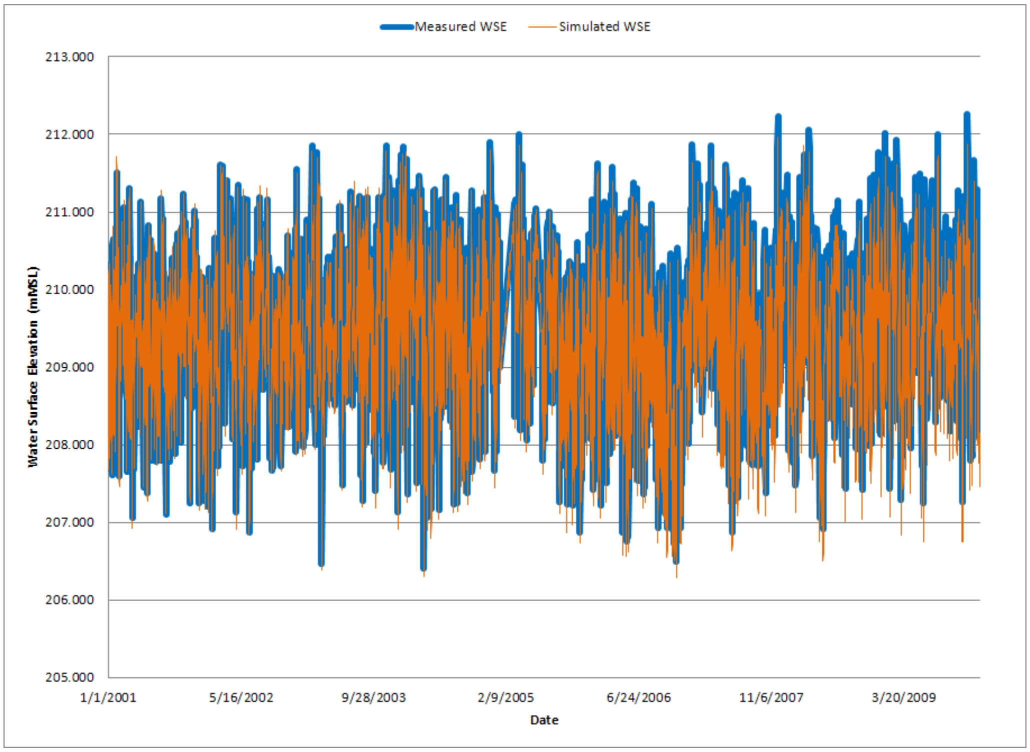


Figure 17. Water Surface Elevation Calibration at the Reregulation Dam Forebay for the Period 2001-2009

Temperature is simulated in EFDC using solar radiation, atmospheric temperature, heat transfer at the water surface, and the temperature of the hydraulic inputs. Accurate simulation of temperature in deep lakes and reservoirs can be enhanced by properly accounting for the thermal mass of the underlying earth. The EFDC bed thermal model is based on the assumption that temperature is seasonally invariant at a specified elevation below the ground surface. This elevation of constant temperature and the corresponding temperature are user specified. Many runs were made with different values input for the bed thermal model. The final calibrated values utilized for the bed thermal model are presented in Table 24.

Table 24. EFDC Bed Thermal Model Inputs

EFDC Input Parameter	Description	Value
DABEDT	Thickness of Active Bed Temperature Layer (meters)	10
TBEDIT	Initial Bed Temperature (°C)	4
HTBED1	Convective Heat Coefficient Between Bed and Bottom Water Layer (dimensionless)	0.005
HTBED2	Heat Transport Coefficient Between Bed And Bottom Water Layer (m2/sec)	0.00003
KBH	Number of Bed Thermal Layers (integer)	4

The Carters Lake EFDC model was calibrated to water temperature profile data collected by GA EPD during the growing season (April through October) from 2002 through 2009 collected at three locations. Figure 18 shows the temperature calibration at the Coosawattee River Embayment during 2006. The model appears to overestimate the bottom temperatures.

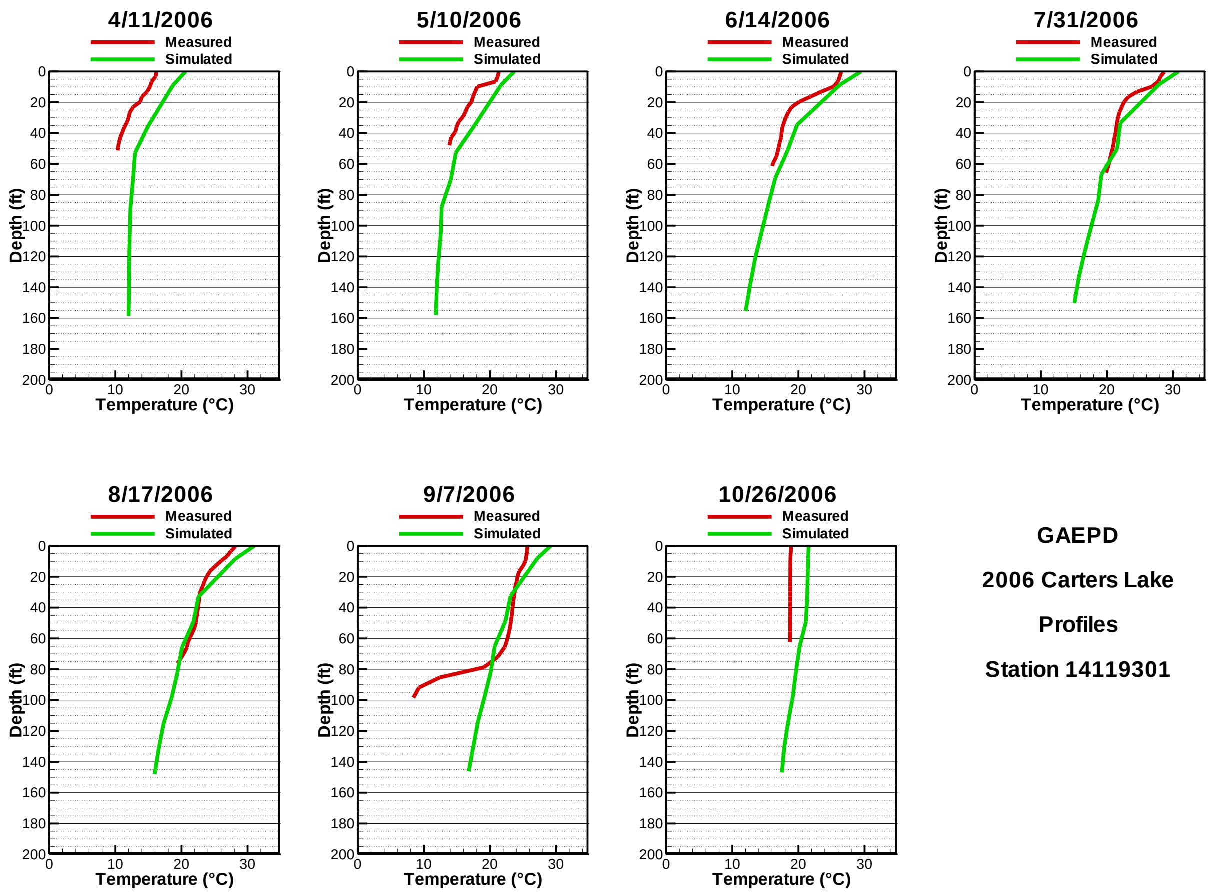


Figure 18. Temperature Calibration at the Coosawattee River Embayment for 2006

In 2008, GA EPD installed two continuous water quality monitors that measured dissolved oxygen, temperature, pH, and conductivity on an hourly basis. These data were also used for model calibration. Figures 19 and 20 present the surface water temperature comparison for the Coosawattee River Embayment station and the Woodring Branch station to the model results.

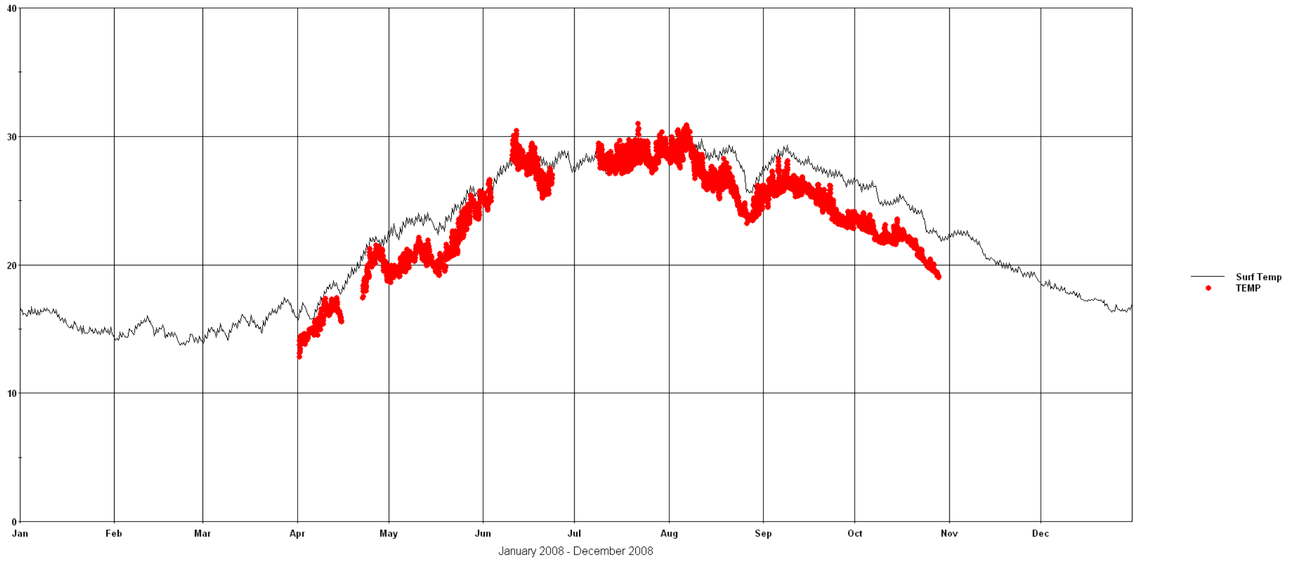


Figure 19. 2008 Model and Continuous Monitor Temperature Comparison at Coosawattee River Embayment Station

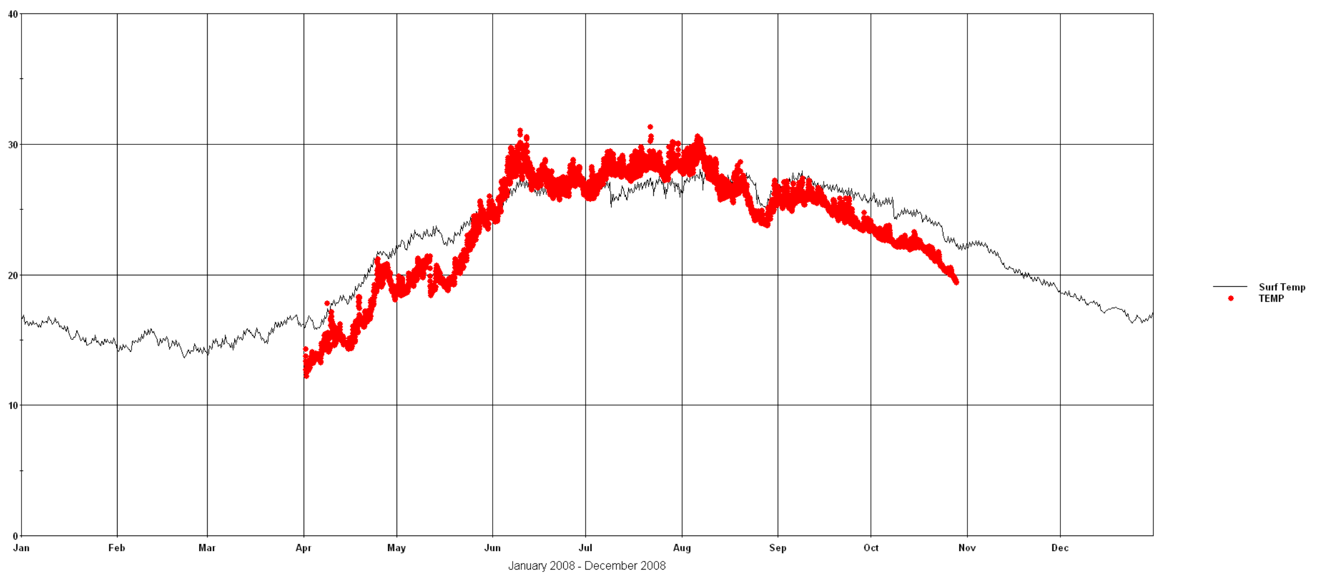


Figure 20. 2008 Model and Continuous Monitor Temperature Comparison at Woodring Branch Station

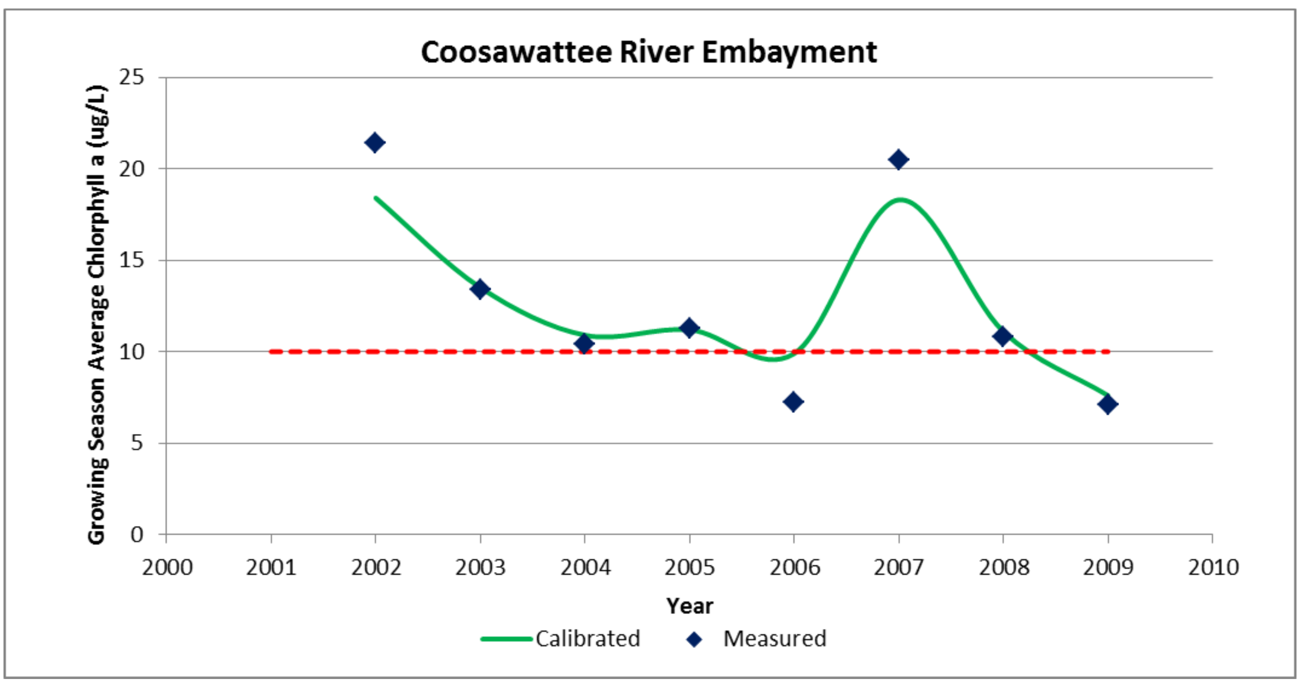
The model calibration period was determined from an examination of the GA EPD 2002-2009 water quality data for the lake. The data examined included chlorophyll *a*, nitrogen components, phosphorus components, dissolved oxygen profiles, and water temperature profiles. The calibration models were run using input data for this period, including boundary conditions and meteorological data.

Measured chlorophyll *a*, total phosphorus, organic phosphorus, total nitrogen, Total Kjeldahl Nitrogen, ammonia, nitrate/nitrate data, Total Organic Carbon and Biochemical Oxygen Demand (5-day) for the 2002 through 2009 growing seasons were used as targets to calibrate the model. These data were collected as a photic zone composite sample. Table 25 presents the average depth and range of the photic zone measured at the three monitoring sites along with the average model layer thickness. The field data were compared with modeled results for layer 1.

Table 25. Photic Zone Depth in Carters Lake and the Reregulation Reservoir

Station	Number of Observations	Mean Photic Depth (m)	Min Photic Depth (m)	Max Photic Depth (m)	Average Layer Thickness (m)
Coosawattee River Embayment	55	5.20	3.0	7.91	5.28
Woodring Branch	55	6.07	3.3	10.59	5.77
Carters Reregulation Dam Forebay	1	4.86	4.86	4.86	3.25

Dissolved oxygen data from the monthly profile data, monthly surface data and continuous monitoring data were used to calibrate model for dissolved oxygen. Figure 21 shows the chlorophyll *a* calibration curves for the Coosawattee River Embayment and upstream from Woodring Branch compliance points for 2002-2009.



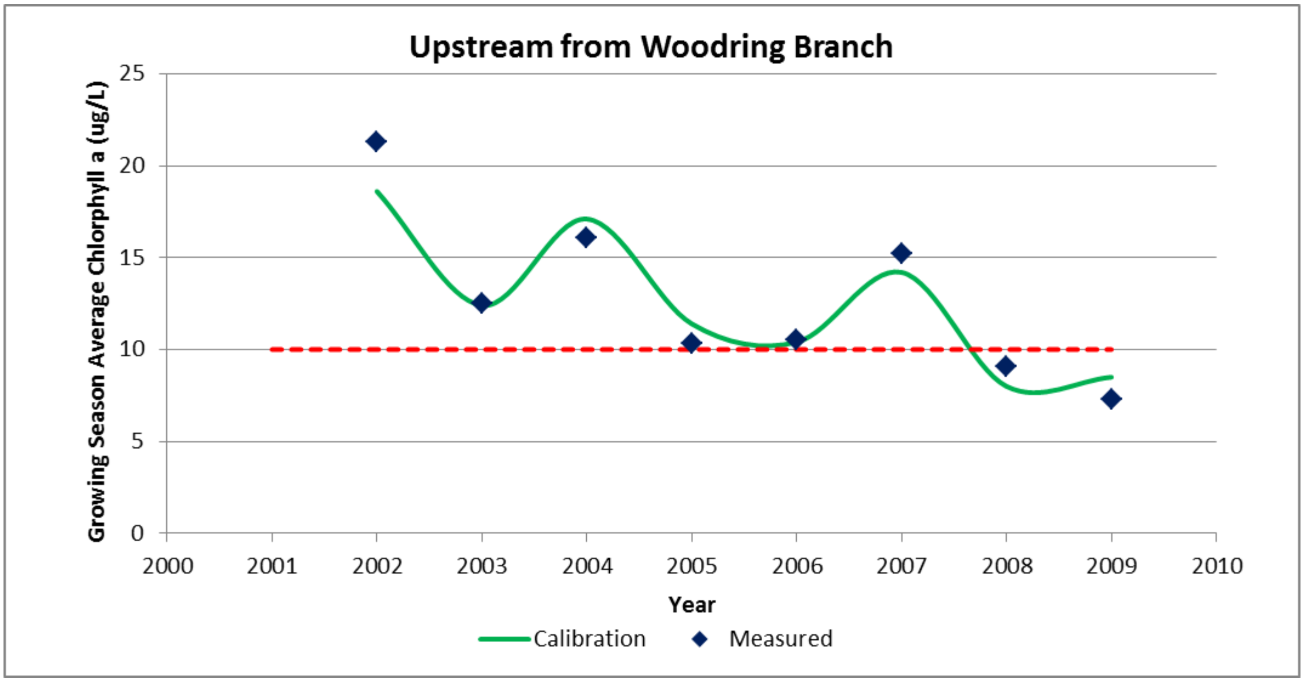


Figure 21. Growing Season Average Chlorophyll *a* Calibration at Coosawattee River Embayment and Upstream from Woodring Branch Compliance Points for 2002 – 2009

4.5 Critical Conditions Models

The critical conditions model was used to assess the nutrient loads and chlorophyll *a, and* to determine if a problem exists requiring regulatory intervention. Model critical conditions were developed in accordance with GA EPD standard practices (GA EPD, 1978).

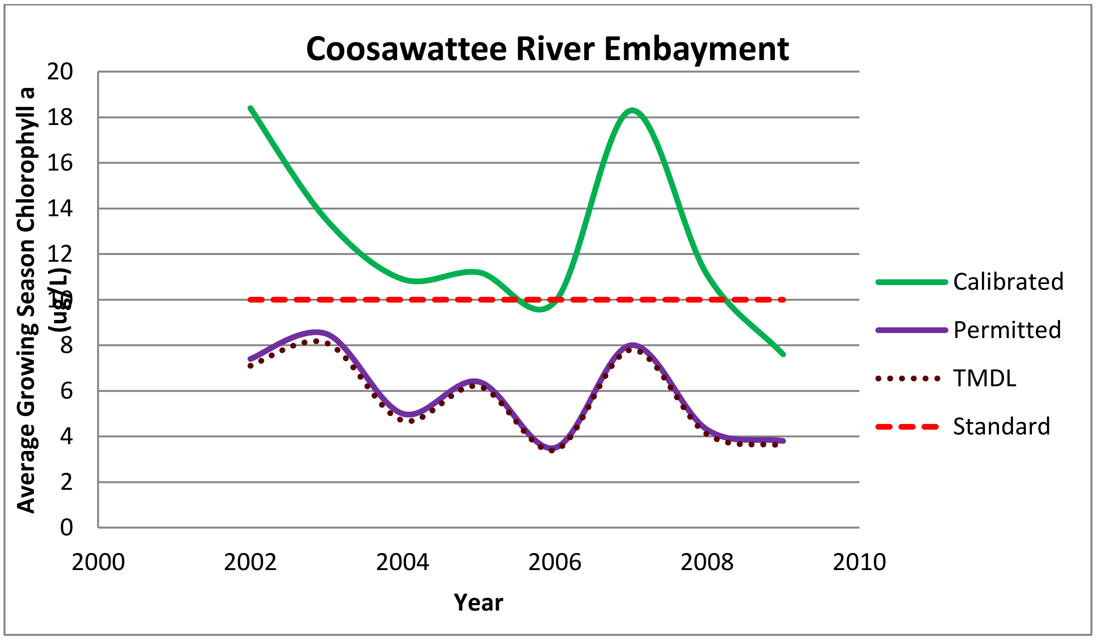
The complex dynamics simulated by the models demonstrated the critical conditions for nutrient uptake and the corresponding algal growth in the embayment. The critical conditions include:

- Meteorological conditions
- Available sunlight
- Watershed flows
- Retention time in embayment
- High water temperatures
- Watershed nutrient loads

The most critical time period for excess algal growth appears to be the low-flow year following a high to normal flow year when excess nutrients have been delivered to the system. During these years, the rainfall is low, sunlight is unlimited, and nutrient fluxes may be high. Small amounts of nutrients during these low-flow sunny periods can cause algae to bloom and measured chlorophyll *a* can exceed the numeric standards.

Drought conditions were experienced a couple of times during the period from 2002 through 2009. This simulation period exhibited a wide variety of flow conditions, which included low flows drought conditions in 2001-2002 and 2006-2007, high flows in 2003, 2005, and 2009 and normal flows in 2004.

The critical condition scenario was run with the NPDES point sources at the full permit loads. The permit limits are listed in Table 3. Results of critical conditions runs are plotted in the graphs in Figure 22 along with the existing conditions and TMDL results at the Etowah River and Carters Creek compliance points for comparison. Please note that the permitted and TMDL run use the City of Ellijay's Total P permit limit of 1 mg/L.



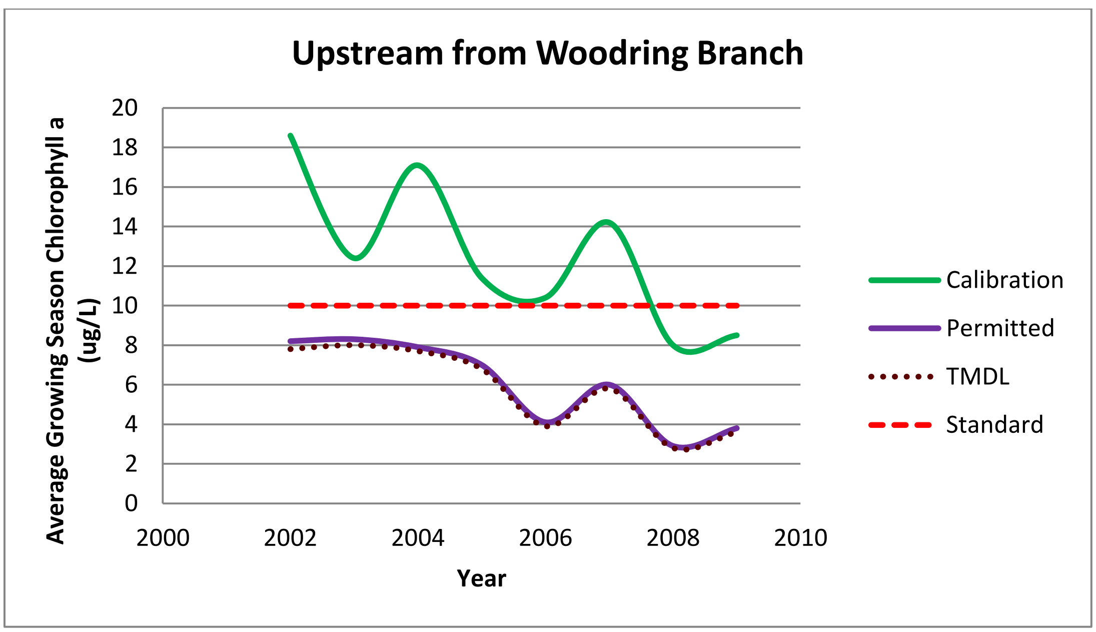


Figure 22. Growing Season Average Chlorophyll *a* Levels at Permitted, Critical, and TMDL Conditions at Coosawattee River Embayment and Upstream from Woodring Branch Compliance Points

5.0 TOTAL MAXIMUM DAILY LOADS

A Total Maximum Daily Load (TMDL) is the amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality standard, which in this case, is the growing season average chlorophyll *a* standards. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measures; for nutrients the TMDLs are expressed as lbs/day.

A TMDL is expressed as follows:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

The TMDL calculates the WLAs and LAs with margins of safety to meet the lake's water quality standards. The allocations are based on estimates that use the best available data and provide the basis to establish or modify existing controls so that water quality standards can be achieved. In developing a TMDL, it is important to consider whether adequate information is available to identify the sources, fate, and transport of the pollutant to be controlled.

TMDLs may be developed using a phased approach. Under a phased approach, the TMDL includes: 1) WLAs that confirm existing limits and controls or lead to new limits, and 2) LAs that confirm existing controls or include implementing new controls (US EPA, 1991). A phased TMDL requires additional data be collected to determine if load reductions required by the TMDL are leading to the attainment of water quality standards.

The TMDL Implementation Plan establishes a schedule or timetable for the installation and evaluation of point and nonpoint source control measures, data collection, assessment of water quality standard attainment, and if needed, additional modeling. Future monitoring of the listed segment water quality will then be used to evaluate this phase of the TMDL, and if necessary, to reallocate the loads. The nutrient loads calculated for each listed lake segment include the sum of the total loads from all point and nonpoint sources for the segment.

5.1 Waste Load Allocations

The waste load allocation is the portion of the receiving waterbody's loading capacity that is allocated to existing or future point sources. WLAs are provided to the point sources from municipal wastewater treatment systems with NPDES effluent limits. The maximum allocated phosphorus and nitrogen loads for these wastewater treatment facilities are given in Table 26. The two mines do not have nutrients levels above background levels; therefore are not given permit limits. In the future, if there is a new facility or a proposed expansion, then the WLA for the facility would not change but the allowable concentrations would be reduced in proportion to the flow, unless the LA or another WLA can be reduced via pollutant trading.

Table 26. Total Phosphorus and Total Nitrogen WLAs for the Carters Lake Watershed Facilities

Facility Name	NPDES Permit No.	Receiving Stream	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)
Ellijay WPCP	GA0021369	Coosawattee River	9,150	184,000
Oakland Elementary School	GA0047210	Lick Log Creek	125	850

An adaptive management approach will be used to implement the nutrient WLAs in NPDES permits. Georgia EPD has already incorporated the Total Phosphorus WLAs in NPDES permits. Using the adaptive management approach, the Total Nitrogen WLAs will not be implemented in permits at this time as long as the Carters Lake chlorophyll *a* and Total Nitrogen standards are met. However, there is some concern that single nutrient control can enhance export of the uncontrolled nutrient and degrade downstream water quality. It should be noted that EPA states in the Lake Weiss Nutrient TMDL that they “determined that reduction in phosphorus, without concurrent reductions in nitrogen, are expected to result in attainment of the Weiss Lake chlorophyll *a* criteria, Although total nitrogen loads are considered in the modeling analysis, reductions to the existing nitrogen loads are not necessary to address the nutrient impairment within Weiss Lake (EPA 2008).” EPA also looked at potential impacts of nitrogen downstream from Weiss Lake and based on modeling analyses, found that reductions in total phosphorus alone would address the nutrient impairments in the downstream reservoirs (Lake Neeley Henry, Lake Logan Martin, Lay Lake and Lake Mitchell (EPA 2008). Therefore, future monitoring will be conducted to ensure there are no downstream impacts (excess chlorophyll *a* or macrophytes) in the Coosawattee, Oostanaula and Coosa Rivers, or Lake Weiss. If the Total Nitrogen WLAs need to be incorporated into the NPDES permits in the future, permittees will be given compliance schedules.

5.2 Load Allocations

The load allocation is the portion of the receiving water’s loading capacity that is attributed to existing or future nonpoint sources or to natural background sources. Nonpoint sources are identified in 40 CFR 130.6 as follows:

- Residual waste;
- Land disposal;
- Agricultural and silvicultural;
- Mines;
- Construction;
- Saltwater intrusion; and
- Urban storm water (non-permitted).

As described above, there are two types of load allocations: loads to the stream independent of precipitation, including sources such as failing septic systems, leachate from landfills, animals in the stream, leaking sewer system collection lines, and background loads; and loads associated with nutrient accumulation on land surfaces that is washed off during storm events, including runoff from saturated LAS fields. To determine the LA, the nutrient accumulation loading rates for each land use and the associated land use areas were used.

5.3 Seasonal Variation

The Georgia lake chlorophyll *a* criteria are based on the growing season average. The most critical time period for excess algal growth appears to be the low flow year following a high to normal flow year when excess nutrients have been delivered to the system. During this critical time, the rainfall is low, sunlight is unlimited, and nutrient fluxes may be high. Small amounts of nutrients during these low-flow sunny periods can cause algae to bloom and measured chlorophyll *a* can exceed the numeric standards.

A wide variety of flow conditions were exhibited during the simulation period, 2002-2009. This included low flow drought conditions in 2001-2002 and 2006-2007, high flows in 2003, 2005 and 2009, and normal flows in 2004.

The low-flow critical conditions incorporated in this TMDL are assumed to represent the most critical design conditions, thereby providing year-round protection of water quality. This TMDL is expressed as a total load based on the nutrient accumulation rate for each land use.

5.4 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) implicitly incorporate the MOS using conservative modeling assumptions to develop allocations; or 2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

For this TMDL, the MOS was implicitly incorporated by using the following conservative modeling assumptions:

- Critical low flows into the embayment
- Hot summer temperatures
- Critical meteorological conditions
- Long retention times
- Conservative reaction rates

5.5 Total Nutrient Load

In order to meet the chlorophyll *a* limits in the lake, the total phosphorus load from the City of Ellijay has been reduced by 90%. In addition, the rate each nutrient accumulates for each land use **may** need to be reduced to allow for future loads due to land use changes. For example, if the agricultural nutrient surface loading is reduced by 40% and the subsurface loading is reduced by 10%, it will result in a total land loading reduction of 25% for Pasture, 21% for Cropland and 27% for Chicken Land. Table 27 provides the 2009 Total Nitrogen and Total Phosphorus export loads for each land use for the critical conditions and TMDL model runs. These values are associated with land use and ignore in-stream biochemical cycling. Therefore, they are not comparable to the annual Total Phosphorus load delivered to the major tributary compliance points.

Table 27. Critical Year Nutrient Land Use Export Rates (lbs/yr)

		Barren	Forest	Wetland	Pasture	Chicken Land	Cropland	Urban	Golf	Failing Septic Tanks
Critical Condition	**TP**	11,018	90,533	117	8,906	28,276	1,623	18,671	72	272
	TN	64,597	715,252	1,239	98,456	539,218	19,025	122,456	537	2,425
TMDL	**TP**	11,018	90,533	117	6,675	20,720	1,286	18,671	72	272
	TN	64,597	715,252	1,239	73,793	395,139	15,070	122,456	537	2,425
% Reduction		0%	0%	0%	0-25%	0-27%	0-21%	0%	0%	0%

The nutrient load that enters the lake each year is dependent on the annual rainfall. Table 28 presents the annual Total Phosphorus load delivered to the major tributaries compliance points. This table includes the annual load from the calibration model run, as well as the percent reduction needed to meet the TMDL assuming a 90% reduction in the total phosphorus load from the City of Ellijay and a reduction in the agricultural loadings outlined above.

Table 28. Annual Total Phosphorus Load Delivered to Carters Lake

Station	Total P Standard (lbs/yr)	Run	Annual Total Phosphorus Load (lbs)							
			2002	2003	2004	2005	2006	2007	2008	2009
Coosawattee River @ GA Hwy 5	**151,500**	Calibration	96,500	126,800	126,900	109,400	94,900	104,900	105,300	177,600
		TMDL	29,500	57,400	50,500	44,400	23,600	16,300	22,700	63,000
		Reduction	69%	55%	60%	59%	75%	84%	78%	65%
Mountaintown Creek at US Hwy 76	**16,000**	Calibration	5,500	12,100	10,500	7,900	3,100	1,600	2,700	14,600
		TMDL	5,200	11,600	10,100	7,600	2,900	1,500	2,600	14,100
		Reduction	5%	4%	4%	4%	6%	6%	4%	3%

Table 29 presents the total load allocation expressed in lbs/day for the 303(d) listed segments located in Carters Lake and includes the current critical loads and corresponding TMDLs, WLAs, LAs, MOSs, and percent load reductions. The LA is based on each land use accumulation rate. The WLA is the daily amount that can be discharged and is given for accounting purposes only. With the dramatic reduction in total phosphorus loads to the lake as a result of the WLA reduction, it is not necessary to provide a WLA for total nitrogen in this TMDL. The relationship between instream water quality and the potential sources of pollutant loading is an important component of TMDL development, and is the basis for later implementation of corrective measures and BMPs.

Table 29. Total Daily Nutrient Loads, Wasteloads, and Required Load Reductions

Stream Segment		Carters Lake – Coosawattee River Embayment		Carters Lake – Woodring Branch		Total Carters Lake	
		Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)
Critical Load* (lbs/day)		2,738	346	2,778	350	2,791	349
TMDL Components	WLA (lbs/day)	979	26	979	26	980	26
	LA (lbs/day)	1558-1759	113-121	1598-1799	118-126	1598-1811	119-127
	MOS (lbs/day)	Implicit	Implicit	Implicit	Implicit	Implicit	Implicit
	TMDL (lbs/day)	2,537-2738	139-147	2,577-2778	144-151	2,590-2791	145-153
Percent Reduction		0-7%	58-60%	0-7%	57-59%	0-7%	56-58%

*- Prior to Total P limit in the City of Elijay's NPDES permit

6.0 RECOMMENDATIONS

The TMDL process consists of an evaluation of the sub-watersheds for each 303(d) listed stream segment to identify, as best as possible, the sources of the nutrient loads causing the stream to exceed lake standards. The TMDL analysis was performed using the best available data to specify WLAs and LAs that will meet chlorophyll *a* water quality criteria to support the use classification specified for each listed segment.

This TMDL represents part of a long-term process to reduce nutrient loadings to meet water quality standards in Carters Lake. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase (next five-year cycle). The phased approach will support progress toward water quality standard attainment in the future. In accordance with US EPA TMDL guidance, these TMDLs may be revised based on the results of future monitoring and source characterization data efforts. The following recommendations emphasize further source identification and involve the collection of data to support the current allocations and subsequent source reductions.

6.1 Monitoring

Water quality monitoring is conducted at a number of locations across the State each year. Sampling is conducted statewide by EPD personnel in Atlanta, Brunswick, Cartersville, and Tifton. Additional sites are added as necessary.

The TMDL Implementation Plan will outline an appropriate water quality monitoring program for the listed streams in the Carters Lake watershed. The monitoring program will be developed to help identify the various nutrient sources. The monitoring program may be used to verify the 303(d) stream segment listings.

6.2 Nutrient Management Practices

Based on the findings of the source assessment, NPDES point source nutrient loads from the wastewater treatment facilities significantly contribute to the impairment of the listed segments. In 2011, the City of Ellijay was issued a permit with a Total Phosphorus limit of 1 mg/L, greatly reducing the permitted load. Other significant sources can be nutrient loads from urban areas which include wastes attributable to fertilizers, domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, leaking septic systems, runoff from improper disposal of waste materials, and leachate from both operational and closed landfills. In agricultural areas, potential sources of nutrients may include CAFOs, animals grazing in pastures, manure application, manure lagoons, and direct access of livestock to streams. Wildlife, especially waterfowl, can also be a significant source of nutrients.

Nutrient management practices are recommended to reduce nutrient source loads to the listed 303(d) stream segments, with the result of achieving the lake chlorophyll *a* standard criteria. These recommended management practices include:

- Compliance with NPDES permit limits and requirements;
- Adoption of NRCS Conservation Practices; and
- Application of Best Management Practices (BMPs) appropriate to agricultural or urban land uses, where applicable.

6.2.1 Point Source Approaches

Point sources are defined as discharges of treated wastewater or storm water into rivers and streams at discrete locations. The NPDES permit program provides a basis for issuing municipal, industrial, and storm water permits, monitoring and compliance with limitations, and appropriate enforcement actions for violations.

In accordance with GA EPD rules and regulations, all discharges from point source facilities are required to be in compliance with the conditions of their NPDES permit at all times. In the future, all municipal and industrial wastewater treatment facilities with the potential for nutrients to be present in their discharge will only be permitted if there can be an appropriate decrease in the nonpoint source load or another point source load. This may be allowed under a pollutant-trading program that will allow point to nonpoint source trading and/or nonpoint (agricultural) to nonpoint (urban) source trading. Wastewater treatment facilities may be able to increase their nutrient discharge if there is an appropriate reduction in the nonpoint source load or another point source load, and this reduction is maintained. In addition, the permits will include routine monitoring and reporting requirements.

6.2.2 Nonpoint Source Approaches

The GA EPD is responsible for administering and enforcing laws to protect the waters of the State. The GA EPD is the lead agency for implementing the State's Nonpoint Source Management Program. Regulatory responsibilities that have a bearing on nonpoint source pollution include establishing water quality standards and use classifications, assessing and reporting water quality conditions, and regulating land use activities that may affect water quality. Georgia is working with local governments, agricultural and forestry agencies such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of BMPs to address nonpoint source pollution. In addition, public education efforts are being targeted to individual stakeholders to provide information regarding the use of BMPs to protect water quality. The following sections describe, in more detail, recommendations to reduce nonpoint source loads of nutrient in Georgia's surface waters.

6.2.2.1 Agricultural Sources

The GA EPD should coordinate with other agencies that are responsible for agricultural activities in the state to address issues concerning nutrient loadings from agricultural lands. It is recommended that information such as livestock populations by sub-watershed, animal access to streams, manure storage and application practices, etc. be periodically reviewed so that watershed evaluations can be updated to reflect current conditions. It is also recommended that BMPs be utilized to reduce the amount of nutrients transported to surface waters from agricultural sources to the maximum extent practicable.

The following three organizations have primary responsibility for working with farmers to promote soil and water conservation and to protect water quality:

- University of Georgia (UGA) - Cooperative Extension Service;
- Georgia Soil and Water Conservation Commission (GSWCC); and
- Natural Resources Conservation Service (NRCS).

UGA has faculty, County Cooperative Extension Agents, and technical specialists who provide services in several key areas relating to agricultural impacts on water quality.

The GA EPD designated the GSWCC as the lead agency for agricultural Nonpoint Source Management in the State. The GSWCC develops nonpoint source management programs and conducts educational activities to promote conservation and protection of land and water devoted to agricultural uses.

The NRCS works with federal, state, and local governments to provide financial and technical assistance to farmers. The NRCS develops standards and specifications for BMPs that are to be used to improve, protect, and/or maintain our state's natural resources. In addition, every five years, the NRCS conducts the National Resources Inventory (NRI). The NRI is a statistically-based sample of trends in land use and natural resource conditions that covers non-federal land in the United States.

The NRCS is also providing technical assistance to the GSWCC and the GA EPD with the Georgia River Basin Planning Program. Planning activities associated with this program will describe conditions of the agricultural natural resource base once every five years. It is recommended that the GSWCC and the NRCS continue to encourage BMP implementation, education efforts, and river basin surveys with regard to river basin planning.

All farmers should develop and implement a Nutrient Management Plan. In addition, a nutrient management assessment, such as EPA's Clean EAST program or similar initiative, should be utilized to ensure that farmers have implemented appropriate nutrient management plans.

All farmers should conduct a Phosphorus Index Test on their farm. The Phosphorus Index is a phosphorus assessment tool that determines the ability of phosphorus to move off the land into a waterbody. The Phosphorus Index is based on eight site characteristics including:

- soil erosion
- irrigation erosion
- runoff class
- soil P test
- P fertilizer application rate
- P fertilizer application method
- organic P source application rate
- organic P source application method

If the Phosphorus Index indicates there is a high potential for phosphorus to move from the site, then BMPs should be utilized to reduce the amount of nutrient transported to surface waters from agricultural sources to the maximum extent practicable. In areas where there are elevated nutrient levels in the soil due to historic manure application, BMP's should be utilized which will minimize the movement of nutrients in storm water. These BMPs may include using riparian buffers, reducing the application rate, planting and harvesting crops, determining the appropriate agronomic rate of manure and fertilizer applications using a Nutrient Management Plan and Phosphorus Index tool, changing the time of application, composting the manure, transporting the manure out of the Carters Lake watershed to other areas that are nutrient deficient, or incinerating the manure as an alternative fuel source.

6.2.2.2 Urban Sources

Both point and nonpoint sources of nutrients can be significant in the Carters Lake watershed urban areas. Urban sources of nutrients can best be addressed using a strategy that involves public participation and intergovernmental coordination to reduce the discharge of nutrients to the maximum extent practicable. Management practices, control techniques, public education, and other appropriate methods and provisions may be employed. In addition to water quality monitoring programs, discussed in Section 6.1, the following activities and programs conducted by cities, counties, and state agencies are recommended:

- Uphold requirements that all new and replacement sanitary sewage systems be designed to minimize discharges into storm sewer systems;

- Further develop and streamline mechanisms for reporting and correcting illicit connections, breaks, and general sanitary sewer system problems;

- Maintain compliance with storm water NPDES permit requirements;

- Work with County Health Departments to encourage proper installation and maintenance of septic tanks; and

- Continue efforts to increase public awareness and education towards the impact of human activities in urban settings on water quality, ranging from the consequences of industrial and municipal discharges to the activities of individuals in residential neighborhoods including appropriate application of fertilizers and the use of green infrastructure to reduce and reuse stormwater.

Nutrients, specifically phosphorus, bind to sediment. The phosphorus load delivered to the lake can be reduced by controlling erosion and sedimentation. The Erosion and Sedimentation Act, established in 1975, provides the mechanism for controlling erosion and sedimentation from land-disturbing activities. This Act establishes a permitting process for land-disturbing activities. Many local governments and counties have adopted erosion and sedimentation ordinances and have been given authority to issue and enforce permits for land-disturbing activities. Approximately 113 counties and 237 municipalities in Georgia have been certified as the local issuing authority. In areas where local governments have not been certified as an issuing authority, the GA EPD is responsible for permitting, inspecting, and enforcing the Erosion and Sedimentation Act.

To receive a land-disturbing permit, an applicant must submit an erosion and sedimentation control plan that incorporates specific conservation and engineering BMPs. The *Field Manual for Erosion and Sediment Control in Georgia*, developed by the State Soil and Water Conservation Commission, may be used as a guide to develop erosion and sedimentation control plans (GSWCC, 1997).

Local governments, with oversight by the GA EPD and the Soil and Water Conservation Districts, are primarily responsible for implementing the Georgia Erosion and Sedimentation Act, O.C.G.A. §12-7-1 (amended in 2003). It is recommended that the local and State governments continue to work to implement the provisions of the Georgia Erosion and Sedimentation Act across Georgia.

Once the sediment reaches the lake, there are concerns that the bound nutrients may be released back into the water column. It may be possible to reduce this internal nutrient load by removing sediment from the lake or control the conditions that cause the nutrients to be released from the bottom sediments in the lake.

6.3 Reasonable Assurance

Permitted discharges will be regulated through the NPDES permitting process described in this report. An allocation to a point source discharger does not automatically result in a permit limit or a monitoring requirement. Through its NPDES permitting process, GA EPD will determine whether a new or existing discharger has a reasonable potential of discharging nutrient levels equal to or greater than the total allocated load. The results of this reasonable potential analysis will determine the specific type of requirements in an individual facility's NPDES permit. As part of its analysis, the GA EPD will use its EPA approved 2003 NPDES Reasonable Potential Procedures to determine whether monitoring requirements or effluent limitations are necessary.

Georgia is working with local governments, agricultural and forestry agencies, such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of best management practices to address nonpoint sources. In addition, public education efforts will be targeted to individual stakeholders to provide information regarding the use of best management practices to protect water quality.

6.4 Public Participation

A thirty-day public notice was provided for this TMDL. During this time, the TMDL was available on the GA EPD website, a copy of the TMDL was provided on request, and the public was invited to provide comments on the TMDL.

7.0 INITIAL TMDL IMPLEMENTATION PLAN

This plan identifies applicable statewide programs and activities that may be employed to manage point and nonpoint sources of nutrient loads for two segments in the Coosa River Basin. Local watershed planning and management initiatives will be fostered, supported or developed through a variety of mechanisms. Implementation may be addressed by GA EPD-initiated Watershed Improvement Projects, Section 319 (h) grant projects, the development of watershed assessment and protection plans, and watershed management initiatives. Any watershed plan that addresses impaired water bodies and/or TMDL implementation will replace this initial plan.

7.1 Impaired Segments

This initial plan is applicable to the following waterbodies that were added to Georgia's 305(b) list of impaired waters in *Water Quality in Georgia* (GA EPD, 2008 – 2009) available on the GA EPD website:

Waterbodies Listed on the Draft 2014 303(d) List for Carters Lake

Lake Segment	Category	Criterion Violated	Segment Area (acres)	Designated Use
Coosawattee River Embayment (Gilmer County)	5	Total P	1,280	Recreation/ Drinking Water
Upstream Woodring Branch/Midlake (Gilmer County)	5	Total P Chlorophyll *a*	1,472	Recreation/ Drinking Water

The water use classifications for Carters Lake are Drinking Water and Recreation. The criterion violated is listed as chlorophyll *a* and the Major Lake Tributary Total P load. The potential causes listed are urban runoff and nonpoint source runoff. The specific criteria for chlorophyll *a* in Carters Lake, as stated in Georgia's Rules and Regulations for Water Quality Control, Chapter 391-3-6-.03(17)(f) is:

(i) Chlorophyll *a*: For the months of April through October, the average of monthly mid-channel photic zone composite samples shall not exceed the chlorophyll *a* concentrations at the locations listed below more than once in a five-year period:

1. Carters Lake upstream from Woodring Branch 10 μg /L
2. Carters Lake at Coosawattee River embayment mouth 10 μg /L

(viii) Major Lake Tributaries: For the following major tributaries, the annual total phosphorous loading at the compliance monitoring location shall not exceed the following:

1. Coosawattee River at Old Highway 5 151,500 pounds
2. Mountaintown Creek at U.S. Highway 76 16,000 pounds

7.2 Potential Sources

EFDC was used to simulate the fate and transport of nutrients into and out of the embayment and the uptake by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter called chlorophyll *a*.

Phytoplankton contains chlorophyll *a* to carry out photosynthesis. They also need nutrients such as nitrogen and phosphorus to produce food. If nutrient loadings are high, then the number of phytoplankton in a waterbody can increase, thereby increasing the amount of measurable chlorophyll *a* in the water. This can lead to water quality impairments due to excessive nutrients from various sources. Source assessments characterize the known and suspected nutrient sources in the watershed. These generally consist of both point and nonpoint sources.

NPDES permittees discharging treated wastewater are the primary point sources of nutrients. It is recognized that effluent from biological treatment systems that meet their nutrient permit limits is not expected to contribute significantly to nutrient loads.

Nonpoint sources of nutrients are diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land use activities that contribute nutrients to streams during rainfall runoff events.

Prior to the implementation of this plan, a detailed assessment of the potential sources should be carried out. This will better determine what practices are needed and where they should be focused. Assessment of the potential sources within the watershed will also help when requesting funding assistance for the implementation of this plan. GA EPD is available to provide assistance in completing a watershed survey of the potential sources of impairment through its NonPoint Source Program.

Through water quality modeling, it has been determined that the nutrient loading found in these segments needs to be reduced. This nutrient loading may be due to activities including, but not limited to, fertilizers (residential, commercial), agriculture, impervious surfaces, failing septic tanks, and others. It is believed that if nutrient loads are not reduced, these segments will continue to degrade over time. Remedies exist for addressing excess sediment from both point and nonpoint sources in streams, and will be discussed in this plan.

7.3 Management Practices and Activities

Compliance with NPDES permits, the Erosion and Sedimentation Control Act, and local ordinances related to stormwater runoff control will contribute to controlling nutrient delivery from regulated activities, and may help to achieve the reductions necessary to meet the TMDL. Using federal, state, and local laws, enforcement actions are available as a remedy for excess sediment coming from regulated sources. These may include illicit discharges, construction, wastewater discharges, and excessive nutrient runoff from other land use activities.

Nutrients produced from nonpoint sources such as run-off from domestic lawns, agricultural fields, paved surfaces, illicit discharges, failing septic tanks, and others are not regulated and are, therefore, not subject to most enforcement actions. Best Management Practices (BMPs) may be used to help reduce average annual sediment loads and achieve water quality standards, as well as improve the overall aquatic health of the system. Table 1 below lists examples of BMPs that address excess nutrients through buffer protection, filtration, or other methods. This is not an exhaustive list, and additional management measures may be proposed, and will be considered as non-point source controls consistent with this plan.

Table 1. Examples of BMPs for Use in Controlling Nutrients from Non-Point Sources

Name of BMP	Type (Ag, Forestry, Urban, Other)
Filter Strips	Agriculture
Reduced Tillage System	Agriculture
Exclusion	Agriculture
Timber Bridges	Forestry
Re-vegetation	Forestry
Sediment Basin	Urban
Porous Pavement	Urban
Wet Detention Pond	Urban
Organic Filter	Urban
Streambank Protection and Restoration	Ag, Forestry, Urban, Other
Stream Buffers	Ag, Forestry, Urban, Other
Additional Ordinances	Ag, Forestry, Urban, Other

Management practices that may be used to help maintain average annual nutrient loads at current levels include:

- Compliance with NPDES (wastewater and/or MS4) permit limits and requirements;
- Implementation of the Georgia Forestry Commission's BMPs for Forestry;
- Application of Georgia and NRCS agricultural BMPs;
- Adoption of proper fertilization practices;
- Implementation of Conservation Management Plans for agricultural runoff;
- Adherence to DNR River Corridor Protection guidelines;
- Mitigation and prevention of riparian buffer loss due to land disturbing activities;
- Promulgation and enforcement of local natural resource protection ordinances such as land development, stormwater, water protection, protection of environmentally sensitive areas, and others.

Public education efforts target individual stakeholders to provide information regarding the use of BMPs to protect water quality. GA EPD will continue efforts to increase awareness and educate the public about the impact of human activities on water quality.

The GA EPD Watershed Improvement Program should be consulted when selecting appropriate management practices for addressing this TMDL, particularly when determining the best practices for specific watersheds.

7.4 Monitoring

Monitoring of nutrients through field tests may be carried out through GA EPD's Adopt-A-Stream Program. Additional opportunities for monitoring may be available in the future. If it is determined through stakeholder involvement that either of these types of monitoring should occur, GA EPD will work with those responsible for the monitoring activities, to conduct the necessary training, and take the needed steps to establish a well-organized monitoring program.

7.5 Future Action

This initial TMDL Implementation Plan includes a general approach to pollutant source identification as well as management practices to address pollutants. In the future, GA EPD will continue to determine and assess the appropriate point and nonpoint source management measures needed to achieve the TMDLs, and also to protect and restore water quality in impaired water bodies.

For point sources, any wasteload allocations for wastewater treatment plant discharges will be implemented in the form of water quality-based effluent limitations in NPDES permits. Any wasteload allocations for regulated storm water will be implemented in the form of best management practices in the NPDES permits. Contributions of sediment from regulated communities may also be managed using permit requirements such as watershed assessments, watershed protection plans, and long-term monitoring. These measures will be directed through current point source management programs.

GA EPD will work to develop Watershed Improvement Projects (WIPs) to address nonpoint source pollution. This is a process whereby GA EPD and/or Regional Commissions or other agencies or local governments, under a contract with GA EPD, will develop a Watershed-Based Plan intended to address water quality at the small watershed level (HUC 12). These plans will be developed as resources, needs, and willing partners become available. The development of these plans may be funded through several grant sources including, but not limited to: Clean Water Act Section 319(h), Section 604(b), and/or Section 106 grant funds. These plans are intended for implementation upon completion.

Any Watershed-Based Plan that specifically addresses water bodies contained within this TMDL, and is accepted by GA EPD, will supersede the Initial TMDL Implementation Plan. Future Watershed-Based Plans intended to address this TMDL and other water quality concerns, written by GA EPD, and for which GA EPD and/or the GA EPD Contractor are responsible, will contain at minimum the US EPA's 9-Key Elements of Watershed Planning:

1) An identification of the sources or groups of similar sources contributing to nonpoint source pollution to be controlled to implement load allocations or achieve water quality standards. Sources should be identified at the subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of cattle feedlots needing upgrading, Y acres of row crops needing improved sediment control, or Z linear miles of eroded streambank needing remediation);

2) An estimate of the load reductions expected for the management measures;

3) A description of the NPS management measures that will need to be implemented to achieve the load reductions established in the TMDL or to achieve water quality standards;

4) An estimate of the sources of funding needed, and/or authorities that will be relied upon, to implement the plan;

5) An information/education component that will be used to enhance public understanding of and participation in implementing the plan;

6) A schedule for implementing the management measures that is reasonably expeditious;

7) A description of interim, measurable milestones (e.g., amount of load reductions, improvement in biological or habitat parameters) for determining whether management measures or other control actions are being implemented;

8) A set of criteria that can be used to determine whether substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised; and;

9) A monitoring component to evaluate the effectiveness of the implementation efforts, measured against the criteria established under item (8).

The public will be provided an opportunity to participate in the development of Watershed-Based Plans that address impaired waters and to comment on them before they are finalized.

GA EPD will continue to offer technical and financial assistance, when and where available, to complete Watershed-Based Plans that address the impaired water bodies listed in this and other TMDL documents. Assistance may include but will not be limited to:

- Assessments of pollutant sources within watersheds;
- Determinations of appropriate management practices to address impairments;
- Identification of potential stakeholders and other partners;
- Developing a plan for outreach to the general public and other groups;
- Assessing the resources needed to implement the plan upon completion; and
- Other needs determined by the lead organization responsible for plan development.

GA EPD will also make this same assistance available, if needed, to proactively address water quality concerns. This assistance may be in the way of financial, technical, or other aid, and may be requested and provided outside of the TMDL process or schedule.

7.6 References

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Appendix A

Carters Lake Water Quality Monitoring Data

2000 Though 2013 Monitoring Water Quality Stations

Segment	Location	GA EPD Monitoring Station No.	Monitoring Station Description
Carters Lake	Coosawattee Embayment	14119301	Carters Lake at Coosawattee River Embayment mouth
Carters Lake	Woodring Branch	114119401	Carters Lake upstream from Woodring Branch/Midlake

Coosawattee Embayment
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/02	18.89	0.51	0.30	<0.03	0.21	0.05	<.04	11.61	16.83
05/07/02	34.38	0.31	0.29	0.04	<0.02	0.02	<0.04	11.75	20.04
06/11/02	28.80	37446.80	0.42	0.06	0.11	0.06	<0.04	9.86	26.09
07/02/02	14.56	37453.56	0.35	<0.03	0.09	0.04	<0.04	10.17	28.18
08/13/02	20.13	37501.13	0.22	<0.03	0.05	0.02	<0.04	8.84	27.46
09/10/02	14.26	0.52	0.49	<0.03	0.03	0.02	<0.04	7.86	25.96
10/02/02	12.03	37543.03	0.20	<0.03	0.10	0.03	<0.04	7.94	23.66

Coosawattee Embayment
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/22/03	12.39	0.35	0.23	0.04	0.12	0.04	<0.04	9.97	18.68
05/20/03	17.34	0.56	0.44	<0.03	0.12	0.03	<0.04	9.24	20.01
06/12/03	10.84	0.14	0.10	<0.03	0.04	0.02	<0.04	8.61	25.55
07/23/03	14.72	0.14	<0.10	<0.03	0.04	<0.02	<0.04	9.04	27.49
08/20/03	11.15	0.43	0.33	<0.03	0.10	0.03	<0.04	9.31	28.88
09/23/03	11.46	0.25	0.18	<0.03	0.07	<0.02	<0.04	7.32	23.68
10/21/03	16.11	0.36	0.23	<0.03	0.13	0.02	<0.04	7.72	19.99

Coosawattee Embayment
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/04	10.22	0.35	0.23	<0.03	0.12	0.05	<0.04	9.84	19.82
05/25/04	12.08	0.24	0.11	<0.03	0.13	0.04	<0.04	9.50	26.52
06/23/04	7.12	0.44	0.36	<0.03	0.08	0.05	<0.04	9.27	27.27
07/28/04	9.30	0.41	0.37	0.04	0.04	0.46	<0.04	9.42	28.15
08/25/04	19.20	0.39	0.31	<0.03	0.08	0.04	<0.04	9.31	26.58
09/22/04	3.10	NM	NM	<0.03	0.14	NM	<0.04	6.68	23.21
10/20/04	3.41	NM	NM	0.11	0.16	NM	<0.04	4.76	21.17

Coosawattee Embayment
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/05	18.58	0.37	0.35	<0.03	0.02	0.03	<0.04	10.89	16.35
05/18/05	10.53	0.47	0.39	<0.03	0.08	0.02	<0.04	11.01	22.23
06/22/05	10.53	0.38	0.28	<0.03	0.10	0.04	<0.04	10.45	26.60
070/27/05	13.63	0.44	0.38	<0.03	0.06	0.02	<0.04	9.92	31.61
08/30/05	8.05	0.38	0.26	0.05	0.12	0.04	<0.04	7.23	25.60
09/21/05	9.91	0.36	0.30	<0.03	0.06	0.02	<0.04	8.87	25.28
10/18/05	7.74	0.37	0.23	<0.03	0.14	<0.02	<0.04	6.42	22.59

Coosawattee Embayment
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/11/06	5.27	0.49	0.26	0.07	0.23	<0.02	<0.04	10.45	16.08
05/10/06	7.12	0.51	0.30	0.04	0.21	0.06	<0.04	12.82	21.17
06/14/06	6.50	1.45	1.40	<0.03	0.05	0.03	<0.04	9.88	26.25
07/31/06	9.60	0.38	0.30	<0.03	0.08	0.05	<0.04	10.24	28.10
08/17/06	10.84	0.35	0.21	<0.03	0.14	0.06	<0.04	8.47	27.48
09/07/06	2.79	0.57	0.42	<0.03	0.15	0.07	0.05	8.65	25.64
10/26/06	8.05	0.27	0.14	>0.03	0.13	0.03	<0.04	7.94	18.87

Coosawattee Embayment
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/30/07	14.00	0.27	0.23	<0.03	0.04	0.04	NM	11.91	20.06
05/20/07	26.37	0.53	0.51	<0.03	0.02	<0.02	NM	11.77	21.61
06/27/07	21.40	0.43	0.41	0.05	<0.02	<0.02	NM	9.34	27.05
07/23/07	29.82	0.34	0.32	<0.03	<0.02	<0.02	NM	10.47	25.95
08/30/07	29.82	0.52	0.50	<0.03	<0.02	<0.02	NM	9.08	28.20
09/26/07	14.14	0.27	0.21	<0.03	0.06	0.03	NM	8.39	24.98
10/24/07	7.86	0.40	0.31	0.10	0.09	<0.02	NM	7.06	21.33

Coosawattee Embayment
2008 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/01/08	19.54	0.42	<0.20	<0.03	0.22	0.08	<0.04	11.22	12.29
05/06/08	12.56	0.26	0.24	<0.03	0.02	0.06	<0.04	11.5	19.29
06/03/08	8.38	0.54	0.43	<0.03	0.11	0.09	<0.04	11.27	24.61
07/08/08	11.68	0.49	0.46	<0.03	0.03	0.06	<0.04	10.55	28.62
08/05/08	20.07	0.71	0.69	<0.03	0.02	0.04	<0.04	11.04	28.61
09/09/08	5.58	0.29	0.25	<0.03	0.04	0.04	<0.04	9.44	26.22
10/07/08	5.28	0.35	<0.20	<0.03	0.15	0.03	<0.04	5.51	22.52

Coosawattee Embayment
2009 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/09	2.9	0.42	0.22	<0.03	0.2	0.06	NM	10.62	21.94
05/06/09	3.58	0.21	<0.20	<0.03	0.21	0.08	NM	9.27	20.12
06/03/09	8.13	0.31	0.23	<0.03	0.08	0.06	NM	11.49	25.12
07/08/09	10.23	0.38	0.35	<0.03	0.03	0.04	NM	10.93	26.86
08/05/09	8.11	0.25	0.2	<0.03	0.05	0.07	NM	11.15	27.25
09/09/09	11.29	0.25	<0.20	<0.03	0.05	0.03	NM	9.79	25.53
10/07/09	5.16	0.38	<0.20	<0.03	0.18	<0.02	NM	5.86	22.32

Coosawattee Embayment
2010 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/6/2010	9.21	0.43	<0.20	<0.03	0.23	0.06	NM	10.79	16.71
5/24/2010	4.7	0.24	<0.20	<0.03	0.04	0.05	NM	11.12	24.03
6/28/2010	8.73	0.41	0.36	<0.03	0.05	0.08	NM	10.59	29.85
7/19/2010	15.98	0.47	0.42	<0.03	0.05	0.09	NM	10.22	28.89
8/23/2010	8.37	0.49	0.39	<0.03	0.1	0.14	NM	9.85	28.54
9/27/2010	8.48	0.33	0.24	<0.03	0.09	0.03	NM	6.32	24.93
10/7/2010	7.44	0.41	<0.20	<0.03	0.21	<0.02	NM	5.04	22.66

Coosawattee Embayment
2011 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/11/2011	13	0.43	<0.20	<0.03	0.23	0.06	<0.04	11	18.3
5/23/2011	14	0.39	0.34	<0.03	0.05	0.05	<0.04	12	24.91
6/7/2011	24	0.22	<0.20	<0.03	0.02	0.08	<0.04	10.76	28.25
7/18/2011	NM	0.22	<0.20	<0.03	<0.02	0.09	<0.04	12.69	28.97
8/23/2011	18	0.3	0.2	<0.03	0.1	0.1	0.04	11.92	31.25
9/27/2011	9.5	0.33	<0.20	<0.03	0.13	0.03	<0.04	7.91	23.75
10/18/2011	8	0.43	0.25	0.03	0.18	0.03	<0.04	7.38	21.62

Coosawattee Embayment
2012 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/11/2012	11	0.36	0.31	0.04	0.05	0.02	NM	10.26	19.49
5/10/2012	7.9	0.4	<0.20	<0.03	0.2	0.03	NM	9.55	23.58
6/21/2012	8.8	0.29	<0.20	<0.03	0.09	0.02	NM	9.8	26.78
7/2/2012	6.4	0.35	0.29	<0.03	0.06	<0.02	NM	9.59	29.3
8/22/2012	5.1	0.28	<0.20	<0.03	0.08	<0.02	NM	8.52	26.39
9/24/2012	3.9	0.36	<0.20	<0.03	0.16	<0.02	NM	6.13	24.08
10/23/2012	3.1	0.35	<0.20	<0.03	0.15	<0.02	NM	7.67	20.74

Coosawattee Embayment
2013 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/09/13	2.1	0.57	0.36	0.11	0.21	<0.02	NM	11.01	14.21
05/20/13	13	0.36	0.22	<0.03	0.14	0.02	NM	10.66	20.1
06/05/13	7.8	0.29	<0.20	<0.03	0.16	0.03	NM	8.67	25.41
07/01/13	4.5	0.38	0.21	<0.03	0.17	<0.02	NM	9.01	27.91
08/06/13	8.9	0.35	0.28	<0.03	0.07	<0.02	NM	9.71	27.21
09/12/13	0.71	0.37	0.31	<0.03	0.06	<0.02	NM	9.94	27.23
10/21/13	7.6	0.41	0.21	<0.03	0.2	<0.02	NM	6.57	25.41

Woodring Branch
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/02	33.45	37394.45	0.36	<0.03	0.04	0.03	<0.04	13.67	16.93
05/07/02	40.88	37423.88	0.42	0.03	0.02	0.02	<0.04	11.64	19.88
06/11/02	39.33	37457.33	0.58	0.04	0.02	0.02	<0.04	9.65	25.90
07/02/02	13.01	37452.01	0.33	<0.03	0.05	0.02	<0.04	8.63	28.54
08/13/02	11.46	37492.46	0.56	<0.03	0.05	<0.02	<0.04	7.83	27.99
09/10/02	9.90	37518.90	0.38	<0.03	0.02	<0.02	<0.04	7.76	26.63
10/02/02	7.82	37538.82	0.16	<0.03	0.09	0.04	<0.04	7.82	23.90

Woodring Branch
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/22/03	2.17	0.26	0.12	0.06	0.14	0.04	0.04	9.23	17.94
05/20/03	25.40	0.39	0.37	<0.03	0.02	0.02	<0.04	9.33	20.88
06/12/03	9.29	0.83	0.80	<0.03	0.03	0.02	<0.04	8.56	25.03
07/23/03	13.94	0.15	<0.10	<0.03	0.05	<0.02	<0.04	9.09	27.27
08/20/03	14.25	0.35	0.31	<0.03	0.04	<0.02	<0.04	8.87	29.11
09/23/03	9.60	0.19	0.10	<0.03	0.09	<0.02	<0.04	7.35	23.79
10/21/03	12.70	0.32	0.18	<0.03	0.14	<0.02	<0.04	7.81	20.30

Woodring Branch
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/04	6.50	0.39	0.27	<0.03	0.12	<0.02	<0.04	10.88	19.74
05/25/04	25.40	0.20	0.15	<0.03	0.05	0.02	<0.04	9.38	26.27
06/23/04	25.40	0.37	0.33	<0.03	0.04	0.02	<0.04	9.49	27.52
07/28/04	20.75	0.42	0.40	<0.03	<0.02	0.05	<0.04	9.00	28.02
08/25/04	12.70	0.30	0.28	<0.03	0.02	0.02	<0.04	8.52	26.52
09/22/04	7.74	NM	NM	<0.03	0.12	NM	<0.04	7.75	23.66
10/26/04	14.25	NM	NM	<0.03	0.17	NM	<0.04	8.67	20.51

Woodring Branch
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/05	12.70	0.31	0.23	<0.03	0.08	<0.02	<0.04	10.19	16.73
05/18/05	9.91	0.23	0.23	<0.03	<0.02	<0.02	<0.04	10.13	22.22
06/22/05	13.63	0.39	0.36	<0.03	0.03	0.03	<0.04	10.18	25.80
07/27/05	14.25	0.42	0.42	<0.03	<0.02	<0.02	<0.04	8.65	31.28
08/30/05	5.88	0.35	0.21	<0.03	0.14	0.03	<0.04	6.97	25.47
09/21/05	9.29	0.23	0.23	0.04	<0.02	0.14	<0.04	8.55	25.79
10/18/05	6.19	0.41	0.27	0.05	0.14	<0.02	<0.04	6.12	22.50

Woodring Branch
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/11/06	7.74	0.38	0.24	<0.03	0.14	0.02	<0.04	10.88	16.31
05/10/06	31.36	0.42	0.42	<0.03	<0.02	0.08	<0.04	11.16	20.28
06/14/06	6.20	0.25	0.20	0.03	0.05	<0.02	<0.04	9.16	26.27
07/31/06	6.19	0.19	0.14	<0.03	0.05	0.03	<0.04	9.08	28.14
08/17/06	5.88	0.04	<0.10	<0.03	0.04	<0.02	<0.04	8.40	27.93
09/07/06	6.19	0.38	0.34	<0.03	0.04	0.03	<0.04	7.83	26.14
10/26/06	9.91	0.25	0.14	<0.03	0.11	0.02	<0.04	7.41	18.82

Woodring Branch
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/30/07	17.00	0.27	0.25	<0.03	<0.02	0.09	NM	12.39	18.96
05/20/07	20.71	0.59	0.57	<0.03	<0.02	0.06	NM	11.55	21.86
06/27/07	17.86	0.30	0.28	0.03	<0.02	0.04	NM	9.18	26.75
07/23/07	19.90	0.34	0.32	<0.03	<0.02	0.05	NM	9.48	25.64
08/30/07	15.07	0.42	0.37	<0.03	0.05	0.04	NM	8.55	27.82
09/26/07	7.15	0.10	<0.20	<0.03	0.08	0.02	NM	8.01	25.29
10/24/07	8.42	0.11	<0.20	<0.03	0.09	<0.02	NM	6.88	21.67

US Woodring Branch/ Midlake
2008 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/01/08	18.51	0.42	<0.20	<0.03	0.22	0.03	<0.04	11.2	11.97
05/06/08	10.91	0.39	0.34	<0.03	<0.02	<0.02	<0.04	10.7	19.17
06/03/08	3.57	0.44	0.4	<0.03	0.04	0.04	<0.04	9.9	24.58
07/08/08	7.66	0.39	0.37	<0.03	<0.02	0.02	<0.04	9.6	28.07
08/05/08	11.64	0.33	0.29	0.16	0.04	0.04	<0.04	9.99	28.46
09/09/08	5.7	0.28	0.22	<0.03	0.06	0.02	<0.04	8.74	25.74
10/07/08	6.53	0.31	<0.20	<0.03	0.11	0.02	<0.04	6.05	22.57

US Woodring Branch/ Midlake
2009 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/09	6.26	0.1	ND	<0.03	0.1	0.05	NM	11.89	20.04
05/06/09	6.08	0.13	ND	<0.03	0.13	0.04	NM	9.61	20.1
06/03/09	9.74	<0.20	ND	<0.03	<0.02	<0.02	NM	11.1	26.19
07/08/09	7.53	0.31	0.27	<0.03	0.04	<0.02	NM	9.34	26.44
08/05/09	9.24	0.22	<0.20	<0.03	<0.02	<0.02	NM	10.3	27.35
09/09/09	7.31	0.27	<0.20	<0.03	0.07	0.02	NM	9.48	24.88
10/07/09	4.82	0.41	ND	<0.03	0.21	<0.02	NM	5.58	22.1

Woodring Branch
2010 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/6/2010	10.91	0.25	0.24	<0.03	0.1	0.04	NM	13	17.08
5/24/2010	1.58	0.27	0.21	<0.03	0.06	0.03	NM	9.68	24.1
6/28/2010	6.34	0.38	0.32	0.07	0.06	0.05	NM	9.89	29.89
7/19/2010	10.58	0.35	0.28	<0.03	0.07	0.04	NM	9.68	28.62
8/23/2010	21.87	0.67	0.65	<0.03	<0.02	0.07	NM	10.76	28.65
9/27/2010	9.43	0.37	0.26	<0.03	0.11	0.02	NM	6.48	24.98
10/7/2010	6.86	0.41	<0.20	<0.03	0.21	<0.02	NM	5.12	22.72

Woodring Branch
2011 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/11/2011	15	0.35	<0.20	<0.03	0.15	0.04	<0.04	11.29	18.12
5/23/2011	11	0.37	0.34	<0.03	0.03	0.05	<0.04	10.88	24.25
6/7/2011	9.6	0.22	<0.20	<0.03	<0.02	0.04	<0.04	12.51	27.41
7/18/2011	26	0.55	0.53	<0.03	<0.02	0.04	<0.04	9.89	28.12
8/4/2011	26	0.26	0.22	<0.03	0.04	0.05	<0.04	11.12	30.86
9/27/2011	6.3	0.34	<0.20	<0.03	0.14	0.02	<0.04	7.78	23.8
10/18/2011	4.6	0.4	0.22	<0.03	0.18	0.02	<0.04	7.73	21.39

Woodring Branch
2012 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
4/11/2012	15	0.25	0.23	<0.03	0.02	<0.02	NM	10.53	19.02
5/10/2012	3.2	0.29	<0.20	<0.03	0.09	0.03	NM	9.56	23.64
6/21/2012	5.7	0.24	<0.20	<0.03	0.04	<0.02	NM	9.17	26.71
7/2/2012	4.7	0.31	0.25	<0.03	0.06	<0.02	NM	8.79	28.78
8/22/2012	3.1	0.24	<0.20	<0.03	0.04	<0.02	NM	8.6	26.26
9/24/2012	4.5	0.31	0.21	<0.03	0.1	<0.02	NM	6.41	24
10/23/2012	4.3	0.33	<0.20	<0.03	0.13	<0.02	NM	7.36	20.72

Woodring Branch
2013 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/09/13	0.76	0.45	0.21	<0.03	0.23	<0.02	NM	11.21	13.46
05/20/13	32	0.4	0.38	0.05	ND	0.02	NM	10.7	20.6
06/05/13	27	0.37	0.32	<0.03	0.05	0.02	NM	9.36	26.36
07/01/13	8.7	0.39	0.29	0.06	0.09	<0.02	NM	8.95	27.84
08/06/13	4.95	0.33	0.24	<0.03	0.09	<0.02	NM	9.38	27.11
09/12/13	10	0.34	0.25	<0.03	0.09	<0.02	NM	9.2	27.35
10/21/13	8.2	0.41	<0.20	<0.03	0.21	<0.02	NM	6.19	21.1

Appendix B

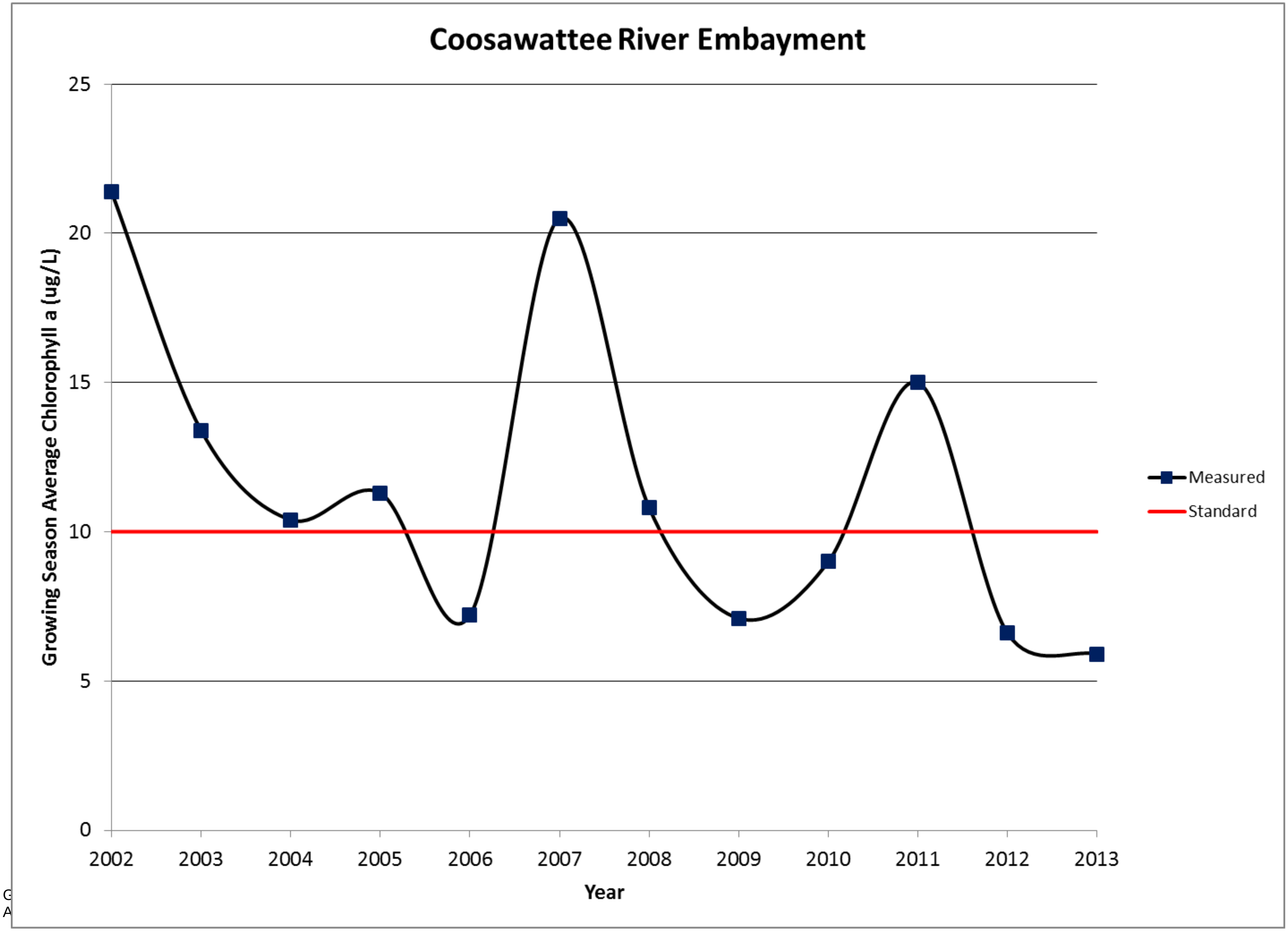
Average Annual Growing Season Chlorophyll *a* Plots

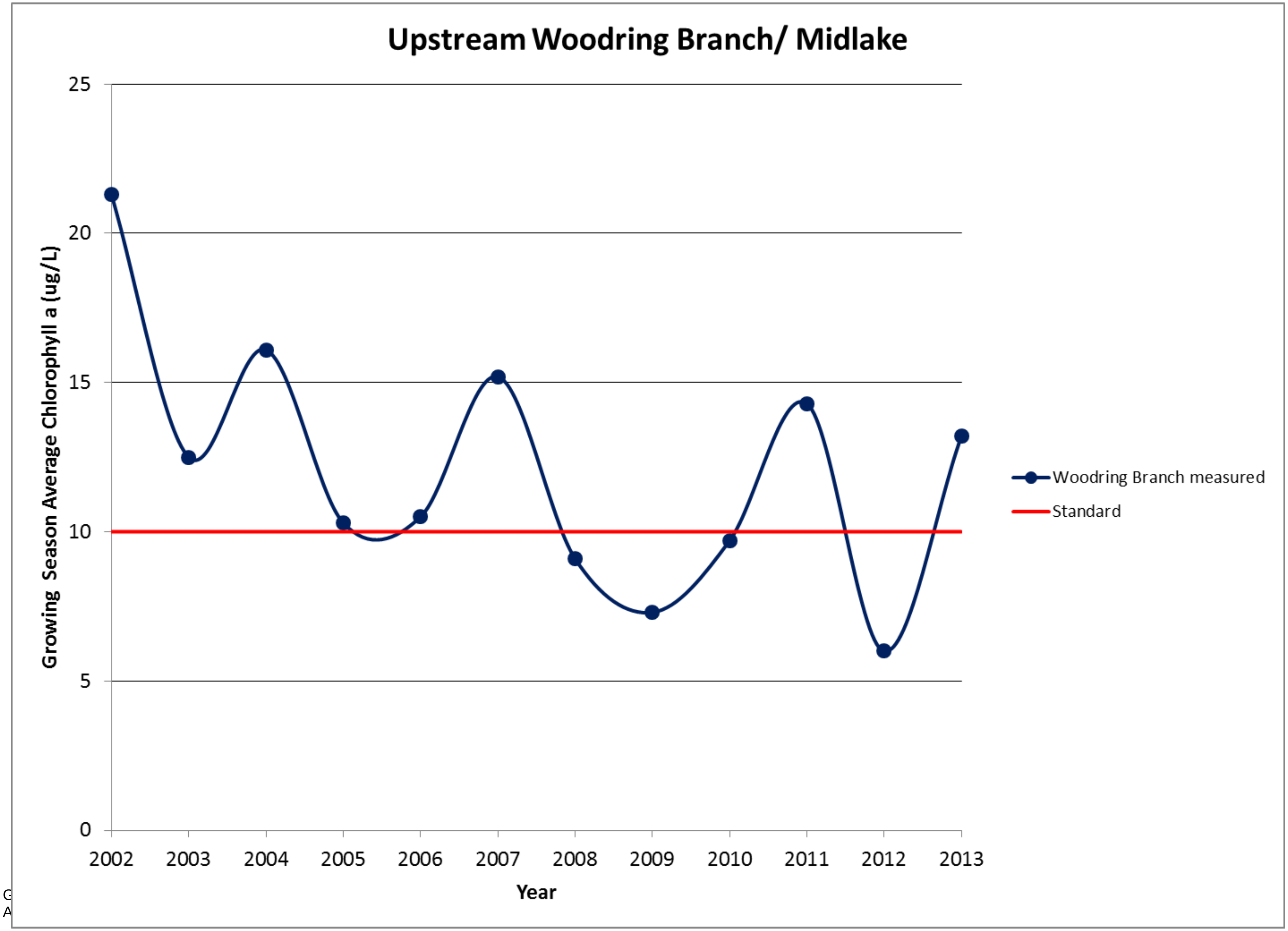
Average Annual Growing Season Chlorophyll *a (ug/L)*

Station	Standard	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Coosawattee Embayment	10	21.4	13.4	10.4	11.3	7.2	20.5	10.8	7.1	9.0	15.0	6.6	5.9
US Woodring Branch/ Midlake	10	21.3	12.5	16.1	10.3	10.5	15.2	9.1	7.3	9.7	14.3	6.0	13.2

Annual Average Total Phosphorus Load (lbs/yr)

Station	Standard	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Coosawattee River at Old Highway 5	151,500	93,000	106,600	156,400	277,000	85,400	127,580	127,600	265,948	203,751	143,902	34,848
Mountaintown Creek at U.S. Highway 76	16,000	2,700	5,000	6,800	15,900	5,700	2,710	4,700	19,658	6,639	12,303	7,719


Coosawattee River Embayment
25
20
15
10
5
0
Growing Season Average Chlorophyll a (ug/L)
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
Measured
Standard


Upstream Woodring Branch/ Midlake
Growing Season Average Chlorophyll a (ug/L)
0
5
10
15
20
25
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
Woodring Branch measured
Standard

Appendix C

Carters Lake Model Scenarios
Description and Results for Nutrient Criteria Revisions

Georgia Environmental Protection Division
Atlanta, Georgia

Table of Contents

List of Figures

FIGURES

List of Tables

TABLES

1.0 INTRODUCTION

Carters Lake lies in the Coosawattee Watershed (HUC# 03150102) in Northwest Georgia (Figure 1-2) approximately 70 miles north northwest of the city of Atlanta. Carters Lake is a US Army Corps of Engineers Lake (USACE), and has been complete and operational since 1977. Carters Lake was formed by the Carters Dam and Reregulation Dam project, from the bed of the Coosawattee River, between Ellijay and Carters. It is the deepest manmade reservoir east of the Mississippi River and has 62 miles of shoreline with no development or private docks. The reservoir was developed as a multipurpose project for flood control, hydropower, navigation, water quality, fish and wildlife enhancement, recreation, and spans an area of about 3,220 acres. Carters Dam has a drainage area of 372 square miles and the Carters Reregulation Reservoir has a drainage area of 148 square miles for a total drainage area at the Reregulation Dam of 520 square miles (Figure 1-3). Five counties are located either completely or partially in the Carters Lake Watershed, therefore making the watershed very important to a wide-range of communities. There will be an ever-increasing need to balance water resources protection while allowing for smart economic development in these local communities.

The Georgia Environmental Protection Division (GA EPD) proposed water quality standards for Carters Lake in 2001, as those waters impounded by Carters Dam and upstream on the Coosawattee River as well as other impounded tributaries to an elevation of 1072 feet mean sea level corresponding to the normal pool elevation of Carters Lake. The Board of Natural Resources adopted water quality standards for Carters Lake and its major tributaries in 2002 with its designated uses of Recreation and Drinking Water. Lake wide standards for pH, total nitrogen, phosphorus, fecal coliform bacteria, dissolved oxygen, and temperature were established. Also, site-specific growing season average (April-October) chlorophyll *a* standards and annual total phosphorus loading standards for major lake tributaries were established. Below are the current standards related to nutrients and chlorophyll *a*:

> Chlorophyll *a*: For the months of April through October, the average of monthly mid-channel photic zone composite samples shall not exceed the chlorophyll *a* concentrations at the locations listed below more than once in a five-year period:

1	Carters Lake upstream from Woodring Branch	5 μg/L
2	Carters Lake at Coosawattee River embayment mouth	10 μg/L

> Phosphorous: Total lake loading shall not exceed 172,500 pounds or 0.46 pounds per acre-foot of lake volume per year.

> Major Lake Tributaries: For the following major tributaries, the annual total phosphorous loading at the compliance monitoring location shall not exceed the following:

1	Coosawattee River at Old Highway 5	151,500 pounds
2	Mountaintown Creek at U.S. Highway 76	8,000 pounds

In 2006, the GA EPD listed both segments of Carters Lake, Woodring Branch and Coosawattee River Embayment, on the State's 303(d) list for not meeting the chlorophyll *a* water quality standard. The GA EPD has recently completed TMDL modeling to address these exceedances. When the preliminary TMDL reductions were modeled in the watershed, the growing season average chlorophyll *a* levels at the Woodring Branch site were still above 5 μg/L. Therefore, EPD is reevaluating the chlorophyll *a* criteria at this location, as well as revisiting the nitrogen and phosphorus standards as part of the model analysis, to ensure the current standards are scientifically sound and protective.

Two computer models were developed for Carters and its watershed. The models included a watershed model, and an in-lake hydrodynamic and water quality model. The watershed model of Carters Lake was developed using the Loading Simulation Program in C++ (LSPC). This model includes all point sources that have a permitted discharge of 0.1 MGD or greater within the watershed. The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to data collected from 2001 through 2009. The results of this model were used as tributary flow inputs in the hydrodynamic model, Environmental Fluid Dynamics Code (EFDC) (Figure 1-1).

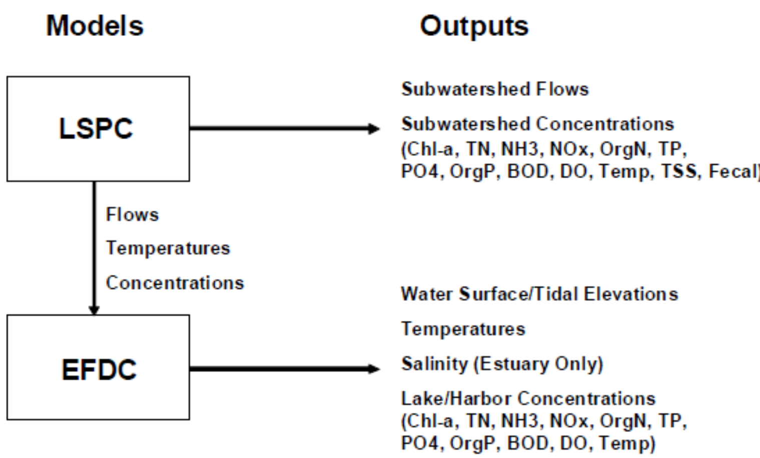


Figure 1-1 Linkage between LSPC and EFDC model

EFDC was used to simulate the transport and flow of water within the lake, the fate and transport of nutrients within the lake, and the uptake by phytoplankton. The growth and death of phytoplankton was measured through a surrogate parameter called chlorophyll *a*. The EFDC model was calibrated to nutrient and chlorophyll *a* concentrations measured in the lake during the 2001 through 2009 growing seasons. The setup, calibration and validation of these computer models are documented in the following two reports:

- *Watershed Hydrology and Water Quality Modeling Report for Carters Lake, Georgia – REV1 (Tetra Tech 2011)*
- *Hydrodynamic and Water Quality Modeling Report for Carters Lake, Georgia – REV1 (Tetra Tech 2012)*

Once the models were calibrated for Carters Lake and its watershed, various scenarios were run and analyzed to evaluate the nutrient sources. The following section describes these scenarios.

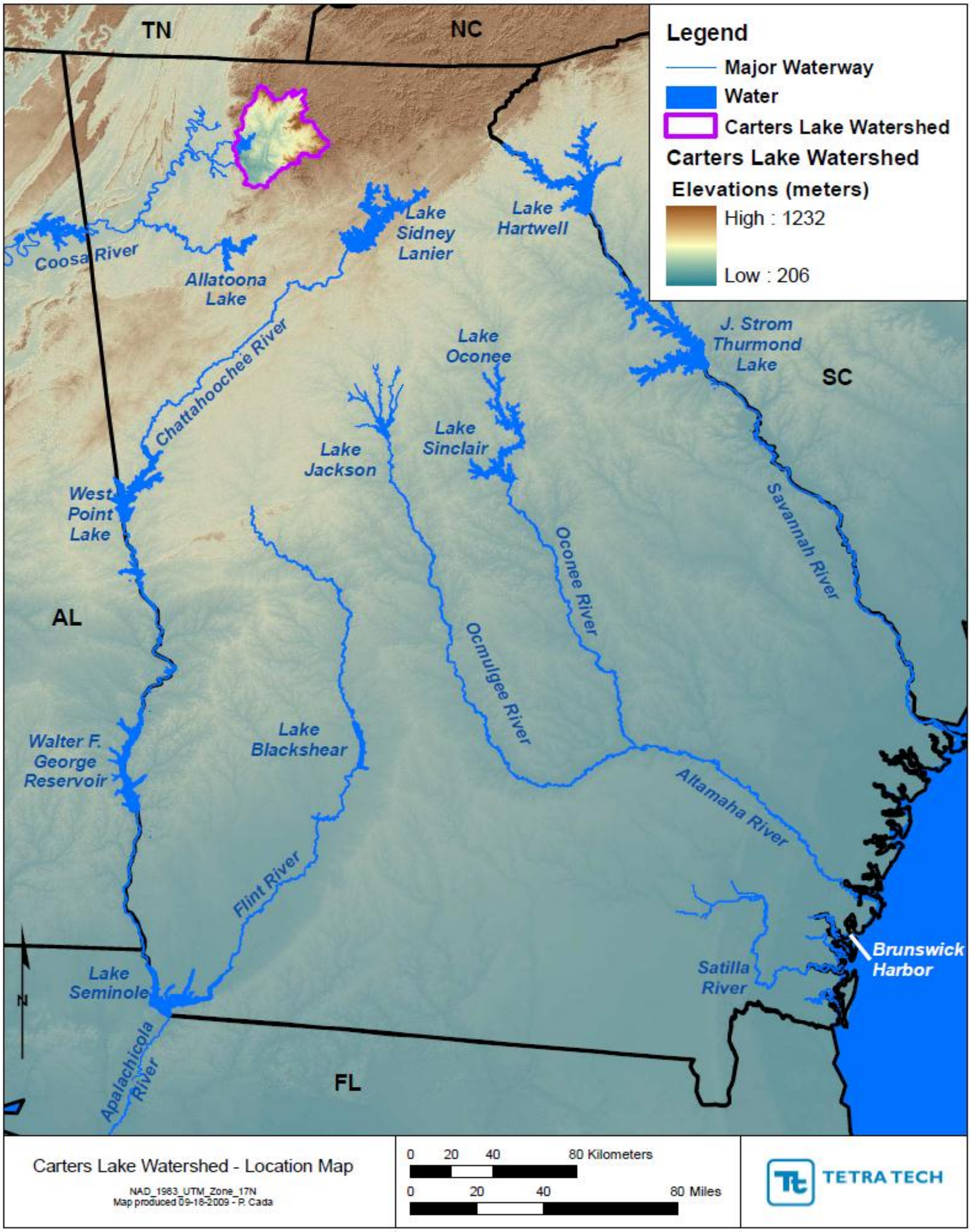


Figure 1-2 Location of Carters Lake

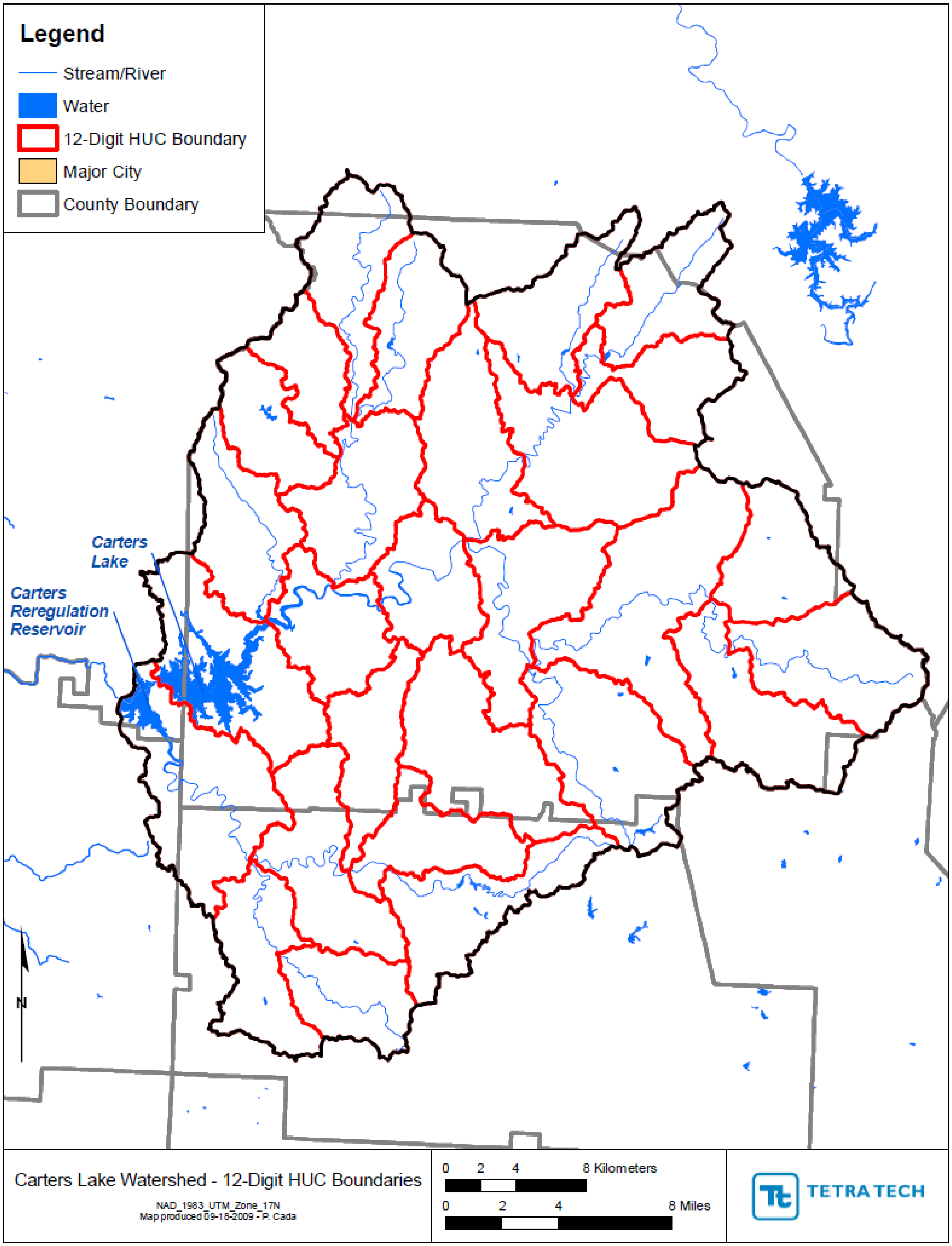


Figure 1-3 Carters Lake Watershed

2.0 DESCRIPTION OF SCENARIOS

Seven scenarios were run using the models developed for the Carters Lake to explain the sources and contributions of chlorophyll *a* levels observed, and for use in establishing new or revised chlorophyll *a* criteria. For each scenario, both hydrology (Figure 2-1) and water quality (Figure 2-2) was calibrated and validated at locations within the watershed from the LSPC model. However, only three tributary locations were evaluated for purposes of assessment in the Carters Lake watershed (Table 2-1). The outputs were examined from January 1, 2001 through December 31, 2009. Watershed flows were evaluated based on monthly and annual average flows and percentiles of daily average flows. Watershed water quality was evaluated based on annual and monthly loading, annual and monthly concentrations, and percentiles of daily average concentrations. Watershed flows and water quality were input into the EFDC model. The hydrodynamic and water quality outputs (Figure 2-3) from the EFDC model were evaluated at two locations (Table 2-2) in Carters Lake from 2001 through 2009. Results were evaluated based on growing season averages (April 1 through October 31). A short description of each scenario is presented below.

2.1 Scenario 1A (Calibration Baseline)

Scenario 1A was performed using the calibrated Carters Lake Watershed hydrology and water quality model (LSPC) and the calibrated Carters Lake model (EFDC). The calibrated LSPC model was run using monthly flow data for watershed water withdrawals, as well as daily and/or monthly flow and water quality data from point source discharges. If no data were available for the point source discharges, values were input at the permitted limits, or in some cases values were assumed if no permit limit existed.

2.2 Scenario 1B (Full Permit)

Scenario 1B was performed using the calibrated (Scenario 1A) Carters Lake Watershed hydrology and water quality model (LSPC) and the calibrated Carters Lake model (EFDC) as a starting point. Point source discharges and water withdrawals were then input at their full current permitted limits.

2.3 Scenario 1C (TMDL)

Scenario 1C was performed by taking Scenario 1B and reducing the agricultural nutrient surface loading by 40%. For the TMDL scenario, it was assumed that a 40% reduction in surface loading had a corresponding 10% reduction in subsurface loading. The combination of a 40% surface load reduction and a 10% subsurface load reduction equated to a total land use reduction of 25% for Pasture, 21% for Cropland and 27% for Chicken Land. However, the Woodring Branch site was still not in compliance, which will be discussed later.

2.4 Scenario 1D (All Forest)

Scenario 1D was an all forested scenario. This scenario was performed using the calibrated (Scenario 1A) Carters Lake Watershed hydrology and water quality model (LSPC) and the calibrated Carters Lake model (EFDC) as a starting point. Point source discharges, water withdrawals, and septic tanks were then removed and all land use was converted to forest.

2.5 Scenario 1E (No Point Source)

Scenario 1E was a No Point Source scenario. This scenario was performed using the calibrated (Scenario 1A) Carters Lake Watershed hydrology and water quality model (LSPC) and the calibrated Carters Lake model (EFDC) as a starting point. Point source discharges and water withdrawals were removed, and current land use was contained in this scenario.

Table 2-1 Summary of Carters Lake Watershed Assessment Sites

Station Name	Station Number	Drainage Area (Acres)	LSPC Subbasin
Coosawattee River @ Old Hwy 5	14109901	150,944	1001
Mountaintown Creek @ US Hwy 76	14115001	39,570	37
Talking Rock Creek in Resort Community	14119981	76,603	1004

Table 2-2 Summary of Carters Lake Evaluation Sites

Station Name	Station Number	EFDC Cell		Segment	Layers
		I-Value	J-Value		
Carters Lake at Coosawattee River embayment	14119301	33	14	199	9
Carters Lake upstream from Woodring Branch	14119401	27	8	59	16

2.6 Scenario 1F (2040)

Scenario 1F was a 2040 land use scenario. This scenario was performed by taking Scenario 1C as a starting point and changing the land use to the 2040 projected GLUT. The 2040 Georgia Land use Trends (GLUT) dataset was obtained from the University of Georgia. Septic tanks were included at their projected 2040 numbers and point sources and water withdrawals were unchanged from the Full Permit scenario

2.7 Scenario 1G (Mountaintown Creek Total P Load of 16,000 lbs/year)

Scenario 1G was a Mountaintown Creek 16,000 lb/yr Total Phosphorus Load scenario. This scenario was performed using the models employed in the TMDL scenario (Scenario 1C) as a starting point. Scenario 1C was chosen as a starting point because the simulated results for the critical year of 2009 had the greatest deviation from 16,000 pounds. An additional load (1,900 lbs/yr) was added to Mountaintown Creek so that the annual Total Phosphorus load for Mountaintown Creek for the critical year of 2009 was 16,000 lbs.

2.8 Scenario IH (Total Nitrogen Increase to 4 mg/L)

Scenario 1H was performed using Scenario 1C (TMDL) and increasing the nitrogen load to the lake to 4 mg/L.

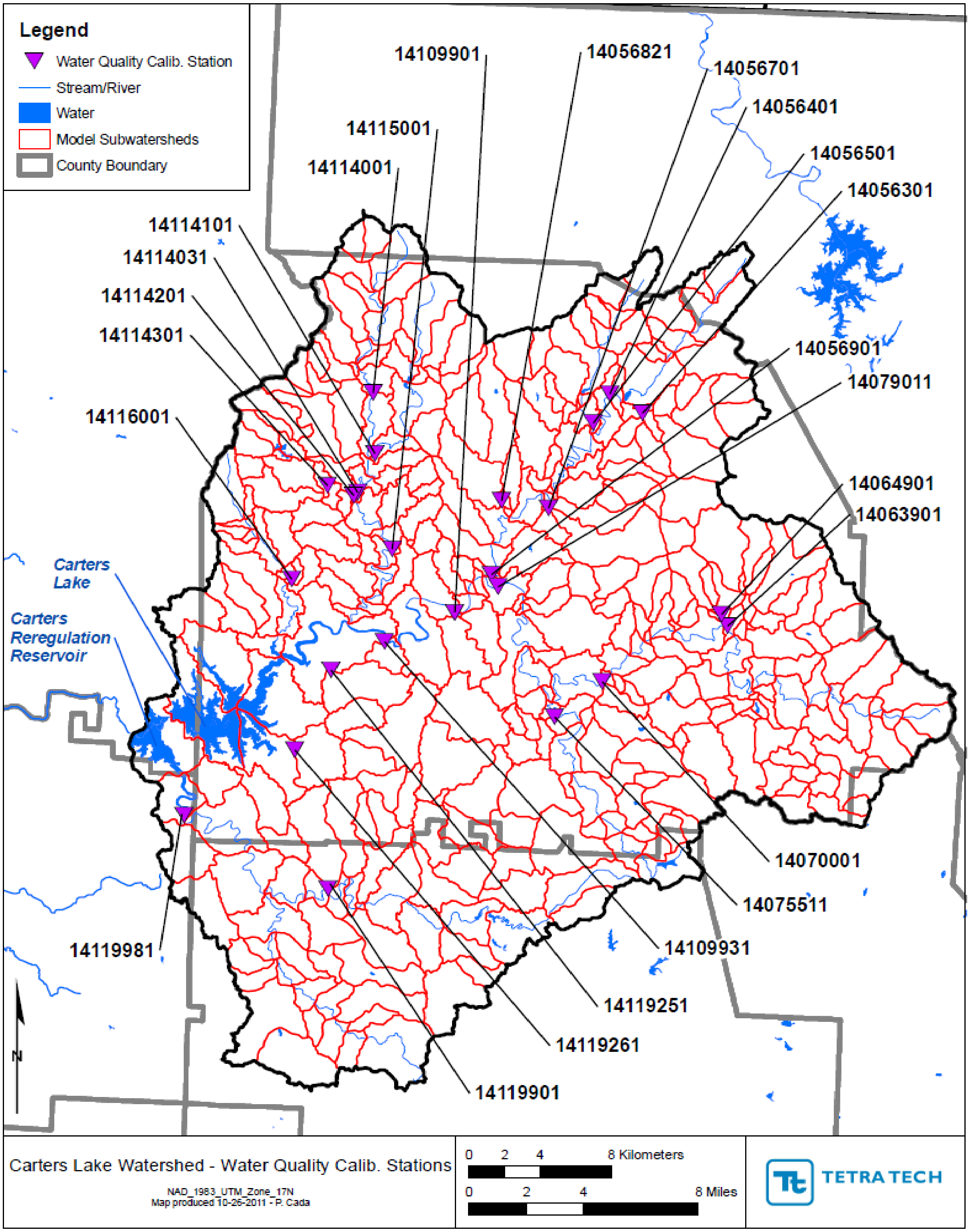


Figure 2-1 Carters Lake Watershed Water Quality Calibration and Validation Sites

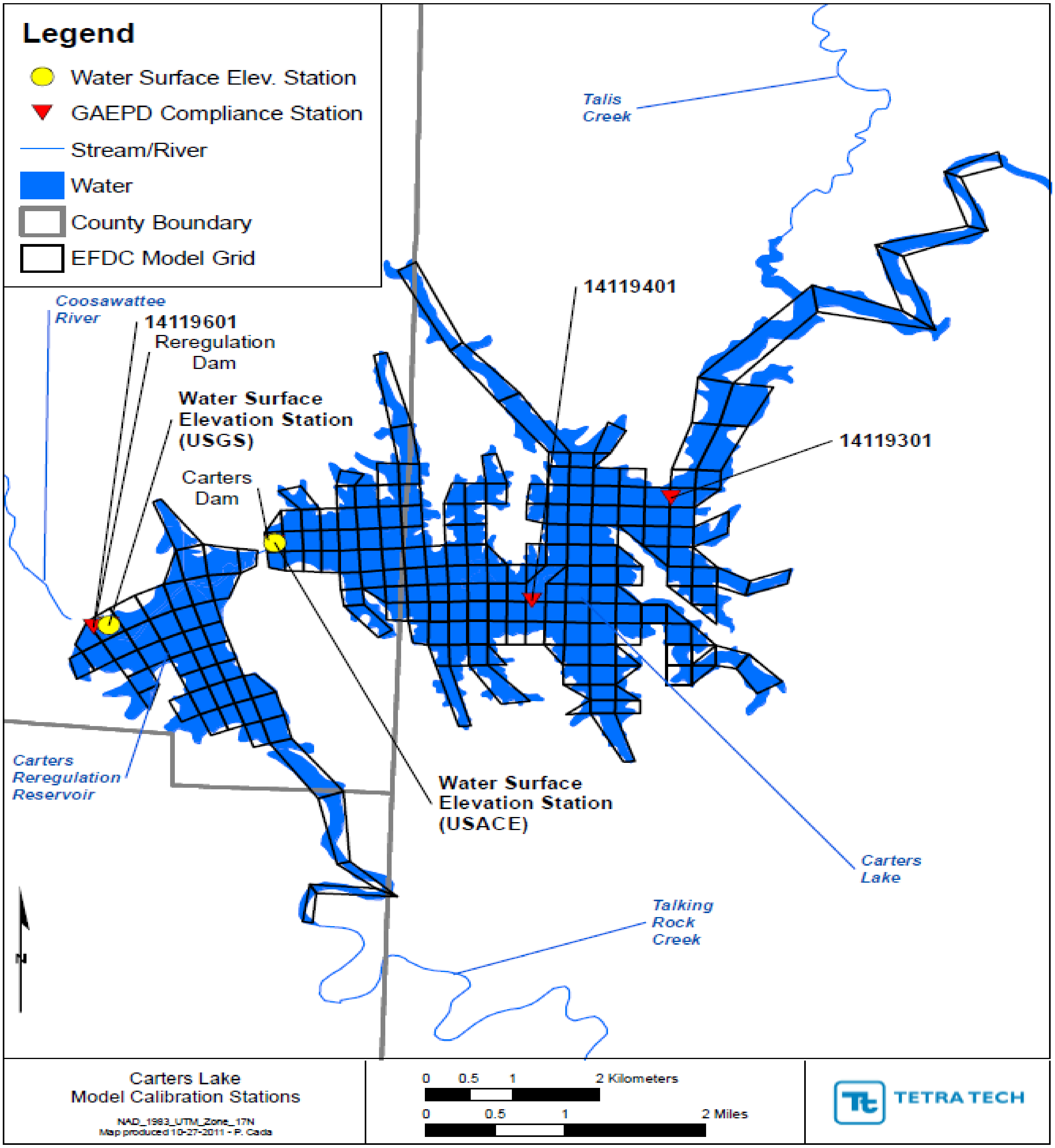


Figure 2-2 Carters Lake Hydrodynamic and Water Quality Calibration Stations

3.0 ANALYSIS OF SCENARIOS

3.1 Phosphorus Loading Standards

The TMDL for Carters Lake was based on reducing the agricultural nutrient surface loading by 40% and the subsurface loading by 10% for a total land loading reduction of 25% for Pasture, 21% for Cropland, and 27% for Chicken Land. Table 3-1 provides the Total Nitrogen and Total Phosphorus export loads for each land use for the existing (Scenario 1A) and TMDL (Scenario 1C) conditions for Critical Year 2009.

Table 3-1 Nutrient Land use Export Rate (lbs/year) for Scenario 1A (Calibration) and Scenario 1C (TMDL) for Critical Year 2009

		Barren	Forest	Wetland	Pasture	Chicken Land	Cropland	Urban	Golf	Failing Septic Tanks
Existing Condition	TP	11,018	90,533	117	8,906	28,276	1,623	18,671	72	272
	TN	64,597	715,252	1,239	98,456	539,218	19,025	122,456	537	2,425
TMDL	TP	11,018	90,533	117	6,675	20,720	1,286	18,671	72	272
	TN	64,597	715,252	1,239	73,793	395,139	15,070	122,456	537	2,425
% Reduction		0%	0%	0%	25%	27%	21%	0%	0%	0%

These values are only land use associated and ignore in-stream biochemical cycling. Therefore, they are not comparable to the annual Total Phosphorus load delivered to the major tributary compliance points. To evaluate compliance with the major tributary Total Phosphorus loading standards at each compliance station, calculations are based on daily flow and monthly Total Phosphorus concentrations measured. Although the flow varies daily, the Total Phosphorus concentrations are held constant until the date of the next monthly measurement.

Table 3-2 compares the modeled calibration annual Total Phosphorus load for Scenario 1A to the actual calculated loads used for compliance for the major tributary annual Total Phosphorus loading standards. In average to above average precipitation years, the calculated annual load is often higher than the modeled load. This may be due to the method of holding Total Phosphorus concentration constant as described above when calculating the annual major tributary load.

Table 3-2 Summary of Annual Total Phosphorus Loads (lbs/year) for Scenario 1A (Calibration) and Actual Calculated Loads

Station	Current Standard		2001	2002	2003	2004	2005	2006	2007	2008	2009
Coosawattee River @ Old Hwy 5	151,500	Modeled	119,600	96,500	126,800	126,900	109,400	94,900	104,900	105,300	**177,600**
		Calculated	N/A	93,000	106,600	**156,400**	**277,00**	85,400	127,580	127,600	**266,00**
Mountaintown Creek @ US Hwy 76	8,000	Modeled	5,000	5,500	**12,100**	**10,500**	7,900	3,100	1,600	2,700	**14,600**
		Calculated	N/A	2,700	5,000	6,800	**15,900**	5,700	2,710	4,700	**19,700**

Table 3-3 provides the modeled annual Total Phosphorus load for the major tributary compliance points for the TMDL scenario (1C). After the agricultural reductions are applied to the Carters Lake watershed, the phosphorus loading at Mountaintown Creek is still higher than the current Total Phosphorus loading standard of 8,000 lbs/year in several years.

Table 3-3 Summary of Annual Total Phosphorus Loads for Scenario 1C (TMDL)

Station	Current Standard	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coosawattee River @ Old Hwy 5	151,500	33,900	29,500	57,400	50,500	44,400	23,600	16,300	22,700	63,000
Mountaintown Creek @ US Hwy 76	8,000	4,800	5,200	**11,600**	**10,100**	7,600	2,900	1,500	2,600	**14,100**

The effects of various land uses on the annual Total Phosphorus load were determined by converting all land uses in the Carters Lake watershed to forest (Scenario 1D). Table 3-4 provides the modeled annual Total Phosphorus loads for each of the major tributaries for the all forested scenario. The all forested load for Mountaintown Creek in 2009 is approximately 16% lower than the TMDL load for Mountaintown Creek. These results indicate that the original annual Total Phosphorus loading standard for Mountaintown Creek may be too low and needs to be revised.

Table 3-4 Summary of Annual Total Phosphorus Loads for Scenario 1D (All Forested)

Station	Current Standard	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coosawattee River @ Old **Hwy 5**	151,500	15,500	12,600	36,000	31,700	24,000	8,200	3,800	7,300	40,400
Mountaintown Creek @ US Hwy 76	8,000	3,700	4,100	**9,800**	**8,700**	6,300	2,200	1,100	1,800	**12,100**
Talking Rock Creek @ Reregulation Reservoir inlet	N/A	10,100	9,300	30,700	20,400	10,300	7,500	2,300	4,900	33,700

Table 3-5 shows that based on 2005 land use, the Mountaintown Creek watershed is approximately 92% forested. The next major land use is agricultural making up approximately 4%. Agricultural lands have higher nutrient loading rates than forested lands, and urbanized lands have increased impervious surfaces that result in higher flows during storm events. Both of these, singularly or in combination, will result in a higher annual nutrient load than an all forested scenario.

Table 3-5 Mountaintown Creek Watershed Land use (GLUT 2005)

Stream	Land use Categories - Acres (Percent)													
	Beach	Water	Low Intensity Development	Medium Intensity Development	High Intensity Development	Barren	Forest	Golf	Pasture	Crop	Wetland	Failing Septic	Chicken Land	Total
Mountaintown Creek	0 (0)	111 (0.3)	1,112 (2.8)	12 (0)	3 (0)	137 (0.3)	36,485 (92.2)	0 (0)	556 (1.4)	90 (0.2)	19 (0)	45 (0)	999 (2.5)	43,337 (100)

Increasing the annual Total Phosphorus load at Mountaintown Creek to 16,000 lbs/year is necessary because in wet years the criteria is currently un-obtainable given the current land use, and also under an all forested scenario. Setting the standard to 16,000 lbs/year allows for a 10% margin of safety compared to the baseline calibration scenario. This new standard will be protective of the growing season average chlorophyll *a* concentrations for each assessment site in the lake (results from Model Scenario 1G) as shown in Table 3-6.

Table 3-6 Summary of Chlorophyll *a* Data (μg/L) as a result of Increasing Total P Load at Mountaintown Creek to 16,000 lbs/year (Scenario 1G)

Station Name	Standard	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carters Lake at Coosawattee River embayment	10 (Current)	7.38	7.86	8.25	5.12	6.32	3.68	8.32	4.58	3.88
Carters Lake upstream from Woodring Branch	10 (Proposed)	4.81	8.28	7.98	7.91	6.89	4.11	6.09	2.99	3.79

Since Carters Lake also has a phosphorus total lake loading of 172,500 pounds or 0.46 pounds per acre-foot of lake volume per year, we also examined whether this standard is appropriate based on an analysis of the modeling. The modeled annual phosphorus loads for Carters Lake are presented in Table 3-7 for the Calibration, Full Permit, and TMDL scenarios.

Table 3-7 Summary of Annual Total Phosphorus Lake Loads for Scenario 1A (Calibration), 1B (Full Permit), and 1C (TMDL)

Standard			2001	2002	2003	2004	2005	2006	2007	2008	2009
Annual Load of Phosphorus (lbs)	172,500	Calibration (1A)	155,502	133,102	**190,356**	**180,395**	163,072	125,430	119,451	129,145	**242,877**
		Full Permit (1B)	77,362	72,215	130,492	110,093	105,993	59,793	36,039	53,280	137,586
		TMDL (1C)	74,430	69,493	125,710	106,225	102,044	57,798	35,134	51,470	132,196
Specific Loading (lbs/Acre-Ft)	0.46	Calibration (1A)	0.41	0.36	**0.50**	**0.48**	0.43	0.35	0.35	0.37	**0.64**
		Full Permit (1B)	0.21	0.19	0.35	0.29	0.28	0.17	0.11	0.15	0.36
		TMDL (1C)	0.20	0.19	0.33	0.28	0.27	0.16	0.10	0.15	0.35

While the calibration scenario shows exceedances of the total lake loading, the full permit and TMDL scenarios show the phosphorus loading for the lake below the current standards. This is due to the reduction in phosphorus in permits and the 40% reduction in agricultural phosphorus loading, respectively. Thus, the current standards are appropriate and protective of the lake.

3.2 Chlorophyll *a* Standards

The watershed and lake models were used to predict the effect of various nutrient loads and sources on the lake chlorophyll *a* levels. The data indicate there were chlorophyll *a* violations at Woodring Branch and the Coosawattee River embayment at baseline calibration conditions. The models were then run at full permitted loads to predict the chlorophyll *a* levels in the lake, and again there were chlorophyll *a* violations at the Woodring Branch site in the middle lake, with the Coosawattee River embayment station in the upper lake meeting its standard (see Figures 3-1 and 3-4). When the preliminary TMDL reduction of 40% in the agricultural nutrient load was applied, the growing season average chlorophyll *a* levels at this middle station were still above 5 μg/L in most years (Figure 3-4). The results of the all forest model scenario also indicate that the Woodring Branch site can still exceed the current chlorophyll *a* criteria (Figure 3-4), further demonstrating that this compliance station needs to be adjusted.

Figures 3-1 through 3-5 show the level of chlorophyll *a* due to the various sources, as well as the model results for most of the scenarios. It is important to note that the TMDL model results were negligible compared to the full permit results. In addition, the 2040 land use at full permit scenario also had a negligible effect of chlorophyll *a* levels. By amending the Woodring Branch site to 10 μg/L, this allows for a safety margin of approximately 17% from both increased land use changes and permit loading. This proposed criterion is still protective of the Recreation and Drinking Water designated uses.

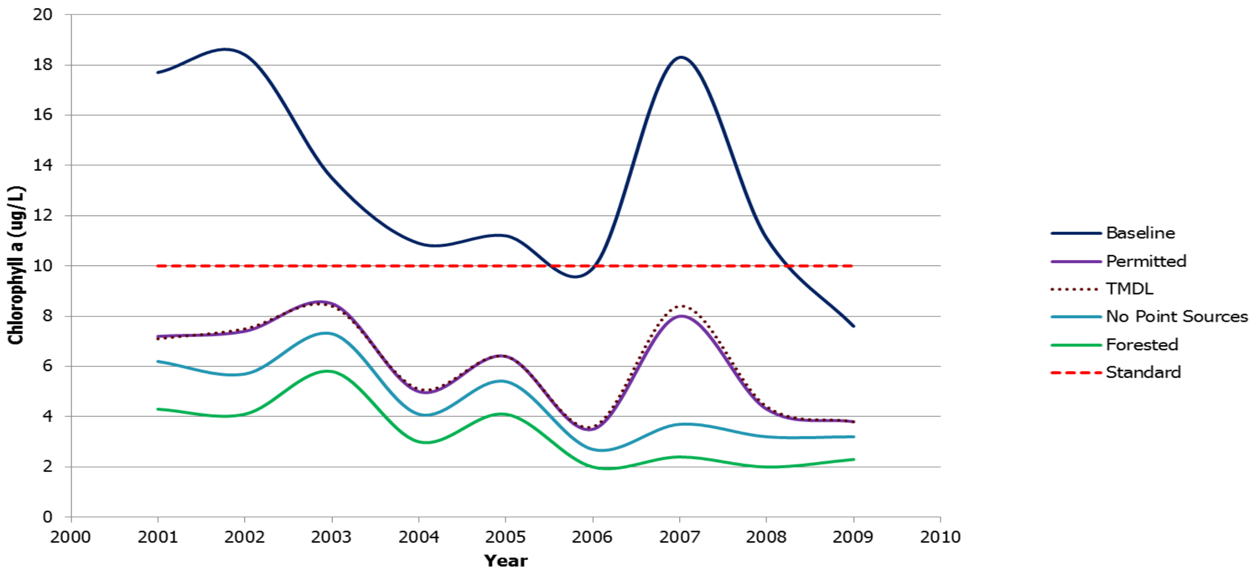


Figure 3-1 Coosawattee River Embayment Scenario Results in Relation to Current Standard

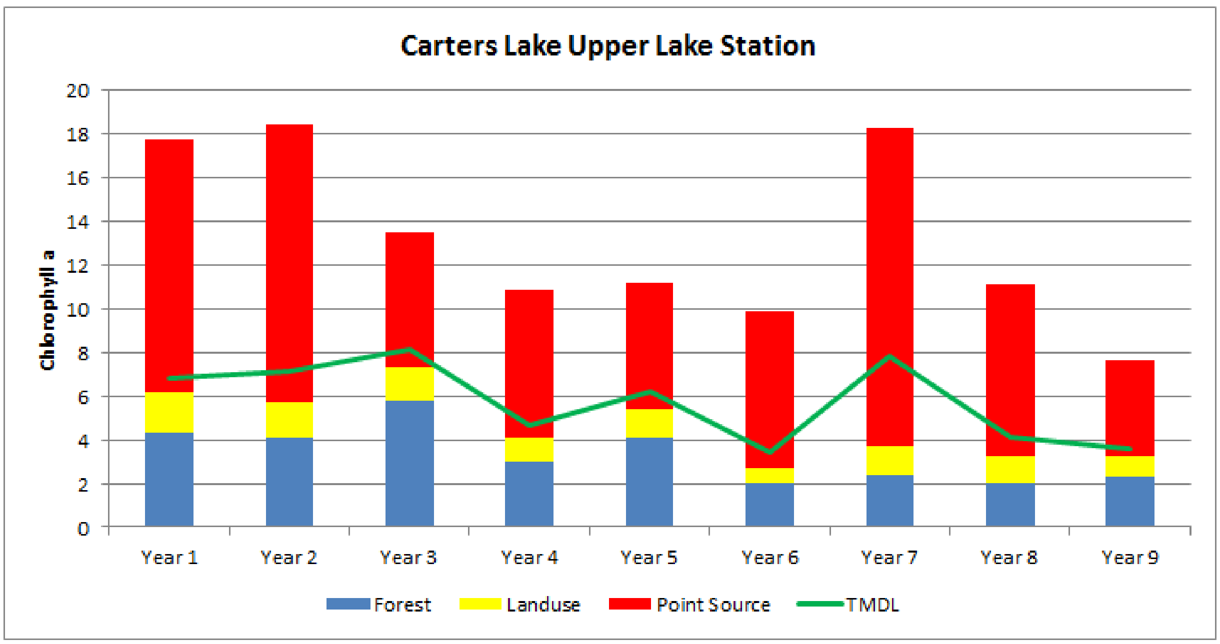


Figure 3-2 Coosawattee River Embayment Chlorophyll *a* Contributions for Baseline Calibration Scenario

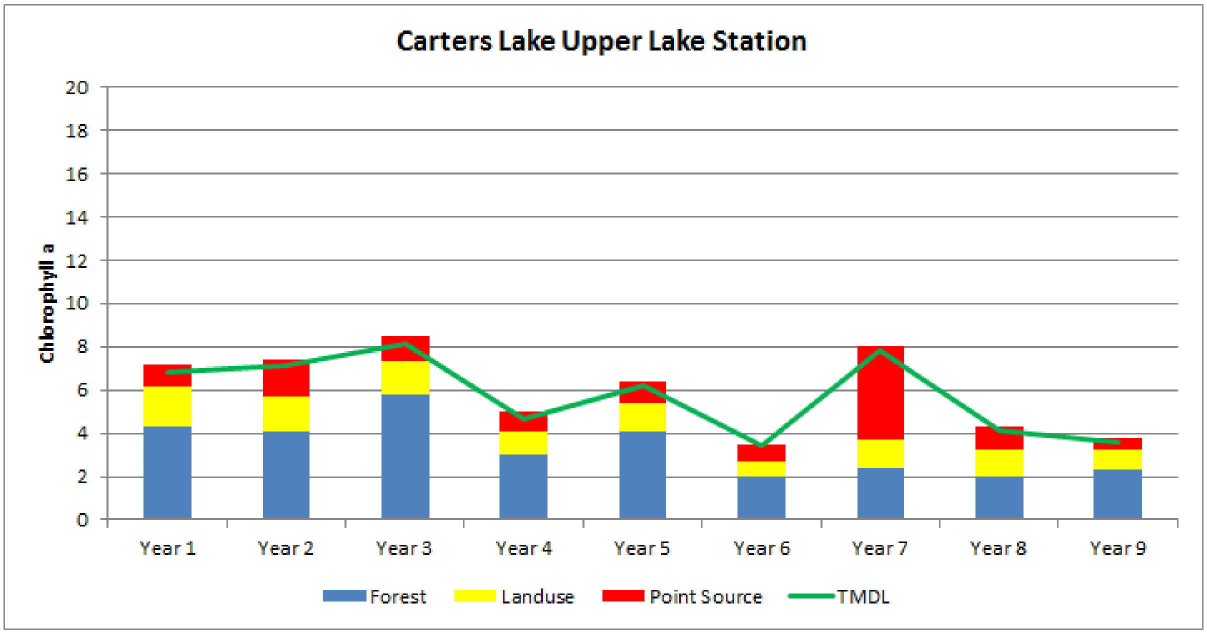


Figure 3-3 Coosawattee River Embayment Chlorophyll *a* Contributions for Full Permit Scenario

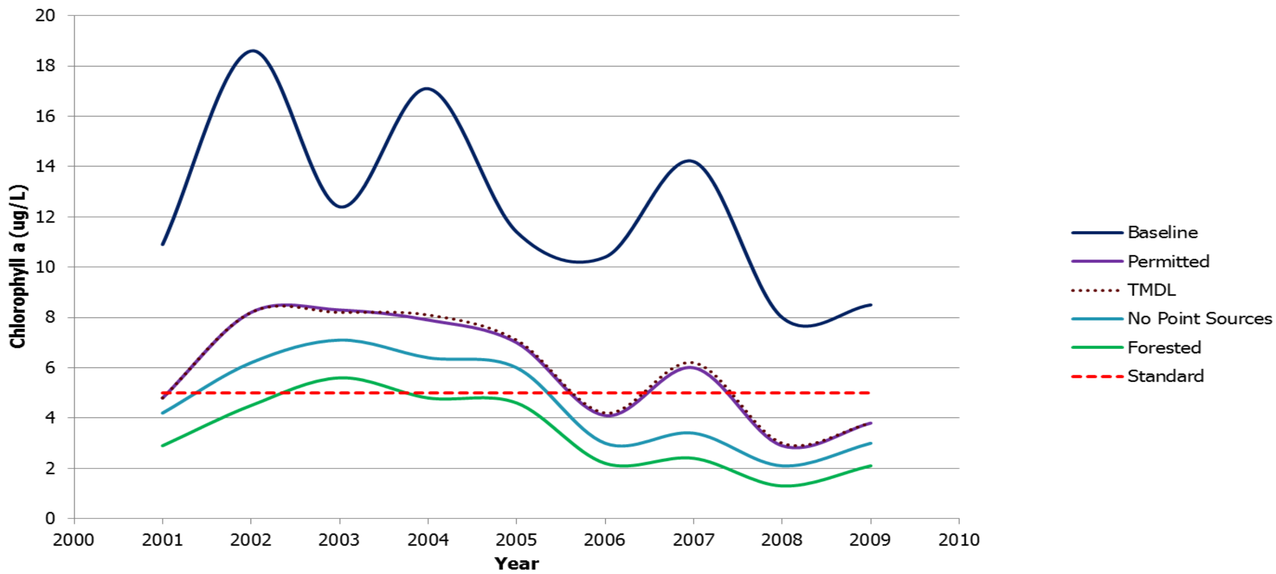


Figure 3-4 Woodring Branch Scenario Results in Relation to Current Standard

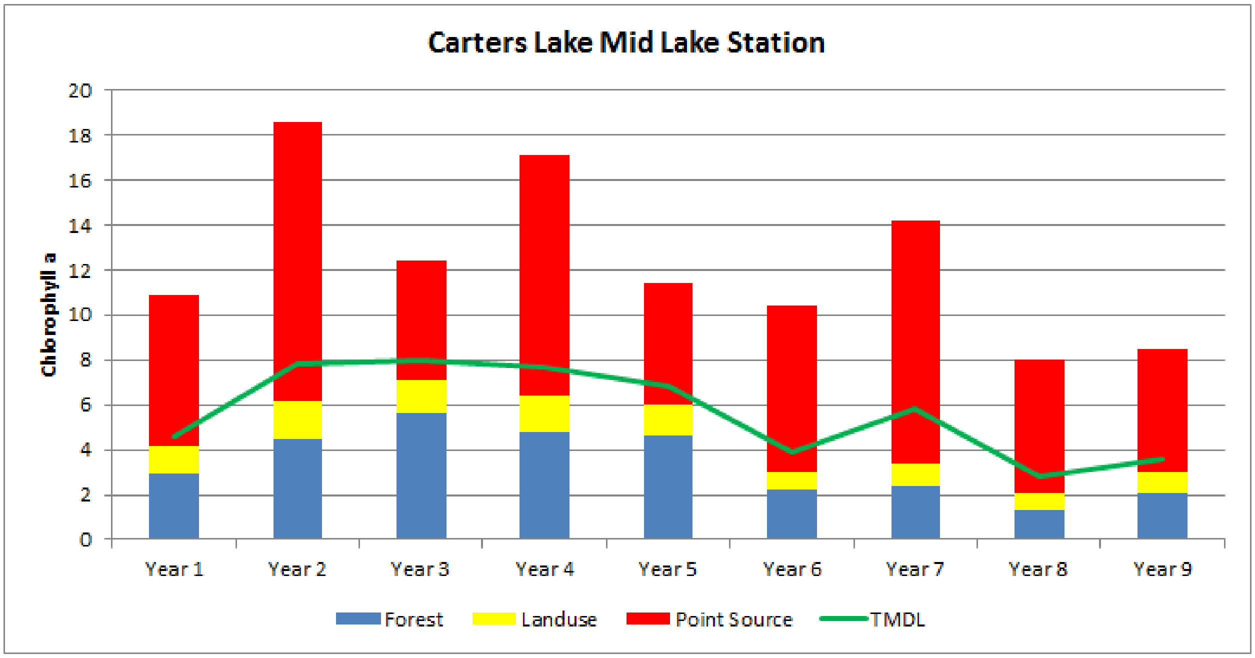


Figure 3-5 Woodring Branch Chlorophyll *a* Contributions for Baseline Scenario

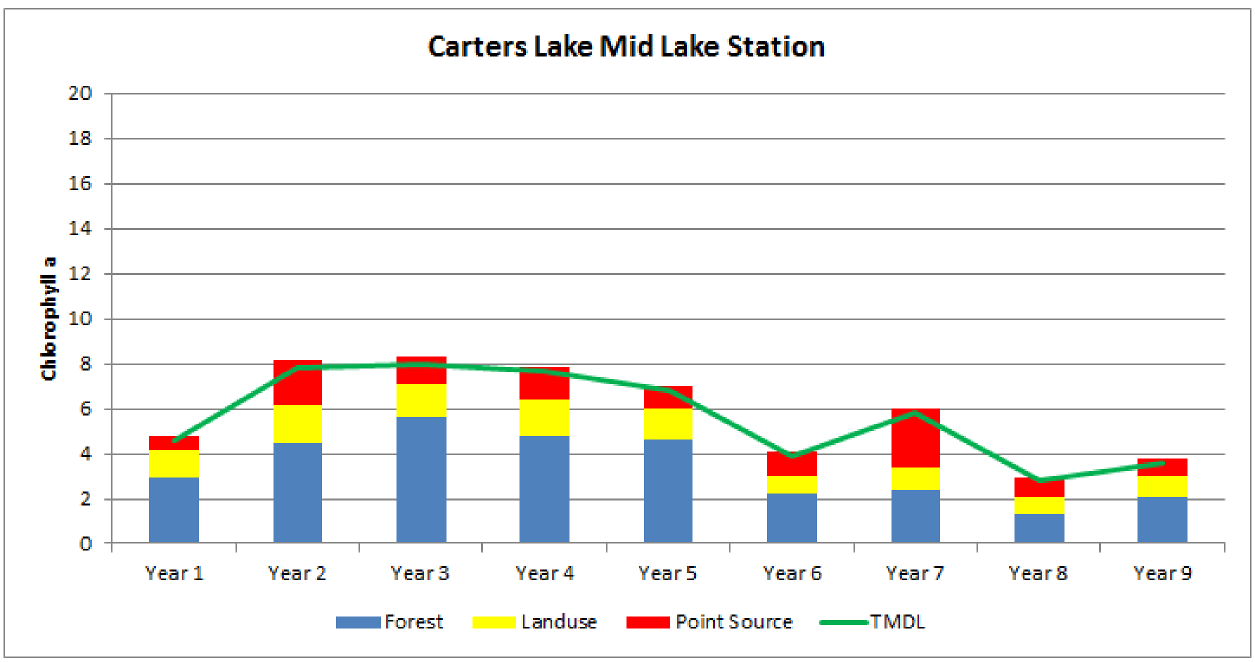


Figure 3-6 Woodring Branch Chlorophyll *a* Contributions for Full Permit Scenario

3.3 Total Nitrogen Standard

The modeling results were also evaluated to examine whether the current 'anytime, anyplace' nitrogen standard of not to exceed 4.0 mg/L is protective of the lake. For each model scenario, the total nitrogen growing season average was evaluated from 2001 to 2009. The preliminary analyses indicated that the total nitrogen standard could be revised to a 'not to exceed a growing season average of 1 mg/L as nitrogen in the photic zone'. This proposed criterion, however, does not take into consideration an accurate model that will indicate if this is protective downstream in Lake Weiss. Until an accurate calibrated model is complete for the Coosa Basin and Lake Weiss to allow for a complete understanding of the nitrogen dynamics, the current total nitrogen standard (4.0 mg/L) will remain. A protective and scientifically, defensible total nitrogen standard will be proposed when this modeling effort is complete.

This criterion is still protective of the Recreation and Drinking Water designated uses in Carters Lake. Modeling (Scenario 1H) indicated that increasing the total nitrogen concentration in the lake to a 4 mg/L level did not affect the chlorophyll *a* levels as indicated in Figures 3-7 through 3-9.

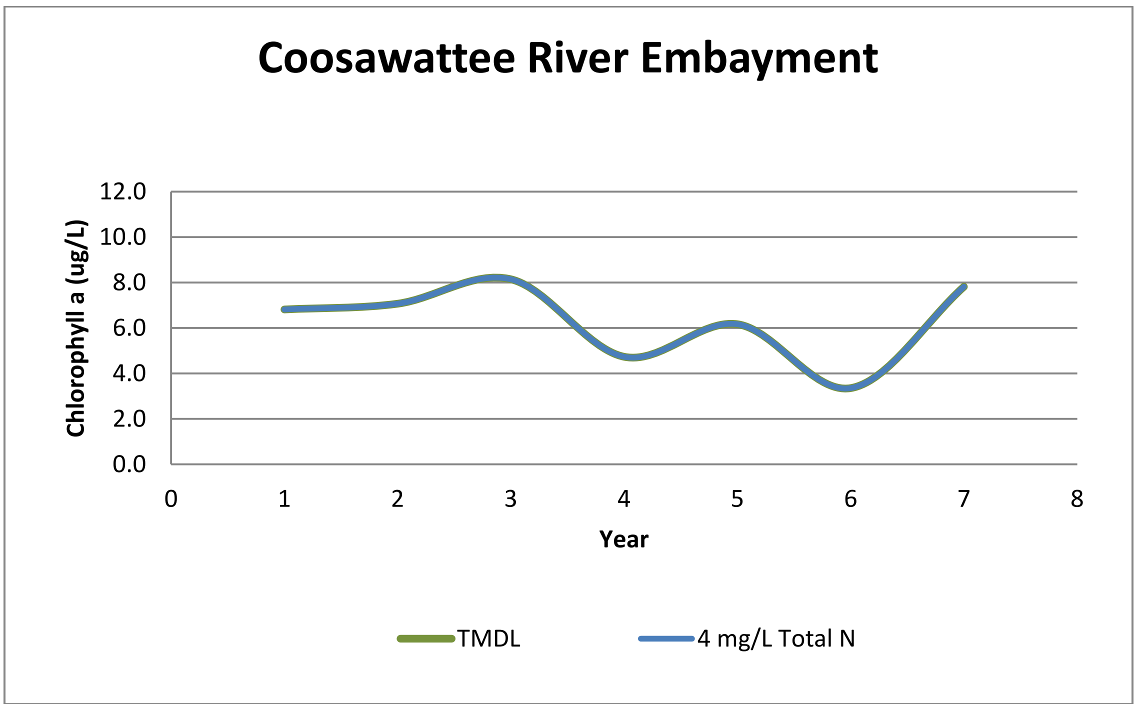


Figure 3-7 Chlorophyll *a* Levels in the Upper Lake from the TMDL (Scenario 1C) and Increasing the Total Nitrogen Load to the Current Standard (Scenario 1H)

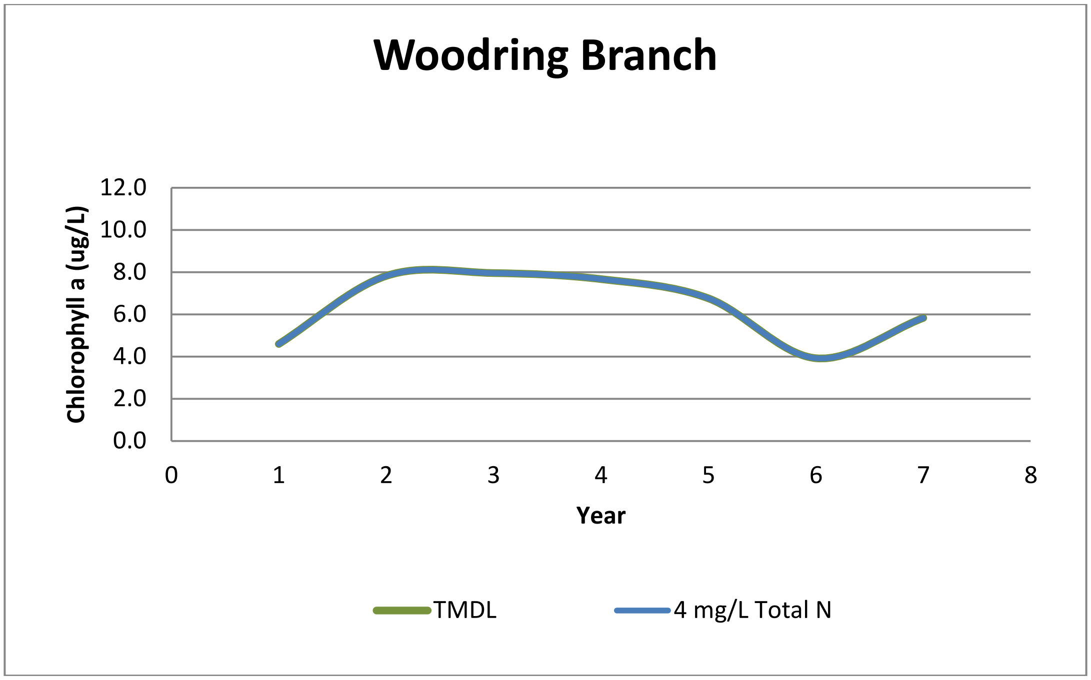


Figure 3-8 Chlorophyll *a* Levels in the Middle Lake from the TMDL (Scenario 1C) and Increasing the Total Nitrogen Load to the Current Standard (Scenario 1H)

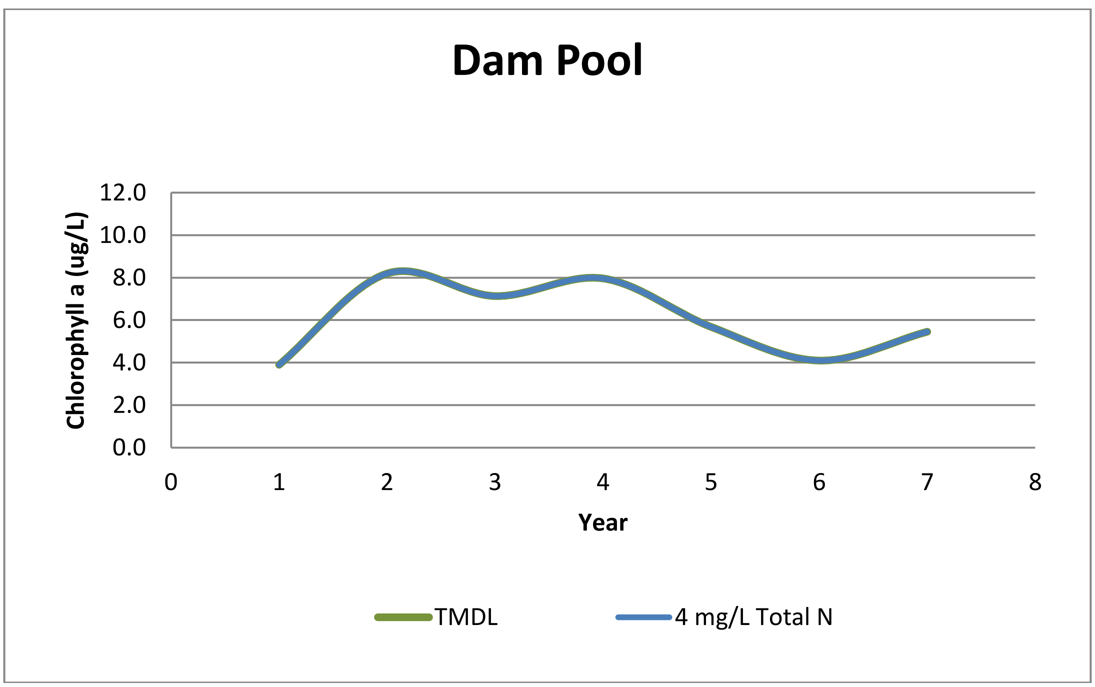


Figure 3-9 Chlorophyll *a* Levels in the Dam Pool from the TMDL (Scenario 1C) and Increasing the Total Nitrogen Load to the Current Standard (Scenario 1H)

4.0 DESIGNATED USE SUPPORT

4.1 Recreational Use Support

There have been no recreational closures due to algal blooms at any of the U.S. Army Corps of Engineers beaches on Carters Lake (personal communication, COE).

4.2 Fisheries Use Support

There have been no fish kills in Carters Lake due to dissolved oxygen deficiency since nutrient standards were adopted. This lake has both a warm water and cool water fishery. The black bass fishery is excellent, with spotted bass representing 90% of the population. Spotted bass prefer clear, cool water and utilize deeper water than largemouth bass. Largemouth bass comprise a much smaller portion of the black bass fishery at Carters. This is likely attributed to the physical habitat at Carters being more suited to spotted bass in this deep, steep-sided impoundment.

The Carters cool water fishery is supported through WRD stocking of striped bass, walleye and since 2003, hybrid bass (striped and white bass cross). Hybrid bass will tolerate warmer water temperatures than striped bass. Hybrid bass growth is good, but the Carters hybrid fishery is still developing. The Carters walleye population is good. Their growth is excellent given the robust forage base. Striped bass require at a minimum critical habitat having temperatures of less than 25 °C and with greater than 3 mg/L of dissolved oxygen. Water temperatures of 22 °C or less with dissolved oxygen concentrations of 5 mg/L or more are optimal for this species. Following the spring spawn the larger striped bass spend the remainder of the summer in cool water refuges within Carters Lake. WRD research of the Carters striped bass fishery indicates that it has likely suffered from high summer water temperatures and low dissolved oxygen (e.g. insufficient habitat with cool temperatures and higher dissolved oxygen). Table 4-1 below is WRD tabulations of their mid-August striped bass habitat ratings and depth thickness (where water temperature was less than 25 °C and dissolved oxygen was greater than 3 mg/L), and the number of stations exceeding the chlorophyll *a* standard for those years (as shown in Figure 4-1). These qualitative results infer no connection with chlorophyll a levels and striped bass habitat quality.

Table 4-1 WRD Fisheries August Striped Bass Habitat Rating For Carters Lake

Table 4-1a: Dam Area (Not Proximal to Standard Station)

Mid-August; Year	Habitat Rating *	Critical Habitat Depth [T<25 and DO > 3]	Optimal Habitat Depth [T<22 and DO > 5]	Number of Stations With Chlorophyll *a* Exceedances
2001	Fair	> 10 meters	0 meters	Standards Not Adopted
2002	Fair	> 10 meters	0 meters	Two (Midlake and Upper Coosawattee Arm)
2003	No data	No data	No Data	Two (Midlake and Upper Coosawattee Arm)
2004	Fair	> 12 meters	0 meters	One ((Midlake)
2005	Fair	> 12 meters	0 meters	Two (Midlake and Upper Coosawattee Arm)
2006	Fair	> 11 meters	0 meters	One ((Midlake)
2007	Fair	8 meters	0 meters	Two (Midlake and Upper Coosawattee Arm)
2008	Fair	18 meters	0 meters	Two (Midlake and Upper Coosawattee Arm)
2009	Fair	13 meters	0 meters	One (Midlake)
2010	Fair	6 meters	0 meters	One (Midlake)
2011	Fair	11 meters	0 meters	Two (Midlake and Upper Coosawattee Arm)
2012	Fair	15 meters	0 meters	One (Midlake)

Table 4-1b: Midlake at Woodring Recreational Area (Proximal to Standard Station)

Mid-August; Year	Habitat Rating *	Critical Habitat Depth [T<25 and DO > 3]	Optimal Habitat Depth [T<22 and DO > 5]	Number of Stations With Chlorophyll *a* Exceedances
2001	Fair	> 9 meters	0 meters	As in 4-1a
2002	Poor	2 meters	0 meters	
2003	No Data	No Data	No Data	
2004	Fair	11meters	0 meters	
2005	Fair	13meters	0 meters	
2006	Fair	12 meters	0 meters	
2007	Fair	8 meters	0 meters	
2008	Fair	17 meters	0 meters	
2009	Fair	9 meters	0 meters	
2010	Poor	0 meters	0 meters	
2011	Poor	2 meters	0 meters	
2012	Fair	13 meters	0 meters	

* Habitat rating is based on a qualitative matrix. "Good" habitat is that which has critical habitat depth greater than three meters and any level of optimal habitat depth present. "Fair" habitat is that which has three or more meters of critical habitat depth but no optimal habitat depth. "Poor" habitat is that which has less than three meters of critical habitat depth.

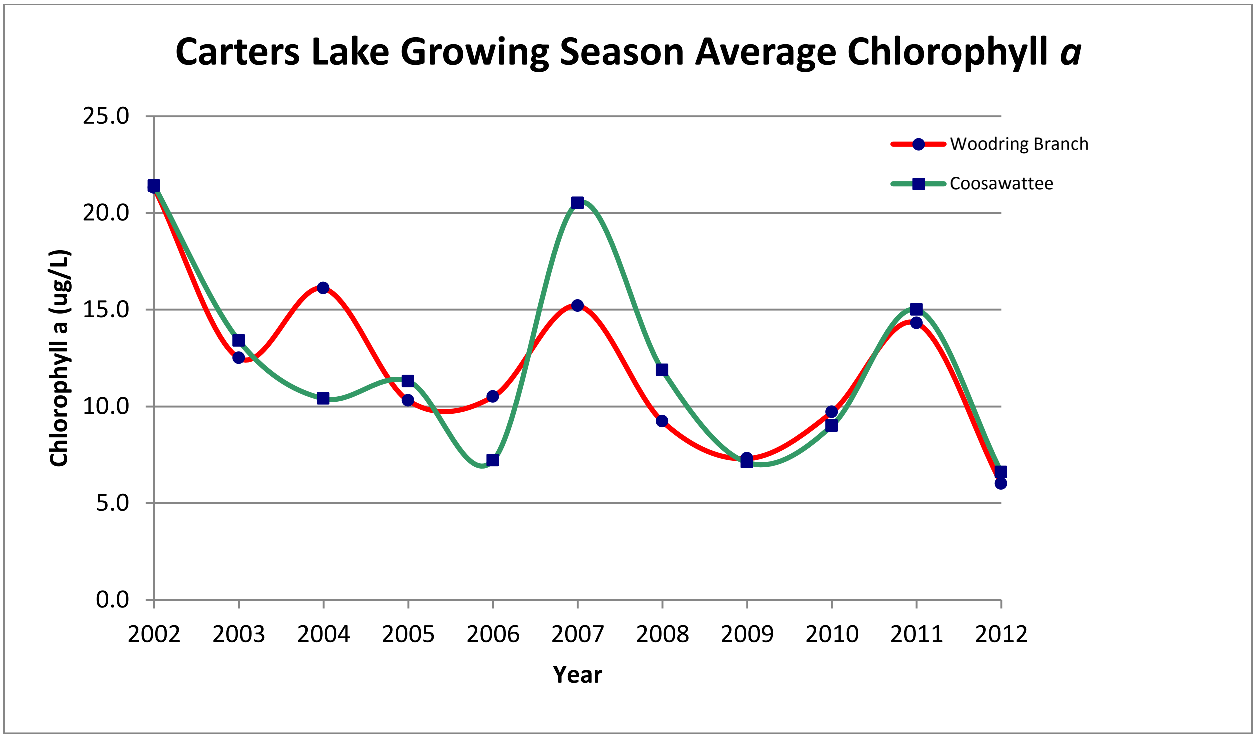


Figure 4-1 Historic Carters Lake Growing Season Average Chlorophyll *a*

4.3 Drinking Water Source Use Support

The City of Chatsworth has a water supply intake at the very upper end of the Wurley Creek arm of Carters Lake, where nutrient loadings are usually highest. The location of the drinking water withdrawal is shallower and not proximal to either of the current chlorophyll *a* standard monitoring locations in the main, deeper portions of the lake. The City has had difficulty on many occasions treating this water source due to algal concentrations during the early part of the growing season. These events start in April, right after the turnover of the lake, and usually last a couple of weeks to at worst a few months (see Figure 4.2).

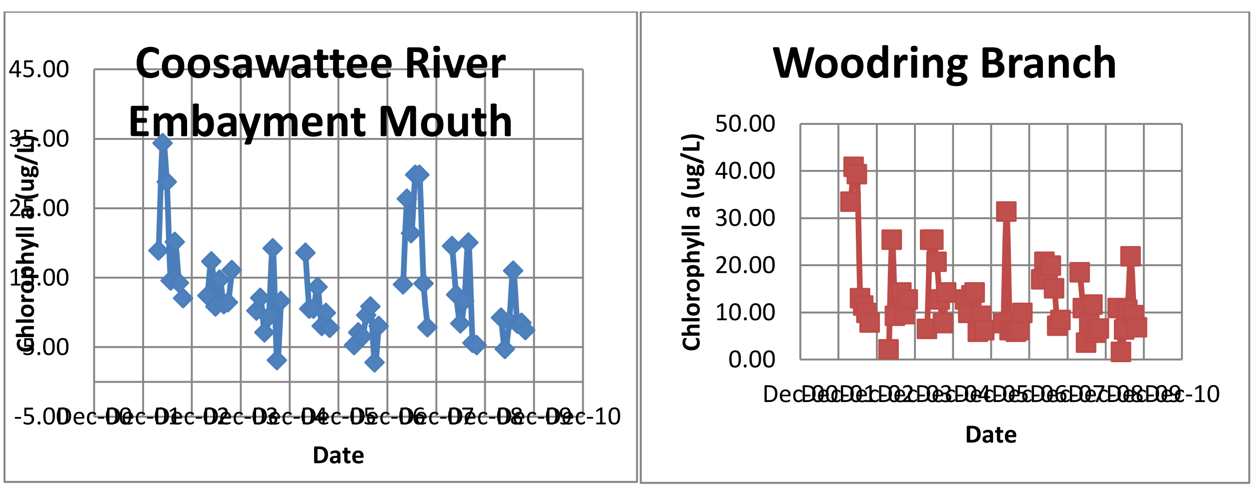


Figure 4.2 Monthly Chlorophyll *a* at the Carters Lake Monitoring Stations

While the algal presence is a nuisance, the issue is typically manageable with an estimated $10,000 to $15,000 per year in treatment costs. During these events, the City of Chatsworth feeds powdered activated carbon (PAC) in an effort to adsorb the taste and odor causing compounds, such Geosmin and MIB, produced by algae. The City of Chatsworth's Carters Lake Plant is a package plant without conventional sedimentation. There is a very short detention time for the PAC to adsorb the taste and odor causing compounds. In recent years, the City of Chatsworth has reduced the amount of water they are withdrawing from Carters Lake for drinking water. In the last couple of years, they are typically withdrawing in the 0.3 to 0.5 MGD range on average, although they are permitted to withdraw up to 2.3 MGD. Economically, it has been more advantageous to buy water from nearby water suppliers than to produce it themselves.

The extent of the algal problem increases during drought conditions when lake levels are low. The worst years the City has had regarding taste and odor complaints were in 2007 and the beginning of 2008, resulting in elevated treatment costs (approximately $65,000 per year). In 2007, the growing season average chlorophyll *a* levels at both the Coosawattee River embayment mouth station and Woodring Branch station were above 10 ug/L and in early 2008 (April and May), the chlorophyll *a* levels at both stations were well above the proposed criteria of 10 ug/L. The lake levels have returned to near normal pools since this time, with no other significant algal related drinking water issues. Chlorophyll *a* levels in the lake should continue to decrease with the implementation of the City of Ellijay Total Phosphorus permit limit and the proposed reduction in agricultural non-point sources as a result of the future TMDL.

The City of Calhoun withdraws water from their intake located approximately 25 miles downstream from the Carters Re-regulation Reservoir dam, on the Coosawattee River. Calhoun has experienced problems with treating this source water due to elevated algal concentrations. These events generally occur in the spring from April to June and last approximately 2 to 6 weeks. During these events, the City of Calhoun feeds powdered activated carbon (PAC) to adsorb the taste and odor causing compounds at a cost of approximately $20,000 to $40,000 per year in added treatment costs. Although some of the nutrient loading to the Coosawattee below Carters is contributed by other sources such as from the high agricultural land use along this segment, outflow from Carters is a contributor.