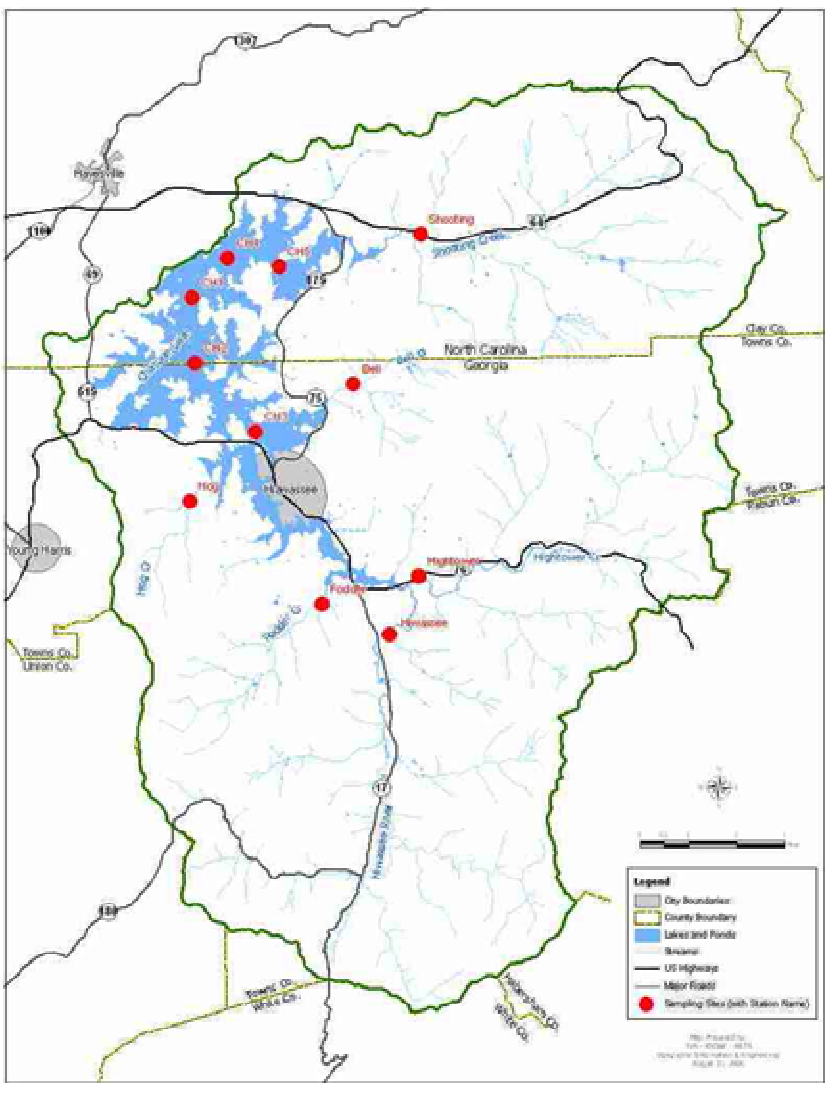
# SECTION 4
# DATA COLLECTION AND MODELING METHODS

## 4.1 Physical/Chemical Data

### 4.1.1 Site Selection

Prior to the HRWC study, annual water quality data only existed from two locations near the lower end of Lake Chatuge (CH1 and CH4). The water quality monitoring program was developed not only to have additional baseline data before any watershed improvements were made, but also to provide data inputs for the computer models discussed in Section 4.3. Monitoring sites were selected to provide the best representation of the water quality and pollutant loading of Lake Chatuge. A total of eleven sites were monitored in the Lake Chatuge watershed as part of the study (Fig 11).

Figure 11. Sites Sampled During Intensive Study of Lake Chatuge.



Site selection was based on physiographic features such as land uses, reservoir length and width, the number and size of major tributary streams, and the location of wastewater treatment plant discharges. Five of the sites were in the lake and Shooting Creek embayment; five sites were on major streams flowing into the lake: Hiwassee River, Hightower Creek, Fodder Creek, Hog Creek, and Bell Creek in Georgia and Shooting Creek in North Carolina. Table 3 presents information about the sampling sites, including what types of data were collected at each location.

Table 3. Sampling Locations and Type of Monitoring

| Station | Drainage Area*/ (% of total) | Location | Flow Monitoring | Water Quality Monitoring |
|---|---|---|---|---|
| **Lake Samples** | | | | |
| CH1 | N/A | Hiwassee River Mile 122.0 | ☒ | ✓ |
| CH2 | N/A | Hiwassee River Mile 123.7 | ☒ | ✓ |
| CH3 | N/A | Hiwassee River Mile 126.0 | ☒ | ✓ |
| CH4 | N/A | Shooting Creek Mile 1.5 | ☒ | ✓ |
| CH5 | N/A | Shooting Creek Mile 3.0 | ☒ | ✓ |
| **Stream Samples** | | | | |
| Shooting Creek | 50.7 $mi^2$/ (26.8%) | On Hwy. 64 just past Little Brook Rd. | ✓ | ✓ |
| Bell Creek | 8.0 $mi^2$/ (4.2%) | Off Upper Bell Creek Rd. in Bell Creek Estates | ✓ | ✓ |
| Hightower Creek | 33.2 $mi^2$/ (17.6%) | On Hwy. 76 across from Bearmeat Rd. | ✓ | ✓ |
| Hiwassee River | 26.7 $mi^2$/ (14.1%) | On GA Hwy. 75 just upstream from Rice bridge | ✓ | ✓ |
| Fodder Creek | 10.6 $mi^2$/ (5.6%) | On Fodder Creek Rd. under bridge just past rock quarry | ✓ | ✓ |
| Hog Creek | 8.0 $mi^2$/ (4.2%) | At Hog Creek Rd. just upstream from the first bridge crossing | ✓ | ✓ |

Note:
✓ Indicates monitoring of this parameter at this location.
☒ Indicates that this parameter was not monitored at this location.
* Calculated by TVA from USGS Quadrangle Maps (1942).
N/A Not Applicable

### 4.1.2 Methodology

Lake Sampling

Eight sampling events were conducted at each of the five lake sampling locations for the following 13 parameters: temperature, pH, conductivity, dissolved oxygen, chlorophyll-

*a*, total suspended solids, total dissolved solids, total organic carbon, biological oxygen demand, Ortho-phosphate, nitrate-nitrite, bicarbonate alkalinity, and total Kjeldahl nitrogen. Three discrete grab samples were collected on a monthly basis from each of the sampling locations at various depths to address lake stratification. All three discrete samples were analyzed for each of the parameters with the exception of chlorophyll-*a*; only one sample was collected from the top 1.5 meters of the lake surface for chlorophyll-*a* analysis (very little growth occurs below this depth due to limited light penetration). The *Monitoring Plan for the Lake Chatuge Eutrophication Study* contains details about sample collection and analysis, including quality assurance and quality control procedures (HRWC, March 2003b).

<u>Stream Sampling</u>

Nineteen sampling events were conducted at each of the six stream sampling locations for the following 12 parameters: temperature, pH, conductivity, dissolved oxygen, total suspended solids, total dissolved solids, total organic carbon, bicarbonate alkalinity, Ortho-phosphate, nitrate-nitrite, ammonia, and total Kjeldahl nitrogen. In addition to these routine, "ambient" samples, two additional wet-weather sampling events were also conducted during this period. A qualifying wet-weather event had a minimum rainfall of over 0.10 inches and result in an increase in flow depth at the sampling locations. Qualifying wet-weather events will also have a minimum of a 72-hour dry period preceding the rainfall event. Rainfall events less than 0.1 inches are considered dry-weather periods. The *Monitoring Plan for the Lake Chatuge Eutrophication Study* contains details about sample collection and analysis, including quality assurance and quality control procedures (HRWC, March 2003b).

### 4.1.3 Time Frame and Other Considerations

Physical/chemical data were collected in the Lake Chatuge watershed between December 2002 and November 2003. Stream samples were collected biweekly from December 2002 through April 2003, and monthly May through November 2003. Lake samples were collected on a monthly basis from April 2003 through November 2003 (HRWC, March 2003b). Although the area experienced a moderate drought between 1999 and 2001, the area had recovered by fall of 2002 and 2003 was considered a normal flow year in terms of precipitation and runoff.

## 4.2 Land Use Data Collection and Analysis

### 4.2.1 Integrated Pollutant Source Identification (IPSI)

Integrated Pollutant Source Identification (IPSI) is a geographic database and set of tools designed to aid citizens and planners in implementing water quality improvement and protection projects within a watershed. The geographic database consists of information on watershed features, such as land use/land cover, stream bank erosion sites, and other suspected sources of nonpoint pollution. Information for the database is generated by interpretation of low-altitude color infrared aerial photography (TVA, 1992).

The IPSI process generates a unique database for the study area and provides a means to screen areas by land activities and conditions that can affect water quality. The data is managed using commercially available geographic information system (GIS) software (TVA, 1992).

### 4.2.2 Methodology

Low-altitude, color infrared aerial photography was taken of the Lake Chatuge watershed by TVA. Over a period of several months, the photography was interpreted by experienced photo-analysts for geographic features that contribute or are suspected to contribute nonpoint source pollution within the watershed. GIS attributes that describe the set of geographic features were then generated (HRWC, March 2003b).

Components of the Lake Chatuge IPSI include:

- Land cover information
- Road conditions
- Riparian buffer conditions
- Impervious cover
- Soil loss estimates
- Nutrient loading rates

HRWC staff and partners field-verified much of the Lake Chatuge IPSI data to insure its viability for use in the study. Figures presented in Sections 2 and 5 display land cover (Fig 7), impervious area (Fig 12), and riparian condition (Fig 13) data developed as part of the IPSI analysis for the Lake Chatuge watershed.

### 4.2.3 Time Frame and Other Considerations

The Lake Chatuge watershed IPSI database was completed in 2003 based on aerial photographs that were acquired in early spring 2002.

## 4.3 Modeling

### 4.3.1 Watershed Model

The Hydrological Simulation Program-Fortran (HSPF) model was used to calibrate the nutrient and organic concentrations flowing into Lake Chatuge from the watershed with field measurements collected during the 2003 sampling. HSPF uses hydrology and land use data inputs to model runoff rates and concentrations of sediment and nutrients, as well as a wide variety of other substances carried in the runoff. HSPF divides precipitation that reaches the ground into surface runoff, interflow (water moving through the soil and/or rock beneath the ground surface), and groundwater. The water that reaches a stream, after losses from evaporation, transpiration and storage, is routed through the stream network to simulate discharge rates.

Rainfall detaches sediment in the model based on soil and land cover characteristics. The sediment is carried by surface runoff to the channel, where it is subject to settling and re-suspension processes while being routed with the water flow. HSPF also simulates nitrogen and phosphorus cycles, and the transport of nutrients by water to streams. Alkalinity, pH, biological oxygen demand, and organic carbon can also be tracked using the model (TVA, December 2004).

#### 4.3.2 Reservoir Model

CE-QUAL-W2 (Version 2) is a two-dimensional, longitudinal/vertical, hydrodynamic and water quality model. Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients. The model predicts water surface elevations, velocities, temperatures, and 21 water quality parameters including nutrient/phytoplankton/ dissolved oxygen interactions under anoxic conditions (TVA, December 2004).

A two-dimensional CE-QUAL-W2 water quality model of Chatuge reservoir was calibrated using field data collected in 2003. Calibration results showed that the model well reproduced the measured seasonal temperature and dissolved oxygen patterns. However, the computed algal productivity is not considered validated due to poor pH calibration (TVA, December 2004).

#### 4.3.3 Confidence in Results

The goal of watershed model (HSPF) calibration was to match model output with measured flows and actual water quality data while accurately accounting for the physical processes in the watershed and attributing pollutant loads to the correct sources. A "weight of evidence" approach was used for calibration. The model was run repeatedly to test sensitivity of the many different factors and to match concentrations of the water quality parameters to the various sub-watersheds based on the land uses within the particular sub-watershed. The reservoir model (CE-QUAL-W2) used the output of the watershed model as the initial input. Again, calibration was performed to match model output to measured water quality parameters in the reservoir.

Because good models that are well calibrated accurately capture the most important physical processes in the watershed and reservoir, it becomes possible to predict the response of the system to management changes. These models are accepted and state-of-the-art. The calibration was performed based on reliable, professionally-collected data and discussions with local natural resource personnel. Modelers with experience and insight into the appropriate processes ran both the calibration and management scenarios.