BASINWIDE ASSESSMENT REPORT

LITTLE TENNESSEE RIVER

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND
NATURAL RESOURCES
Division of Water Quality
Water Quality Section
Environmental Sciences Branch

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EXECUTIVE SUMMARY

This document presents a water quality assessment of the Little Tennessee River basin. Monitoring programs covered within this report include benthic macroinvertebrates, lake assessment, ambient water quality, and aquatic toxicity for the period 1994 - 1999. Studies conducted prior to and including 1994 were previously summarized in NCDEHNR (1996a).

In general, the document is structured such that each subbasin is physically described and an overview of water quality is given at the beginning of each subbasin section. General water quality conditions are presented in an upstream to downstream format. Subbasins within the Little Tennessee River basin are described by a six digit code (040401 - 040404), but are often referred to by their last two digits (e.g. Subbasin 01).

The Little Tennessee River basin is located within the Blue Ridge Province of the Appalachian Mountains of western North Carolina. It encompasses about 1,800 mi^2 in Swain, Macon, Clay, Graham, Cherokee, and Jackson counties (Figure 1). Much of the land within the basin is federally owned (49%) and in the U.S. Forest Service's Nantahala National Forest (including the Joyce Kilmer/Slick Rock Wilderness Area) or the Great Smoky Mountains National Park (GSMNP). The basin also includes the Cherokee Indian Reservation.

The North Carolina section of the Little Tennessee River is typical of many other mountain rivers. The gradient is relatively steep in most reaches of the river and the substrate is dominated by riffle habitats. The headwater reaches of the Little Tennessee River are located in Georgia. Most tributaries are high gradient streams capable of supporting trout populations in the upper reaches. Most of the basin is forested. However, lower reaches of many tributary catchments are farmed or developed resulting in the increased potential for nonpoint source problems.

The Little Tennessee River is one of three major tributaries of Fontana Lake. The other two are the Nantahala River and the Tuckasegee River. The Cheoah River, the fourth major tributary of the Little Tennessee River in North Carolina, has its confluence with the river below Fontana Lake.

The Little Tennessee River is critical habitat for three federally listed endangered species: a fish, the Spotfin chub (*Cyprinella monacha*) and two mussels, the Appalachian elktoe (*Alasmidonta raveneliana*) and the Little-wing pearly mussel (*Pegias fabula*). Two other important aquatic species are found in the Little Tennessee River: *Alasmidonta viridis* (Slippershell mussel) and *Fusconaia barnesiana* (Tennessee pigtoe). These two species are found only in a portion of the Little Tennessee River in North Carolina, although more extensive populations are known from the Mississippi drainage or from Tennessee. Both species are considered as endangered in the state.

Upper Little Tennessee River (Subbasin 01)

The upper section of the Little Tennessee River contains approximately 35 river miles from the North Carolina/Georgia state line to the confluence of Burningtown Creek below Franklin. Franklin, and a portion of the Town of Highlands, are the only large urban areas. The Cullasaja River and Cartoogechaye Creek are the major tributaries to this part of Little Tennessee River. Other smaller tributaries include Middle Creek, Coweeta Creek, Cowee Creek and Burningtown Creek.

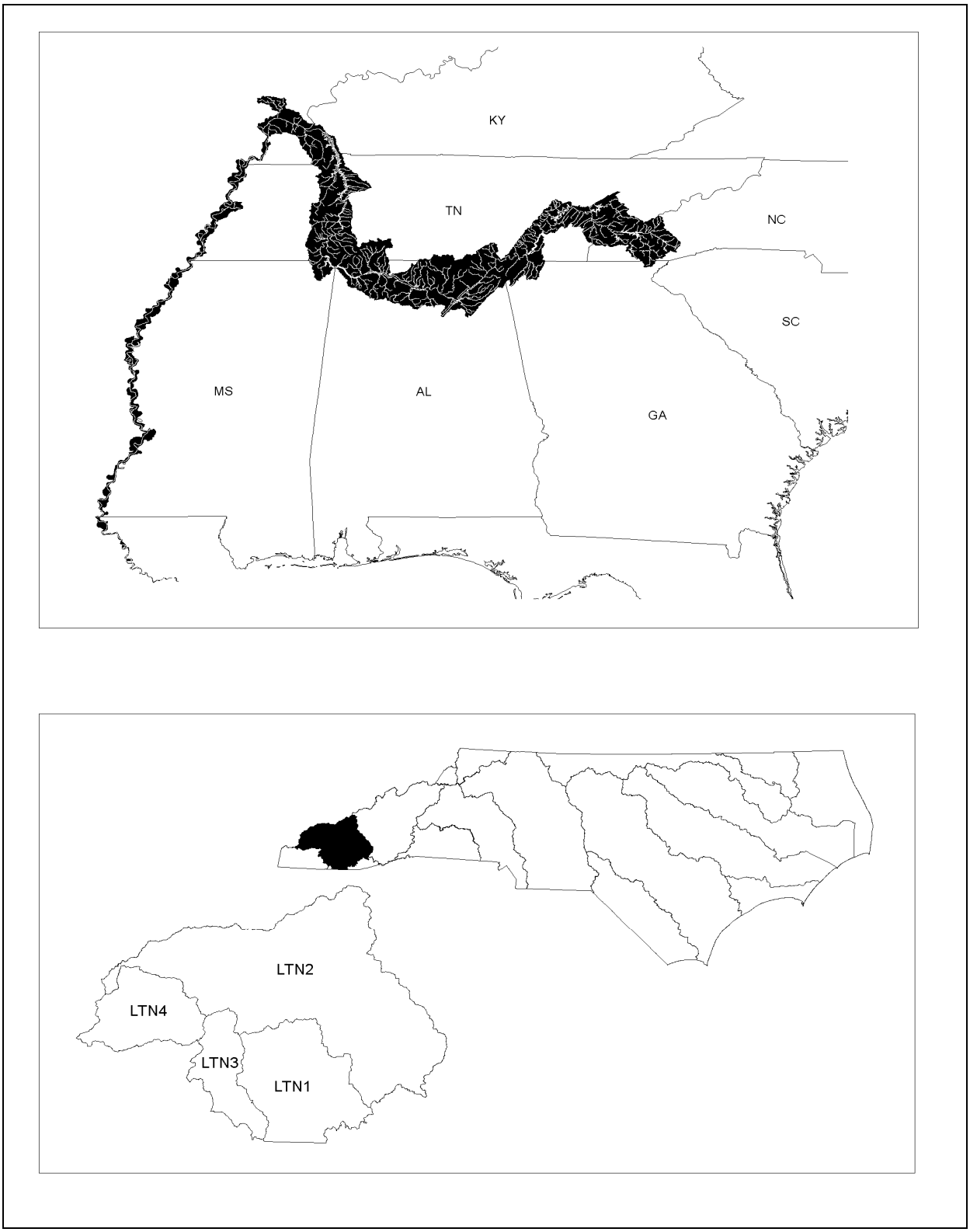

Figure 1. Geographical relationships of the Little Tennessee River and its subbasins to the lower Tennessee River and lower Mississippi River drainages.

This area is within the US Forest Service's Nantahala National Forest and is characterized by many mountain ranges. Most tributaries are high gradient streams capable of supporting trout populations in the upper reaches. The water quality of rivers and streams in this area is generally high. The Little Tennessee River, though, and some of its tributaries become very turbid after rainfalls. Sedimentation is the dominant water quality problem. Sources of sedimentation include agriculture, development, and silviculture.

The Cullasaja River watershed was given special attention in 1999 at the request of the Asheville Regional Office. Four mainstem river sites and seven tributaries were sampled for benthic macroinvertebrates. All Cullasaja River sites downstream of Highlands were Excellent as were Big Creek, Brush Creek, Buck Creek, Ellijay and North Prong Ellijay Creek, and Turtle Pond Creek. Walnut Creek was Good; the Cullasaja River in Highlands was Fair, as was Mill Creek. The Cullasaja River site receives runoff from the Town of Highlands area as well as from golf courses. These tributary sites were all sampled for the first time. Prior data has been collected from the Cullasaja River, and no substantial changes were found in water quality since it was first sampled in 1990. Lake Sequoyah, an impoundment of the upper Cullasaja River, was mesotrophic in 1999.

Water quality problems were found in the Little Tennessee River, especially near the Georgia state line. Nonpoint source runoff may contribute to some of the degradation at the upstream Little Tennessee River site, although point source dischargers in Georgia seem to be a potential source of problems. This site was given a Fair bioclassification in 1999, a decline from the Good-Fair rating found in 1994. The next downstream site at Prentiss was also Good-Fair in 1999. The Little Tennessee River at Iotla is below Franklin and Lake Emory. This site was given a Good-Fair bioclassification in 1999, a rating that has been found since 1983.

Of the six tributary streams sampled for benthic macroinvertebrates during this monitoring cycle, four showed considerable improvement from 1994 ratings. Coweeta Creek and Tellico Creek were both Excellent in 1994 and 1999. Cowee Creek and Iotla Creek improved from Good-Fair to Good, while Burningtown Creek and Cartoogechaye Creek improved from Good to Excellent. Extremely high flows in 1994 prior to sample collection most likely caused the lower 1994 ratings.

Middle Little Tennessee River (Subbasins 02 and 03)

Principal tributaries to the Little Tennessee River in this area are the Oconaluftee River, the Tuckasegee River, Hazel Creek, and Deep Creek. The largest tributary watershed in the Little Tennessee River basin is that of the Tuckasegee River which flows into Fontana Lake. The Nantahala River is another large tributary of Fontana Lake. Fontana Lake is the largest impoundment in this region and is operated by the Tennessee Valley Authority (TVA). Much of its immediate watershed lies within either the Great Smoky Mountains National Park or the Cherokee Indian Reservation. Most streams on the north side of Fontana Lake are in a roadless wilderness region and can be reached only by boat (across the lake) or by hiking.

The area contains some of the most pristine areas and cleanest waters in North Carolina. This portion of the basin also contains some of the most famous trout streams in eastern North America including Hazel Creek, Forney Creek, Deep Creek and Noland Creek. Streams designated High Quality Waters include the headwaters of Alarka Creek, the Tuckasegee River upstream of Tanassee Creek, Caney Fork and tributaries above Mull Creek, most of the Oconaluftee River catchment, and several small streams that were formerly classified for water supply. The Tuckasegee River upstream of Tanassee Creek is classified Outstanding Resource Waters.

The rest of this watershed is included in the Nantahala National Forest, although this does

not preclude some other land uses. Portions of this area are developed and erosion from these areas causes some minor nonpoint source problems. Major municipal areas include Bryson City, Cherokee, and Sylva.

Benthic macroinvertebrate sampling during this monitoring cycle in 1999 found, that overall, water quality was very good. Fifteen of the 20 sites sampled had a bioclassification of Excellent, while the other five sites were Good. Moses Creek, Cullowhee Creek, Tuckasegee River, Oconaluftee River, and Stecoah Creek had a change in bioclassification compared to 1994 from Good to Excellent, but these changes seemed to be related more to extremely high flows in 1994, rather than to any long term change in water quality. More significant improvement in water quality was observed at Scott Creek, where the bioclassification improved from Good-Fair in 1994 to Good in 1999. Declining water quality was observed only at Savannah Creek.

Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake and Thorpe Reservoir were monitored in 1999. All were rated as oligotrophic with no algal blooms or nuisance aquatic plants occurring.

Ambient monitoring data were collected from the Oconaluftee River at Birdtown and the Tuckasegee River at Bryson City. Neither site had any indication of water quality problems. Fecal coliform concentrations have declined over time at both these sites.

The Nantahala River, from its source to the confluence with Roaring Fork, is currently classified as Outstanding Resource Waters. Much of the land adjacent to this reach is privately owned by the Rainbow Springs Corporation. The Nantahala River and most tributaries are high gradient systems capable of supporting wild trout populations. Nantahala Power and Light Company maintains a power generation facility at Nantahala Lake. Flow is diverted to downstream power generators, bypassing a seven mile reach of the river prior to discharging back into the original channel above the Nantahala Gorge. The regulated reach of the Nantahala River below the powerhouse is very popular for white water rafting and kayaking. Development has increased along the Nantahala Gorge corridor as it relates to this recreational industry.

Overall water quality in the Nantahala River watershed is high. Excellent bioclassifications have been found using benthos data for the river above Nantahala Lake near Rainbow Springs since 1984. Ambient chemistry data from this location demonstrated the lowest variability for total suspended solids, hardness, fecal coliform bacteria, turbidity, nitrite+nitrate as nitrogen, and total phosphorus of all ambient sites in the basin. Medians were low for most parameters, indicating a high frequency of samples with low concentrations for these parameters.

Nantahala Lake is oligotrophic and has been since first monitored in 1981. Benthos samples from the bypass reach of the river below the lake improved from Good in 1993 to Excellent in 1999. Further downstream, in the flow regulated portion of the river, benthos data have resulted in Good bioclassifications in 1994 and 1999, although heavy periphyton growths reduced the abundance of many taxa. Benthos samples of tributary streams in 1999 resulted in an Excellent bioclassification for Queens Creek, and Good bioclassifications for Dicks Creek and Whiteoak Creek. The Dicks Creek rating was an improvement from the Good-Fair bioclassification found in 1993.

Lower Little Tennessee River (Subbasin 04)

The Cheoah River and significant sections of most tributary catchments are within the Nantahala National Forest and are minimally impacted. These tributaries are typically high-gradient streams capable of supporting trout populations. However, lower reaches of some tributaries and corridors along Tulula Creek, Sweetwater Creek, Little Snowbird Creek, Yellow Creek, and the Cheoah River are not in the national forest. Thus, they are more likely to be impacted by land-disturbing

activities. Tulula Creek flows through the Town of Robbinsville, where the stream becomes the Cheoah River at its confluence with Sweetwater Creek. Robbinsville is the only urban area.

The Cheoah River is dammed below Robbinsville to form Santeetlah Lake. Tapoco, Inc. operates the hydroelectric dam to provide hydroelectric power for the Aluminum Company of America (ALCOA). The tailwater reach below the dam is approximately nine river miles above the confluence with the Little Tennessee River.

Good or Excellent bioclassifications have been recorded at all benthic macroinvertebrate monitoring locations in this watershed since 1983. Trout farms and land disturbing activities are the main potential sources of water quality problems.

The 1994 benthos sites had extremely high stream flows immediately prior to sample collection. This may explain the improvement found at 2 of the 3 basin sites sampled in 1999. Tulula Creek was sampled in Robbinsville where nonpoint source runoff is a potential impact, but an Excellent rating was found. Further downstream, the Cheoah River was also Excellent where sampled below the Robbinsville WWTP (0.63 MGD), which discharges to Long Creek, a tributary of the Cheoah River. An ambient chemistry station on the Cheoah River had slightly higher fecal coliform values in the past five years than earlier, but no other notable values. Snowbird Creek had been Excellent before the 1994 Good rating, and was Excellent again in 1999, supporting the contention that high flows in 1994 may have displaced some taxa.

Monitoring of Cheoah Lake on the Little Tennessee River and Santeetlah Lake on the Cheoah River in 1999 found oligotrophic conditions in the mainstem of both lakes.

Division studies during the 1990s indicated excessive phosphorus loading into the Snowbird Creek and West Buffalo Creek arms of Santeetlah Lake. Bluegreen algal blooms and chlorophyll *a* values greater than 15 µg/l were noted. The cause of the accelerated eutrophication was nearby trout farms. The 1999 study concluded that the Snowbird Creek arm of the lake cannot tolerate additional nutrient contributions. The West Buffalo Creek arm was determined to be impaired and only partly supporting its uses for swimming and biological integrity. A benthos sample from West Buffalo Creek above the lake but below the trout farms gave an Excellent bioclassification. The stream did show some signs of enrichment, however.

Executive Summaries By Program Area

BENTHIC MACROINVERTEBRATES

Bioclassification and Water Quality Changes

Water quality in the basin, as assessed using benthic invertebrates, is generally Good or Excellent. Two hundred seven ratable samples, representing 112 sites, have been collected since 1983. Good or Excellent ratings have been assigned for 77% of these samples (Figure 2).

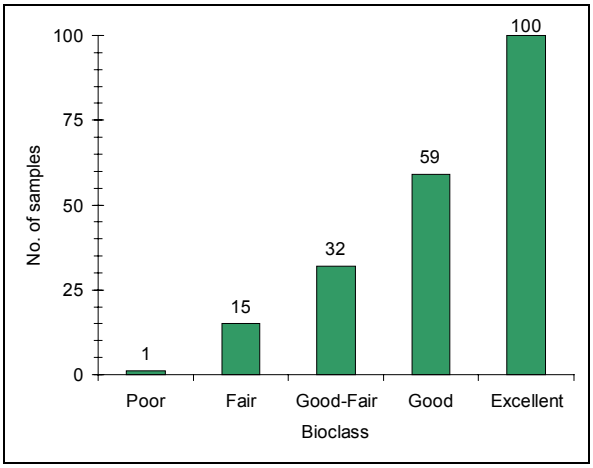

Figure 2. Bioclassifications of 207 samples collected from the Little Tennessee River basin, 1983 - 1999.

In 1999, 34 sites were sampled as part of the basinwide monitoring program. An Excellent or Good rating was given to 91% of these sites (Figure 3).

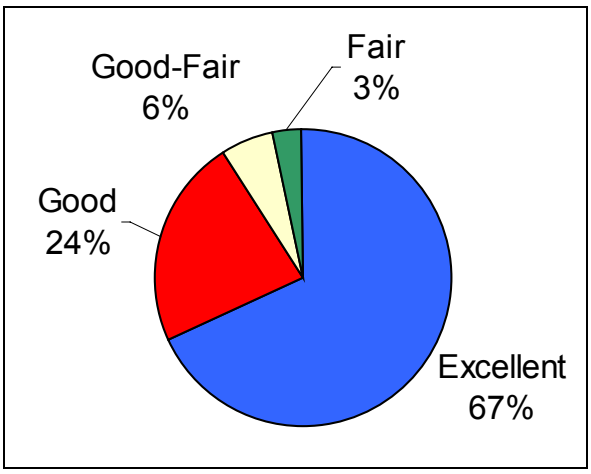

Figure 3. Bioclassifications of 34 basinwide sites in the Little Tennessee River basin, 1999.

Overall, the water quality in the basin has improved slightly since the last monitoring cycle (Figures 4 and 5).

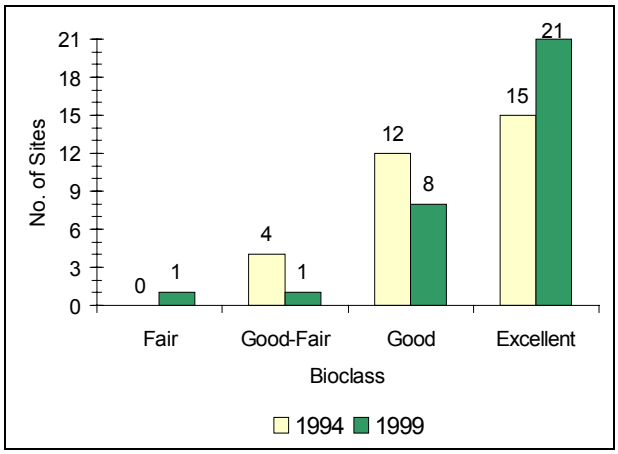

Figure 4. Bioclassifications of the same 31 sites rated in 1994 and 1999 in the Little Tennessee River basin.

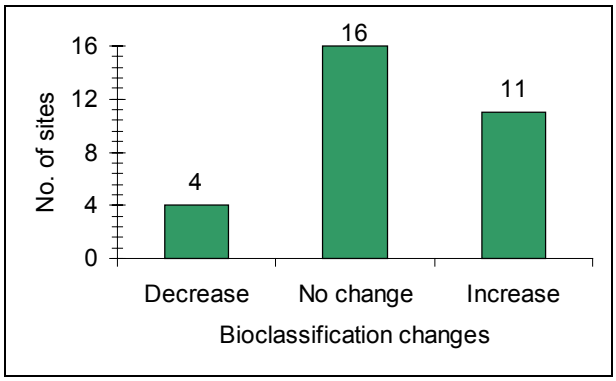

Figure 5. Short-term changes in bioclassifications at 31 sites in the Little Tennessee River basin, 1994 and 1999.

Of the 31 same sites rated in 1994 and 1999, 94% of them were rated Good or Excellent in 1999 in contrast to 87% of the sites in 1994. But, many of these short-term changes were more related to differences in flow rather than actual improvements in water quality between the 1994 and 1999 basinwide monitoring cycles.

One short-term decline in water quality was found at the uppermost site on the Little Tennessee River in Macon County. A decrease in bioclassification was accompanied by a sharp increase in conductivity. This problem seemed to be

associated with an upstream discharger in Georgia.

The distribution of ratings was very similar for the 1999 collections and for all collections made since 1983. This suggested there has been little overall change in water quality within the basin. Individual sites, however, sometimes showed distinct long-term or short-term changes in water quality.

While few problems occurred in the basin, most acute problems (those sites rated Fair) were associated with:

- Nonpoint source runoff from more developed areas. Examples included the Cullasaja River above Mirror Lake and Mill Creek near Highlands.
- High sulfate bearing rock formations. Upper Beech Flats Prong in the Great Smoky Mountains National Park is affected by low pH caused by precipitation coming into contact with the Anakeesta rock formation. This occurs either naturally from rock slides or use of the rock as road fill to maintain US 441 across Newfound Gap.
- Wastewater discharges. This was a major problem only in the upper portion of the Little Tennessee River.

Agricultural runoff may cause less acute problems than point source discharges. Where the only change in stream habitat was from the introduction of sediment, these streams usually received a Good or Good-Fair rating. Many of these streams were also affected by bank erosion and carried heavy sediment loads. This often resulted in the reduction in the number of pools with some streams having fairly uniform riffle and run instream habitat.

Long-term (greater than 5 years of data) changes in bioclassification were evaluated at 13 sites (Figure 6). These data indicated a change in the bioclassifications at 3 of the 13 sites. Like the short-term changes, many of these long-term changes were more related to differences in flow rather than to actual improvements in water quality among the various monitoring cycles. Water quality did not decline at any of these long-term monitoring sites.

Improvements in water quality were related to upgrades or better performing wastewater treatment plants. Examples included Scott Creek below the Town of Sylva's WWTP and the Cheoah River below the Robbinsville WWTP.

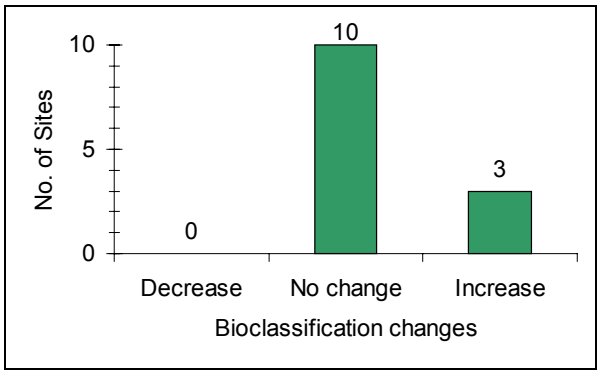

Figure 6. Long-term changes in bioclassifications at 13 sites in the Little Tennessee River basin, 1983 - 1999.

Endangered Benthic Fauna

The Little Tennessee River in Subbasin 02 is critical habitat for two federally listed endangered species of mussels: the Appalachian elk-toe (*Alasmidonta raveneliana*) and the Little-wing pearly mussel (*Pegias fabula*). Other important mussel species in this subbasin include:

- *Alasmidonta viridis* (Slippershell mussel): This species is found only in this portion of the Little Tennessee River in North Carolina. Although more extensive populations are known from the Mississippi River drainage, the species is listed in North Carolina as endangered; and
- *Fusconaia barnesiana* (Tennessee pigtoe): This species is found only in this portion of the Little Tennessee River in North Carolina. Although more extensive populations are known from Tennessee, the species is listed as endangered in North Carolina.

New Species and Distributional Records for the Benthic Invertebrate Fauna

Benthic monitoring in 1999 also recorded several rare taxa from the basin:

- *Baetopus* sp. *nov.*: The first North American record of this mayfly genus was collected from Panthertown Creek. The specimen represents a new species which will be described by Robert Waltz (Indiana Department of Natural Resources).
- *Heterocloeon* sp. *nov*.: Another new species of mayfly was collected from the Oconaluftee River and from the lower Cullasaja River. It will also be described by Robert Waltz. Currently, this taxon is only known only from these two locales.
- *Serratella spiculosa*: This rare mayfly had not been collected since it was originally described in 1962. In 1999 it was found in Snowbird Creek and Brush Creek.

- *Agapetus* spp.: Several distinct species of *Agapetus* were collected in the Cullasaja River and its tributaries, although no key exists for larvae of this genus. Dr. David Etnier (University of Tennessee) will be using this information to try to collect adults in the spring. Prior work by Dr. Etnier has lead to the discovery of many new species of *Agapetus*.
- *Micrasema sprulesi*: This species was collected from Little Snowbird Creek. Also present were an unusually large number of the intolerant mayfly, *Rithrogena fuscifrons.*
- *Megaleuctra williamsae* and *Zapada chila*: These rare stoneflies are confined to small, high elevation, mountain streams, and thus, may be missed by normal Division sampling. Both species were found in the headwaters of Beech Flats Prong in October 1995.
- *Cambarus* (*Jugicambarus*) sp. *nov.*: This taxon, found in the Oconaluftee River, represents a new species of crayfish. It will be officially described by Dr. John Cooper (North Carolina State Museum of Natural Science).

FISHERIES

Fish Community Assessment

Sixty-eight species have been collected from the Little Tennessee River basin in North Carolina (Menhinick 1991, 1995 (pers. com.)). Special status has been granted to six of them by the United States Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337 (LeGrand and Hall 1999; Menhinick and Braswell 1997) (Table 1). Additional information on these six species may be found in Menhinick and Braswell (1997).

The North Carolina Index of Biotic Integrity is one of the tools the NCDWQ uses which summarizes all classes of factors such as water and habitat quality, flow regime, and energy sources which influence the freshwater fish communities of wadeable streams throughout the state. No stream fish community basinwide monitoring was conducted during 1999 in the Watauga River basin because of recent revisions and a reexamination of the criteria and metrics.

Fish Tissue Contaminants

No fish tissue contaminant monitoring in the basin was conducted by the Division between 1994 and 1999 because there were no significant contaminant issues to be addressed.

As part of the relicensing effort of the Tapoco Hydroelectric Project, Normandeau Associates, under contract with Stone and Webster Engineering Corporation, collected baseline fish tissue data from the three project reservoirs in North Carolina (Lake Cheoah, Lake Santeetlah, and Calderwood Lake) (Normandeau Associates 1999). Common carp, white sucker, channel catfish, largemouth bass, and yellow perch were collected in October 1997 and June 1998. The tissues were analyzed for mercury and polychlorinated biphenyl (PCBs) compounds.

Where mercury was detected, all concentrations were less than the State of North Carolina, the Federal Drug Administration, and the US Environmental Protection Agency consumption criteria. PCBs concentrations were less than the laboratory detection limit at all three reservoirs.

Fish Kills

The Division has systematically monitored and reported on fish kill events across the state since 1996. No fish kills have been reported from the Little Tennessee River basin during this time period. Information on fish kills in other basins may be found on the Division's website (refer to the Glossary).

Table 1. Species of fish listed as endangered, rare, threatened, or of special concern in the Little Tennessee River basin in North Carolina.

Species	Common Name	State or Federal Status	State Rank[1]
Cyprinella monacha	Spotfin chub	Federal - Threatened	S1
Noturus flavus	Stonecat	State - Endangered	S1
Clinostomus funduloides ssp.	Little Tennessee Rosyside dace (Smoky dace)	State - Special Concern	S2
Etheostoma vulneratum	Wounded darter	State - Special Concern	S2
Notropis lutipinnis	Yellowfin shiner	State - Special Concern	S3
Percina squamata	Olive darter	State - Special Concern	S2

[1]S1 = critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina; S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; S3 = rare or uncommon in North Carolina (LeGrand and Hall 1999).

LAKE ASSESSMENT

Eight lakes in the basin were sampled as part of the Lake Assessment Program (Table 2). Lakes in this basin typically exhibited very good water quality. Six of the eight lakes had exceptional water clarity and low biological productivity resulting in oligotrophic conditions (NCTSI < -2.0) (Figure 7). Nantahala Lake, Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake, Thorpe Reservoir and Lake Cheoah demonstrated excellent to very good water quality.

Two lakes demonstrated water quality conditions which were of concern. Lake Sequoyah near the Town of Highlands was moderately productive (mesotrophic) and had chlorophyll *a* values which were greater than the state water quality standard of 15 µg/l for lakes designated as Trout Waters (Tr). Seven species of algae collected at this lake are known to contribute taste and odor problems in drinking water.

The West Buffalo and Snowbird Creek arms of Santeetlah Lake have been exhibiting symptoms of accelerated eutrophication such as algae blooms and elevated dissolved oxygen saturation levels. In 1993, in response to citizen complaints regarding water quality, a special study was conducted which determined that nutrient loading from upstream trout farms enhanced algal blooms observed on the West Buffalo Creek arm. Voluntary management actions were taken by the trout farms. The Division also instituted a new permitting policy to restrict new or expanding trout farm facilities within the Santeetlah Lake drainage area.

A second special study was conducted from April through October 1999. This study determined that the mainstem of Santeetlah Lake was continuing to support its designated uses. The Snowbird Creek arm, however, was found to be experiencing accelerated eutrophication and cannot tolerate additional nutrient loading. The West Buffalo Creek arm was determined to be impaired and only partially supporting its uses for swimming and biological integrity.

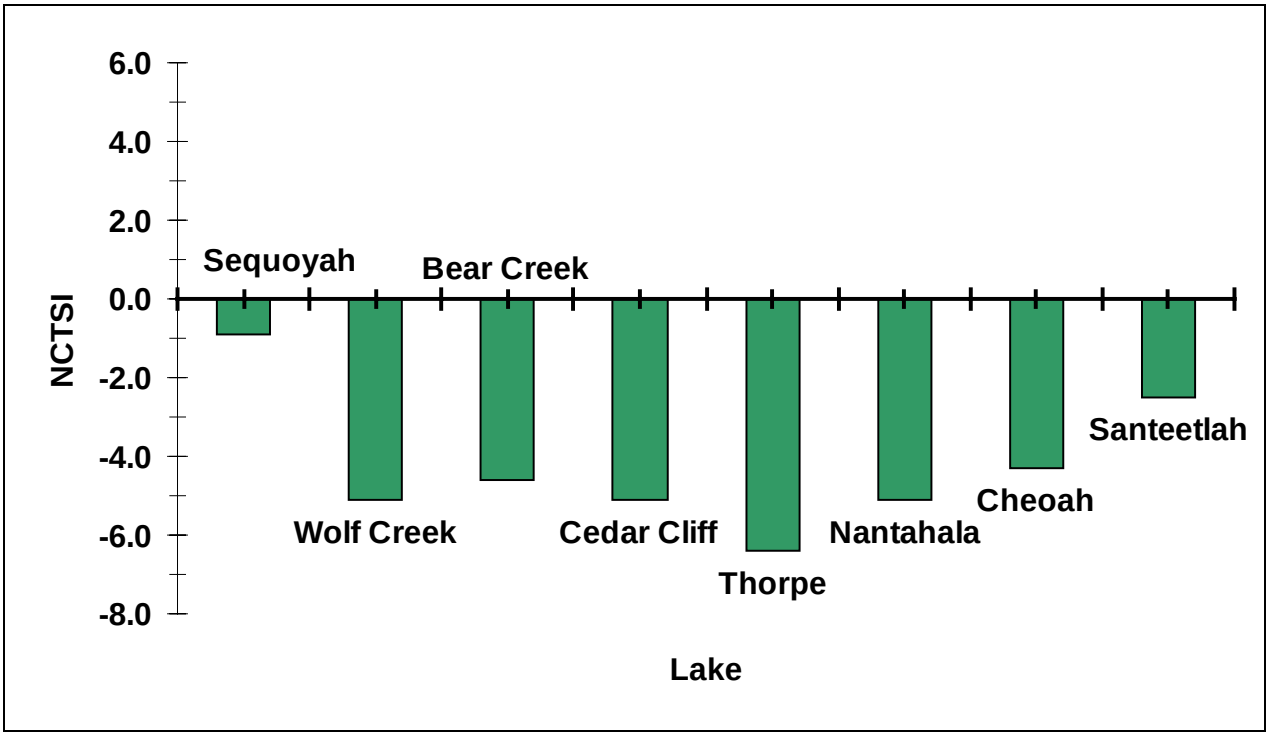

Figure 7. North Carolina Trophic State Index scores for lakes in the Little Tennessee River basin, August 1999.

Table 2. Lakes monitored in the Little Tennessee River basin in 1999.

Subbasin/Lake	County	Classification	Surface Area (Ac)	Mean Depth (ft)	Volume (X 10^6 m^3)	Watershed (mi^2)
01						
Lake Sequoyah	Macon	WS-III, Tr, CA	150	7	0.1	14
02						
Wolf Creek Reservoir	Jackson	WS-III, B, Tr, HQW	193	89	2.1	40
Bear Creek Reservoir	Jackson	WS-III, B, Tr	475	108	5.6	75
Cedar Cliff Lake	Jackson	WS-III, B, Tr, CA	146	89	7.2	81
Thorpe Reservoir	Jackson	WS-III, B, HQW	1462	76	82.6	37
03						
Nantahala Lake	Macon	B, Tr	1606	125	160.0	108
04						
Lake Cheoah	Swain/Graham	C, Tr	633	131	297.5	1608
Santeetlah Lake	Graham	B, Tr	2849	56	195.0	176

AMBIENT MONITORING SYSTEM

There are six active ambient water quality monitoring stations located in the Little Tennessee River basin. These stations are sampled monthly for 27 parameters. Important findings during the recent (09/01/1994 to 08/31/1999) monitoring cycle included:

- Dissolved oxygen concentrations were greater than 7.0 mg/l for all stations during this assessment period.
- A period of low pH (some values between 5.5 - 6.5 s.u.) was noted between 1990 and 1995 for all stations. The cause(s) were unknown. Atmospheric deposition was speculated but there was also the possibilities of monitoring personnel error and pH meter equipment variability. Since 1995 pH has increased to values greater than those observed before 1990.
- Increases in conductivity were observed at two stations since 1994 (the Little Tennessee River at Prentiss and at Iotla). Measurements were corrected for flow and the increases over time were found to be statistically significant. Flow was not an explanatory variable for these temporal increases. No explanation has been determined for this change in water quality.
- The geometric mean for fecal coliform bacteria ranged from 1 to 13 colonies/100ml for samples collected during this assessment period. All stations showed a decrease in the geometric mean from the assessment periods before June 1989.
- No temporal patterns were observed for any of the other parameters.
- The only parameters that exceeded water quality standards or action levels for more than 10% of the number of samples collected were copper and iron, and this did not occur at all stations.

AQUATIC TOXICITY MONITORING

Three facilities in the Little Tennessee River have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Franklin, Bryson City, and Tuckasegee Water and Sewer Authority wastewater treatment plants. Since 1993, all facilities have been operating within a compliance rate of 90-95%.

INTRODUCTION TO PROGRAM METHODS

The Division uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Watauga River basin was sampled by the Environmental Sciences Branch in 1994 and 1999.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Little Tennessee River basin include benthic macroinvertebrates, lake assessment, ambient monitoring, and aquatic toxicity monitoring.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Sampling methods and criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1). Likewise, ratings can be assigned with a North Carolina Biotic Index (NCBI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies.

Bioclassifications listed in this report (Appendix B2) may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

LAKE ASSESSMENT

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. Assessments have been made at publicly accessible lakes, at lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed.

Physical field measurements (dissolved oxygen, pH, water temperature, and conductivity) are made with a calibrated Hydrolab™. Readings are taken at the surface of the lake (0.15 meters) and at 1 m increments to the bottom of the lake. Secchi depths are measured at each sampling station with a weighted Secchi disk attached to a rope marked off in centimeters. Surface water samples are collected for chloride, hardness, fecal coliform bacteria, and metals. A Labline™ sampler is used to composite water samples within the photic zone (a depth equal to twice the Secchi depth). Nutrients, chlorophyll *a*, solids, turbidity and phytoplankton are collected at this depth. Nutrients and chlorophyll *a* from the photic zone are used to calculate the North Carolina Trophic State Index score. The Labline™ sampler is also used to collect a grab water samples near the bottom of the lake for nutrients. Water samples are collected and preserved in accordance with protocols specified in (NCDEHNR 1996b).

Data are used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity. These determinations are based on information from the most recent summertime sampling (Appendices L1 - L3).

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the biological communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters appended when justified (Table 3).

Summaries of water quality parameters measured during the five year period (September 1, 1994 – August 31, 1999) are provided (refer to Tables 27 - 33). These tables present the number of samples collected and the number (and proportion) of samples greater than or less than a water quality reference value.

In addition, a description of how the data are distributed is provided using percentiles. Percentiles describe the proportion of observations less than a specific value or concentration. For example, the 50th percentile (also called the median) provides the value (or concentration) of the parameter in which one half (50%) of the observations lie.

The water quality reference value may be a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200. Zinc is not included in the summaries for metals because recent (since April 1995) sampling or analyses may have been contaminated with zinc and the data may be unreliable.

In this report, conductivity is synonymous with conductivity. It is given in micromhos per centimeter (µmhos/cm) at 25 ^{o}C.

AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, *Ceriodaphnia dubia*). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations.

Table 3. Freshwater parametric coverage for the ambient monitoring system.[1]

Parameter	All freshwater	Water Supply
Field		
Dissolved oxygen	x	x
pH	x	x
Conductivity	✔	✔
Temperature	✔	✔
Nutrients		
Total phosphorus	✔	✔
Ammonia as N	✔	✔
Total Kjeldahl as N	✔	✔
Nitrate + nitrite as N	✔	x
Other		
Total suspended solids	✔	.
Total dissolved solids	.	x
Turbidity	x	x
Hardness	✔	x
Chloride	x	x
Bacteria		
Fecal coliform bacteria	x	x
Total coliform bacteria	.	x
Metals		
Aluminum	✔	✔
Arsenic	x	x
Cadmium	x	x
Chromium	x	x
Copper	x	x
Iron	x	x
Lead	x	x
Mercury	x	x
Nickel	x	x
Silver	x	x
Zinc	x	x
Manganese	.	x
Biological		
Chlorophyll *a*[2]	x	x

[1] A check (✔) indicates the parameter is collected; an 'x' indicates the parameter is collected and has a standard or action level.
[2] Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Facilities without monitoring requirements may have their effluents evaluated for toxicity by the Division's Aquatic Toxicology Laboratory. If toxicity is detected, the Division may include aquatic toxicity testing upon permit renewal.

The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and Division administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

LITTLE TENNESSEE RIVER SUBBASIN 01

Description

This subbasin contains the uppermost reaches of the Little Tennessee River in North Carolina. The headwater reaches of the river, however, are located in Georgia (Figure 8).

The subbasin contains approximately 35 river miles of the Little Tennessee River from the North Carolina/Georgia state line to the confluence of Burningtown Creek below Franklin. The North Carolina section of the river has a relatively steep gradient, thus, the substrate is dominated by riffle habitats. The river elevation falls approximately 500 ft. from the state line to Fontana Lake (NCDWR 1960).

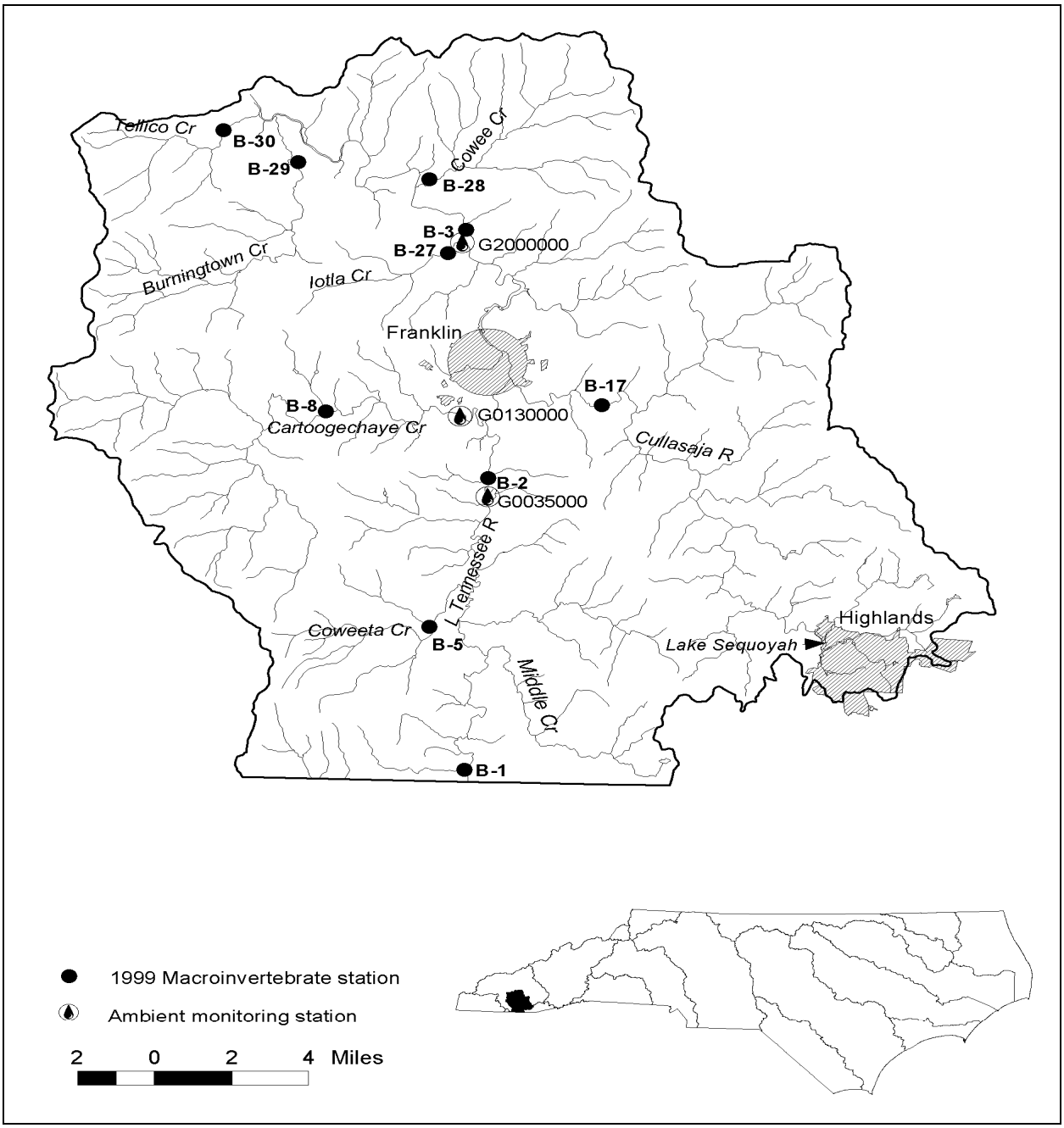

Figure 8 Sampling sites in Subbasin 01 of the Little Tennessee River basin.

The Cullasaja River and Cartoogechaye Creek are the major tributaries to the Little Tennessee River in this subbasin. Other smaller tributaries include Middle Creek, Coweeta Creek, Cowee Creek, and Burningtown Creek. The Little Tennessee River is one of three major tributaries of Fontana Lake.

This subbasin is within the US Forest Service's Nantahala National Forest and is characterized by many mountain ranges. Most tributaries are high gradient streams capable of supporting trout populations in the upper reaches. Lower reaches of many tributary catchments are farmed or developed and may be affected by erosion, scour, and sediment deposition. Franklin and a portion of the Town of Highlands are the only large population centers in this subbasin.

Overview of water quality

The water quality of rivers and streams in this subbasin is generally high (Table 4). Seven of the 11 benthos basin assessment sites sampled in 1999 were rated as Good or Excellent. The Little Tennessee River, especially near the Georgia state line, and Middle Creek were rated Good-Fair. Special studies in 1999 found Fair water quality in the Cullasaja River in the Town of Highlands and water quality impacts in Crawford Branch in the Town of Franklin.

Nonpoint source runoff may contribute to some of the degradation at the upstream Little Tennessee River site, although dischargers in Georgia seemed to be causing more problems. This site was given a Fair bioclassification in 1999, a decline from the Good-Fair rating found in 1994. The next downstream site at Prentiss was also Good-Fair in 1999. The Little Tennessee River at Iotla is below Franklin and Lake Emory. This site was given a Good-Fair bioclassification in 1999, a rating that has been found since 1983.

The Cullasaja River watershed was given special attention in 1999 at the request of the Asheville Regional Office. Four mainstem river sites and seven tributaries were sampled for benthic macroinvertebrates. All Cullasaja River sites downstream of Highlands were Excellent, as were Big Creek, Brush Creek, Buck Creek, Ellijay and North Prong Ellijay Creek, and Turtle Pond Creek. Walnut Creek was Good; the Cullasaja River in Highlands was Fair. This site receives runoff from Highlands as well as from golf courses. These tributary sites were all sampled for the first time. Prior data has been collected from the Cullasaja River, and no substantial changes were found in water quality since first sampled in 1990.

Of the six tributary streams sampled for benthic macroinvertebrates during this basin monitoring cycle, four showed considerable improvement from 1994 ratings. Cowee Creek and Iotla Creek improved from Good-Fair to Good, while Burningtown Creek and Cartoogechaye Creek improved from Good to Excellent. Extremely high flows in 1994 prior to sample collection most likely caused the lower 1994 ratings. Coweeta Creek and Tellico Creek were both Excellent in 1994 and 1999.

Table 4. Waterbodies monitored in Subbasin 01 in the Little Tennessee River basin for basinwide assessment, 1994 - 1999.

Map #[1]	Waterbody	County	Location	1994	1999
B-1	L Tennessee R	Macon	off SR 1629	Good-Fair	Fair
B-2[2]	L Tennessee R	Macon	SR 1651	---	Good-Fair
B-3[2]	L Tennessee R	Macon	NC 28	Good-Fair	Good-Fair
B-4	Middle Cr	Macon	SR 1635	---	Good-Fair
B-5	Coweeta Cr	Macon	SR 1115	Excellent	Excellent
B-8	Cartoogechaye Cr	Macon	SR 1146	Good	Excellent
B-17	Cullasaja R	Macon	US 64/SR 1668	---	Excellent
B-27	Iotla Cr	Macon	SR 1372	Good-Fair	Good
B-28	Cowee Cr	Macon	NC 28	Good-Fair	Good
B-29	Burningtown Cr	Macon	SR 1371	Good	Excellent
B-30	Tellico Cr	Macon	SR 1367	Excellent	Excellent
	Lake Sequoyah	Macon		Mesotrophic	Mesotrophic

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994, refer to Appendix B2.

River and Stream Assessment

Little Tennessee River, off SR 1629
This site is near the North Carolina/Georgia state line and was selected to assess the water quality of the Little Tennessee River as it enters North Carolina. The watershed at this point is 56 mi^2, the river is about 15 m wide and the bottom substrate is mainly sand, gravel and rubble.

In 1994, a Good-Fair bioclassification was assigned based on an EPT taxa richness value of 27 and a BI value of 5.27. In 1999, the bioclassification declined to Fair; EPT taxa richness decreased by 13 taxa to 14; and the NCBI increased to 6.23. EPT abundance also decreased from 110 in 1994 to 58 in 1999.

A conductivity value of 427 umhos/cm on the day of sampling suggested possible impacts from dischargers in Georgia. A low habitat score of 49 resulted from eroding banks, heavily embedded substrate, few riffles and little canopy cover. The only abundant EPT taxa were tolerant organisms: *Baetis propinquus, Stenonema modestum, Triaenodes ignitus*, and *Cheumatopsyche*.

Little Tennessee River, SR 1561
A Good-Fair bioclassification was given in 1999 to this site near Prentiss. This site had not been sampled since 1987 due to difficulty in sampling even under normal flow conditions. Prior samples also indicated Good-Fair water quality. The 1999 sample had 15 more EPT taxa (29) than the upstream site, and a much lower BI value (4.41).

The river is slightly wider here (20 m) than at the site off SR 1629. And though the bottom substrate is still mostly sand with some gravel and rubble, the habitat score was 71. Bank erosion and infrequent riffles were the most evident habitat problems.

Little Tennessee River, NC 28
At this site, near Iotla and below Lake Emory and Franklin, the river is very wide (45 m) with swift flow over primarily bedrock. This homogeneous substrate resulted in a slightly lower habitat score (67) than the site at Prentiss. The Good-Fair bioclassification in 1999 has been consistent since 1983. More EPT taxa (32) were collected in 1999 than ever before, and 12 of the 32 taxa were abundant.

Coweeta Creek, SR 1115
Coweeta Creek was selected during the first round of basinwide sampling to represent a relatively undisturbed watershed. The Coweeta Creek watershed contains 5,600 acres of experimental forest within the US Forest Service's Coweeta Hydrologic Laboratory. The Laboratory was established to determine how forests and forestry practices affect water yields and water quality in streams typical of the southern Appalachian Mountains. Coweeta Creek is a medium-sized (10 m wide with a drainage area of 17 mi^2 near its mouth) tributary of the Little Tennessee River in Macon County. The substrate at the collection location was primarily rubble with very little embeddedness, suggesting little erosion in the catchment.

An Excellent bioclassification was given to Coweeta Creek based on EPT samples in 1999 and 1994. Thirty-nine EPT taxa were collected in both years, even though 1994 had very high flows prior to sampling. This stability of taxa richness reflects the lack of nonpoint source impacts in the watershed, as does the high habitat score of 95. The fauna included many intolerant taxa such as *Drunella* and *Goera*.

Cartoogechaye Creek, SR 1146
Cartoogechaye Creek is a relatively large tributary of the Little Tennessee River (57 square mile watershed size). This benthos site is further upstream than the ambient chemistry site and is about 15 m wide. The substrate at this site was mainly boulder and gravel with some embeddedness. The site received a habitat score of 84.

EPT taxa richness increased from 30 in 1994 to 41 in 1999 and EPT N increased from 75 to 202. The high flows in 1994 had a major impact on the benthic fauna. The normal flows in 1999 resulted in an increase in bioclassification from Good in 1994 to Excellent in 1999. An upstream restoration project, which included bank restoration and exclusion of cattle from the stream in the restoration area, also may have helped improve water quality.

Iotla Creek, SR 1372
Iotla Creek is a small tributary (five meters wide with a watershed size of 10 mi^2) of the Little Tennessee River. This site is located downstream of the Macon County airport. The substrate at the collection location consisted primarily of sand and gravel which, with the low habitat score of 54, indicated the impacts of erosion in the watershed. Stream banks were relatively stable, but pools were filled in and little boulder substrate was found. The effects of this erosion are more severe in this tributary due to its low gradient.

An EPT taxa richness of 35 resulted in a Good bioclassification - a major improvement from the 21 EPT (Good-Fair) found in 1994 after high flows. EPT abundance also doubled from 60 to 125 in the past five years.

Cowee Creek, NC 28
Cowee Creek is a medium sized tributary (10 m wide and a drainage area of 26 mi^2 at West's Mill) of the Little Tennessee River near Iotla. The collection site on Cowee Creek is below several gem and ruby mines. The substrate was a heterogeneous mix of boulder, rubble and gravel, with little accumulation of sand and silt. A fairly low habitat score of 65 reflected problems with all of the habitat metrics. A Good-Fair bioclassification in 1994 (24 EPT) improved to Good in 1999, when 35 EPT taxa were collected. The enrichment indicator species that were found in 1994 were not present in 1999.

Burningtown Creek, SR 1371
Burningtown Creek is the most downstream tributary of the Little Tennessee River in this subbasin. It was nine meters wide and has a drainage area of 27 mi^2 at Stiles. The substrate at this site is composed primarily of boulder and rubble, but in 1999 there was also a lot of sand in the stream. It had a habitat score of 71.

EPT taxa richness increased from 30 in 1994 to 39 in 1999, with a resultant bioclassification increase from Good to Excellent. The benthic macroinvertebrate fauna was represented by a fairly diverse assemblage dominated by intolerant and facultative taxa which included *Isonychia, Epeorus, Acroneuria abnormis, Perlesta, Dolophilodes*, and *Symphitopsyche sparna*.

Middle Creek, SR 1635
This stream was not sampled in 1994 due to high flows. It is a small tributary (seven meters wide) with a very sandy substrate. Pools were filled in; the streambank was severely eroded; and the water was turbid after a rain. Poor instream and riparian conditions resulted in a habitat score of 47. These habitat problems are reflected in the low EPT taxa richness (25), and the Good-Fair bioclassification. No intolerant taxa were abundant.

Tellico Creek, SR 1367
The catchment of Tellico Creek above this site included agricultural and residential areas and a trout farm. In spite of this development, the conductivity was only 16 μmhos/cm. At the SR 1367 access, the stream was 6 m wide and there were abundant growths of periphyton. The substrate was about 40% embedded; there were relatively few pools; and there were many breaks in the riparian zone.

Tellico Creek received an Excellent rating in 1994 and 1999. Nine more EPT taxa were collected under low-flow conditions in 1999 than under high flow conditions in 1994.

SPECIAL STUDIES
Cullasaja River Watershed
The Cullasaja River watershed was sampled in 1999 at the request of the Asheville Regional Office. Four mainstem river sites and seven tributaries were sampled for benthic macroinvertebrates. All Cullasaja River sites downstream of Highlands were Excellent as were Big Creek, Brush Creek, Buck Creek, Ellijay and North Prong Ellijay Creek, and Turtle Pond Creek. Walnut Creek was Good and the Cullasaja River in Highlands was Fair. This latter site receives runoff from suburban Highlands as well as from golf courses. Data on these tributary sites were all new, but prior data has been collected from the Cullasaja River. No substantial changes were found in water quality in the river since first sampled in 1990.

Mill Creek, a tributary of Mirror Lake, is a small stream located in a residential area of Highlands. It was also sampled below where the old WWTP had discharged until the discharge was moved to the Cullasaja River in 1994. The same Fair bioclassification was found in 1999 as was found in 1990 and 1991 both upstream and downstream of the WWTP.

Crawford Branch is a very small tributary of the Little Tennessee River that flows through downtown Franklin. Although Crawford Branch is too small (three meters wide) to receive a bioclassification, the invertebrate community clearly indicated severe stress (only seven EPT taxa and all rare) at a downstream site on East Main Street.

Urban development in this portion of the Crawford Branch watershed results in a high percentage of impervious surface area, and such development often results in toxic stress from the runoff. Another portion of Crawford Branch was evaluated by sampling upstream at Franklin Memorial Park. Much higher EPT taxa richness was found at this site (24) with five abundant species.

Lake Assessment

Lake Sequoyah

Lake Sequoyah, an impoundment of the upper Cullasaja River, is located near the Town of Highlands (Figure 9). The lake's shoreline consists of residential homes and commercial businesses. The Highlands Country Club, which consists of a golf course and private homes, is also located in the watershed. However, much of the watershed is undeveloped and lies within the Nantahala National Forest.

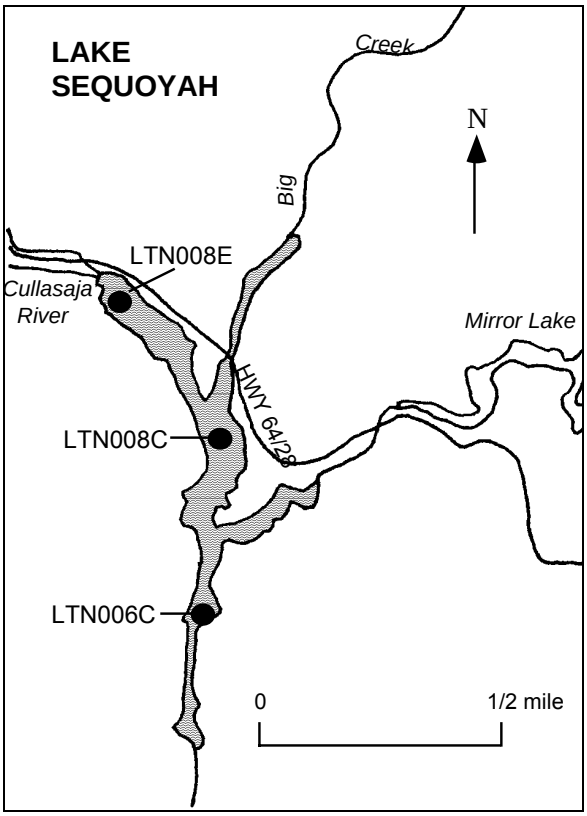

Figure 9. Monitoring sites at Lake Sequoyah, Macon County.

Lake Sequoyah was most recently sampled during the summer of 1999 (Table 5 and Appendices L2 and L3). All of the chlorophyll a concentrations were ≥ 15 µg/l (the state water quality standard for surface waters designated as Trout Waters). Phytoplankton samples reflected mesotrophic to eutrophic lake conditions. Seven algal species found in the samples are known to contribute to taste and odor problems in drinking water.

Concentrations of metals, except iron, in the surface waters were within applicable water quality standards. The mean iron concentration equaled the water quality standard for waters designated as water supply. Based on the calculated NCTSI scores, Lake Sequoyah was determined to be mesotrophic in June and August. [The score for July could not be calculated due to a sample collection error.]

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 10).

Median Secchi depths were similar among the three lake sampling sites while median total phosphorus and median total organic nitrogen were greatest at the upstream lake sampling site and decreased in a downstream manner. Median chlorophyll a values were greater than the state water quality for Trout Waters.

There have been no complaints of taste or odor problems from processed raw water taken from Big Creek near the point where the creek widens into the arm of Lake Sequoyah (Wade Wilson, Superintendent of the Town of Highlands Water Treatment Facility, pers. com.). There have also been no recently reported problems with low dissolved oxygen, nuisance aquatic macrophytes, or algal blooms in the lake.

Table 5. Biological and water chemistry data from Sequoyah Lake, 1994-1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/10/1999	-0.9	Mesotrophic	0.01	0.23	20	1.2
07/01/1999	---	---	0.03	0.15	---	1.0
06/23/1999	-0.4	Mesotrophic	0.03	0.16	24	1.4
08/09/1994	-0.1	Mesotrophic	0.05	0.29	4	1.0

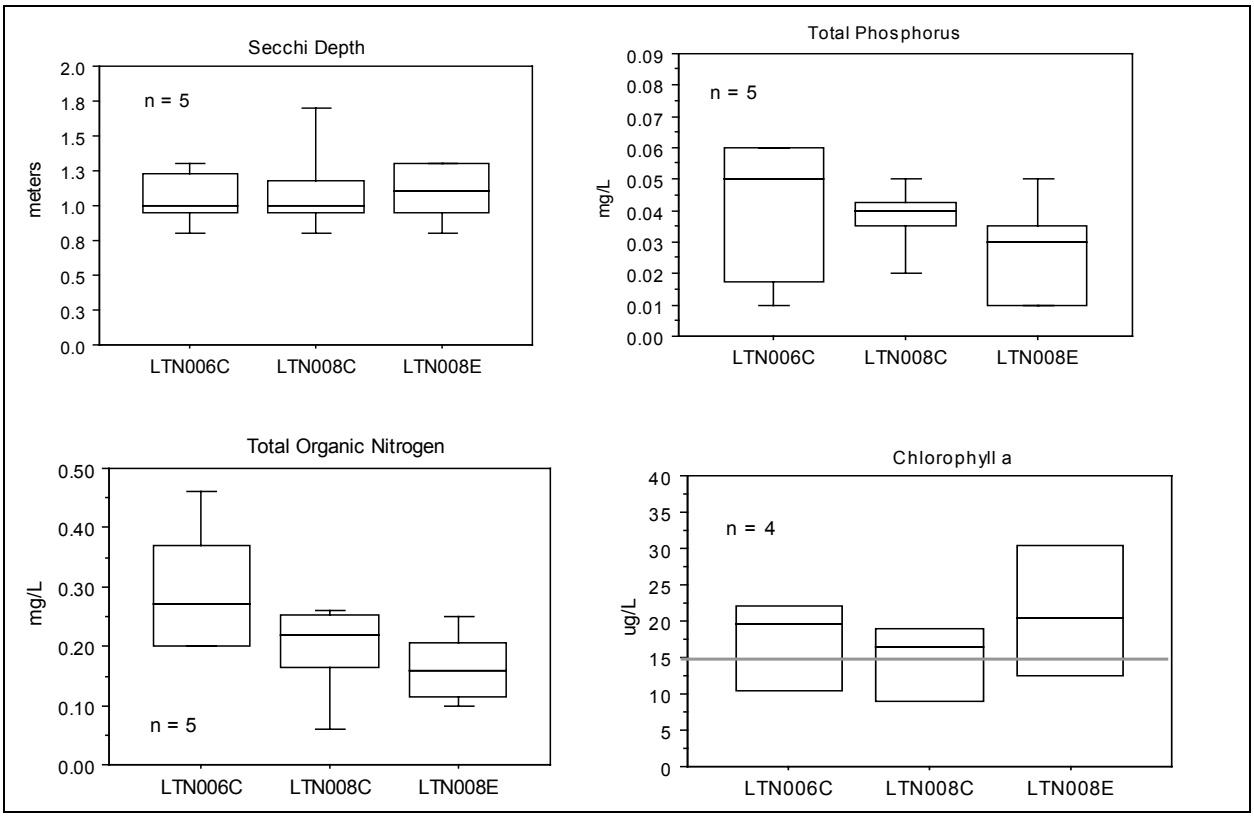

Figure 10. Spatial relationships among biological and water chemistry data from Lake Sequoyah, 1988 – 1999. The water quality standard for chlorophyll a for Trout Waters is shown as a gray line.

A water quality study of the lake was conducted from early May through late October 1997. The study was commissioned by the Town of Highlands to characterize the existing water quality. The town currently withdraws water from Big Creek, a tributary of Lake Sequoyah. Demand for drinking water exceeds what the creek can deliver, resulting in concerns that more water is being taken from the lake proper than from Big Creek alone. For this reason, the Town of Highlands has a strong interest in having Lake Sequoyah used as a public water supply source. Currently, the lake is designated WS-III because of its location to the water intake in Big Creek.

No apparent water quality problems were found during the 1997 study period which would preclude the lake's use as a water supply for the town. No algal blooms were observed; the phytoplankton communities contained few taxa and were algal species were not abundant. In October, copper was detected at a concentration of 9.3 µg/l which was greater than the state water quality action level of 7.0 µg/l. This excursion was thought to be due to a heavy rainfall event (Fish and Wildlife Associates, Inc. 1997).

LITTLE TENNESSEE RIVER SUBBASIN 02

Description

This subbasin is located in the western portion of the mountain ecoregion (Figure 11). Fontana Lake is the largest impoundment in this region and is operated by the Tennessee Valley Authority. Principal tributaries to the Little Tennessee River are the Oconaluftee River and the Tuckasegee River.

Much of the catchment to the north of the Little Tennessee River is within either the Great Smoky Mountains National Park or the Cherokee Indian Reservation. Most streams on the north side of the lake are in a roadless area and can only be reached by boat or by hiking.

This subbasin contains some of the most famous trout streams in North Carolina, including Hazel Creek, Forney Creek, Deep Creek, and Noland Creek. Most of the rest of this subbasin is included in the Nantahala National Forest, although this does not preclude other land uses.

The area also contains some of the most pristine and some of the highest quality waters of the state. Portions of Alarka Creek, the Tuckasegee River, Caney Fork, and most of the Oconaluftee River catchment have been supplementally classified HQW. Small streams, formerly classified for water supply, have also been reclassified as HQW: Whiterock Creek, Wolf Creek, Long Branch, Jenkins Branch, Clingman's Creek, Dednan Branch, Twentymile Creek, and Moore Spring Branch. The Tuckasegee River upstream of Tanassee Creek is classified ORW.

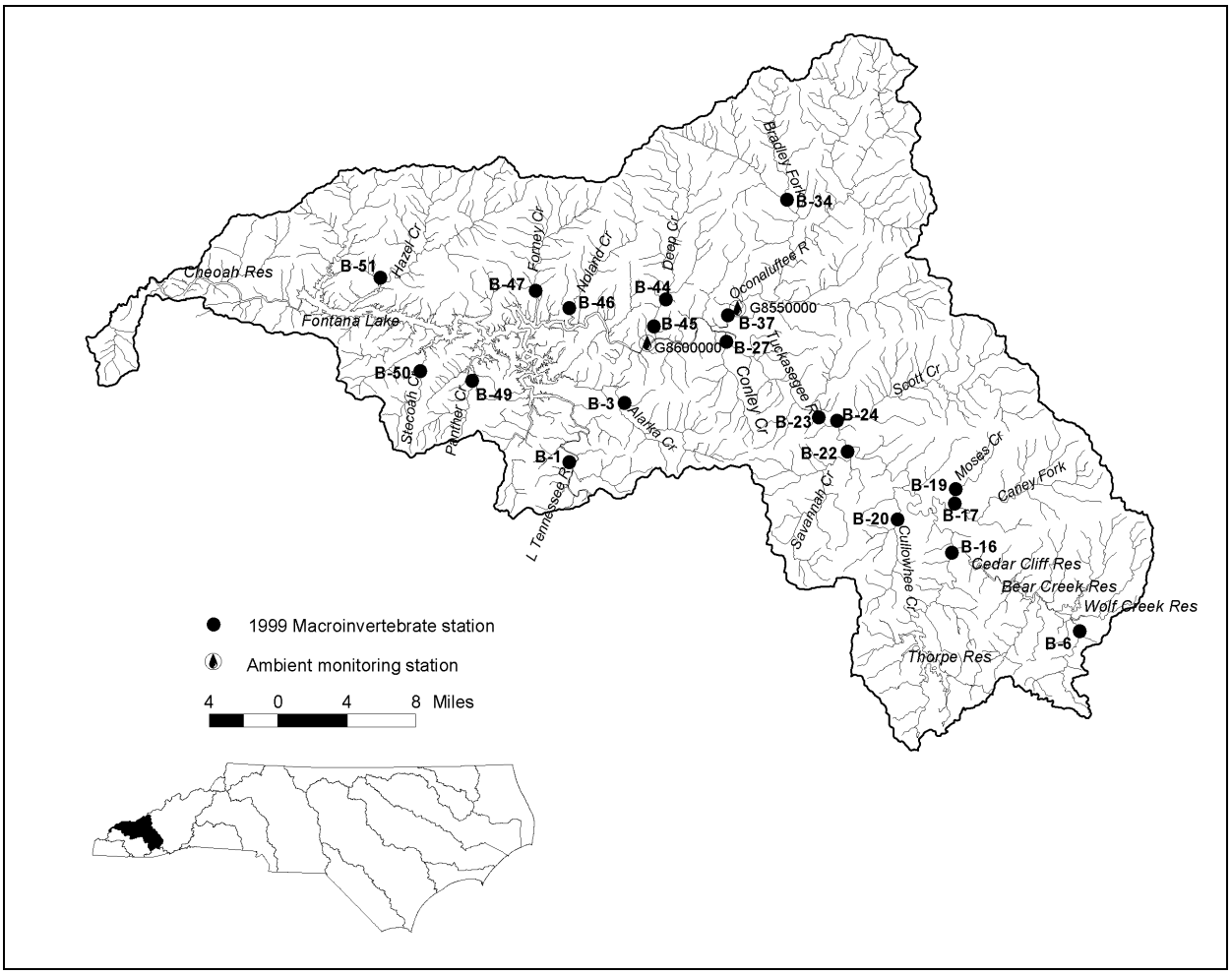

Figure 11. Sampling sites in Subbasin 02 in the Little Tennessee River basin.

The largest towns are Bryson City, Cherokee, and Sylva. There are about 20 NPDES permitted dischargers in this subbasin, but only three have permitted flows greater than 0.5 MGD: Sylva (0.5 MGD to Scott Creek), Dillsboro (1.5 MGD to the Tuckasegee River), and Bryson City (0.6 MGD to the Tuckasegee River). Only the latter two facilities are required to monitor their effluents' toxicity.

Overview of water quality

Benthic macroinvertebrate data indicated stable water quality at most sites (Table 6). Moses Creek, Cullowhee Creek, Tuckasegee River, Oconaluftee River, and Stecoah Creek had a change in bioclassification from Good to Excellent, but these changes seemed to be related more to differences in flow regimes than to any improvements in water quality.

More significant improvement in water quality was observed at Scott Creek, where the bioclassification improved from Good-Fair in 1994 to Good in 1999. Declining water quality was observed only at Savannah Creek.

The primary problem in this basin is nonpoint source runoff, including inputs of sediment and(or) nutrients. Although much of this subbasin is forested, development is often located along the stream corridor. Both farmland and new residential areas are typically found adjacent to streams, often with inadequate riparian buffer zones. Water quality was not a problem throughout most of this area, But there was evidence of habitat problems: few pools, relatively uniform riffles and runs and an embedded substrate (Table 7). These changes have been shown to have some slight affects on the benthic macroinvertebrates, but are presumed to have greater affects on the fish fauna.

Table 6. Waterbodies monitored in Subbasin 02 in the Little Tennessee River basin for basinwide assessment, 1994 - 1999.[1]

Map #	Waterbody	County	Location	1994	1999
B-1	L Tennessee R	Swain	Off SR 1113	Good	Good
B-3	Alarka Cr	Swain	SR 1185	Excellent	Excellent
B-6[2]	Tuckasegee R	Jackson	SR 1140	Excellent	Excellent
B-16	W Fk Tuckasegee R	Jackson	SR 1133	---	Good
B-17	Caney Fk	Jackson	SR 1740	Excellent	Excellent
B-19	Moses Cr	Jackson	SR 1739	Good	Excellent
B-20	Cullowhee Cr	Jackson	SR 1001	Good	Excellent
B-22	Savannah Cr	Jackson	SR 1367	Excellent	Good
B-23[2]	Tuckasegee R	Jackson	Off SR 1377	Excellent	Good
B-24	Scott Cr	Jackson	SR 1556	Good-Fair	Good
B-27	Conley Cr	Swain	SR 1177	Excellent	Excellent
B-34[2]	Bradley Fk	Swain	Off US 441	Excellent[3]	Excellent
B-37[2]	Oconaluftee R	Swain	SR 1359	Good	Excellent
B-44	Deep Cr	Swain	Above campground	Excellent	Excellent
B-45	Deep Cr	Swain	SR 1340	Excellent	Excellent
B-46	Noland Cr	Swain	Near mouth	---	Excellent
B-47	Forney Cr	Swain	Near mouth	Excellent	Excellent
B-49	Panther Cr	Graham	SR 1233	Excellent	Excellent
B-50	Stecoah Cr	Graham	SR 1237	Good	Excellent
B-52	Hazel Cr	Swain	Near mouth	Excellent	Excellent
	Wolf Creek Reservoir	Jackson		Mesotrophic[4]	Oligotrophic
	Bear Creek Reservoir	Jackson		Oligotrophic	Oligotrophic
	Cedar Cliff Lake	Jackson		Oligotrophic[4]	Oligotrophic
	Thorpe Reservoir	Jackson		Oligotrophic	Oligotrophic

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994, refer to Appendix B2.
[3]Data were collected in 1995.
[4]Data were collected in 1996.

Table 7. Water quality and habitat characteristics of streams in agriculturally and residentially developed watersheds in Subbasin 02 in the Little Tennessee River basin.[1]

✓ Elevated conductivity	✓ Embedded substrate (20 - 40%)
✓ Riparian zone breaks	✓ Uniform instream habitat of riffles and runs
✓ Sediment deposition	✓ Bank erosion
✓ Abundant periphyton	✓ Few number of pools
✓ Narrow riparian zone	

[1]Note: not all of these characteristics were found at all sites. The table represents a compilation of the habitat degradation across all sites.

Many streams in the Little Tennessee River basin are discussed as having some habitat problems, yet are given Excellent bioclassifications using benthic macroinvertebrate data. There are several reasons for this paradox. For example, undisturbed streams in this region are characterized by having highly intolerant macroinvertebrate species. These taxa have been assigned very low tolerance values, resulting in extremely low biotic index scores for many sites.

Such streams can experience significant degradation (as evidenced by an increase in biotic index values) without exceeding the range used to assign an Excellent rating. As an example, compare the biotic index scores for streams in forested catchments *vs*. streams in slightly developed areas (Figure 12). There was an increase from 2.8 for forested sites to 3.7 for more developed sites. But both mean scores are within the range expected for an Excellent bioclassification (< 4.0). For this reason, a criteria revision is being considered for the western mountains, including the entire Little Tennessee River basin.

Furthermore, benthic macroinvertebrates are more sensitive to changes in water quality than to changes in habitat. The habitat degradation seen in many Little Tennessee River basin streams is expected to have more of an impact on the fish communities than on the benthic macroinvertebrates, although there has been no recent data to verify this hypothesis. There is, however, abundant literature (e.g., Waters 1995) to show that filling of pools and a more embedded substrate have negative affects on coldwater fisheries.

Based upon the 1999 macroinvertebrate data, overall water quality was very good, with all sites having a bioclassification of Good or Excellent (Table 6). Sites with an Excellent bioclassification fell into two broad groups: streams in largely forested catchments and streams with some agricultural or residential development (Figure 12).

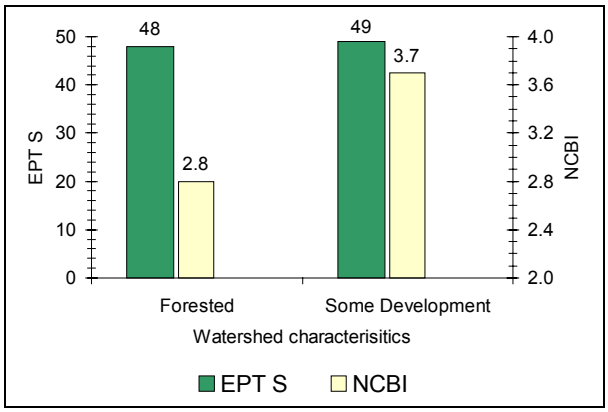

Figure 12-. Mean metric scores for Excellent rated streams in Subbasin 02 in the Little Tennessee River, 1999.

Streams with forested watersheds include the upper Tuckasegee River, Bradley Fork, upper Deep Creek, Noland Creek, Forney Creek, and Hazel Creek. These streams had extremely low conductivity (8 - 12 µmhos/cm) and high habitat scores (draft scores = 89 - 96, where maximum score = 100). The only site with a low habitat score (77) was the upper Tuckasegee River. Due to local geological characteristics, streams in the upper Tuckasegee River basin (especially Panthertown Valley) have coastal plain, bog-like characteristics of humic-colored water and sandy substrates.

Most of these sites were sampled during a period of high flow in 1994 and during a period of low flow in 1999. Low flow conditions would be expected to produce slightly higher taxa richness, higher EPT taxa richness, but no significant change in biotic index scores. This was the general pattern observed for reference sites as most sites had an increase of 3 - 5 EPT taxa richness between 1994 and 1999.

Typical residential or agriculturally developed sites included Alarka Creek, Caney Fork, Moses Creek, Conley Creek, Lower Deep Creek, Panther Creek, and Stecoah Creek. These streams generally had conductivity measurements of 20 - 25 µmho/cm. The two exceptions in this group were lower Deep Creek (12 µmhos/cm and 100% forested

headwaters area) and Stecoah Creek (40 μmhos/cm).

Deep Creek and Panther Creek had fairly good habitat (habitat scores = 82 - 84), but other sites showed slightly lower habitat scores (70 - 80). Alarka Creek, Caney Fork, Moses Creek, Stecoah Creek and Conley Creek showed similar changes in habitat relative to the reference sites: 20 - 40% embedded substrate, infrequent pools and poor riparian buffer zones. This latter group of streams was characterized by relatively uniform riffle-run habitat. This type of habitat change may have a negative effect of fish populations, especially those that require pool habitats. Streams in developed areas often had more periphyton growth than streams in forested areas, with a resultant increase in the numbers of benthic macroinvertebrates.

Taxa richness values were identical for these two types of streams, but a change in biotic index values indicated a slight shift towards more tolerant organisms in the developed catchments. Taxa richness values were below the expectations for two streams rated as Excellent and having forested catchments: Bradley Fork (a basinwide site) and Panthertown Creek (a special study site). These sites may be slightly stressed by low pH, although there was little chemical data to support this hypothesis.

Four lakes were monitored in this subbasin in 1999: Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake, and Thorpe Reservoir. All were oligotrophic, with no algal blooms or nuisance aquatic plants.

Ambient monitoring data were collected from the Oconaluftee River at Birdtown and the Tuckasegee River at Bryson City. Neither site had any indication of water quality problems. Fecal coliform concentrations have declined over time at both these sites.

Two wastewater treatment plants in this subbasin are required to monitor the toxicity of their effluent. Neither facility had problems meeting its toxicity limits in 1999.

River and Stream Assessment

Stream flow in the Little Tennessee River basin was generally low to normal for June-August 1999. For example, the Little Tennessee River near Prentiss had mean daily flows for this three-month period between 45% and 83% of the long-term mean flows. There were, however, considerable geographic differences in rainfall and flow patterns within this subbasin. The eastern section, as exemplified by the Oconaluftee River near Birdtown, had high flows during July 1999. The mean daily flow for that month was 170% of the long-term mean.

Because the 1999 benthic invertebrate sampling was spread out over much of July and August, samples were collected under a wide variety of flow conditions. The Little Tennessee River at Needmore was sampled at very low flow, while the next upstream site (the Little Tennessee River at Iotla) was sampled at high flow and it was almost too deep for normal collections. The majority of monitoring sites were sampled under conditions of low flow and low scour and would be expected to show slight improvements compared to the high flow conditions in 1994. Analysis of changes at reference sites predicted a between sampling period increase in EPT taxa richness of 3 to 5 species.

Little Tennessee River, off SR 1113

The Little Tennessee River at Needmore was the largest site monitored in this basin with a mean width of 70 m. This section of the river received a Good rating for all collections (Table 8 and Figure 13), although the EPT abundance in 1999 (150) was slightly lower as compared with 1994 (185 and 173).

Table 8. Flow and bioclassifications for the Little Tennessee River off SR 1113, Swain County.

Year	Flow	Rating
June 1994	Normal	Good
July 1994	Normal	Good
August 1999	Low	Good

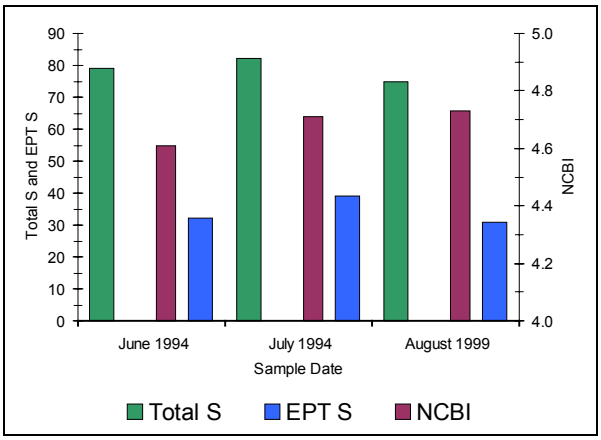

Figure 13. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Little Tennessee River off SR 1113, Swain County.

Water quality data collected in 1999 during the invertebrate monitoring indicated atypical characteristics for a stream in this river basin. Elevated readings were observed for water temperature, conductivity, and pH. The high temperature (28 ^{o}C) might have been influenced by the open canopy, while the high pH (9.0) indicated extremely high levels of primary production by river weed and periphyton under the low flow conditions of 1999. Conductivity (100 µmhos/cm) exceeded any values recorded from this site prior to 1999 and paralleled an increase observed at all upstream sites (cf. Ambient Chemistry). These changes in some water quality variables may be due to a change in the effluent from an upstream discharger (for example in Georgia).

The elevated temperature and pH conditions observed in 1999 could eliminate many of the coldwater or coolwater species seen in prior samples. The elevated temperature and pH conditions observed in 1999 could eliminate many of the coldwater or coolwater species seen in prior samples. For example, between 2 and 6 species of stoneflies were collected for the two collections in 1994, but only a single specimen of one species was collected in August 1999.

Alarka Creek, SR 1185
Alarka Creek is a medium-sized stream (10 m wide) with a relatively uniform riffle-run habitat. An Excellent bioclassification was assigned in 1994 and 1999. Almost identical EPT taxa richness (48 and 49) and NCBI values (3.7) were recorded in both collections. The substrate was highly embedded (40%) and there were occasional breaks in the riparian zone.

Tuckasegee River, SR 1140
This site, located in Panthertown Valley, was about 10 m wide. Due to local geological characteristics, this portion of the river is naturally sandy (70% sand and gravel) with humic-colored water. Conductivity was very low (8 µmhos/cm).

EPT samples in 1994 and 1999 produced an Excellent rating. Seven more EPT taxa were collected in 1999 under low flow conditions than in 1994 under normal flow conditions.

W Fk Tuckasegee River, SR 1133
This site was sampled for the first time in July 1999. It is located downstream of Thorpe Reservoir. This reservoir has a hypolimnetic release, causing the stream to have much colder water in summer months than other nearby streams. The West Fork had a stream temperature of 12 ^{o}C in July 1999, *vs*. 17 - 22°C for other streams in this area. This situation is similar to that observed in the lower segment of the Nantahala River.

Such a change in the water temperature regime is often associated with a slight decline in diversity. This site received only a Good rating based on EPT taxa richness of 33. The presence of many intolerant species, however, indicated no other significant water quality problems.

Discharge of water from Thorpe Reservoir is used to generate electrical power, with resulting hourly, daily, and seasonal variations in flow. These variations may affect some taxa associated with bank habitats. This site also had many of the habitat problems that are widespread in the Little Tennessee River basin: infrequent pools, relatively uniform riffle and runs, bank erosion, and many breaks in the riparian zone.

Caney Fork, SR 1740
An Excellent rating was assigned to this site in both 1994 and 1999. The biotic index was slightly elevated relative to the reference sites (3.3 and 3.7), although this site had very high EPT taxa richness (52 and 53 taxa).

Caney Fork is virtually identical to the site on Alarka Creek: 10 m wide, uniform riffle-run habitat, few pools, 40% embedded substrate, and many breaks in the riparian zone.

Moses Creek, SR 1737 (SR 1740)
Moses Creek is a small (4 – 5 m wide) tributary of Caney Fork and had similar habitat problems (Table 7). This stream, however, had a higher

gradient, a more closed canopy, and less abundant periphyton than Caney Fork.

The bioclassification at this site changed from Good in 1994 to Excellent in 1999. Three more EPT taxa were collected in 1999 than in 1994. This change was equivalent to that observed at reference sites, thus it was unlikely that the change in bioclassification indicated a significant change in water quality.

Cullowhee Creek, SR 1001
Cullowhee Creek flows through Western Carolina University campus, although the monitoring site was upstream from all urban areas. This portion of the stream is seven meters wide with good boulder and rubble habitat.

The bioclassification for this site changed from Good in 1994 to Excellent in 1999, based on an increase in EPT taxa richness from 32 to 41 (Table 9 and Figure 14). However, there was no significant between-sampling period change in either EPT abundance (150 *vs*. 153) or EPT biotic index. Lower flow in 1999 probably contributed to the increase in EPT taxa richness.

Table 9. Flow and bioclassifications for Cullowhee Creek, SR 1001, Jackson County.

Year	Flow	Rating
1994	High	Good
1999	Low	Excellent

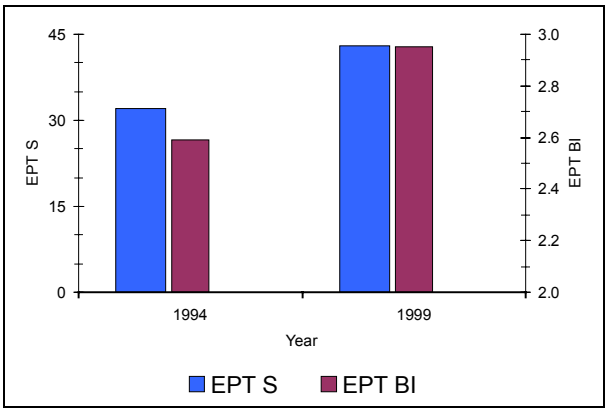

Figure 14. EPT taxa richness (EPT S) and biotic index (EPT BI) for Cullowhee Creek, SR 1001, Jackson County

This site shares some of the habitat problems observed for the other developed catchments (Table 7).

Savannah Creek, SR 1367
Savannah Creek is a medium-sized stream (12 m wide) between Dillsboro and Franklin. While most of the catchment is forested, there is much residential and agricultural land use adjacent to the stream. This site had a low habitat score (58), in part because of altered habitat (Table 7).

Savannah Creek was sampled in 1994 and 1999 under high flow conditions (Table 10). Ten fewer EPT taxa were collected in 1999 than in 1994 (Figure 15), resulting in a bioclassification change from Excellent to Good.

Table 10. Flow and bioclassifications for Savannah Creek, SR 1367, Jackson County.

Year	Flow	Rating
1994	High	Excellent
1999	High	Good

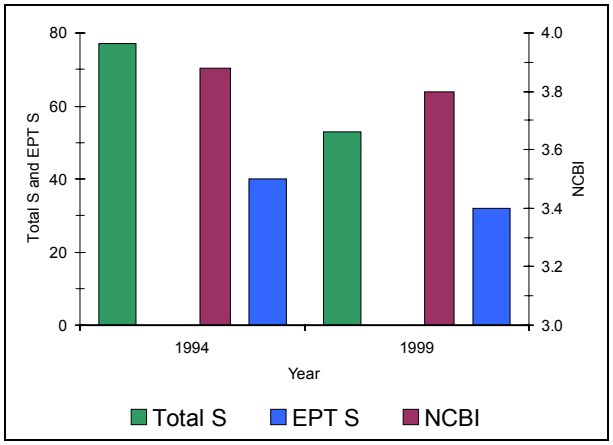

Figure 15. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for Savannah Creek, SR 1367, Jackson County.

There was little change, however, in either EPT abundance or Biotic Index between the two sampling periods. No tolerant community was observed at this site although the low EPT abundance values (EPT N = 138 in 1999 and 136 in 1994) suggested sediment stress to the benthic macroinvertebrate community.

Tuckasegee River, off SR 1377 (SR 1378)
The Tuckasegee River, at Dillsboro, is another large river site, with a mean width of 50 m.

The Dillsboro site had shown a steady improvement in water quality from 1984 to 1994, changing from a Good-Fair rating to an Excellent rating (Table 11). The rating decreased to Good in 1999,

but this sample did not appear to be different from the samples collected in 1988 or 1990 (Figure 16).

Table 11. Flow and bioclassifications for Tuckasegee River, off SR 1377, Jackson County.

Year	Flow	Rating
1984	High	Good-Fair
1986	Low-Normal	Good
1988	Low	Good
1990	Normal	Good
1994	High	Excellent
1999	Variable	Good

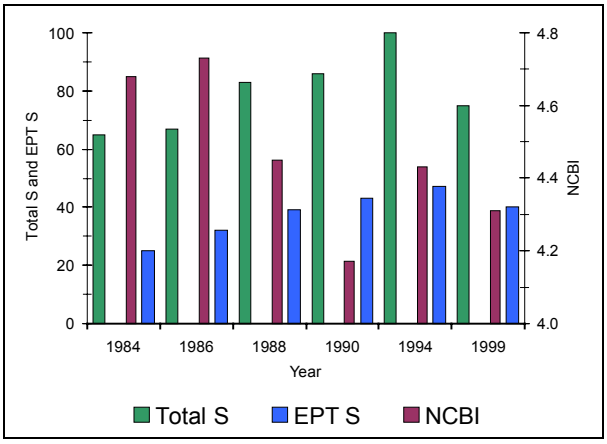

Figure 16. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Tuckasegee River, off SR 1137, Jackson County.

The overall pattern still suggested water quality improvements. The bioclassifi-cations at this site may be expected to vary between Good and Excellent, depending on the amount of scour that precedes the invertebrate collections.

The substrate at this site was 40-50% sand and gravel, and some silt also was observed along the banks. Although the habitat was clearly affected by sediment inputs (habitat score = 69), good rubble and boulder substrate was present, and bank habitats supported a variety of slow-water species. The 1999 samples were collected under high flow conditions, although flow had been low earlier throughout much of the summer.

Scott Creek, SR 1556

Scott Creek is a medium-sized stream (13 m wide), which flows through downtown Dillsboro. Although the land use near the monitoring site is urban, most of the drainage area is agricultural or residential. The stream channel is highly modified within the town as much of the bank is protected by rip-rap. . The low habitat score (59) reflects the poor riparian zone in Dillsboro, plus a relatively uniform riffle/run habitat.

The monitoring site on Scott Creek is downstream of the Sylva WWTP as well as several other small dischargers. This facility has reported few problems and the town is working on reducing the number of sewer leaks. An increased percentage of Jackson County's wastewater is also being routed to the newer treatment plant which discharges to the Tuckasegee River.

The high biotic index in 1994 indicated dominance by facultative and tolerant taxa, including Chironomidae, Oligochaeta, Simuliidae, Baetidae, and Hydropsychidae. In 1999, many EPT taxa increased in abundance, resulting in a sharp decrease in the biotic index value in contrast to the scores for 1994 (Figure 17). This is the only site in the subbasin where an improvement in bioclassifi-cation (Tables 6 and 12) reflected a significant change in water quality.

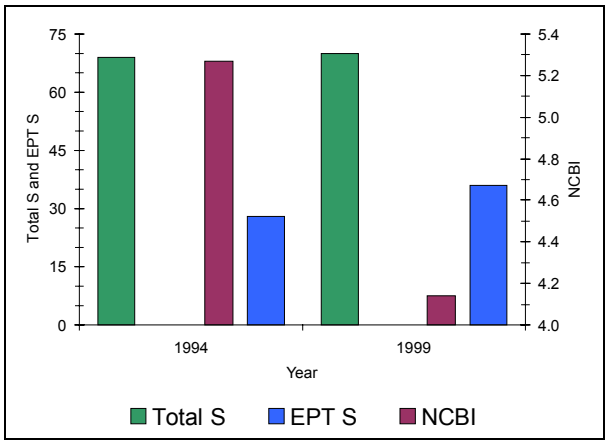

Figure 17. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for Scott Creek, SR 1556, Jackson County.

Table12. Flow and bioclassifications for Scott Creek, SR 1556, Jackson County.

Year	Flow	Rating
1994	High	Good-Fair
1999	High	Good

Conley Creek, SR 1177

Conley Creek (= Connelly Creek) received an Excellent bioclassification in 1994 and 1999. It is a small stream (six meters wide), with habitat problems typical of developed catchments in this subbasin (Table 7). A silt and periphyton layer was observed over much of the stream bottom, and the stream was turbid at the time of sampling.

Bradley Fork, off US 441

Bradley Fork was sampled above the Great Smoky Mountains National Park's Smokemont campground. This site was about 14 m wide with high quality habitat. Conductivity at the time of the benthic invertebrate sampling was only 12 µmhos/cm.

Lower than expected EPT taxa richness was observed in 1999, a pattern that also had occurred in 1994. The very low biotic index values for this site (2.7), however, clearly indicated that this site should have an Excellent rating. It was possible that episodic low pH values affect the species diversity at this site, although the pH at the time of the Division sampling was not unusually low (6.6).

Oconaluftee River, SR 1359

The Oconaluftee River and its tributaries drain the Great Smoky Mountain National Park and the Cherokee Indian Reservation. The lower portion of this stream (near Birdtown) receives heavy recreational use and urban runoff from the Town of Cherokee.

The bioclassification of the river has varied between Good and Excellent (Figure 18 and Table 13). There have been few between-year changes in water quality, other than changes due to high flow.

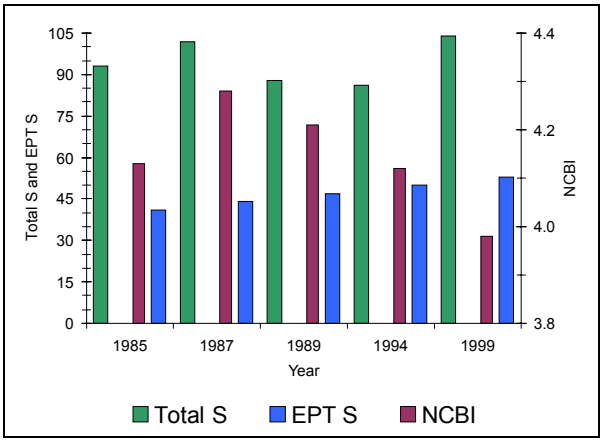

Figure 18. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Oconaluftee River, SR 1359, Swain County.

Table 13. Flow and bioclassifications for the Oconaluftee River, SR 1359, Swain County.

Year	Flow	Rating
1985	Normal	Good
1987	Normal	Excellent
1989	Low	Excellent
1994	High	Good
1999	Variable	Excellent

Deep Creek, above campground

This site on Deep Creek is 13 m wide with high quality instream and riparian habitat. Conductivity at the time of the benthic invertebrate sampling was 12 µmhos/cm. Although this part of the stream is within the Great Smoky Mountains National Park, there is a heavy recreational use ("tubing") during the summer. The stream was rated as Excellent in 1994 and again in 1999.

Deep Creek, SR 1340

This site received an Excellent bioclassification in 1994 and again in 1999. In comparison to the upstream site in the Great Smoky Mountains National Park, the EPT taxa richness at this lower site remained high. There was, however, a shift towards more tolerant species.

There were few water quality differences between the two sites on Deep Creek, but there were habitat differences. The lower site at SR 1340 had fewer pools, a more embedded substrate, more breaks in the riparian zone, and much greater periphyton growths than the upstream site.

Noland Creek, near mouth

Noland Creek at this site was about 13 m wide with high quality riparian and instream habitat. This site is accessible only by boat. As expected for a protected watershed in the Great Smoky Mountains National Park, the conductivity at the time of the benthic macroinvertebrate sampling was only 11 µmhos/cm. The 1999 sample was the first collection from this site and produced an Excellent rating, based on an EPT taxa richness of 40.

Forney Creek, near mouth

Like Noland Creek, Forney Creek was sampled near its mouth. And as expected for a protected watershed in the Great Smoky Mountains National Park, this site has good habitat and water quality. An Excellent rating was assigned to this site, based on virtually identical results in 1994 and 1999: EPT = 46, and NCBI = 2.5 - 2.7. These biotic index values were among the lowest values recorded in North Carolina.

Panther Creek, SR 1233
Panther Creek was rated as Excellent in 1994 and 1999 with virtually identical results from these two collections. It is a small stream (seven meters wide) with many of the habitat problems associated with agricultural and (or) residential land use in this subbasin (Table 7).

Stecoah Creek, SR 1237
Stecoah Creek is a small stream (five meters wide) located in a developed watershed. As observed in many other streams in this subbasin, a large increase in EPT taxa richness was noted between 1994 and 1999 (Figure 19). This resulted in a change in bioclassification from Good to Excellent (Table 14).

Table 14. Flow and bioclassifications for Stecoah Creek, SR 1237, Graham County.

Year	Flow	Rating
1994	High	Good
1999	Normal (?)	Excellent

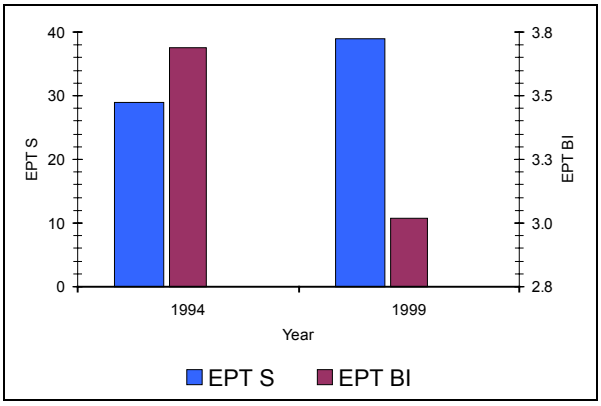

Figure 19. EPT taxa richness (EPT S) and biotic index (EPT BI) for Stecoah Creek, SR1237, Graham County.

There was also a large increase in EPT abundance and a shift towards more intolerant species. Taxa which were rare or absent in 1994, but abundant in 1999, included *Baetis pluto*, *Paraleptophlebia*, *Leuctra*, *Dolophilodes*, and *Psychomyia flavida*. This pattern indicated stress under high flow conditions by nonpoint source pollution. It is to be expected that the bioclassification will continue to fluctuate between Good and Excellent, depending on flow conditions.

The substrate was mostly rubble and boulder (only slightly embedded, although much of the stream was a uniform riffle-run habitat with few pools.

Hazel Creek, near mouth
Like Noland Creek and Forney Creek, Hazel Creek was sampled near its mouth. And as expected for a protected watershed in the Great Smoky Mountains National Park, this stream had high quality habitat and very low specific conductivity. The stream has been consistently rated as Excellent.

The biotic index values were virtually identical for 1994 and 1999 (2.9 and 3.0). Nine more EPT taxa were collected under low flow conditions in 1999 in contrast to the high flow conditions in 1994.

SPECIAL STUDIES

Great Smoky Mountains National Park
The National Park Service has initiated several monitoring programs within the Great Smoky Mountains National Park. The water quality in many streams is regularly monitored using techniques almost identical to the Division's macroinvertebrate sampling program.

The National Biological Service has documented low pH problems in some of the streams within the Great Smoky Mountains National Park (Flum, et al. 1996). Data, including almost 2,500 measurements of stream pH, have been collected from 350 monitoring sites. About 5% of the samples were found to have pH values < 5.0, 11% had pH values < 5.5, and 22% had pH values < 6.0. Low pH values were found in two types of streams:

- *Streams in catchments with Anakeesta rock deposits*. This includes Beech Flats Prong and Bradley Fork. A characteristic symptom of this problem is high sulfate concentrations in the Anakeesta rock which produces sulfuric acid as it weathered. Road cuts or landslides in areas of this deposit, or use of fill containing this rock can result in stream pH values < 5.0.
- *Streams above 3500' in old-growth (undisturbed) forest*. The terrestrial systems may become nitrogen saturated after many years of acid precipitation. Eventually, the acid-neutralizing capacity of the catchment is depleted. A characteristic of this problem is high aqueous nitrate concentrations, especially after rainfall. Headwater catchments with low pH values (usually at sites above 4,000' feet) include Raven Fork and several tributaries of Lake Fontana such as Eagle Creek, Forney Creek, and Noland Creek.

Lower elevation sites rarely have records of pH < 6.2, but this may reflect sampling frequency bias.

It is possible that these lower elevation sites may have occasional pH values less than 6.0, but for a period of only a few days.

Tennessee Valley Authority
During April and July 1999, TVA biologists collected data on fish, benthic invertebrates, and habitat characteristics at four sites in the Little Tennessee River basin (unpublished data) (Table 15). The macroinvertebrate data was limited to the number of EPT families with a maximum score of about 25 families/site. The habitat assessment score had a maximum value of 52.

Overall, results were similar to those from the Division studies. Habitat problems were observed at most sites, but high invertebrate taxa richness also indicated good water quality at most sites. A slight depression in EPT taxa richness was observed at the Little Tennessee River site, but this large river site had a good diversity of fish, including six species of darters, five species of suckers, and nine species of minnows.

Table 15. Biological and habitat data collected by the Tennessee Valley Authority from the Little Tennessee River basin, April and July, 1999. Note: EPT ratings are not equivalent to Division ratings

Stream	Location	County	No. of EPT Families	EPT Rating	No. of Fish Species	No. of Fish	TVA IBI	Habitat Score
Little Tennessee R	NC 28	Macon	15	Good	33	523	56	39
Caney Fk	Off SR1737	Jackson	22	Excellent	15	421	34	39
Cullowhee Cr	Off SR 1001	Jackson	21	Excellent	19	799	40	35
Tuckasegee R	Off SR 1001	Jackson	22	Excellent	11	144	26	44

Lake Assessment

Wolf Creek Reservoir
This small reservoir is on a tributary to the upper Tuckasegee River (Figure 20). Built in 1955, it is owned by the Nantahala Power & Light Company (NP&L). Its watershed is within the Nantahala National Forest near the county borders of Jackson and Transylvania counties.

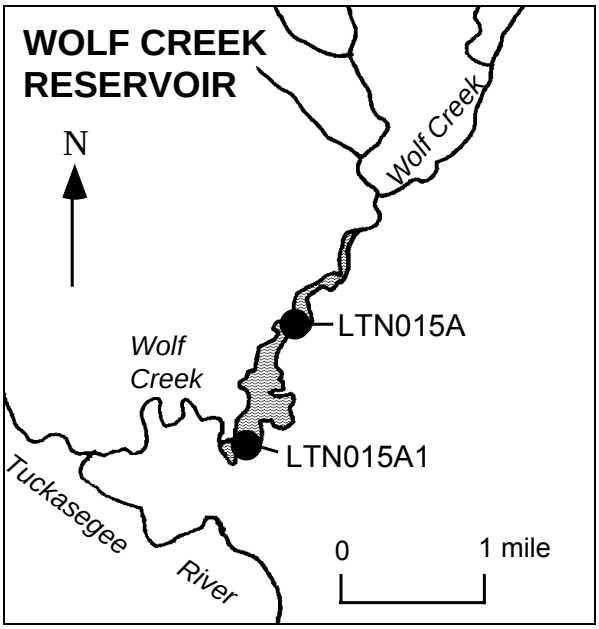

Figure 20. Monitoring sites at Wolf Creek Reservoir, Jackson County.

The reservoir was most recently sampled during the summer of 1999 (Table 16 and Appendices L2 and L3). Mean Secchi depths ranged from 5.9 m in June to 4.2 m in August. Nutrient and chlorophyll *a* concentrations were low. Fecal coliform bacteria concentrations were ≤ 10 colonies/100 ml. The calculated NCTSI scores indicated that the reservoir was oligotrophic.

Previous data was collected from the reservoir in August 1996. Secchi depths were less than those usually observed, ranging from 2.1 to 2.4 m. Total phosphorus concentrations were also greater than those generally observed (0.02 to 0.03 mg/l). Chlorophyll *a* values were low. The NCTSI score (– 1.4) rated the lake as mesotrophic. Localized storms a few days earlier within the watershed may have contributed to the decreased transparency and increased nutrient concentrations that were measured later.

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 21). As expected for a mountain reservoir, median Secchi depths and chlorophyll *a* concentrations were greater near the dam as compared with the upper end of the reservoir. By contrast, median total phosphorus and total organic nitrogen were greater at the upper end of the lake than near the dam.

The reservoir has not experienced any recent changes in water clarity, nor have there been reports of algal blooms, nuisance aquatic macrophytes, or water quality complaints by swimmers (Richard Conley, NP&L, pers. com).

Table 16. Biological and water chemistry data from Wolf Creek Reservoir, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/11/1999	-5.1	Oligotrophic	< 0.01	0.14	6	4.2
07/08/1999	no score	---	< 0.01	0.10	---	5.1
06/24/1999	-5.7	Oligotrophic	< 0.01	0.10	9	5.9
08/06/1996	-1.4	Mesotrophic	0.03	0.24	7	2.3

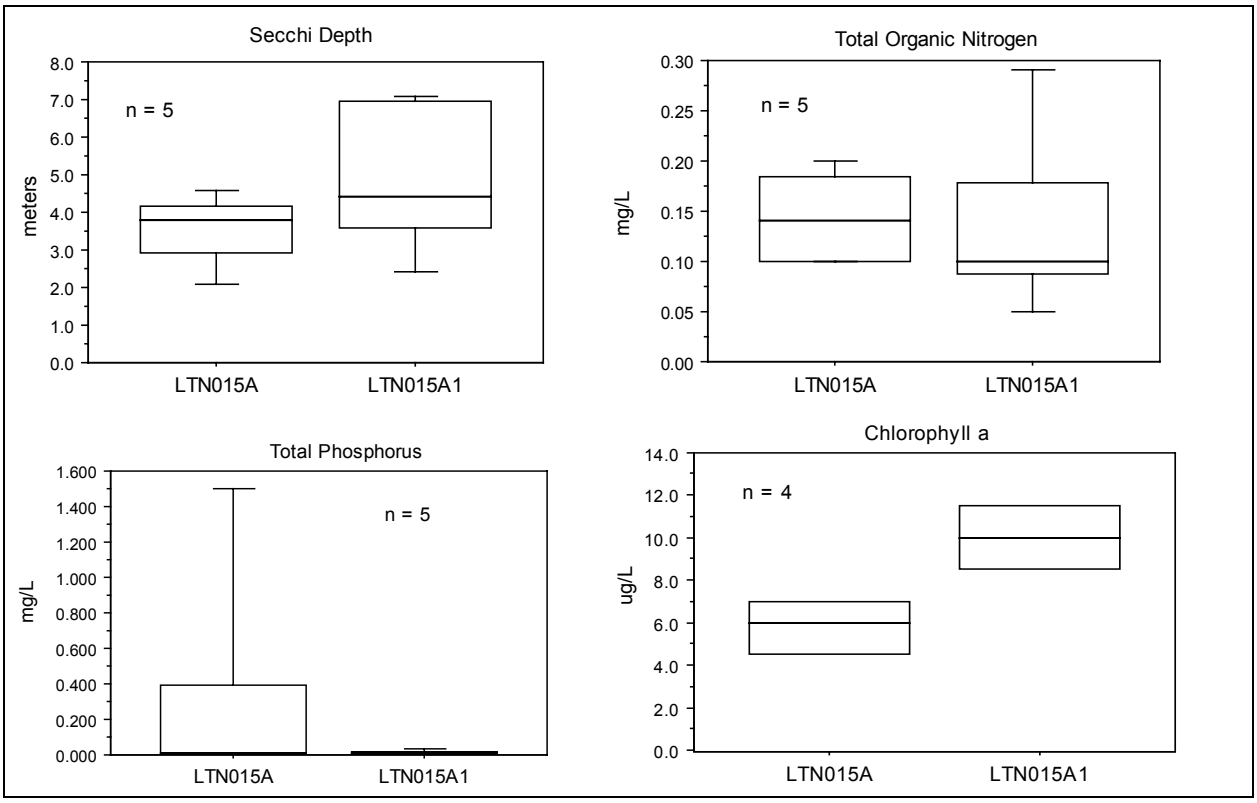

Figure 21. Spatial relationships among biological and water chemistry data from Wolf Creek Reservoir, 1988 – 1999.

Bear Creek Reservoir

Bear Creek Reservoir is the first impoundment on the upper Tuckasegee River (Figure 22). Like other reservoirs in this subbasin, it is owned by the NP&L. The reservoir is located within the Nantahala National Forest and consequently, its watershed is primarily forested.

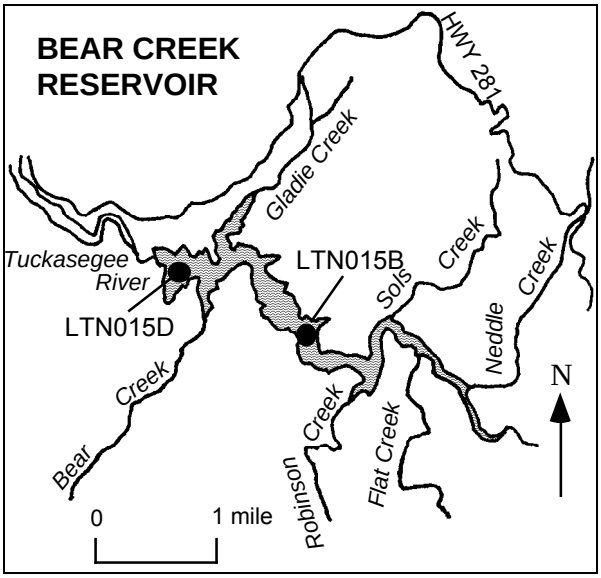

Figure 22. Monitoring sites at Bear Creek Reservoir, Jackson County.

The reservoir was most recently sampled during the summer of 1999 (Table 17 and Appendices L2 and L3). Secchi depths ranged from 3 to 4 m. Fecal coliform bacteria concentrations were consistently less than 10 colonies/100 ml and surface metal concentrations at the sites closest to the dam were within applicable state water quality standards. The reservoir was rated as oligotrophic based upon the NCTSI.

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 23). Median values for each parameter were similar between the two sample sites.

Like Wolf Creek Reservoir, Bear Creek Reservoir has not experienced any recent changes in water clarity. Neither has there been reports of algal blooms, nuisance aquatic macrophytes. There has been very little increase in development activities within the watershed (Richard Conley, NP&L, pers. com).

Table 17. Biological and water chemistry data from Bear Creek Reservoir, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/11/1999	-4.6	Oligotrophic	< 0.01	0.17	6	3.6
07/08/1999	no score	---	< 0.01	0.10	---	3.3
06/23/1999	-2.4	Oligotrophic	0.02	0.22	7	3.5
08/09/1994	-4.2	Oligotrophic	0.03	0.11	2	2.7

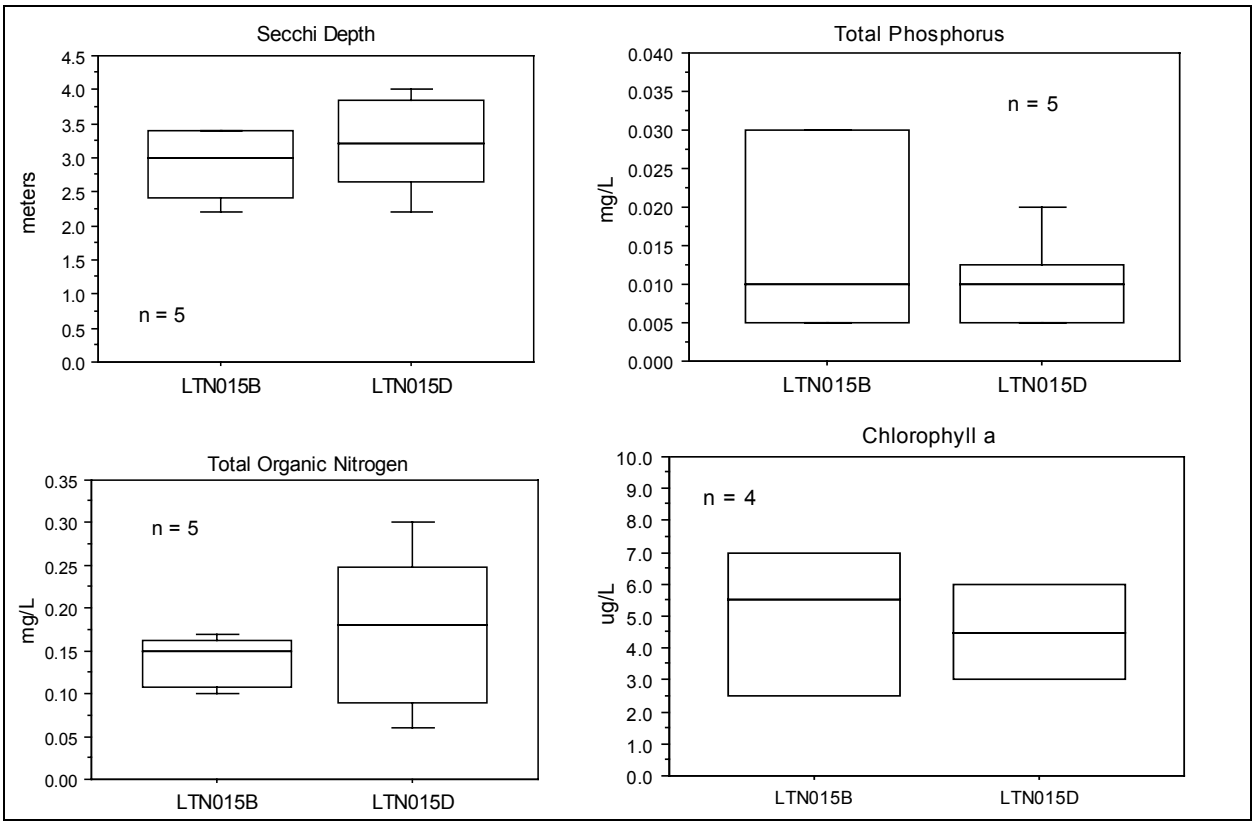

Figure 23. Spatial relationships among biological and water chemistry data from Bear Creek Reservoir, 1988 – 1999.

Cedar Cliff Lake

Cedar Cliff Lake is the next downstream reservoir on the Tuckasegee River and is immediately below Bear Creek Reservoir (Figure 24). It is also owned by NP&L which created the reservoir in 1952. The reservoir's watershed is within the Nantahala National Forest.

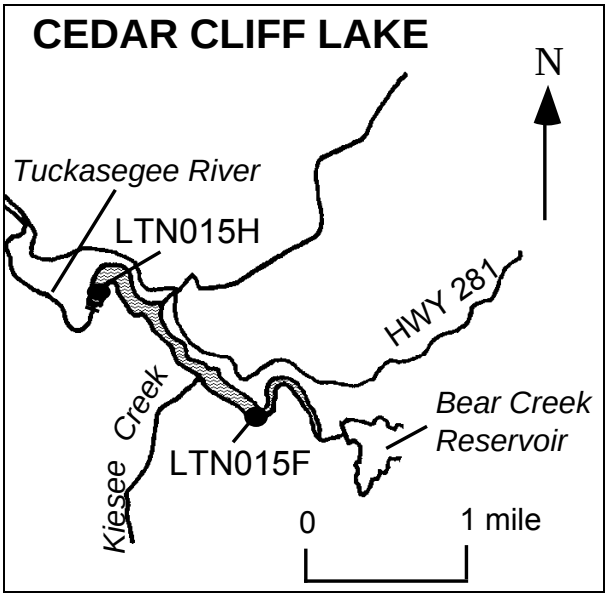

Figure 24. Monitoring sites at Cedar Cliff Lake, Jackson County.

The reservoir was most recently sampled during the summer of 1999 (Table 18 and Appendices L2 and L3). Secchi depths were greatest at the site nearest the dam (Station LTN015H). The maximum Secchi depth (6.3 m) observed at this lake was recorded in July 1999.

Although the maximum transparency was recorded at the downstream site, on the same day a chlorophyll *a* concentration of 26 µg/l was observed at the upstream site. This was the greatest concentration recorded for this parameter since monitoring at this reservoir began in 1988. This value was also greater than the state water quality standard of 15 µg/l for waters designated as Trout Waters.

Mean ammonia nitrogen concentrations in June (0.06 mg/l) and August (0.08 mg/l) were also greater than those previously observed. Despite the elevated nutrient and algal biomass concentrations, the reservoir continued to be rated as oligotrophic.

Also like Wolf Creek and Bear Creek reservoirs, there have been no recent reports of algal blooms, decreased water clarity, or nuisance aquatic macrophytes. There has been some limited residential development within the lake's watershed (Richard Conley, NP&L, pers. com).

Table 18. Biological and water chemistry data from Cedar Cliff Lake, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/11/1999	-5.1	Oligotrophic	< 0.01	0.17	4	4.0
07/07/1999	-3.2	Oligotrophic	0.01	0.20	16	3.8
06/23/1999	-4.4	Oligotrophic	< 0.01	0.19	7	4.0
08/06/1996	-2.0	Oligotrophic	0.02	0.18	11	2.5

Thorpe Reservoir

Thorpe Reservoir, also known as Glenville Lake, is an impoundment of the West Fork Tuckasegee River (Figure 25). The reservoir was built in 1941 by NP&L for hydroelectric power production. The lake is secondarily used for fishing, swimming, and boating. Most of its watershed is forested; development is limited to low density residential uses. Major tributaries include Norton Creek, Hurricane Creek, Cedar Creek, Mill Creek, and Pine Creek. In 1998, Thorpe Reservoir was supplementally reclassified to HQW based upon its historical excellent water quality characteristics.

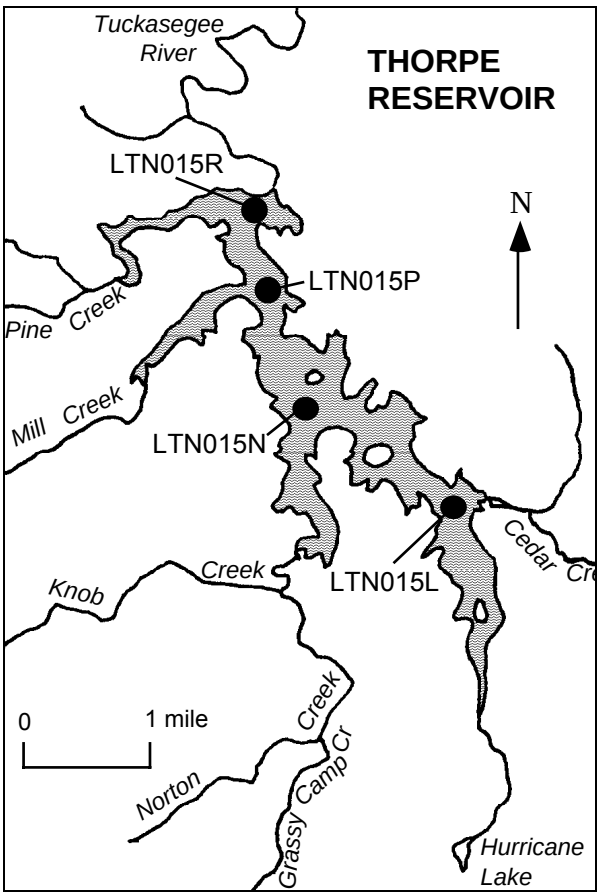

Figure 25. Monitoring sites at Thorpe Reservoir, Jackson County.

The reservoir was most recently sampled during the summer of 1999 (Table 19 and Appendices L2 and L3). The decrease in lakewide Secchi depth along with an increase in turbidity (mean = 1.5 NTU) may have been related to recent rainfall events within the lake's watershed. Maximum total phosphorus concentrations were measured in June, with the greatest concentration (0.10 mg/l) measured at the station closest to the dam (Station LTN015R).

Detectable concentrations of ammonia nitrogen were measured only in August (mean = 0.09 mg/l). Algal biomass was also low during all sampling periods (1 -10 µg/l). Based on the calculated NCTSI scores, the reservoir continued to be rated oligotrophic.

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 26). Median Secchi depths and median total phosphorus were generally similar among the four lake sampling sites. Median total organic nitrogen was slightly lower at the sampling site near the Mill Creek arm (Station LTN015P) and median chlorophyll *a* was also lowest at this site.

Like other NP&L reservoirs, there have been no recent reports of algal blooms, decreased water clarity, or nuisance aquatic macrophytes at Thorpe Reservoir (Richard Conley, NP&L pers. com).

Table 19. Biological and water chemistry data from Thorpe Reservoir, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/10/1999	-6.4	Oligotrophic	< 0.01	0.08	3	3.5
07/07/1999	-6.0	Oligotrophic	< 0.01	0.12	4	5.3
06/23/1999	-3.9	Oligotrophic	0.04	0.08	7	5.6
08/07/1995	-5.1	Oligotrophic	0.01	0.07	4	2.4
08/08/1994	-4.6	Oligotrophic	0.02	0.15	1	3.0

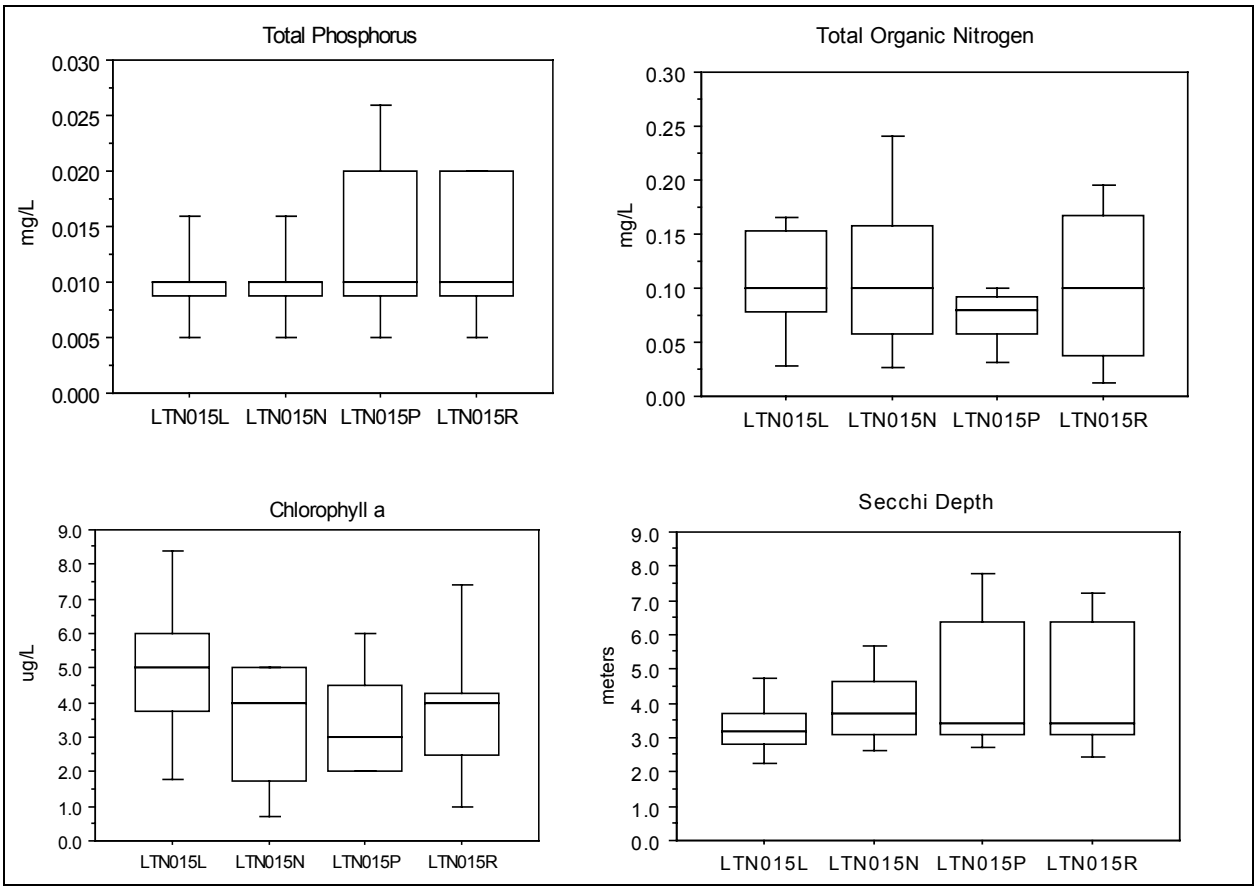

Figure 26. Spatial relationships among biological and water chemistry data from Thorpe Reservoir, 1988 – 1999.

LITTLE TENNESSEE RIVER SUBBASIN 03

Description

This subbasin contains most of the Nantahala River catchment (Figure 27). Headwaters of this river entirely within the Nantahala National Forest. The river, from its source to the confluence with Roaring Fork, is supplementary classified ORW. Much of the land adjacent to this reach is privately owned. The river and most tributaries are high gradient systems capable of supporting wild trout populations.

Nantahala Power and Light Company impounded the river creating Nantahala Lake. Flow is diverted to downstream generators at Beechertown, bypassing a seven-mile reach of the river prior to discharging back into the original channel above the Nantahala Gorge. The regulated reach of the river below the powerhouse is very popular for rafting and canoeing. Development has increased along the gorge corridor as it relates to the recreational industry.

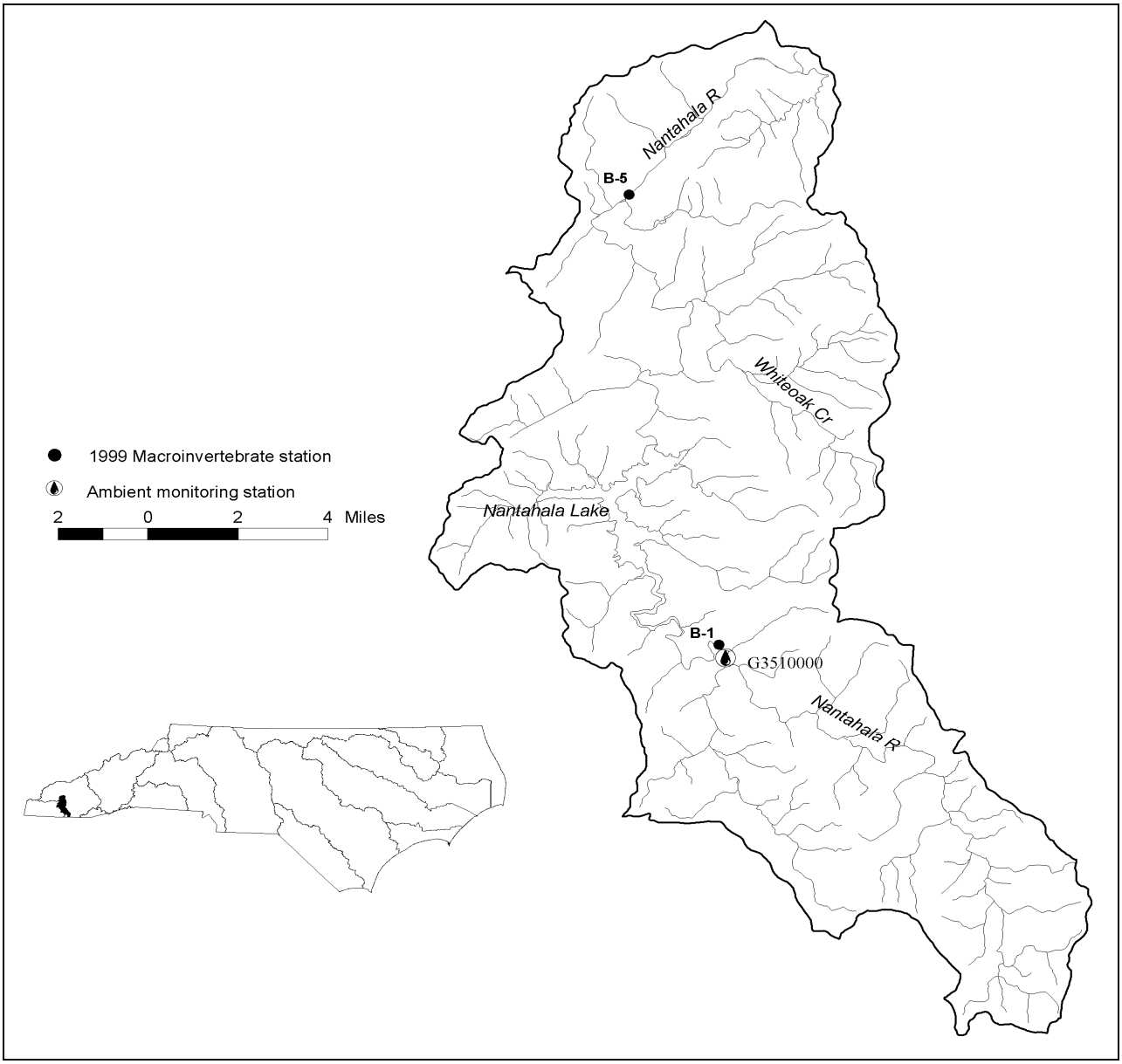

Figure 27. Sampling sites in Subbasin 03 in the Little Tennessee River basin.

Overview of water quality

Overall water quality in the Nantahala River watershed is high (Table 20). Excellent bioclassifications have been found using benthos data for the river above Nantahala Lake near Rainbow Springs since 1984. The river at this station is supplemen-tally classified as ORW.

Ambient chemistry data from this location indicated the lowest variability for total suspended solids, hardness, fecal coliform bacteria, turbidity, nitrite+nitrate as nitrogen, and total phosphorus of all ambient sites in the basin. Medians were low for most parameters, indicating a high frequency of samples with low concentrations for these parameters.

Nantahala Lake is oligotrophic and has been so evaluated since first monitored in 1981. Benthos samples from the bypass reach of the river below the lake improved from Good in 1993 to Excellent in 1999. Further downstream, in the regulated portion of the river, benthos data have resulted in Good bioclassifications in 1994 and 1999, although heavy periphyton growths reduced the abundance of many taxa. Benthos samples of tributary streams in 1999 resulted in an Excellent bioclassification for Queens Creek, and Good bioclassifications for Dicks Creek and Whiteoak Creek. The Dicks Creek rating was an improve-ment from the Good-Fair bioclassification found in 1993.

Table 20. Waterbodies monitored in Subbasin 03 in the Little Tennessee River basin for basinwide assessment, 1994 - 1999.[1]

Map # [1]	Waterbody	County	Location	1994	1999
B-1[2]	Nantahala R	Macon	USFS Road 437	Excellent	Excellent
B-5[2]	Nantahala R	Swain	off US 19/74	Good	Good
	Nantahala Lake	Macon		Oligotrophic	Oligotrophic

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994, refer to Appendix B2.

River and Stream Assessment

Nantahala River
Benthos samples have been collected from this site on US Forest Service Road 437 near Rainbow Springs since 1984. Excellent bioclassifications have been found during all surveys, and this stretch of the river above Roaring Fork has been designated ORW. The benthic fauna is characterized by many intolerant taxa. A full scale sample above the lake in 1999 had 49 EPT taxa, an EPT abundance of 239, and an EPT BI value of 2.45.

The bypass reach off USFS Road 308 was also sampled as part of a special study. The stream was about nine meters wide, with a good heterogeneous substrate and swift flow. An EPT sample produced 41 taxa and an Excellent bioclassification. EPT abundance was high at 203. This was an improvement from a full scale sample collected in November 1993 when the 37 EPT and a NCBI value of 3.55 resulted in a Good rating.

It seemed that either the minimum flow release from Nantahala Lake or tributary flow in the bypass reach allowed development of a diverse and abundant fauna. But., the fauna is not quite as good as that found in the natural section of the river above the lake.

A site in the regulated portion of the river (off US 19/74 at a private campground just above the old gage site) was sampled in the evening after the powerhouse ceased generating and water levels had subsided. A very thick periphyton growth covered all the rocks which made collecting difficult. An EPT sample resulted in 35 taxa, an EPT abundance of 143, and an EPT BI value of 2.29. This site, as in 1994, was rated Good.

SPECIAL STUDIES
Response of Benthic Macroinvertebrates to Minimum Flow Releases
Three sites were sampled as part of a larger study to gather information from streams that currently have or will have minimum flow releases from upstream impoundments.

- **Dicks Creek**

Dicks Creek at SR 1400 (near Appletree campground) improved noticeably from the 26 EPT taxa collected in November 1993 (Good-Fair bioclassification) to 34 EPT taxa and a Good rating

in 1999. Fast flows and substrate dominated by boulder and rubble provided good instream habitat.

This small stream (five meters wide) was very productive (EPT N = 200). There is a small dam about one mile above its confluence with the Nantahala River, but the stream has been free flowing for about the last two years.

➢ **Queens Creek**

Queens Creeks is a very small stream (two meters wide) that was sampled in a USFS campground just beyond the bridge over the Nantahala River. The impoundment on this stream does not yet have a minimum flow release.

Though only 29 EPT taxa were collected, corrections for small stream size resulted in an Excellent rating for the site. The substrate was a good mixture of boulder, rubble, and gravel. Thirteen of the 29 taxa were abundant.

➢ **Whiteoak Creek**

The Whiteoak Creek sampling site off SR 1310 is below a large trout farm and above an old dam off SR 1310. The stream at this site is medium size (seven meters wide) with swift flow over primarily boulder and rubble substrate.

Samples collected at this site since 1988 during special studies have always resulted in a Good bioclassification. This was again the case in 1999. Two August samples, an EPT sample in 1999 and a full scale in 1990, suggested some improvement. EPT richness increased from 26 in 1990 to 31 in 1999 (full scale equivalent richness would be about 36 taxa).

Evaluation of the Impact of Logging on Benthic Macroinvertebrates

A special study was conducted in 1995 and 1998 to evaluate the impact of logging techniques on the benthic invertebrate community in Bryson Branch. This stream is a tributary to the Nantahala River in the river's ORW headwaters area. Post-logging samples collected in 1998 resulted in a decline from Excellent to Good in the logged and reference (Roaring Fork) watersheds. This suggested that the very dry summer in 1998 influenced the fauna more so than did the logging.

Lake Assessment

Nantahala Lake

Nantahala Lake is an impoundment on the middle portion of the Nantahala River (Figure 28). The river was impounded in 1942 for hydroelectric power generation by Nantahala Power & Light Company (NP&L). Its forested watershed drains the eastern portion of Clay County and the western portion of Macon County. While there has been some limited development within its watershed, approximately 50% of it lies within the Nantahala National Forest.

The reservoir was most recently sampled during the summer of 1999 (Table 21 and Appendices L2 and L3). Secchi depths were fairly consistent in 1999 with mean depths ranging from 5.1 to 5.5 m. Total phosphorus, total nitrogen, and chlorophyll *a* concentrations were also low. Maximum chlorophyll a concentrations (11 µg/l) were observed in June.

Based on the calculated NCTSI score, Nantahala Lake was rated oligotrophic. This rating has not changed since the reservoir was first monitored in 1981. This lake continued to exhibit excellent water quality and may be of the best water quality of any lake in the mountain ecoregion.

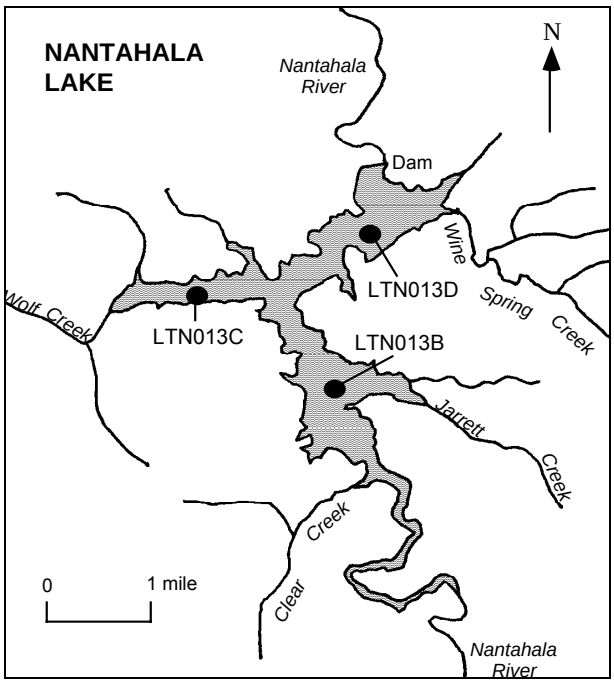

Figure 28. Monitoring sites at Nantahala Lake, Macon County.

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 29). Median values for these parameters were relatively similar, temporally and spatially.

As to be expected from a lake with excellent water quality, there have been no reports of algal blooms or nuisance aquatic macrophytes in Nantahala Lake (Richard Conley, NP&L, pers. com.).

Table 21. Biological and water chemistry data from Nantahala Lake, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/09/1999	-5.1	Oligotrophic	< 0.01	0.15	7	5.2
07/07/1999	-6.1	Oligotrophic	0.01	0.10	3	5.1
06/21/1999	-5.4	Oligotrophic	< 0.01	0.11	9	5.5
08/30/1994	-5.6	Oligotrophic	0.02	0.10	0	4.7

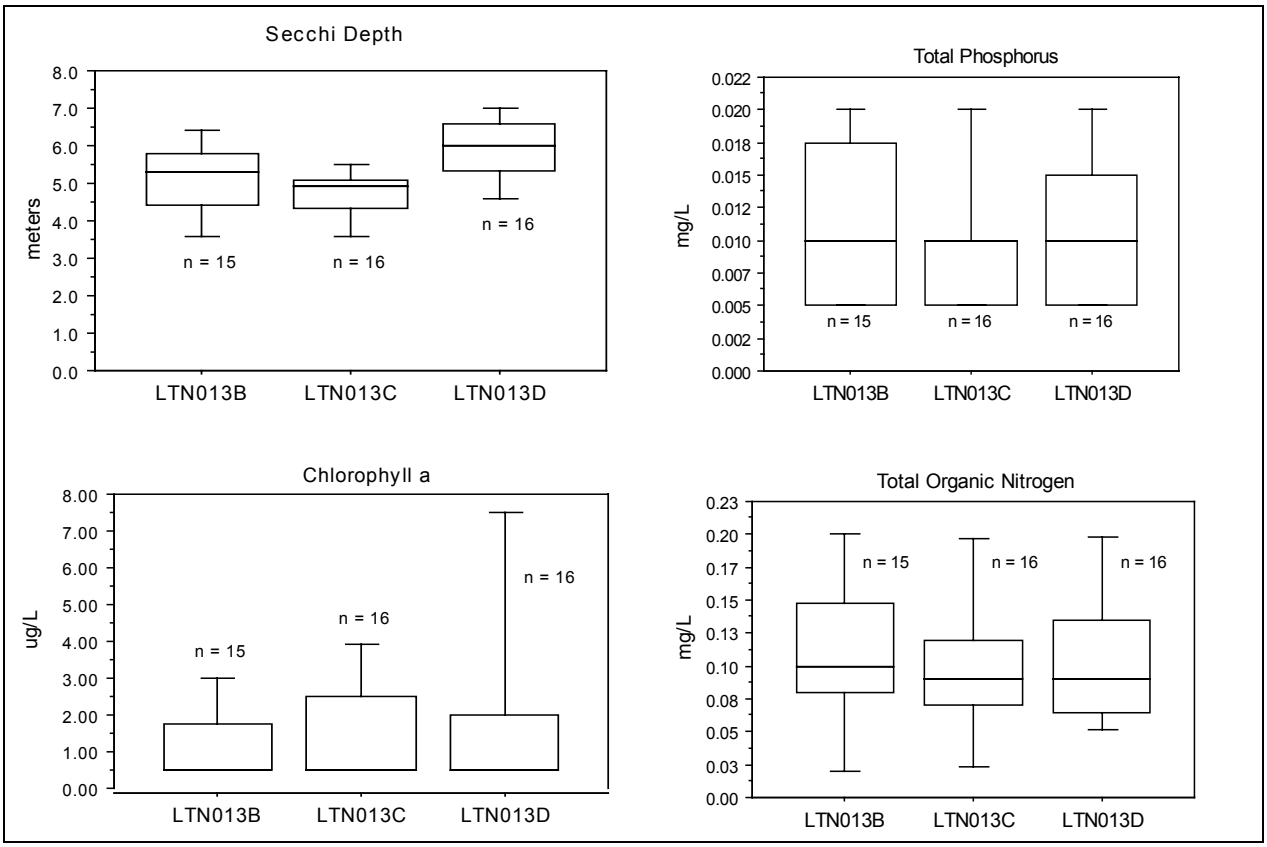

Figure 29. Spatial relationships among biological and water chemistry data from Nantahala Lake, 1981 – 1999.

LITTLE TENNESSEE RIVER SUBBASIN 04

Description

This subbasin contains the Cheoah River and all of its tributaries (Figure 30). Significant sections of most tributary catchments are within the Nantahala National Forest and are minimally impacted. These tributaries are typically high-gradient streams capable of supporting trout populations. However, lower reaches of some tributaries and corridors along Tulula Creek, Sweetwater Creek, Little Snowbird Creek, Yellow Creek, and the Cheoah River are not in the national forest. Thus, they are more likely to be impacted by land-disturbing activities. Tulula Creek flows through the Town of Robbinsville, where the stream becomes the Cheoah River at its confluence with Sweetwater Creek. Robbinsville is the only urban area in this subbasin.

The Cheoah River is dammed below Robbinsville to form Santeetlah Lake. Tapoco, Inc. operates the hydroelectric dam to provide hydroelectric power for the Aluminum Company of America (ALCOA). The tailwater reach below the dam is approximately 9 river miles prior to the confluence with the Little Tennessee River.

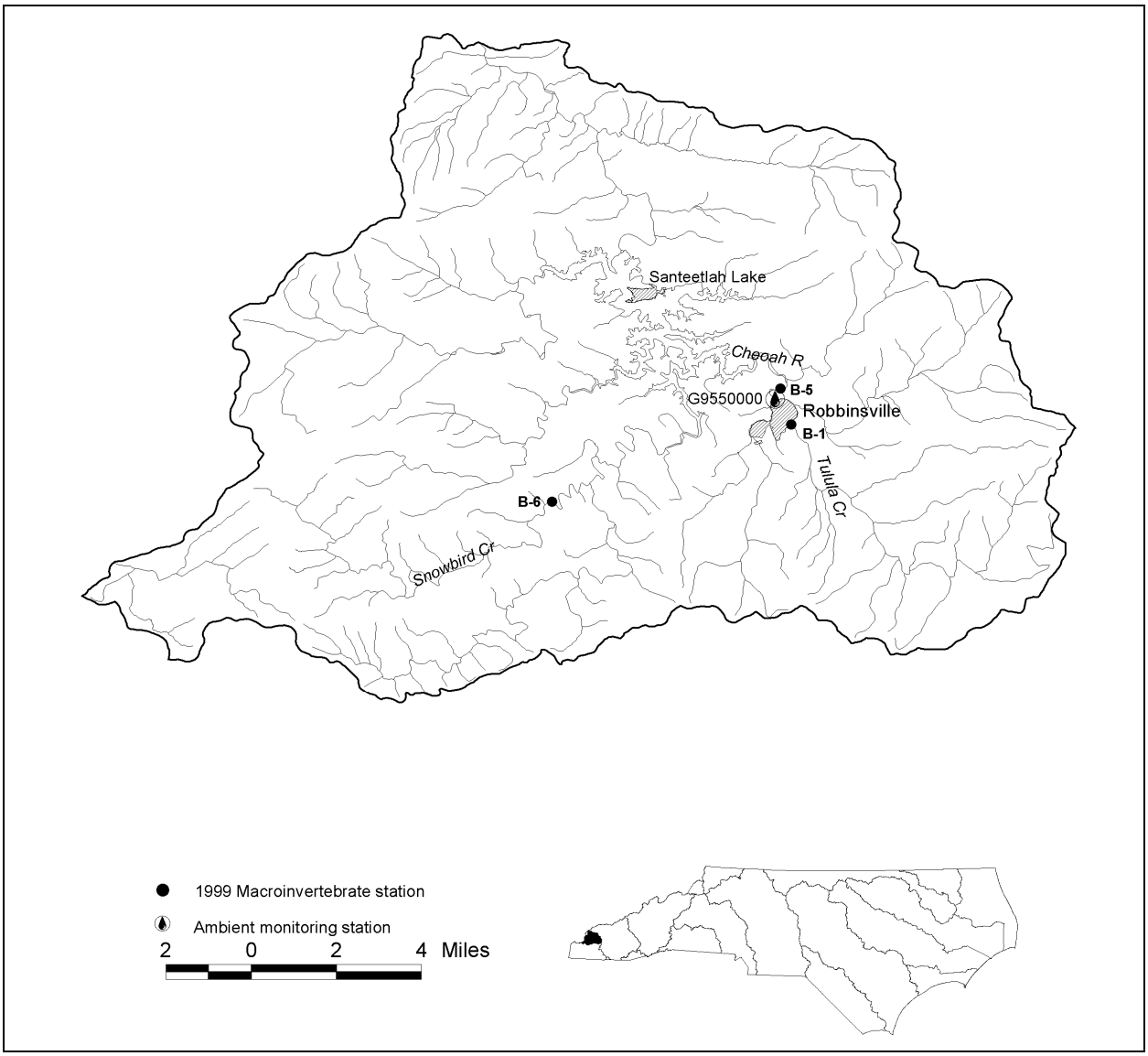

Figure 30. Sampling sites in Subbasin 04 in the Little Tennessee River basin.

Overview of water quality

Good or Excellent bioclassifications have been recorded at all benthic macro-invertebrate monitoring locations in this subbasin since 1983. Trout farms and land disturbing activities are the main potential sources of water quality problems. Several trout farms discharge to Snowbird Creek and West Buffalo Creek. Phytoplankton blooms in Lake Santeetlah have been associated with the effluents from these farms.

The 1994 benthos sites had extremely high stream flows immediately prior to sample collection. This may explain the improvement found at 2 of the 3 basin sites (Table 22).

Tulula Creek was sampled in Robbinsville, where nonpoint source runoff is a potential impact. Further downstream, however, the Cheoah River was Excellent where sampled below the Robbinsville WWTP (0.63 MGD), which discharges to Long Creek, a tributary of the Cheoah River. Snowbird Creek had been Excellent before the 1994 Good rating and was Excellent again in 1999, supporting the contention that high flows in 1994 may have displaced some taxa.

Monitoring of Cheoah Lake on the Little Tennessee River and Santeetlah Lake on the Cheoah River in 1999 found oligotrophic conditions in the mainstem of both lakes. A special study of Santeetlah Lake in 1998 and 1999 found that trout farms in the watersheds of the Snowbird Creek and West Buffalo Creek arms of the lake were causing accelerated eutrophication in those arms. Frequent chlorophyll *a* concentrations greater than 15 µg/l were noted. The study concluded that the Snowbird Creek arm of the lake cannot tolerate additional nutrient contributions. The West Buffalo Creek arm was determined to be impaired and only partly supporting its uses for swimming and biological integrity.

An ambient chemistry station on the Cheoah River had slightly higher fecal coliform values in the past five years than earlier, but no other notable values.

Table 22. Waterbodies monitored in Subbasin 04 in the Little Tennessee River basin for basinwide assessment, 1994 - 1999.[1]

Map #	Waterbody	County	Location	1994	1999
B-1	Tulula Cr	Graham	SR 1275	Good	Good
B-5	Cheoah R	Graham	off SR 1138	Good	Excellent
B-6[2]	Snowbird Cr	Graham	SR 1120 and SR 1119	Excellent	Excellent
	Cheoah Lake	Swain/Graham		Oligotrophic	Oligotrophic
	Santeetlah Lake	Graham		Oligotrophic	Oligotrophic

[1]B = benthic macroinvertebrate monitoring sites.
[2]Data are available prior to 1994, refer to Appendix B2.

River and Stream Assessment

Tulula Creek and Cheoah River

Good and Excellent bioclassifications were given to Tulula Creek and the Cheoah River above and below the Robbinsville WWTP. The WWTP discharges to Long Creek, a tributary of the Cheoah River, immediately below the confluence of Tulula and Sweetwater Creeks.

Benthic macroinvertebrate samples have been collected from Tulula Creek at SR 1275 above the WWTP, but still in an urban section of Robbinsville. Benthos data from the Cheoah River below the WWTP were collected in 1994 at NC 129, but about a quarter to one-half mile downstream, off SR 1138 in 1999. These two locations are equivalent to one another for rating purposes.

This entire reach of river is high gradient, with a width of 15 - 20 m and a drainage area of 43 mi^2 miles at Robbinsville. The bottom substrate reflects the high gradient, as it is dominated by boulders and rubble with very little sand and silt accumulations.

EPT taxa richness increased from 40 at the upstream site to 48 at the downstream site. At the downstream site, there was an increase of 16 EPT taxa between 1994 and 1999.

Snowbird Creek, SR 1120 and SR 1119

A benthos sample was collected from Snowbird Creek near a previously assessed location (SR 1119). This regional reference site was about 15 m wide with a boulder and rubble substrate and

good instream and riparian habitats (score = 87). Deep pools and clear water made it a scenic stream.

The 1999 EPT taxa richness of 52 was much greater than the value of 33 found in 1994 after extremely high flows. But, it was comparable to data collected from in 1990 (49 EPT). The Good rating in 1994 improved to Excellent in 1999.

SPECIAL STUDIES

Impacts of Trout Farms on Benthic Macroinvertebrate Communities

A sample was collected from West Buffalo Creek at SR 1123 to determine any potential impacts from the many trout farms in the watershed. An Excellent rating was given to the stream based on an EPT sample. The stream showed some signs of enrichment, including increased periphyton growth and an increased abundance of filter feeding organisms.

Impacts of Acid Deposition on Benthic Macroinvertebrate Communities

Little Snowbird Creek was sampled for benthic macroinvertebrates in the extreme upper part of the watershed to replicate samples collected by Trout Unlimited volunteers as part of an acid deposition study. This small stream had many intolerant taxa and received an Excellent rating, based on the 39 EPT taxa collected. The dominant taxon was *Rithrogena*, a mayfly that is seldom abundant, much less dominant. Acid deposition did not seem to be impacting this stream.

Lake Assessment

Lake Cheoah

Lake Cheoah is a narrow, deep reservoir located on the Little Tennessee River near the North Carolina/Tennessee state line (Figure 31). This lake is owned by the Tallassee Power Company (TAPOCO) and was built for hydroelectric power generation. Inflow is dominated by the hypolimnetic release from Fontana Lake, which is located immediately upstream. The watershed is the entire Little Tennessee River basin in North Carolina.

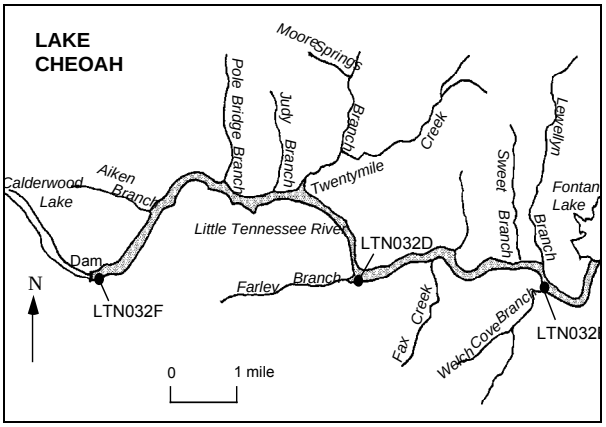

Figure 31. Monitoring sites at Lake Cheoah, Swain and Graham counties.

The reservoir was most recently sampled during on August 9, 1999 (Table 23 and Appendices L2 and L3). Secchi depths ranged from 5.5 to 7.4 m. Ammonia nitrogen and total phosphorus concentrations were less than laboratory detection levels. Chlorophyll *a* concentrations were also low. Lake Cheoah was again rated oligotrophic.

Like other oligotrophic reservoirs within the Little Tennessee River basin, Lake Cheoah has not experienced any recent changes in water clarity, nor have there been reports of algal blooms or nuisance aquatic macrophytes (Burlin Gladden, TAPOCO, pers. com).

Lake Cheoah was sampled by TAPOCO as part of the Federal Energy Regulatory Commission's relicensing process (Normandeau Associates 1999). Data were collected from August 1997 through April 1999 to provide a comprehensive analysis of water quality conditions in the project area.

Baseline fish tissue data were also collected from the reservoir in June 1998 as part of the relicensing process. Tissue from five white suckers was analyzed for mercury and polychlorinated biphenyl (PCBs) compounds. The mercury concentration in the composited sample was less than the state and federal consumption criteria. The PCBs result was less than the laboratory detection level.

Table 23. Biological and water chemistry data from Cheoah Lake, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/09/1999	-4.3	Oligotrophic	< 0.01	0.26	7	6.6
08/10/1994	-5.3	Oligotrophic	0.03	0.12	< 1	3.4

Santeetlah Lake

Santeetlah Lake, an impoundment of the Cheoah River, is located in central Graham County (Figure 32). The lake is owned by the Aluminum Company of America (ALCOA) and is used to generate hydroelectric power. Secondarily, it is used for recreational purposes. The major tributaries to the lake are the Santeetlah River, West Buffalo Creek, and Snowbird Creek. The watershed, which is almost entirely forested, consists of portions of the Nantahala National Forest (including the Joyce Kilmer - Slickrock Wilderness Area) and the Town of Robbinsville.

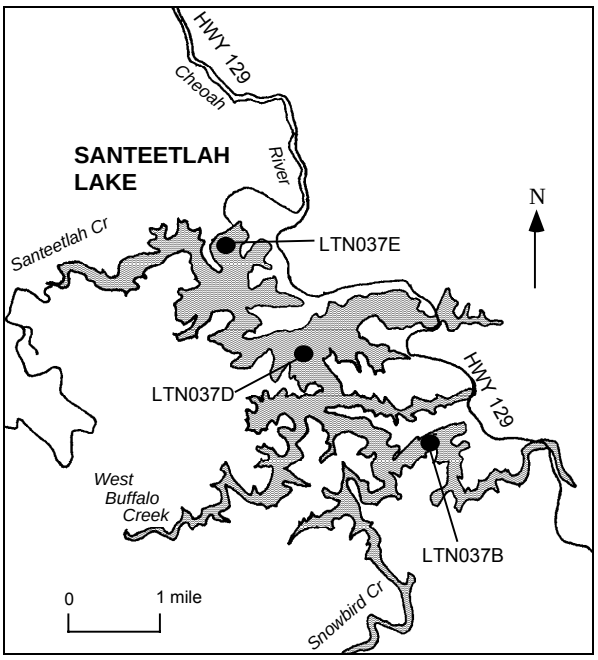

Figure 32. Monitoring sites at Santeetlah Lake, Graham County.

Monitoring has been conducted since 1981 at three sites located in the mainstem of the lake. These three sites have consistently been rated as oligotrophic, most recently in 1999 (Table 24).

However, on July 27, and August 9, 1999, increases in chlorophyll *a* concentrations were observed (Appendix L3). On July 27, 1999, the chlorophyll *a* concentrations at Station LTN027D (21 µg/l) and at Station LTN027E (18 µg/l) were greater than the water quality standard for lakes designated as Trout Waters (15 µg/l). Both of the sampling sites were located downstream of the West Buffalo Creek and Snowbird Creek arms.

Santeetlah Lake was sampled by TAPOCO as part of the Federal Energy Regulatory Commission's relicensing process (Normandeau Associates 1999). Data were collected from August 1997 through April 1999 to provide a comprehensive analysis of water quality conditions in the project area.

Baseline fish tissue data were also collected from the reservoir in October 1997 and June 1998 as part of this relicensing process. Tissue from largemouth bass and channel catfish were analyzed for mercury and polychlorinated biphenyl (PCBs) compounds. The mercury concentrations in the composited samples were less than state and federal consumption criteria. The PCBs results were less than the laboratory detection level.

Impact of Trout Farms on Santeetlah Lake Water Quality

As previously mentioned, the mainstem of Santeetlah Lake has consistently demonstrated oligotrophic conditions. The Snowbird Creek and West Buffalo Creek arms, however, have been experiencing symptoms of accelerated eutrophication such as nuisance algal blooms and elevated dissolved oxygen saturation levels. Trout farms are located in the upper ends of both arms.

In response to citizen complaints regarding water quality in these two arms, the Division conducted a special study from April through October, 1993 (NCDEHNR 1994). The purpose of this study was to determine the source and extent of nutrient loading to these two tributary arms. Monitoring sites were located upstream and downstream of the trout farms on Snowbird Creek and West Buffalo Creek.

Table 24. Biological and water chemistry data from Lake Santeetlah, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL *a* (µg/l)	Secchi (m)
08/24/1999	-2.5	Oligotrophic	0.02	0.21	7	3.4
08/09/1999	-3.3	Oligotrophic	< 0.01	0.26	13	3.6
07/27/1999	-3.1	Oligotrophic	< 0.01	0.27	16	4.0
08/02/1995	-4.6	Oligotrophic	0.01	0.12	6	4.7
08/30/1994	-4.5	Oligotrophic	0.01	0.20	2	3.0

Elevated nutrient concentrations and nutrient loads were observed at the sites located immediately downstream of the trout farms. Algal blooms observed on the West Buffalo Creek arm were enhanced by inputs of nutrients from the upstream trout farms. Voluntary management actions were taken by the trout farms. The Division also instituted a new permitting policy which restricted new or expanding trout farm facilities within the lake's drainage area.

During the summer of 1998, a number of public complaints were again received by the Asheville Regional Office regarding noxious algal blooms in the West Buffalo Creek arm of the lake. Monitoring was again conducted in response to these complaints. A blue-green algal bloom of *Anabaena spiroides* was documented at the time.

A second special study was conducted in 1999 to further quantify nutrient inputs from the trout farms and to determine what impacts voluntary nutrient control strategies might have had (NCDENR 2000). Monitor-ing was performed twice monthly from April 20, to October 6, 1999. Seven stream sites, eight additional lake sites, and three historic ambient lake sites were sampled.

During this study, blue-green algae blooms were observed and chlorophyll *a* concentrations frequently exceeded the water quality standard for lakes designated as Trout Waters (15 µg/l). The average phytoplankton biovolume in the West Buffalo Creek arm was three times greater than that in the Santeetlah Creek arm and 1.5 times greater than that in the Snowbird Creek arm. Frequent violations of the water quality standards for pH and percent dissolved gasses saturation were also documented. Nutrient concentrations were consistently highest at the sampling site located downstream of the trout farms on West Buffalo Creek.

These two studies indicated elevated nutrient loads and concentrations at stream sampling sites downstream from the trout farms (Figures 33 and 34). In these two figures, the percentage contribution by "Trout Farms" is represented by Station SL4; Hooper Mill Creek is the unimpacted tributary to West Buffalo Creek; and 'Others" represents phosphorus contributions from nonpoint source runoff.

During both years, the greatest total phosphorus loading was from the trout farms. The greater amount of rainfall in 1999 would have increased the nonpoint source runoff contributions and decreased the trout farm contributions as compared with the two loading rates in 1993.

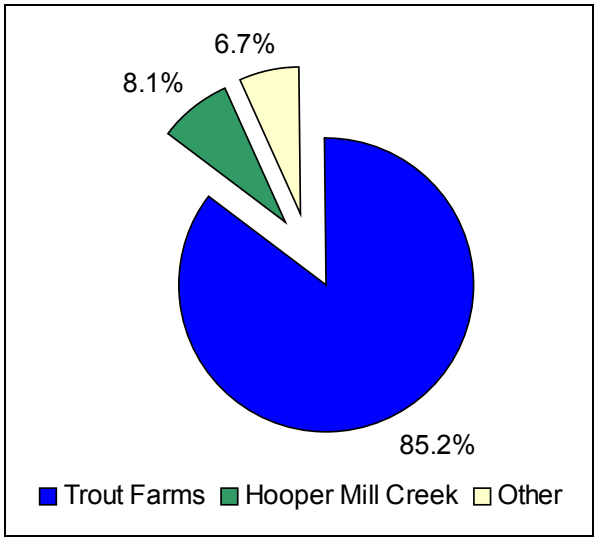

Figure 33. A comparison of the percentage contributions of total phosphorus loads (in pounds/day) on West Buffalo Creek, 1993.

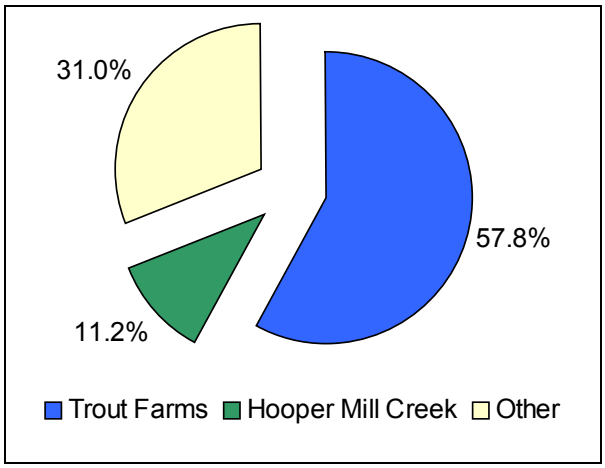

Figure 34. A comparison of the percentage contributions of total phosphorus loads (in pounds/day) on West Buffalo Creek, 1999.

The 1999 study determined that the mainstem of Santeetlah Lake continues to support its designated uses. By contrast, the Snowbird Creek arm of the lake was found to be experiencing accelerated eutrophication and cannot tolerate additional nutrient contributions. The West Buffalo Creek arm was determined to be impaired and only partly supporting its uses for swimming and biological integrity (NCDENR 2000).

AMBIENT MONITORING SYSTEM

The Division collects ambient water quality information from approximately 421 active monitoring stations statewide. In the Little Tennessee River basin there are seven stations (Figure 35 and Table 25).

Regional flow patterns generally showed greater than normal flows beginning in 1994 to about 1998 (Figure 36). Beginning in 1998, yearly and monthly median flows displayed decreases. The graph depicting flow in the Hiwassee River does not include data for the water year 1998-1999, but the yearly median flow follows the same patterns for the Watauga River and Little Tennessee River.

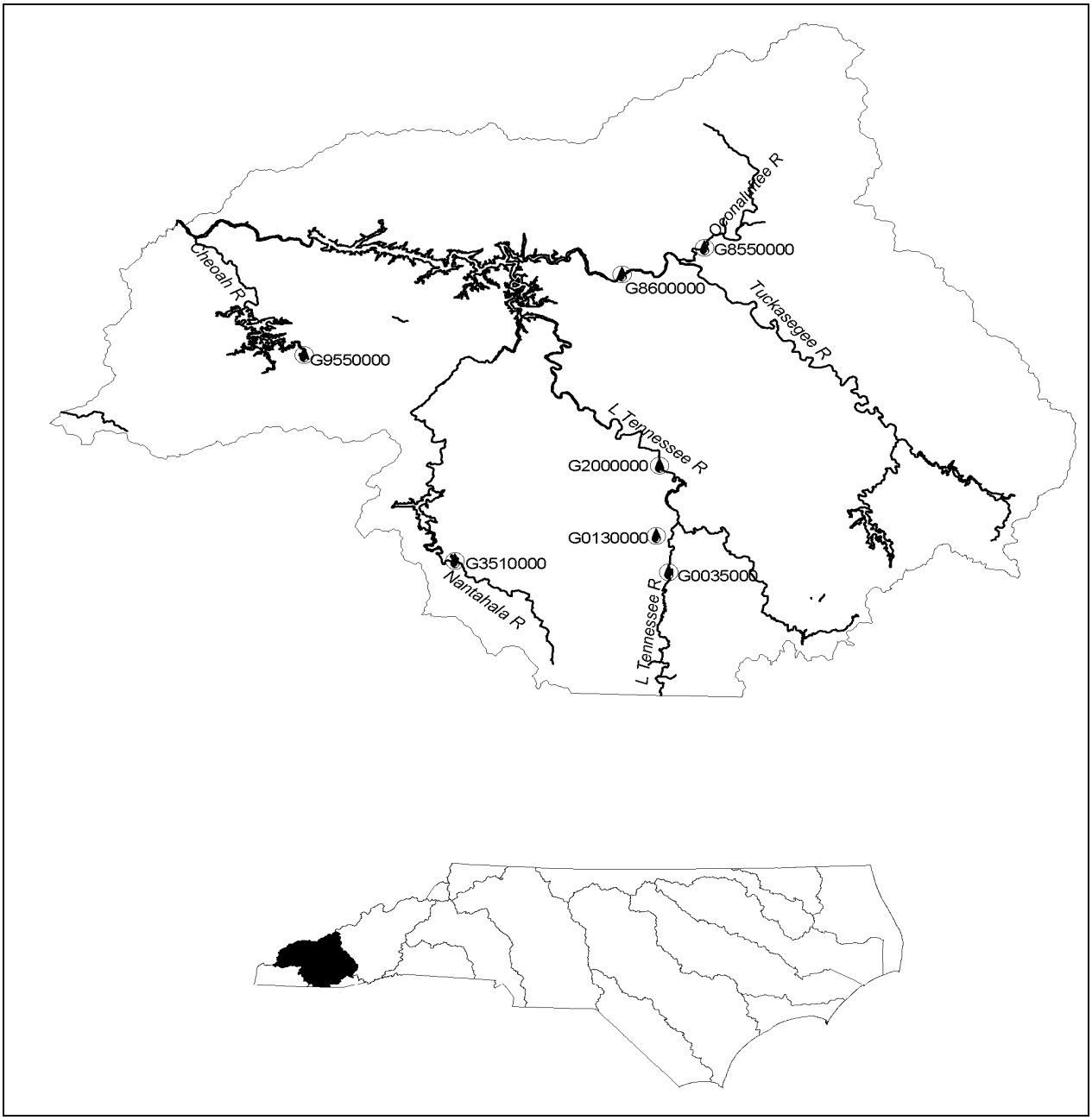

Figure 35. Ambient monitoring sites in the Little Tennessee River basin.

Table 25. Ambient monitoring system stations within the Little Tennessee River basin.

Subbasin	Station code	Station	County	Class
01	G0035000	Little Tennessee River at SR 1651, near Prentiss	Macon	C
	G0130000	Cartoogechaye Creek at SR1152, near Franklin	Macon	B, Tr
	G2000000	Little Tennessee River at NC Hwy 28, at Iotla	Macon	C
02	G8550000	Oconaluftee River at SR1359, at Birdtown	Swain	C, Tr
	G8600000	Tuckasegee River at SR 1364, at Bryson City	Swain	C
03	G3510000	Nantahala River, near Rainbow Springs	Macon	B, Tr, ORW
04	G9550000	Cheoah River at SR 1138, at Robbinsville	Graham	C, Tr

The previous basinwide assessment report stated that the most noticeable feature of water chemistry data was a decline in pH beginning in the winter of 1991 and continuing to the fall of 1994 (NCDEHNR 1996). Data collected since 1994 showed pH recovering to historically observed values after 1995 (Figure 37). There was no known reason for the earlier decline in pH, although episodes of acid deposition could have played a role. There was also the possibilities of monitoring personnel error and pH meter equipment variability.

Fecal coliform bacteria concentrations have decreased considerably from samples collected before 1989 and only occasionally have they exceeded the reference level (Table 26).

For the current basin assessment period (09/01/1994 - 08/31/1999), geometric mean concentrations of fecal coliform bacteria were the lowest among the three time periods, except for samples from the Cheoah River. The geometric mean for the Cheoah River has increased very slightly in contrast to the previous five years (11.5 - 13.2). The proportion of samples greater than the reference level also increased very slightly at the Tuckasegee River (two sites) and at the Cheoah River from the previous five years.

The differences between the geometric mean and proportion of samples greater than 200 colonies/100ml may be biased slightly by considerably fewer samples collected during the period 09/01/1989 to 08/31/1994.

Overall, there were no temporal patterns among any of the parameters at any of the stations. Exceptions include pH (discussed previously) and conductivity measured at the Little Tennessee River at Prentiss and Iotla. At both of these sites, an increase in conductivity was measured beginning in about 1994 (Figure 38). Flow was not found to be an explanatory variable for these increases.

There were few incidents of any parameter exceeding a water quality standard or action level (Tables 27 - 33). The lowest dissolved oxygen concentration observed among all stations was 7.1 mg/l in the Little Tennessee River at Iotla. This concentration was still well above state standards. Copper exceeded the action level of 7 μg/l at all stations, ranging from 7.5% to 20.8% of the total number of samples. Iron exceeded the action level of 1000 μg/l at six stations. However, iron is an element commonly found in soils. The ecological effects of copper and zinc values cannot be inferred without accompanying ecotoxicity data.

Spatial differences in the distribution (percentiles) of several parameters are depicted in groups of box and whisker plots (Figures 39 - 43). Figure 39 explains how to interpret box and whisker plots. These plots provide a graphic representation of the percentiles listed in Tables 27-33 and are useful for depicting spatial differences.

Conductivity was highest and most variable at the Little Tennessee River (at Prentiss and at Iotla) (Figure 40)..

The Nantahala River had the lowest variability for total suspended solids, hardness, fecal coliform bacteria, turbidity, nitrite+nitrate as nitrogen, and total phosphorus (Figures 41 - 43). Medians were low for most parameters, indicating a high frequency of samples with low concentrations for these parameters. The river at this station is supplementally classified as Outstanding Resource Waters.

Hardness appeared to vary the most among the stations, although medians were low, ranging from 4 to 10 mg/l (Figure 41) Geological differences in the watersheds may influence the concentrations of hardness.

Table 26. Summary of fecal coliform bacteria collections from the Little Tennessee River basin, 1968-1999[1].

Site	First Sample	Last Sample	N[2]	Geometric Mean	N > 200	% > 200
L. Tennessee R. at Prentiss	04/29/1981	06/22/1989	72	274.0	45	62.5
	09/06/1989	08/29/1994	14	18.7	2	14.3
	09/28/1994	**08/26/1999**	**49**	**11.5**	**4**	**8.2**
L. Tennessee R. at Iotla	07/29/1968	08/24/1989	150	254.8	84	56.0
	09/06/1989	08/29/1994	17	24.4	2	11.8
	09/28/1994	**08/26/1999**	**49**	**14.4**	**4**	**8.2**
Cartoogechaye Cr	08/23/1971	08/24/1989	42	120.3	18	42.9
	09/06/1989	08/29/1994	20	23.1	3	15.0
	09/28/1994	**08/26/1999**	**49**	**13.7**	**2**	**4.1**
Nantahala R.	04/29/1981	08/24/1989	94	13.4	2	2.1
	09/06/1989	08/29/1994	48	2.3	0	0.0
	09/28/1994	**08/26/1999**	**48**	**1.2**	**0**	**0.0**
Oconaluftee R.	01/31/1985	08/24/1989	36	75.4	9	25.0
	09/06/1989	08/04/1994	17	4.0	0	0.0
	09/20/1994	**08/04/1999**	**50**	**3.2**	**1**	**2.0**
Tuckasegee R.	08/13/1974	08/24/1989	139	294.3	91	65.5
	09/06/1989	0 8/04/1994	15	7.9	1	6.7
	09/20/1994	**08/04/1999**	**50**	**6.6**	**4**	**8.0**
Cheoah R.	04/2/1974	06/15/1989	142	278.6	78	54.9
	09/06/1989	08/04/1994	17	11.5	0	0.0
	09/20/1994	**08/04/1999**	**50**	**13.2**	**2**	**4.0**

[1] Row in bold face represents the summary for the current basin assessment period (9/1/1994 to 8/31/1999).
[2] N = Number of samples; N > 200 = number of samples > 200 colonies/100ml; % > 200 = proportion (%) of samples > 200 colonies/100 ml.

Table 27. Summary of water quality parameters collected from the Little Tennessee River near Prentiss (Station G0035000; Class C) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^{o}C)	56	.	.	.	.	5	23	7	9	14	19	21
Conductivity	56	.	.	.	.	20	216	28	39	54	84	121
Dissolved Oxygen	56	.	5	0	.	7.6	14.2	7.8	8.5	9.7	10.6	11.7
pH (s.u.)	56	.	6-9	1	1.8	5.9	7.3	6.7	6.9	7.0	7.1	7.2
Other												
Total Residue	0	.	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	49	0	.	.	.	2	190	3	7	10	18	40
Hardness	49	0	.	.	.	2	16	4	6	6	8	10
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	49	0	50	4	8.2	2.5	140.0	2.9	4.3	7.7	12.5	35.4
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	4	200	4	8.2	1	1900	1	3	9	35	77
Nutrients												
NH_3 as N	54	17	.	.	.	0.01	0.11	0.01	0.01	0.03	0.06	0.07
TKN as N	54	5	.	.	.	0.1	0.5	0.1	0.1	0.1	0.2	0.3
NO_2+NO_3 as N	54	0	.	.	.	0.04	0.49	0.09	0.13	0.15	0.20	0.24
Total Phosphorus	54	3	.	.	.	0.01	0.38	0.02	0.04	0.06	0.10	0.17
Metals (total)												
Arsenic	53	53	50	0	.	10	10	10	10	10	10	10
Cadmium	53	53	2.0	0	.	2	2	2	2	2	2	2
Chromium	53	53	50	0	.	25	25	25	25	25	25	25
Copper	53	21	7	10	18.9	2	21	2.0	2.0	2.8	5.3	13.2
Iron	51	0	1000	12	23.5	110	8600	206	325	550	953	2200
Lead	53	50	25	0	.	10	20	10	10	10	10	10
Manganese	1	0	.	0	.	28	28	.	.	28	.	.
Nickel	52	52	88	0	.	10	10	10	10	10	10	10
Aluminum	52	0	.	.	.	67	14000	147	330	600	1030	3130
Mercury	53	53	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 28. Summary of water quality parameters collected from Cartoogechaye Creek (Station G0130000 Class B Tr) during the period 09/01/1994 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	56	.	.	.	.	5	23	6	9	14	19	21
Conductivity	56	.	.	.	.	19	53	26	28	33	37	41
Dissolved Oxygen	56	.	6	0	.	7.7	14.4	8.2	8.9	10.2	10.9	11.9
pH (s.u.)	56	.	6-9	0	.	6.0	7.4	6.8	7.0	7.2	7.3	7.3
Other												
Total Residue	49	.	.	.	.	25	120	31	40	50	56	84
Total Sus. Solids	49	3	.	.	.	1	81	1	2	5	8	13
Hardness	49	0	.	.	.	6	17	7	8	10	12	13
Chloride	48	3	230	0	.	1	5	1	1	2	2	2
Turbidity (NTU)	49	0	10	4	8.2	1.5	37.0	1.9	2.7	3.6	6.0	8.9
Bacteria												
Total coliform	49	1	.	.	.	10	9600	44	76	220	570	1160
Fecal coliform	49	3	200	2	4.1	1	980	1	6	16	36	57
Nutrients												
NH_3 as N	55	15	.	.	.	0.01	0.11	0.01	0.01	0.03	0.05	0.07
TKN as N	55	3	.	.	.	0.1	0.5	0.1	0.1	0.1	0.2	0.2
NO_2+NO_3 as N	55	0	.	.	.	0.02	0.30	0.05	0.09	0.10	0.14	0.18
Total Phosphorus	55	19	.	.	.	0.01	0.13	0.01	0.01	0.01	0.02	0.04
Metals (total)												
Arsenic	54	54	50	0	.	10	10	10	10	10	10	10
Cadmium	54	54	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	54	54	50	0	.	25	25	25	25	25	25	25
Copper	54	20	7	9	16.7	2	35	2.0	2.0	3.0	5.0	9.1
Iron	53	0	1000	5	9.4	150	3500	170	260	350	460	768
Lead	54	53	25	.	.	10	12	10	10	10	10	10
Manganese	51	1	.	.	.	10	130	22	25	31	39	51
Nickel	54	54	88	.	.	10	10	10	10	10	10	10
Aluminum	53	0	.	.	.	58	3200	78	138	200	343	620
Mercury	54	54	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 29. Summary of water quality parameters collected from the Little Tennessee River at Iotla (Station G2000000; Class C) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	56	.	.	.	.	5	26	6	9	13	21	23
Conductivity	56	.	.	.	.	23	143	27	35	42	56	79
Dissolved Oxygen	55	.	5	0	.	7.1	14.4	7.4	8.3	9.6	10.7	12.5
pH (s.u.)	55	.	6-9	0	.	6.2	7.8	6.6	6.7	6.9	7.0	7.3
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	49	0	.	.	.	2	130	2	4	7	12	36
Hardness	49	0	.		.	4	19	6	7	9	10	11
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	49	0	50	3	6.1	2.3	120.0	3.1	4.5	6.4	9.3	33.8
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	49	2	200	4	8.2	1	1400	1	3	18	33	154
Nutrients												
NH_3 as N	55	16	.	.	.	0.01	0.17	0.01	0.01	0.03	0.05	0.07
TKN as N	55	4	.	.	.	0.1	0.4	0.1	0.1	0.1	0.2	0.3
NO_2+NO_3 as N	55	0	.	.	.	0.03	0.45	0.07	0.11	0.14	0.19	0.25
Total Phosphorus	55	1	.	.	.	0.01	0.34	0.02	0.02	0.03	0.05	0.08
Metals (total)												
Arsenic	54	54	50	0	.	10	10	10	10	10	10	10
Cadmium	54	54	2	0	.	2	2	2	2	2	2	2
Chromium	54	54	50	0	.	25	25	25	25	25	25	25
Copper	54	19	7	9	16.7	2	16	2.0	2.0	2.6	5.0	9.1
Iron	52	1	1000	9	17.3	10	8200	257	320	510	800	1960
Lead	54	54	25	0	.	10	10	10	10	10	10	10
Manganese	2	0		.	.	36	41	.	36	39	41	.
Nickel	54	54	88	0	.	10	10	10	10	10	10	10
Aluminum	52	0	.	.	.	70	12000	161	215	370	765	2290
Mercury	53	53	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 30. Summary of water quality parameters collected from the Oconaluftee River (Station G8550000; Class C Tr) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	56	.	.	.	.	2	22	5	9	14	18	20
Conductivity	56	.	.	.	.	13	37	17	18	20	22	23
Dissolved Oxygen	56	.	6	0	.	8.3	13.8	8.5	9.1	10.2	11.2	11.8
pH (s.u.)	56	.	6-9	0	.	6.3	8.8	6.7	6.9	7.2	7.4	7.9
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	50	4	.	.	.	1	130	1	2	3	6	13
Hardness	50	0	.	.	.	1	12	2	4	5	6	8
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	50	6	50	1	2.0	1.0	150.0	1.0	1.4	2.2	4.0	6.5
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	50	15	200	1	2.0	1	210	1	1	2	8	24
Nutrients												
NH_3 as N	60	14	.	.	.	0.01	0.12	0.01	0.01	0.03	0.06	0.09
TKN as N	60	3	.	.	.	0.1	1.0	0.1	0.1	0.2	0.2	0.3
NO_2+NO_3 as N	60	0	.	.	.	0.08	1.40	0.14	0.18	0.23	0.27	0.32
Total Phosphorus	60	8	.	.	.	0.01	0.21	0.01	0.01	0.03	0.04	0.06
Metals (total)												
Arsenic	56	56	50	0	.	10	10	10	10	10	10	10
Cadmium	56	56	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	56	56	50	0	.	25	25	25	25	25	25	25
Copper	56	27	7	6	10.7	2	19	2.0	2.0	2.0	3.0	7.4
Iron	56	0	1000	4	7.1	51	5600	76	98	160	255	377
Lead	56	53	25	0	.	10	20	10	10	10	10	10
Manganese	1	1	200	.	.	10	10	.	.	10	.	.
Nickel	56	56	88	0	.	10	10	10	10	10	10	10
Aluminum	56	3	.	.	.	50	6200	66	105	135	205	367
Mercury	56	56	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 31. Summary of water quality parameters collected from Tuckasegee River (Station G8600000; Class C) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	56	.	.	.	.	3	24	6	9	14	19	22
Conductivity	56	.	.	.	.	15	37	21	22	24	26	28
Dissolved Oxygen	56	.	5	0	.	8.1	14.0	8.4	9.2	10.1	11.0	11.8
pH (s.u.)	56	.	6-9	0	.	6.6	8.9	6.8	7.0	7.2	7.6	8.2
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	50	1	.	.	.	1	130	2	3	4	14	44
Hardness	50	0	.	.	.	2	14	4	5	7	8	9
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	50	0	50	4	8.0	1.3	110.0	1.9	2.2	3.2	6.9	28.5
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	50	13	200	4	8.0	1	690	1	1	5	17	89
Nutrients												
NH_3 as N	58	14	.	.	.	0.01	0.19	0.01	0.01	0.03	0.05	0.08
TKN as N	58	3	.	.	.	0.1	0.5	0.1	0.1	0.1	0.2	0.3
NO_2+NO_3 as N	58	0	.	.	.	0.01	1.80	0.06	0.12	0.16	0.20	0.23
Total Phosphorus	58	7	.	.	.	0.01	0.25	0.01	0.01	0.02	0.03	0.10
Metals (total)												
Arsenic	54	54	50	0	.	10	10	10	10	10	10	10
Cadmium	54	54	2	0	.	2	2	2	2	2	2	2
Chromium	54	54	50	0	.	25	25	25	25	25	25	25
Copper	54	19	7	11	20.4	2	17	2.0	2.0	3.0	6.0	9.0
Iron	54	0	1000	9	16.7	130	7400	169	200	315	710	3530
Lead	54	52	25	1	1.9	10	26	10	10	10	10	10
Manganese	2	1	.	.	.	10	10	.	10	10	10	.
Nickel	54	54	88	0	.	10	10	10	10	10	10	10
Aluminum	54	0	.	.	.	77	9200	100	150	210	530	2900
Mercury	54	54	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 32. Summary of water quality parameters collected from the Nantahala River (Station G3510000; Class B Tr ORW) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	55	.	.	.	.	3	21	6	9	13	17	19
Conductivity	54	.	.	.	.	9	36	12	14	15	17	18
Dissolved Oxygen	55	.	6	0	.	7.7	13.9	8.5	9.0	9.9	10.5	11.5
pH (s.u.)	55	.	6-9	1	1.8	5.8	7.5	6.7	6.9	7.0	7.1	7.3
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	48	15	.	.	.	1	7	1	1	2	3	3
Hardness	47	0	.	.	.	1	16	2	3	4	6	7
Chloride	1	0	230	0	.	16	16	.	.	16	.	.
Turbidity (NTU)	48	20	10	0	.	1.0	4.5	1.0	1.0	1.1	1.7	2.2
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	48	37	200	0	.	1	30	1	1	1	1	2
Nutrients												
NH_3 as N	54	19	.	.	.	0.01	0.11	0.01	0.01	0.02	0.05	0.06
TKN as N	54	7	.	.	.	0.0	0.5	0.1	0.1	0.1	0.2	0.2
NO_2+NO_3 as N	54	17	.	.	.	0.01	0.10	0.01	0.01	0.02	0.03	0.04
Total Phosphorus	54	32	.	.	.	0.01	0.03	0.01	0.01	0.01	0.01	0.02
Metals (total)												
Arsenic	53	53	50	0	.	10	10	10	10	10	10	10
Cadmium	53	53	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	53	53	50	0	.	25	25	25	25	25	25	25
Copper	53	24	7	4	7.5	2	50	2.0	2.0	2.2	3.7	6.2
Iron	52	8	1000	0	.	50	410	50	57	100	130	163
Lead	53	53	25	0	.	10	10	10	10	10	10	10
Manganese	1	1			.	10	10	.	.	10	.	.
Nickel	53	53	88	0	.	10	10	10	10	10	10	10
Aluminum	52	9	.	.	.	50	440	50	53	87	120	163
Mercury	53	53	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 33. Summary of water quality parameters collected from the Cheoah River (Station G9550000; Class C Tr) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	56	.	.	.	.	3	23	7	10	13	18	20
Conductivity	56	.	.	.	.	17	46	25	26	29	36	40
Dissolved Oxygen	56	.	6	0	.	8.2	13.0	8.4	8.8	9.9	10.7	11.6
pH (s.u.)	56	.	6-9	0	.	6.6	7.8	6.7	7.0	7.1	7.3	7.4
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	50	2	20	4.	8.0	1	140	1	2	4	8	11
Hardness	50	0	.	.	.	4	19	6	7	10	12	15
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	50	5	10	1	2.0	1.0	95.0	1.0	1.6	2.8	3.8	5.4
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	50	5	200	2	4.0	1	1000	1	5	16	31	81
Nutrients												
NH_3 as N	59	18	.	.	.	0.01	0.15	0.01	0.01	0.03	0.05	0.09
TKN as N	59	4	.	.	.	0.1	0.4	0.1	0.1	0.1	0.2	0.2
NO_2+NO_3 as N	59	0	.	.	.	0.02	0.32	0.09	0.12	0.15	0.20	0.23
Total Phosphorus	59	8	.	.	.	0.01	0.21	0.01	0.01	0.02	0.02	0.05
Metals (total)												
Arsenic	55	55	50	0	.	10	10	10	10	10	10	10
Cadmium	55	55	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	55	55	50	0	.	25	25	25	25	25	25	25
Copper	55	22	7	5	9.1	2	160	2.0	2.0	3.0	4.0	6.0
Iron	55	0	1000	3	5.5	64	5400	100	113	210	280	490
Lead	55	52	25	0	.	10	25	10	10	10	10	10
Manganese	2	0	.	.	.	12	15	.	12	14	15	.
Nickel	55	55	88	0	.	10	10	10	10	10	10	10
Aluminum	55	4	.	.	.	50	6000	57	90	160	218	360
Mercury	55	55	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

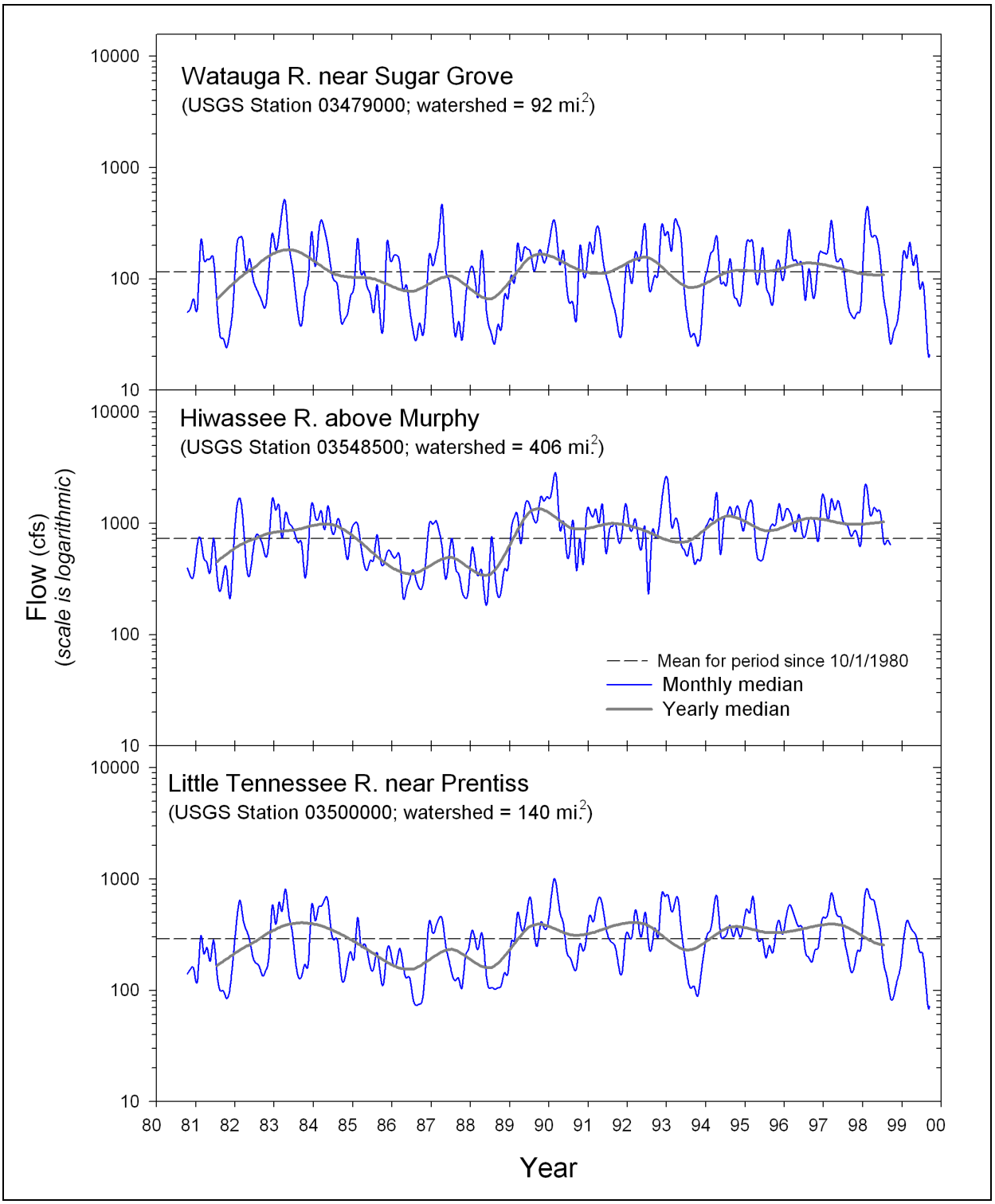

Figure 36. Regional patterns for river flow, 1980 - 1999. (Data from US Geological Survey: http://nc.water.usgs.gov/).

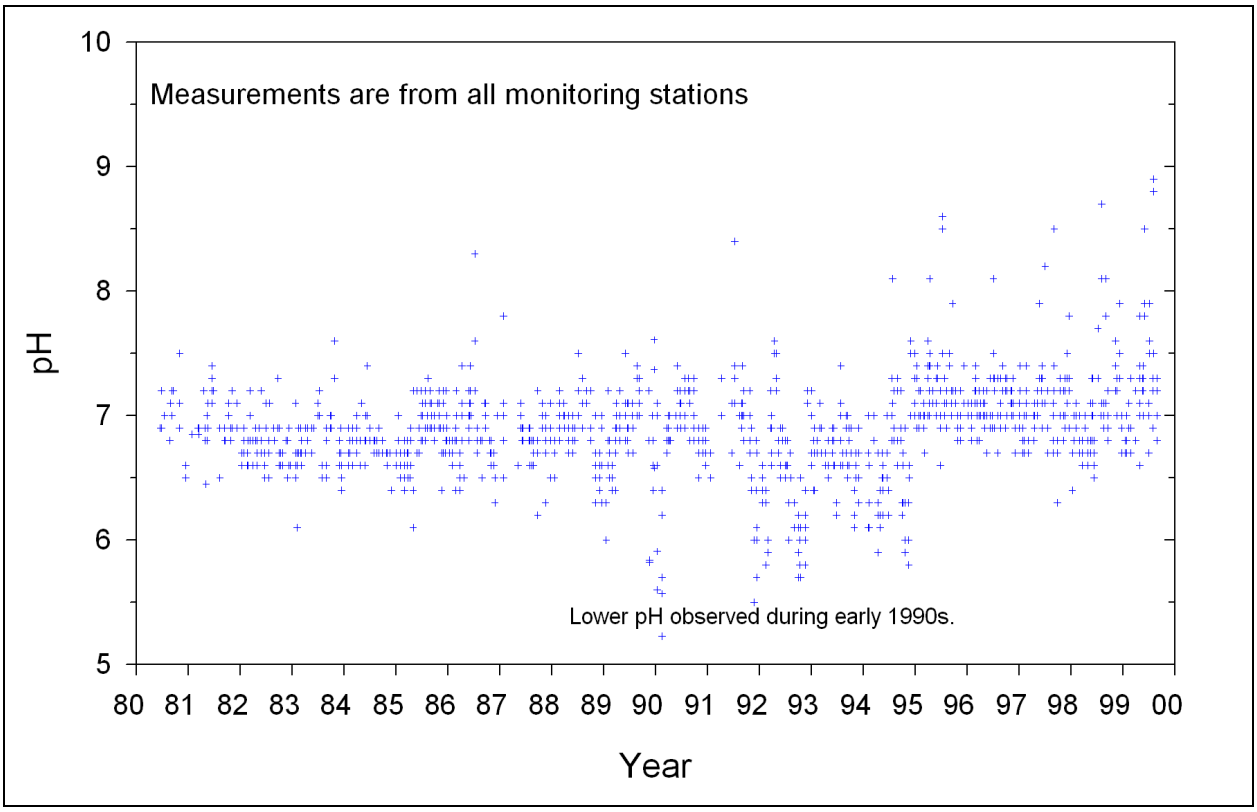

Figure 37. Temporal patterns for pH from all stations in the Little Tennessee River basin, 1980 - 1999.

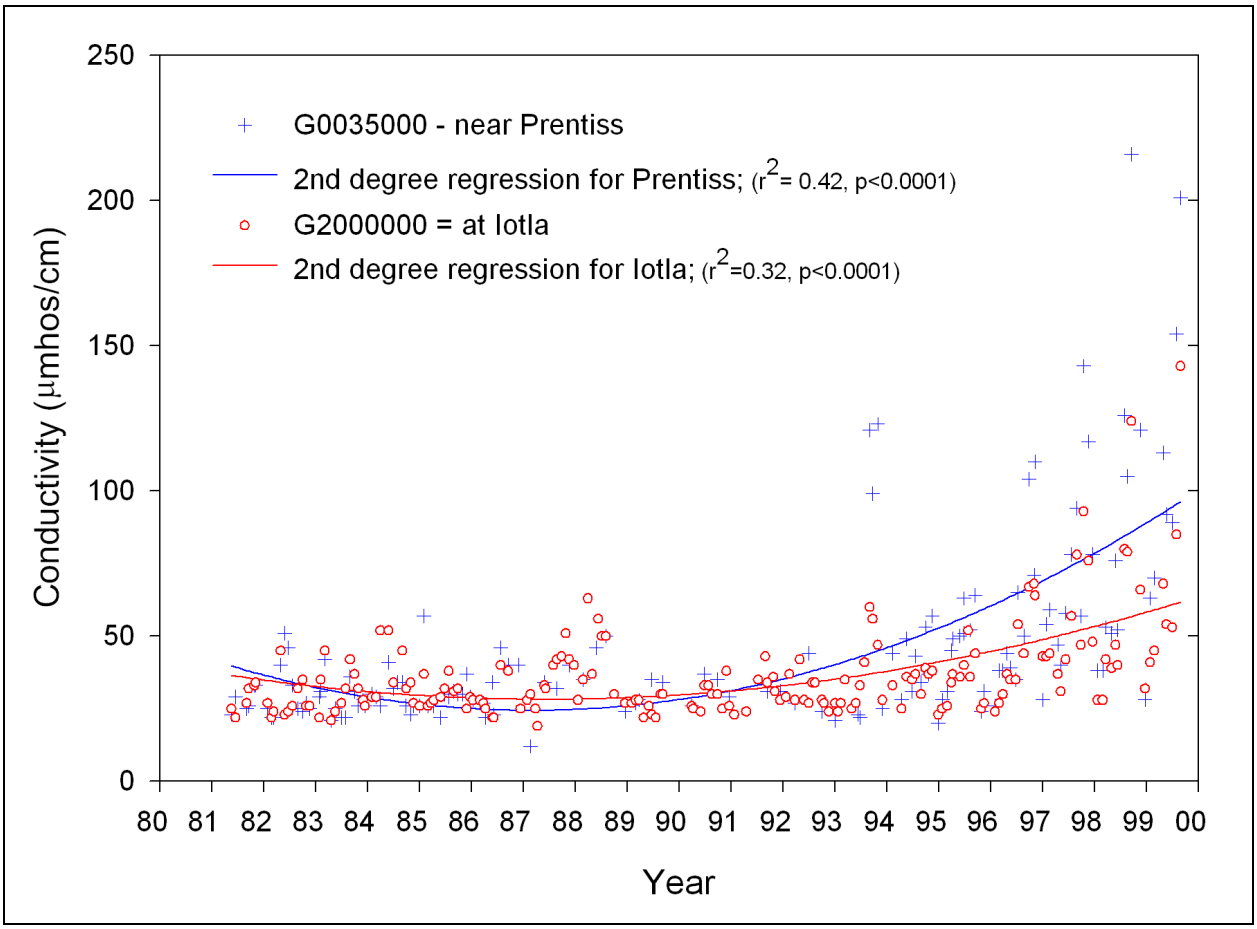

Figure 38. Temporal patterns for conductivity at the Little Tennessee River at Prentiss and at Iotla, 1980 - 1999.

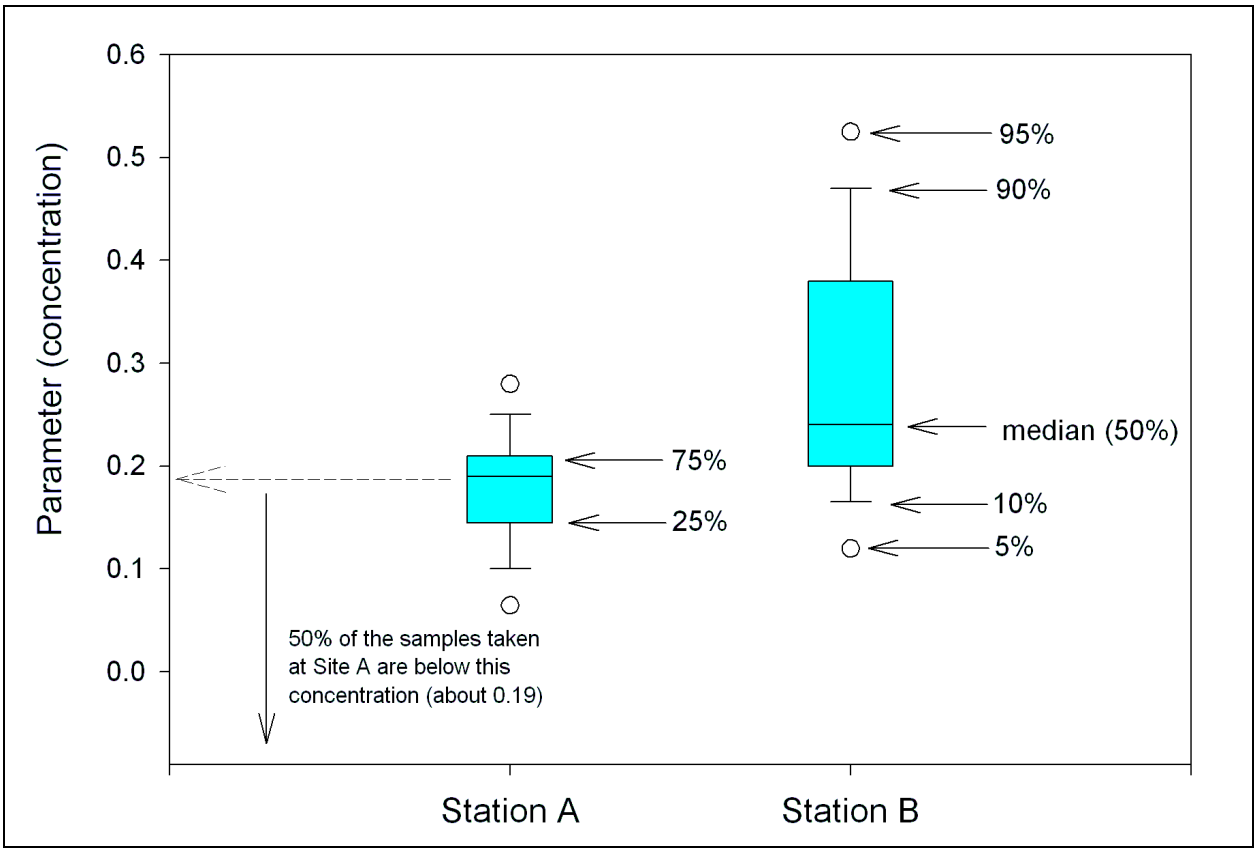

Figure 39. Explanation of box plots. Box plots (or box and whisker plots) show the distribution of measurements of a parameter. Here the distribution of measurements of a hypothetical parameter are compared between Station A and Station B. The percentage of measurements at or below a particular concentration are indicated on the figure. Note that the median and variation of measurements taken at Station B are greater than the median of Station A.

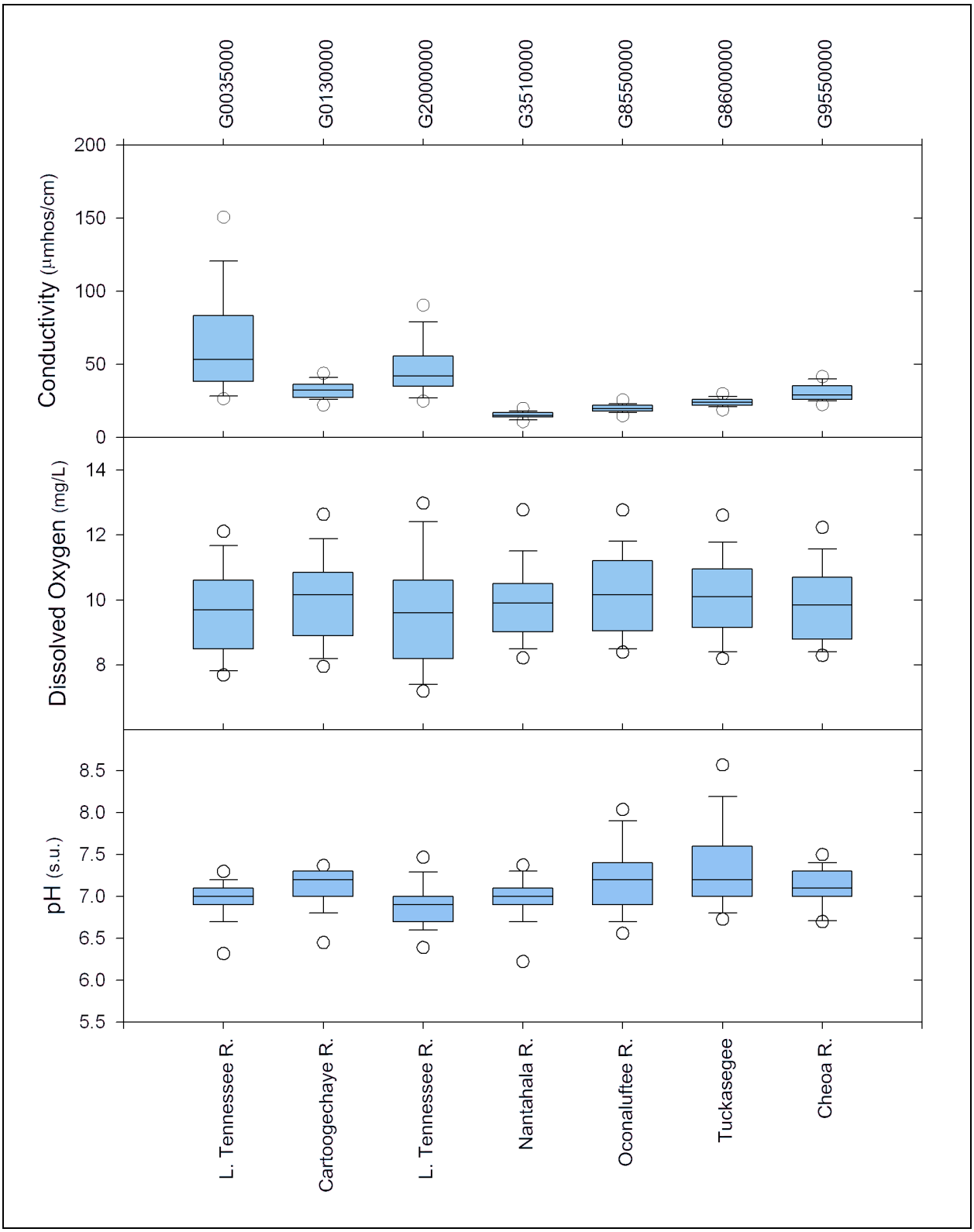

Figure 40. Box plots of conductivity, dissolved oxygen, and pH in the Little Tennessee River basin, 1980 - 1999.

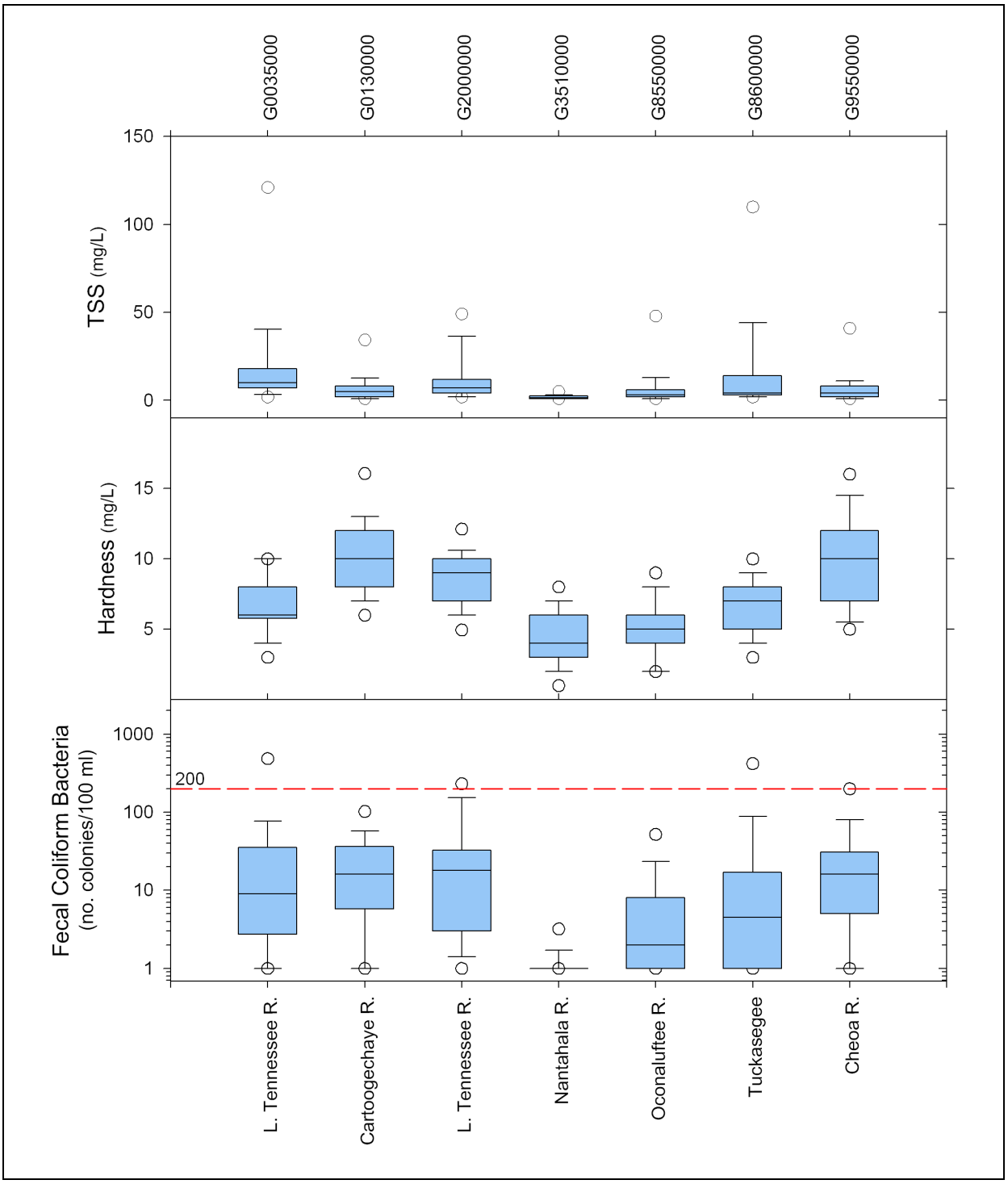

Figure 41. Box plots of total suspended solids (TSS), hardness, and fecal coliform bacteria in the Little Tennessee River basin, 1980 - 1999. Dashed line at 200 colonies/100 ml represents a reference level.

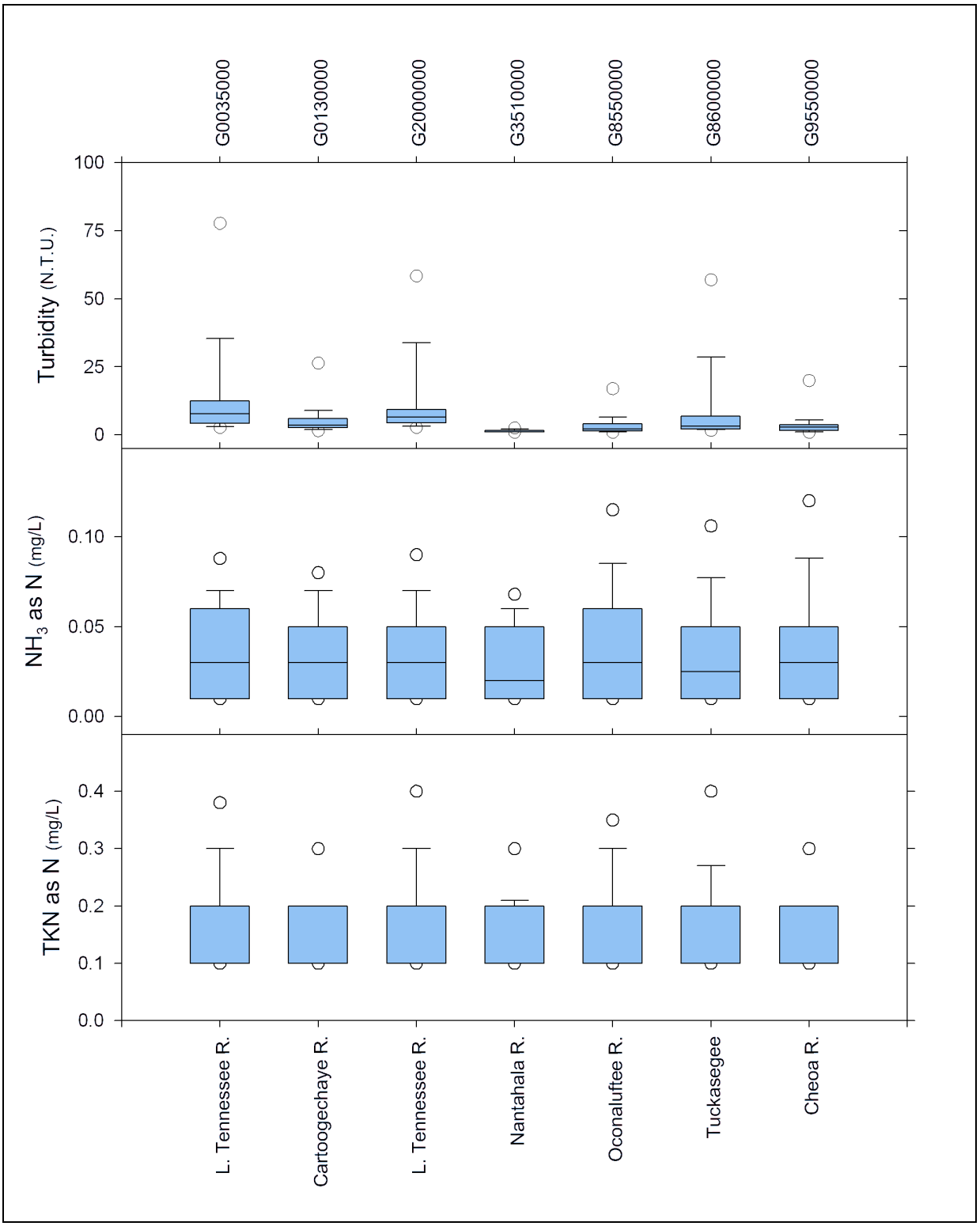

Figure 42. Box plots of turbidity, ammonia (NH_3 nitrogen), and total Kjeldahl nitrogen (TKN) in the Little Tennessee River basin, 1980 - 1999.

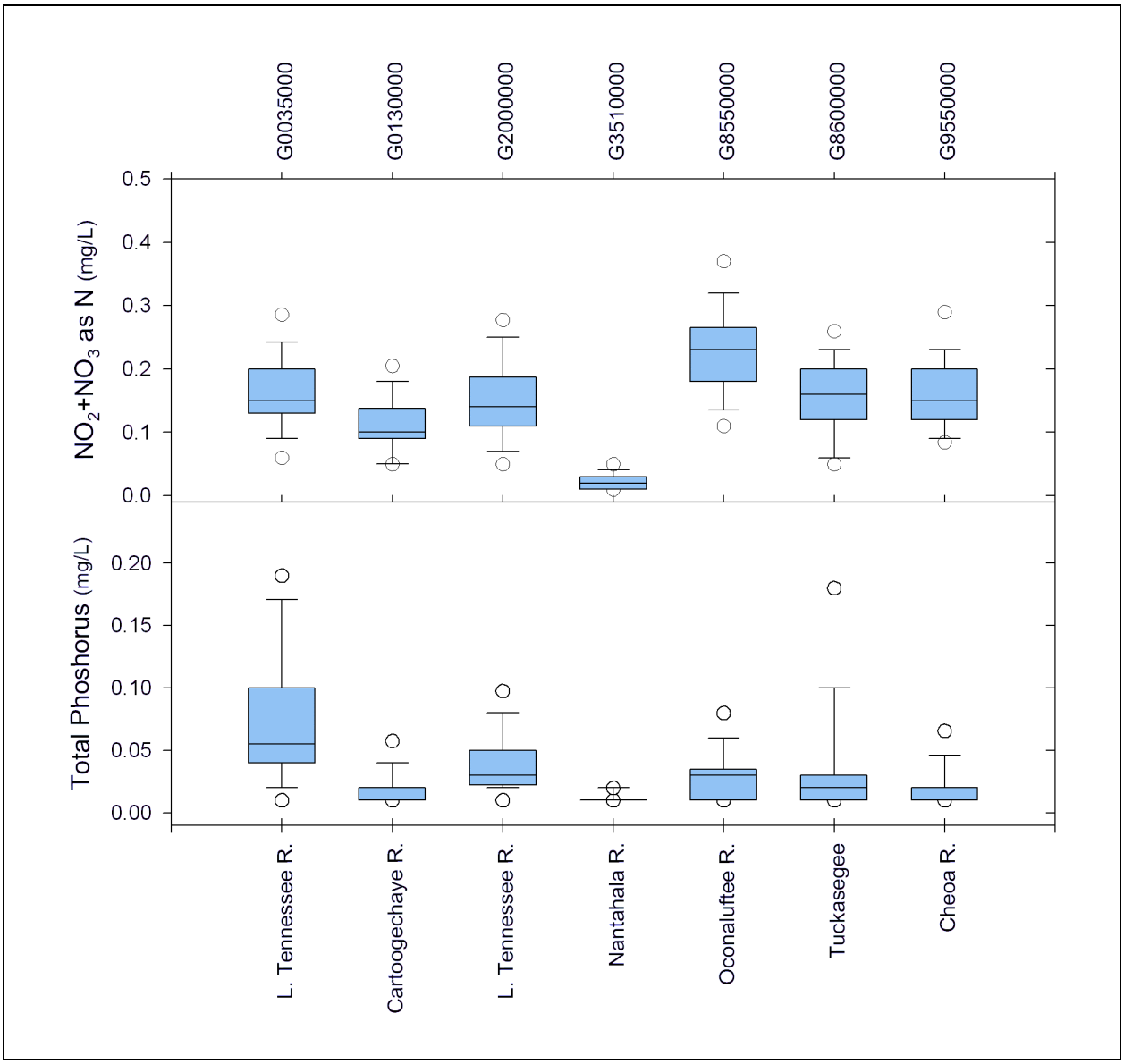

Figure 43. Box plots of nitrite + nitrate (NO_2+NO_3) as nitrogen and total phosphorus in the Little Tennessee River basin, 1980 - 1999.

AQUATIC TOXICITY MONITORING

Three facilities in the Little Tennessee River basin have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Franklin, Bryson City, and Tuckasegee W&SA wastewater treatment plants (Figure 44 and Table 34). All three facilities also have a WET permit limit.

The number of facilities monitoring for whole effluent toxicity has increased from one in 1987 (first year that whole effluent toxicity limits were written into permits in North Carolina) to three by 1992 (Figure 45). The compliance rate of these three facilities has been greater than 96% since 1990 (Figure 45).

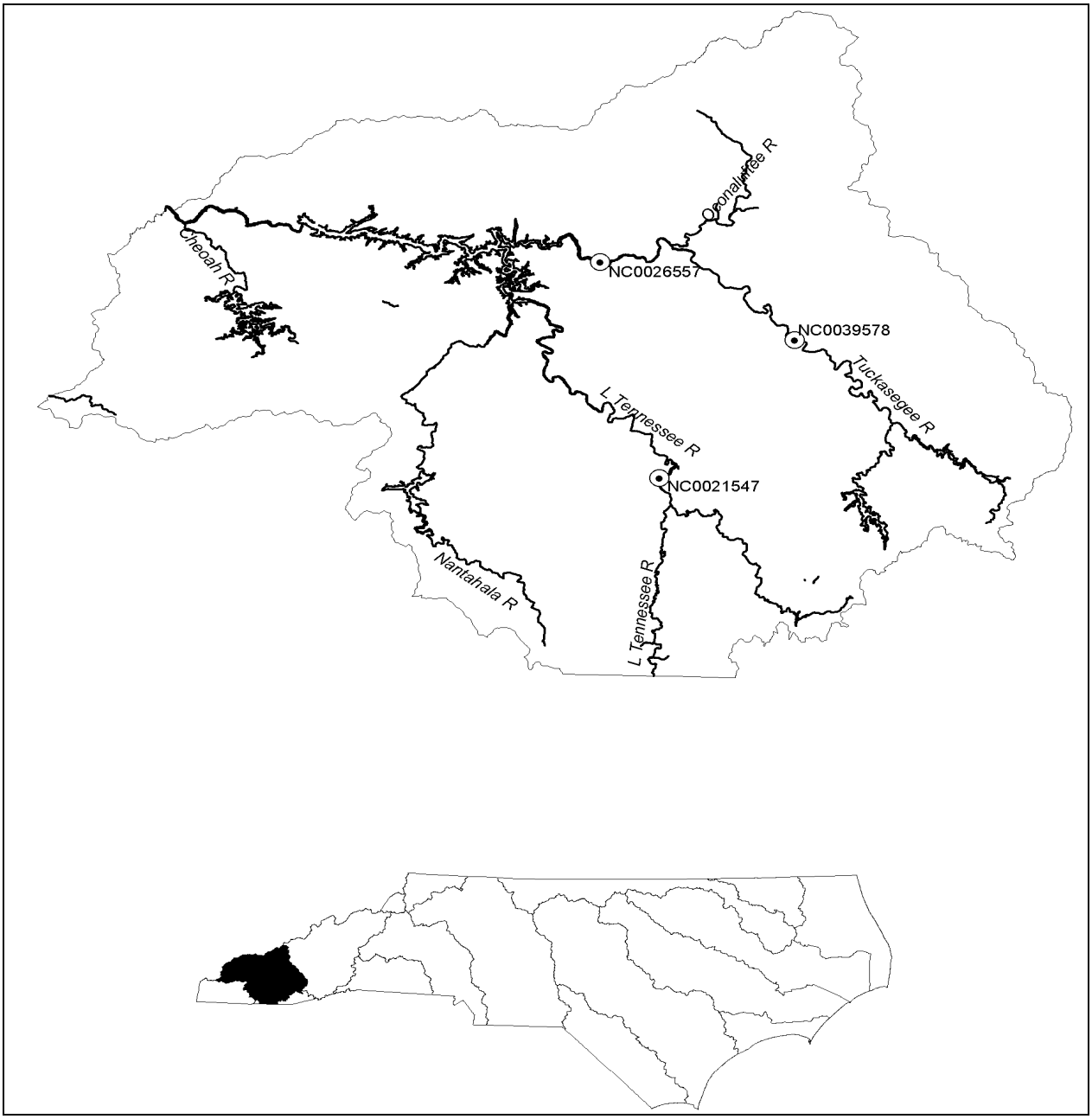

Figure 44. Location of facilities in the Little Tennessee River basin required to perform whole effluent toxicity testing.

Table 34. Facilities in the Little Tennessee River basin required to perform whole effluent toxicity testing and their compliance record.

Facility	Franklin WWTP	Bryson City WWTP	Tuckasegee W & SA WWTP
NPDES Permit No.	NC0021547/001	NC0026557/001	NC0039578/001
Receiving stream	Little Tennessee R	Tuckasegee R	Tuckasegee R
County	Macon	Swain	Jackson
Permitted flow (MGD)	1.65	0.6	1.5
7Q10	157	365	165
IWC[1] (%)	1.60	0.25	1.38
Pre-1999 passes[2]	29	34	44
Pre-1999 fails	1	0	4
1999 passes[2]	6	4	4
1999 fails	0	0	0

[1] Instream waste concentration

[2] Note that "pass" denotes meeting a permit limit or, for those facilities with a monitoring requirement, meeting a target value. The actual test result may be a "pass" (from a pass/fail acute or chronic test), LC_{50}, or chronic value. Conversely, "fail" means failing to meet a permit limit or target value.

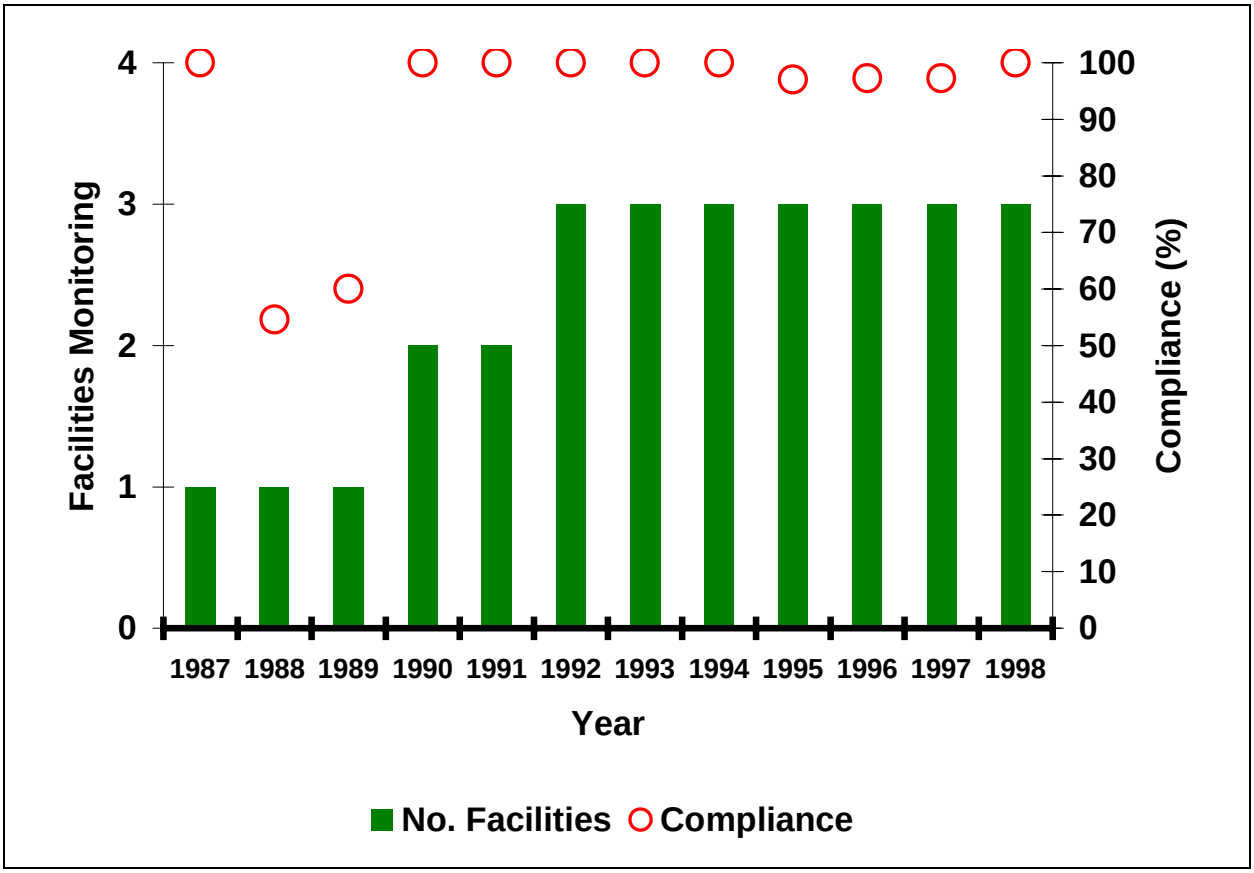

Figure 45. Compliance record of facilities in the Little Tennessee River basin required to perform whole effluent toxicity testing, 1987 - 1998. The compliance values were calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.

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GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL *a*	Chlorophyll *a*.
Division	The North Carolina Division of Water Quality.
D.O.	Dissolved Oxygen.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include mountains, piedmont, coastal plain, sandhills, and slate belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).
NPDES	National Pollutant Discharge Elimination System.
NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters.
NTU	Nephelometric Turbidity Unit.

GLOSSARY (continued)

ORW	Outstanding Resource Waters.
Parametric Coverage	A listing of parameters measured and reported.
SOC	A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits.
Total S (or S)	The number of different taxa present in a benthic macroinvertebrate sample.
UT	Unnamed tributary.
WWTP	Wastewater treatment plant.
Web Sites	Basinwide planning -- http://h2o.enr.state.nc.us/basinwide/basinwide/default.html
	Biological monitoring -- http://www.esb.enr.state.nc.us/bau.html
	Fish kills -- http://www.esb.enr.state.nc.us/fishkill/fishkill00.html
	North Carolina Administrative Code that relates to the Division of Water Quality and water quality protection -- http://h2o.enr.state.nc.us/rules/ruleindex.html

Appendix B1. Benthic macroinvertebrate sampling and criteria for freshwater wadeable and flowing waters.

Benthic macroinvertebrates can be collected using two sampling procedures. The Division's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997b).

An abbreviated method (4-sample EPT) includes one kick-net sample, one bank sweep, one leaf pack sample, and visual collections from large rocks and logs. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification. "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality.

The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥ 10 specimens).

Several data-analysis summaries (metrics) can be produced to detect water quality problems (Table B1).

Table B1. Benthos classification criteria for flowing water systems in the mountain ecoregion.

Metric	Sample type	Bioclass	Score
EPT S	10-sample Qualitative	Excellent	> 41
		Good	32 - 41
		Good-Fair	22 - 31
		Fair	12 - 21
		Poor	0 - 11
	4-sample EPT	Excellent	> 35
		Good	28 - 35
		Good-Fair	19 - 27
		Fair	11 - 18
		Poor	0 - 10
Biotic Index (range 0 – 10)	10-sample Qualitative	Excellent	< 4.05
		Good	4.06 - 4.88
		Good-Fair	4.89 - 5.74
		Fair	5.75 - 7.00
		Poor	> 7.00

These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with criteria to assign water quality ratings (bioclassifications). Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions.

Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for Mountain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

The expected EPT taxa richness values are lower in small high-quality mountain streams (< 4 m wide or with a drainage area < 3.5 mi^2). For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria.

EPT taxa richness and biotic index values also can be affected by seasonal changes. Criteria for assigning bioclassification are based on summer sampling: June-September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Flow Measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes. For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low, or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow > 140% of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow < 60% of the long-term mean, while normal flow is 60-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

Habitat Evaluation

The Division has developed a habitat assessment form to better evaluate the physical habitat of a stream. The habitat score has a potential range of 1-100, based on evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed to assign impairment ratings.

Appendix B2. **Benthic macroinvertebrate data collected in the Little Tennessee River basin, 1983 - 1999. Current basinwide monitoring sites have the Map No. bolded.**

Subbasin/Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
01								
L Tennessee R	SR 1629	Macon	**B-1**	2-(1)	08/99	60/14	6.23/4.74	F
					08/94	69/27	5.27/4.41	G-F
L Tennessee R	SR 1651	Macon	**B-2**	2-(1)	10/99	62/29	4.41/3.48	G-F
					08/87	64/20	5.63/4.74	G-F
					08/85	52/18	5.53/4.77	F
					08/83	66/21	5.94/4.64	F
L Tennessee R	NC 28	Macon	**B-3**	2-(1)	08/99	86/32	5.33/3.75	G-F
					07/94	57/27	5.02/4.27	G
					08/87	75/28	5.49/4.44	G-F
					06/86	72/26	5.70/4.51	G-F
					08/85	64/26	5.18/4.26	G-F
					08/84	64/28	4.92/4.17	G-F
					08/83	73/30	5.28/4.12	G-F
Middle Cr	SR 1635	Macon	B-4	2-(8)	08/99	-/25	-/4.15	G-F
Coweeta Cr	SR 1114	Macon	**B-5**	2-10	08/99	-/39	-/3.01	E
					07/94	-/39	-/2.89	E
Cartoogechaye Cr	SR 1307	Macon	B-6	2-19-(1)	06/96	84/45	3.21/2.70	E
Cartoogechaye Cr (downstream)	SR 1307	Macon	B-7	2-19-(1)	06/96	77/36	3.93/2.83	G
Cartoogechaye Cr	SR 1146	Macon	**B-8**	2-19-(1)	08/99	-/41	-/3.18	E
					07/94	-/30	-/3.29	G
Cartoogechaye Cr	SR 1152	Macon	B-9	2-19-(10.5)	08/88	62/16	5.31/4.44	G-F
Cullasaja R (above Mirror Lake)	US 64	Macon	B-10	2-21-(0.5)	06/99	47/14	5.70/4.97	F
					10/96	-/18	-/4.82	F
					10/91	-/9	-/5.59	P
					12/90	-/14	-/4.87	F
Mill Cr (above old WWTP)		Macon	B-11	2-21-3	10/91	36/12	5.32/4.41	F
					12/90	-/15	-/4.25	F
Mill Cr (below old WWTP)		Macon	B-12	2-21-3	06/99	44/15	4.53/3.69	F
					10/91	50/12	5.49/3.90	F
					12/90	-/17	-/3.14	F
Cullasaja R (below Lake Sequoyah)	off US 64	Macon	B-13	2-21-(5.5)	10/96	-/20	-/4.12	G-F
					07/94	70/27	5.10/3.76	G-F
					10/91	-/20	-/4.02	G-F
					12/90	-/30	-/3.38	G-F
Cullasaja R (at Jackson Hole)	off US 64	Macon	B-14	2-21-(5.5)	06/99	-/49	-/2.70	E
Cullasaja R	SR 1678	Macon	B-15	2-21-(5.5)	06/99	90/50	3.71/2.86	E
					10/96	86/45	3.57/2.60	E
					07/94	85/42	4.01/3.23	E
					10/91	95/48	3.74/3.08	E
					12/90	-/37	-/2.71	G
Cullasaja R	US 64/SR 1524	Macon	B-16	2-21-(5.5)	10/96	-/37	-/2.47	G
					10/91	-/35	-/3.33	G
					12/90	-/28	-/3.17	G-F
Cullasaja R	US 64/SR 1668	Macon	**B-17**	2-21-(5.5)	08/99	99/51	3.95/3.34	E
Big Cr (above Highlands WTP)		Macon	B-18	2-21-51-1-(4)	06/99	-/41	-/2.04	E
Turtle Pond Cr	SR 1620	Macon	B-19	2-21-8	06/99	-/42	-/1.90	E
Brush Cr (near mouth)	near US 64	Macon	B-20	2-21-13	06/99	-/47	-/2.09	E
Buck Cr	NC 28	Macon	B-21	2-21-15	06/99	-/38	-/2.11	E
Walnut Cr	SR 1533	Macon	B-22	2-21-17	06/99	-/34	-/2.03	G
Ellijay Cr	SR 1524	Macon	B-23	2-23-23	06/99	-/40	-/3.20	E
N Pr Ellijay Cr	SR 1001	Macon	B-24	2-21-23-2	06/99	-/39	-/2.01	E
Crawford Br (at Franklin Memorial Pk)		Macon	B-25	2-22	06/99	-/24	-/3.66	NR
Crawford Br (at E Main St, Franklin)		Macon	B-26	2-22	06/99	33/7	7.50/4.70	NR
Iotla Cr	SR 1372	Macon	**B-27**	2-27	08/99	-/35	-/3.80	G
					07/94	-/21	-/4.25	G-F
Cowee Cr	NC 28	Macon	**B-28**	2-29	08/99	-/35	-/3.06	G
					07/94	-/24	-/3.32	G-F
Burningtown Cr	SR 1371	Macon	**B-29**	2-38	08/99	-/39	-/3.19	E
					07/94	-/30	-/2.72	G
Tellico CR	SR 1367	Macon	**B-30**	2-40	08/99	108/54	3.57/2.61	E
					07/94	84/43	3.46/2.69	E

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
02								
Little Tennessee R	off SR 1113	Swain	**B-1**	2-(1)	08/99	75/31	4.73/3.67	G
					07/94	82/39	4.71/4.15	G
					06/94	79/32	4.61/3.98	G
Alarka Cr	SR 1140	Swain	B-2	2-69-(2.5)	11/88	59/37	2.33/1.63	E
Alarka Cr	SR 1185	Swain	**B-3**	2-69-(2.5)	08/99	86/51	3.66/3.11	E
					07/94	91/48	3.69/3.08	E
Bearmeat Br	Near SR 1140	Swain	B-4	2-69-3	11/88	-/24	-/1.71	G
Tuckasegee R (below Greenland Cr)		Jackson	B-5	2-79-(0.5)	06/88	99/51	3.85/2.80	E
Tuckasegee R	SR 1140	Jackson	**B-6**	2-79-(0.5)	07/99	-/46	-/1.95	E
					09/94	-/39	-/2.42	E
					09/89	101/47	3.59/1.97	E
UT Panthertown Creek		Jackson	B-7	2-79-1	06/99	-/26	-/1.25	E
Panthertown Creek		Jackson	B-8	2-79-1	06/99	-/28	-/1.72	G
Hurricane Cr	SR 1145	Jackson	B-9	2-79-23-2	12/91	-/45	-/1.66	E
					09/89	-/39	-/2.06	E
Cedar Cr	SR 1120	Jackson	B-10	2-79-23-3	09/89	89/40	4.36/2.92	G
Grassy Camp Cr (headwaters)		Jackson	B-11	2-79-23-4-1	08/84	52/21	4.27/2.04	G-F
Grassy Camp Cr	SR 1145	Jackson	B-12	2-79-23-4-1	09/89	-/27	-/2.03	G-F
UT Shortoff Cr	SR 1150	Jackson	B-13	2-79-23-4-1-1	08/84	54/27	2.50/1.18	E
Mill Cr	SR 1145	Jackson	B-14	2-79-23-5	09/89	-/28	-/2.08	G
Pine Cr	SR 1145	Jackson	B-15	2-79-23-6	09/89	87/36	4.34/2.96	G
W Fk Tuckasegee R	SR 1133	Jackson	B-16	2-79-23-(7)	07/99	-/35	-/2.98	G
Caney Fk	SR 1740	Jackson	**B-17**	2-79-28-(2.5)	07/99	97/53	3.68/3.03	E
					07/94	93/56	3.25/2.68	E
Mull Cr	SR 1737	Jackson	B-18	2-79-28-3	07/94	-/29	-/1.45	G
Moses Cr	SR 1739	Jackson	**B-19**	2-79-28-8	07/99	-/37	-/1.91	E
Moses Cr	SR 1740	Jackson	B-20	2-79-28-8	07/94	-/33	-/2.47	G
Cullowhee Cr	SR 1001	Jackson	**B-21**	2-79-31	07/99	-/43	-/2.95	E
					08/94	-/32	-/2.59	G
Whiterock Cr (near school)		Jackson	B-22	2-79-31-1-(2)	12/91	-/31	-/1.64	E
Savannah Cr	SR 1367	Jackson	**B-23**	2-79-36	07/99	53/32	3.80/3.48	G
					07/94	77/40	3.88/3.22	E
Tuckasegee R	SR 1378 (at end)	Jackson	**B-24**	2-79-(38)	07/99	75/40	4.31/3.81	G
Tuckasegee R	off SR 1377	Jackson	B-25		07/94	101/48	4.43/3.41	E
					08/90	86/43	4.17/3.32	G
					08/88	83/39	4.45/3.15	G
					07/86	67/32	4.73/3.53	G
					08/84	65/25	4.68/3.77	G-F
Scott Cr	SR 1556	Jackson	**B-26**	2-79-39	07/99	70/36	4.14/3.22	G
					07/94	69/28	5.27/3.91	G-F
Fisher Cr (above WTP)	SR 1447	Jackson	B-27	2-79-39-11-(1)	04/87	-/24	-/2.50	G*
Fisher Cr (below WTP)	SR 1447	Jackson	B-28	2-79-39-11-(2)	04/87	-/24	-/2.49	G*
Conley Cr	SR 1177	Swain	**B-29**	2-79-52	07/99	-/44	-/3.17	E
					07/94	94/42	3.62/3.10	E
Beech Flats Pr (headwaters, above)	US 441	Swain	B-30	2-79-55-2	10/95	39/26	1.46/0.85	E*
Beech Flats Pr (below)	US 441	Swain	B-31	2-79-55-2	10/95	16/7	3.08/0.37	F*
Beech Flats Pr	US 441	Swain	B-32	2-79-55-2	09/94	-/22	-/1.35	G-F
Beech Flats Pr (above Kephart Pr)		Swain	B-33	2-79-55-2	10/95	69/41	1.90/1.17	E
Kephart Pr (near mouth)		Swain	B-34	2-79-55-3	10/95	63/42	1.92/1.26	E
Oconaluftee R (below Bradley Fk)	US 441	Swain	B-35	2-79-55-(11)	03/89	86/48	2.39/1.65	E
Bradley Fk (at Smokemont)	off US 441	Swain	**B-36**	2-79-55-12-(11)	07/99	67/39	2.67/1.87	E
					10/95	69/42	1.94/1.24	E
					09/94	-/31	-/1.24	G
					03/89	-/45	-/1.68	E
Mingus Cr	US 441	Swain	B-37	2-79-55-16-(2)	03/89	-/41	-/2.06	E
Oconaluftee R (below Raven Fk)	US 441	Swain	B-38	2-79-55-(16.5)	03/89	-/42	-/2.29	E
Oconaluftee R (at Birdtown)	SR 1359	Swain	**B-39**	2-79-55-(16.5)	07/99	104/53	3.98/3.28	E
					07/94	86/46	4.12/3.12	G
					07/89	88/47	4.21/3.33	E
					03/89	93/50	3.74/2.83	E
					08/87	102/44	4.28/3.04	E
					08/85	93/41	4.13/2.95	G

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
Raven Fk (above trout farm)	USFS Road	Swain	B-40	2-79-55-17-(13.5)	03/89	-/43	-/1.48	E
Raven Fk (below Cherokee trout farm)		Swain	B-41	2-79-55-17-(15)	03/89	-/43	-/2.28	E
Raven Fk (below Straight Fk)		Swain	B-42	2-79-55-17-(15)	03/89	-/43	-/2.49	E
Raven Fk (below Sequoyah Church)		Swain	B-43	2-79-55-17-(15)	03/89	-/41	-/2.40	G
Straight Fk (below hatchery)		Swain	B-44	2-79-55-17-16-(20.5)	03/89	-/47	-/1.92	E
Soco Cr (near mouth)	old US 441	Swain	B-45	2-79-55-21	03/89	83/41	3.39/2.71	E
Deep Cr (above campground)		Swain	**B-46**	2-79-63-(16)	08/99	-/47	-/2.66	E
					07/94	-/41	-/2.27	E
Deep Cr	SR 1340	Swain	**B-47**	2-79-63-(21)	08/99	-/45	-/3.07	E
					07/94	88/50	3.17/2.42	E
Noland Cr (near mouth)		Swain	**B-48**	2-90	08/99	-/40	-/1.97	E
Forney Cr (near mouth)		Swain	**B-49**	2-97	08/99	81/46	2.66/1.68	E
					07/94	79/46	2.49/1.60	E
Bear Cr (near mouth)		Swain	B-50	2-97-17	07/94	71/44	2.19/1.43	E
Panther Cr	SR 1233	Swain	**B-51**	2-115	08/99	-/39	-/2.24	E
					07/94	-/37	-/1.86	E
Stecoah Cr	SR 1237	Swain	**B-52**	2-130	08/99	-/39	-/3.02	E
					07/94	-/29	-/3.69	G
Hazel Cr (near mouth)		Swain	**B-53**	2-146-(19)	08/99	106/56	2.95/1.96	E
					07/94	96/47	2.86/1.94	E
03								
Nantahala R (near Rainbow Springs)	USFSR 437	Macon	**B-1**	2-57-(0.5)	08/99	100/49	3.43/2.45	E
					07/94	77/48	2.68/2.22	E
					11/93	80/46	3.12/2.31	E
					07/91	94/54	2.45/1.65	E
					08/90	98/53	3.04/2.36	E
					08/88	98/49	3.46/2.67	E
					07/86	106/48	3.67/2.53	E
					08/84	106/45	3.78/2.16	E
Nantahala R	off SR 1401	Macon	B-2	2-57-(22.5)	11/93	-/33	-/3.07	G
Nantahala R	USFSR 308	Macon	**B-3**	2-57-(22.5)	08/99	-/41	-/2.41	E
					11/93	72/37	3.70/3.17	G
Nantahala R	SR 1310	Macon	B-4	2-57-(22.5)	11/93	66/39	4.19/3.12	G
Nantahala R	US 19/74	Swain	**B-5**	2-57-(22.5)	08/99	-/35	-/2.29	G
					07/94	71/36	3.67/2.19	G
					11/93	65/32	4.06/1.92	G
					07/86	68/27	4.68/2.77	G
					08/84	60/22	5.39/3.06	G-F
Bryson Br	USFSR 437	Macon	B-6	2-57-18	10/98	47/27	2.56/1.76	G
					09/95	59/33	2.44/1.70	E
Roaring Fk	USFSR 437	Macon	B-7	2-57-22	10/98	41/27	2.16/1.75	G
					09/95	57/31	2.48/1.68	E
Nantahala R, US 19/74, Swain	US 19/74	Swain	B-8	2-57-(22.5)	11/93	54/24	3.85/2.12	G-F
Jarrett Cr	USFSR 437	Macon	B-9	2-57-27	09/95	-/35	-/1.51	G
Big Choga Cr	USFSR 440	Macon	B-10	2-57-32	09/95	-/30	-/1.40	E
Wine Spring Cr	SR 1310	Macon	B-11	2-57-39	09/95	-/21	-/1.31	G-F
Dick's Cr	off SR 1401	Macon	B-12	2-57-42	08/99	-/34	-/1.93	G
					11/93	-/26	-/2.70	G-F
Whiteoak Cr (above trout farm)	off USFS Road 711	Macon	B-13	2-57-45	08/90	84/47	2.50/1.79	E
					05/90	83/48	2.50/1.52	E
					01/90	78/46	2.10/1.41	E
					11/88	59/34	2.32/1.63	E
Whiteoak Cr (below trout farm)	SR 1397	Macon	B-14	2-57-45	08/90	60/20	5.90/2.58	F
					05/90	79/35	4.06/1.92	G-F
					01/90	83/39	3.92/2.26	G-F
					11/88	41/10	6.16/1.63	F
Whiteoak Cr	SR 1423	Macon	B-15	2-57-45	08/90	94/31	4.32/2.14	G
					05/90	1044/46	3.31/1.86	G
					01/90	77/37	3.61/2.35	G-F

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
Whiteoak Cr (above dam)	off SR 1310	Macon	B-16	2-57-45	08/99	-/31	-/2.14	G
					11/93	-/33	-/2.40	G
					08/90	78/26	4.07/1.91	G
					05/90	96/44	3.32/1.85	G
					11/88	-/33	-/2.50	G
Cold Spring Cr	USFS R 711	Macon	B-17	2-57-45-8	01/90	-/41	-/1.80	G
Queens Cr	SR 1412	Macon	B-18	2-57-51	08/99	-/29	-/1.38	E
					11/93	-/27	-/1.56	E
Silvermine Cr	SR 1103	Swain	B-19	2-57-55	11/93	-/22	-/2.77	G-F
04								
Tulula Cr	SR 1275	Graham	**B-1**	2-190-2-(0.5)	08/99	85/40	4.08/3.24	G
					07/94	78/34	3.76/2.97	G
Bear Cr	SR 1201	Graham	B-2	2-190-2-1	07/94	64/34	3.53/2.60	E
Cheoah R	SR 1138	Graham	B-3	2-190-2-(3.5)	07/89	80/39	3.88/3.07	E
					07/89	-/38	-/2.91	E
					08/87	97/40	4.77/3.45	G
					08/85	74/34	4.74/3.49	G
					08/83	81/32	4.56/3.31	G
Cheoah R	off US 129	Graham	B-4	2/190-(3.5)	07/94	73/32	4.01/3.42	G
Cheoah R	off SR 1138	Graham	**B-5**	2-190-(3.5)	08/99	88/48	3.48/2.84	E
Snowbird Cr	SR 1120	Graham	**B-6**	2-190-9-(0.5)	08/99	-/52	-/2.60	E
					06/90	-/49	-/1.66	E
Snowbird Cr	SR 1119	Graham	B-7	2-190-9-(15.5)	07/94	-/33	-/1.97	G
					06/90	-/47	-/2.08	E
L Snowbird Cr	SR 1115	Graham	B-8	2-190-9-17	08/99	-/39	-/1.41	E
W Buffalo Cr	Off SR 1123	Graham	B-9		06/90	83/40	2.95/1.79	E
W Buffalo Cr	SR 1123	Graham	B-10	2-190-12	08/99	-/39	-/2.54	E
					06/90	-/43	-/2.05	E
Hooper Mill Cr	Near SR 1123	Graham	B-11	2-190-12-3	06/90	85/49	2.24/1.69	E

[1] E = Excellent, G = Good, G-F = Good-Fair, F = Fair, P = Poor, and NR = Not Rated.
*Small stream criteria

Appendix L1. Lake Assessment Program

Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD 1982). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), Secchi depth (SD in inches), and chlorophyll *a* (CHL in µg/L). Lakewide means for these parameters are used to produce a NCTSI score for each lake, using the equations:

$$TON_{Score} = ((Log\ (TON) + 0.45)/0.24)*0.90$$

$$TP_{Score} = ((Log\ (TP) + 1.55)/0.35)*0.92$$

$$SD_{Score} = ((Log\ (SD) – 1.73)/0.35)*-0.82$$

$$CHL_{Score} = ((Log\ (CHL) – 1.00)/0.48)*0.83$$

$$NCTSI = TON_{Score} + TP_{Score} + SD_{Score} + CHL_{Score}$$

In general, NCTSI scores relate to trophic classifications (Table L1). When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state of a lake between years is not unusual because of the potential variability of data collections which usually involve sampling a limited number of times during the growing season.

Table L1. Lakes classification criteria.

NCTSI Score	Trophic classification
< -2.0	Oligotrophic
-2.0 – 0.0	Mesotrophic
0.0 – 5.0	Eutrophic
> 5.0	Hypereutrophic

Lakes are classified for their “best usage” and are subject to the state’s water quality standards. Primary classifications are C (suited for aquatic life propagation /protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses).

Lakes with a CA designation represent water supplies with watersheds that are considered Critical Areas (i.e., an area within 0.5 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 0.5 mile and draining to a river intake).

Supplemental classifications may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

Appendix L2. **Surface waters data collected from the lakes in the Little Tennessee River basin, 1994-1999.[1]**

Subbasin/ Lake	Date	Station	Dissolved oxygen	Temperature	pH	Conductivity	Secchi depth
01							
Lake Sequoyah	08/10/1999	LTN006C	7.6	26.3	6.9	28	1.3
	08/10/1999	LTN008C	8.3	26.1	7.1	28	1.0
	08/10/1999	LTN008E	8.7	25.7	7.2	27	1.3
	07/07/1999	LTN006C	8.4	21.8	6.7	35	1.0
	07/07/1999	LTN008C	8.5	21.7	6.7	32	1.0
	07/07/1999	LTN008E	8.3	21.1	6.6	32	1.1
	06/23/1999	LTN006C	8.2	18.7	6.0	37	1.2
	06/23/1999	LTN008C	8.1	19.1	6.1	32	1.7
	06/23/1999	LTN008E	8.7	19.5	6.2	30	1.3
	08/09/1994	LTN006C	8.5	22.3	6.4	28	1.0
	08/09/1994	LTN008C	9.2	21.2	6.5	26	1.0
	08/09/1994	LTN008E	9.4	21.0	7.0	24	1.0
02							
Wolf Creek Reservoir	08/11/1999	LTN015A	7.6	27.2	7.2	11	4.0
	08/11/1999	LTN015A1	7.9	27.2	7.2	11	4.4
	07/08/1999	LTN015A	8.6	23.5	6.6	13	3.2
	07/08/1999	LTN015A1	8.3	23.7	6.7	13	6.9
	06/24/1999	LTN015A	8.8	22.1	6.3	16	4.6
	06/24/1999	LTN015A1	8.6	22.1	6.4	13	7.1
	08/06/1996	LTN015A	8.1	25.8	6.6	11	2.1
	08/06/1996	LTN015A1	8.6	25.7	6.3	12	2.4
Bear Creek Reservoir	08/11/1999	LTN015B	7.9	26.0	7.4	12	3.4
	08/11/1999	LTN015D	8.0	26.0	7.6	12	3.8
	07/08/1999	LTN015B	8.5	24.4	6.7	13	3.4
	07/08/1999	LTN015D	8.4	24.6	6.7	15	3.2
	06/23/1999	LTN015B	8.7	23.5	6.7	14	3.0
	06/23/1999	LTN015D	8.6	24.1	6.6	15	4.0
	08/09/1994	LTN015B	8.3	23.3	6.2	11	2.5
	08/09/1994	LTN015D	8.1	23.5	6.9	11	2.8
Cedar Cliff Lake	08/11/1999	LTN015F	7.7	26.5	6.9	15	3.8
	08/11/1999	LTN015H	8.5	25.4	7.1	13	4.2
	07/07/1999	LTN015F	9.3	24.7	7.6	18	1.3
	07/07/1999	LTN015H	9.2	24.7	6.9	17	6.3
	06/23/1999	LTN015F	9.1	23.8	6.5	19	3.0
	06/23/1999	LTN015H	8.6	24.9	6.6	20	5.0
	08/06/1996	LTN015F	8.7	25.3	5.5	22	2.5
	08/06/1996	LTN015H	8.7	26.1	5.8	21	2.4
Thorpe Reservoir	08/10/1999	LTN015L	8.0	27.1	7.0	15.1	3.6
	08/10/1999	LTN015N	8.3	26.9	7.0	15	3.7
	08/10/1999	LTN015P	8.0	27.1	7.2	15	3.3
	08/10/1999	LTN015R	8.0	27.1	7.2	14	3.3
	07/07/1999	LTN015L	8.2	24.2	6.8	18	2.3
	07/07/1999	LTN015N	8.2	24.2	6.9	18	4.5
	07/07/1999	LTN015P	8.0	24.1	6.7	18	8.0
	07/07/1999	LTN015R	8.2	24.3	6.8	18	6.2
	06/23/1999	LTN015L	8.6	22.4	6.4	17	4.0
	06/23/1999	LTN015N	8.4	22.6	6.3	17	5.0
	06/23/1999	LTN015P	8.4	22.2	6.5	18	6.0
	06/23/1999	LTN015R	8.4	22.2	6.4	18	7.4
	08/01/1995	LTN015L	8.4	25.5	6.6	15	2.2
	08/01/1995	LTN015N	8.1	25.8	6.0	16	2.4
	08/01/1995	LTN015P	8.4	25.9	5.9	15	2.5
	08/01/1995	LTN015R	8.2	26.0	5.7	14	2.3
	08/08/1994	LTN015L	7.9	24.4	6.7	14	3.0
	08/08/1994	LTN015N	8.4	24.0	6.7	14	3.1
	08/08/1994	LTN015P	8.0	23.8	6.5	14	3.0
	08/08/1994	LTN015R	7.9	23.8	6.9	14	2.7

Appendix L2 (continued).

Subbasin/ Lake	Date	Station	Dissolved oxygen	Temperature	pH	Conductivity	Secchi depth
03							
Nantahala Lake	08/09/1999	LTN013C	7.9	27.1	7.4	11.1	4.9
	08/09/1999	LTN013D	7.8	27.0	7.6	11.7	5.4
	07/22/1999	LTN013B	8.2	24.2	6.8	13	5.2
	07/22/1999	LTN013C	8.1	24.3	6.8	14	4.8
	07/22/1999	LTN013D	8.2	24.3	6.8	14	5.2
	06/21/1999	LTN013B	8.0	23.5	6.7	13	4.5
	06/21/1999	LTN013C	8.2	23.4	6.8	14	5.5
	06/21/1999	LTN013D	8.0	23.3	6.8	13	6.5
	08/30/1994	LTN013B	8.1	23.3	6.7	9	4.2
	08/30/1994	LTN013C	8.3	23.4	6.6	9	4.4
	08/30/1994	LTN013D	7.8	23.5	7.4	9	5.6
04							
Lake Cheoah	08/09/1999	LTN032B	9.3	10.9	6.5	24	5.5
	08/09/1999	LTN032D	9.8	12.4	6.5	22	6.9
	08/09/1999	LTN032F	9.9	15.3	6.5	24	7.4
	08/10/1994	LTN032B	9.2	13.1	6.2	18	3.3
	08/10/1994	LTN032D	8.6	13.4	6.2	18	3.7
	08/10/1994	LTN032F	8.4	21.3	6.4	18	3.2
Santeetlah Lake	08/24/1999	LTN037B	7.8	27.1	7.6	21	2.8
	08/24/1999	LTN037D	7.9	27.2	8.0	19	3.8
	08/24/1999	LTN037E	7.8	27.1	7.3	17	3.7
	08/09/1999	LTN037B	8.0	29.2	7.6	20	2.6
	08/09/1999	LTN037D	7.9	28.7	7.4	18	4.2
	08/09/1999	LTN037E	7.8	28.1	7.3	17	4.5
	07/27/1999	LTN037B	8.1	29.5	6.9	19	3.0
	07/27/1999	LTN037D	7.9	29.3	7.3	17	4.1
	07/27/1999	LTN037E	7.9	28.6	7.2	16	4.9
	08/02/1995	LTN037B	7.8	29.0	6.5	20	4.0
	08/02/1995	LTN037D	7.8	27.7	6.3	19	5.8
	08/02/1995	LTN037E	7.4	27.9	6.2	17	6.2
	08/30/1994	LTN037B	8.1	25.6	8.0	18	3.4
	08/30/1994	LTN037D	8.1	25.2	7.7	17	2.8
	08/30/1994	LTN037E	7.8	24.7	7.6	15	2.8

[1]Units of measure are dissolved oxygen (mg/l), temperature (°C), pH (s.u.), conductivity (µmhos/cm), and Secchi depth (m).

Appendix L3. **Photic zone data collected from lakes in the Little Tennessee River basin, 1994-1999.[1]**

Subbasin/Lake	Date	Station	TP	TKN	NH_3	NO_x	TN	TON	TIN	Chl a	Total Solids	Susp. Solids	Turbidity
01													
Lake Sequoyah	08/10/1999	LTN006C	0.01	0.4	0.06	< 0.01	0.41	0.34	0.07	24	15	1.0	1.8
	08/10/1999	LTN008C	0.02	0.3	0.08	0.02	0.32	0.22	0.10	18	20	7.0	2.8
	08/10/1999	LTN008E	0.01	0.2	0.08	< 0.01	0.21	0.12	0.09	18	32	2.0	1.9
	07/07/1999	LTN006C	0.02	0.2	< 0.01	0.11	0.31	0.20	0.12		28	< 1	2.3
	07/07/1999	LTN008C	0.04	0.2	0.14	0.24	0.44	0.06	0.38		29	5.0	2.9
	07/07/1999	LTN008E	0.03	0.2	0.01	0.08	0.28	0.19	0.09		27	5.0	3.5
	06/23/1999	LTN006C	0.05	0.2	< 0.01	0.12	0.32	0.20	0.13	20	41	7.0	3.7
	06/23/1999	LTN008C	0.04	0.2	< 0.01	0.23	0.43	0.20	0.24	15	54	17.0	2.9
	06/23/1999	LTN008E	0.01	0.1	< 0.01	0.08	0.18	0.10	0.09	38	33	4.0	2.7
	08/09/1994	LTN006C	0.06	0.5	0.04	0.12	0.62	0.46	0.16	2	47	11	3.1
	08/09/1994	LTN008C	0.04	0.3	0.04	0.07	0.37	0.26	0.11	3	43	7	3.2
	08/09/1994	LTN008E	0.05	0.2	0.04	0.04	0.24	0.16	0.08	7	33	7	3.2
02													
Wolf Creek Res.	08/11/1999	LTN015A	< 0.01	0.2	0.06	< 0.01	0.21	0.14	0.07	5	22	1.0	0.5
	08/11/1999	LTN015A1	< 0.01	0.2	0.06	< 0.01	0.21	0.14	0.07	7	32	0.5	0.5
	07/08/1999	LTN015A	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01		24	1.0	1.7
	07/08/1999	LTN015A1	< 0.01	0.1	< 0.01	0.01	0.11	0.10	0.02		24	2.0	< 1.0
	06/24/1999	LTN015A	1.50	0.1	< 0.01	< 0.01	0.11	0.10	0.01	7	12	3.0	1.1
	06/24/1999	LTN015A1	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01	10	19	2.0	1.1
	08/06/1996	LTN015A	0.02	0.2	< 0.01	< 0.01	0.21	0.20	0.01	4	27	< 1.0	4.5
	08/06/1996	LTN015A1	0.03	0.3	0.01	0.01	0.31	0.29	0.02	10	23	< 1.0	1.4
Bear Creek Res.	08/11/1999	LTN015B	< 0.01	0.2	0.09	0.09	0.03	0.11	0.10	7	34	0.5	0.5
	08/11/1999	LTN015D	< 0.01	0.3	0.07	< 0.01	0.31	0.23	0.08	5	23	0.5	0.5
	07/08/1999	LTN015B	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01		26	4.0	2.6
	07/08/1999	LTN015D	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01		26	< 1.0	
	06/23/1999	LTN015B	0.03	0.2	0.05	< 0.01	0.21	0.15	0.06	7	25	< 1.0	2.8
	06/23/1999	LTN015D	0.01	0.3	< 0.01	0.01	0.31	0.30	0.02	7	30	< 1.0	1.0
	08/09/1994	LTN015B	0.03	0.2	0.03	< 0.01	0.21	0.17	0.04	1	23	5.0	1.2
	08/09/1994	LTN015D	0.02	0.1	0.04	< 0.01	0.11	0.06	0.05	2	25	3.0	1.1
Cedar Cliff Lake	08/11/1999	LTN015F	< 0.01	0.3	0.08	< 0.01	0.31	0.22	0.09	5	26	0.5	0.5
	08/11/1999	LTN015H	< 0.01	0.2	0.08	< 0.01	0.21	0.12	0.09	2	21	1.0	0.5
	07/07/1999	LTN015F	0.01	0.2	0.01	< 0.01	0.21	0.20	0.02	26	21	4.0	1.8
	07/07/1999	LTN015H	< 0.01	0.2	< 0.01	0.01	0.21	0.20	0.02	5	15	1.0	< 1.0
	06/23/1999	LTN015F	< 0.01	0.3	0.05	< 0.01	0.31	0.25	0.06	8	28	< 1.0	1.6
	06/23/1999	LTN015H	< 0.01	0.2	0.07	0.01	0.21	0.13	0.08	5	29	1.0	1.2
	08/06/1996	LTN015F	0.02	0.1	0.01	< 0.01	0.11	0.09	0.02	14	29	< 1.0	1.1
	08/06/1996	LTN015H	0.02	0.3	0.04	< 0.01	0.31	0.26	0.05	7	22	< 1.0	1.0
Thorpe Reservoir	08/10/1999	LTN015L	< 0.01	0.2	0.09	< 0.01	0.21	0.11	0.10	6	18	1.0	1.6
	08/10/1999	LTN015N	< 0.01	0.1	0.09	< 0.01	0.11	0.01	0.10	2	23	1.0	1.4
	08/10/1999	LTN015P	< 0.01	0.2	0.12	< 0.01	0.21	0.08	0.13	2	11	1.0	1.6
	08/10/1999	LTN015R	< 0.01	0.2	0.07	< 0.01	0.21	0.13	0.08	1	8	1.0	1.6
	07/07/1999	LTN015L	< 0.01	0.1	< 0.01	0.04	0.14	0.10	0.05	6	16	2.0	< 1.0
	07/07/1999	LTN015N	< 0.01	0.1	< 0.01	0.04	0.14	0.10	0.05	1	23	< 1.0	< 1.0
	07/07/1999	LTN015P	< 0.01	0.1	< 0.01	0.05	0.15	0.10	0.06	3	20	3.0	0.5
	07/07/1999	LTN015R	< 0.01	0.2	< 0.01	0.03	0.23	0.10	0.04	4	17	2.0	< 1.0
	06/23/1999	LTN015L	0.01	0.1	< 0.01	0.06	0.16	0.10	0.07	10	20	< 1.0	< 1.0
	06/23/1999	LTN015N	0.01	0.05	< 0.01	0.07	0.12	0.05	0.08	5	20	< 1.0	< 1.0
	06/23/1999	LTN015P	0.02	0.1	< 0.01	0.08	0.18	0.10	0.09	6	16	< 1.0	< 1.0
	06/23/1999	LTN015R	0.02	0.1	< 0.01	0.07	0.17	0.10	0.08	5	13	1.0	< 1.0
	08/01/1995	LTN015L	0.01	0.1	0.01	< 0.01	0.11	0.09	0.02	4	9	6.0	1.4
	08/01/1995	LTN015N	0.01	0.1	0.04	< 0.01	0.11	0.06	0.05	4	9	6.0	1.2
	08/01/1995	LTN015P	0.02	0.1	0.05	< 0.01	0.11	0.05	0.06	3	14	5.0	1.2
	08/01/1995	LTN015R	0.01	0.1	0.04	< 0.01	0.11	0.06	0.05	3	16	3.0	1.3
	08/08/1994	LTN015L	0.01	0.2	0.05	< 0.01	0.21	0.15	0.06	1	38	2.0	< 1.0
	08/08/1994	LTN015N	0.01	0.3	0.02	< 0.01	0.31	0.28	0.03	< 1	44	1.0	1.1
	08/08/1994	LTN015P	0.02	0.1	0.01	< 0.01	0.11	0.09	0.02	2	49	2.0	< 1.0
	08/08/1994	LTN015R	0.02	0.2	0.01	< 0.01	0.21	0.19	0.02	1	48	5.0	1.0

Appendix L3 (continued).

Subbasin/Lake	Date	Station	TP	TKN	NH_3	NO_x	TN	TON	TIN	Chl a	Total Solids	Susp. Solids	Turbidity
03													
Nantahala Lake	08/09/1999	LTN013C	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01	4	19	1.0	0.5
	08/09/1999	LTN013D	< 0.01	0.2	< 0.01	0.01	0.21	0.20	0.02	9	12	1.0	< 1.0
	07/22/1999	LTN013B	0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01	3	22	2.0	1.5
	07/22/1999	LTN013C	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01	3	15	3.0	< 1.0
	07/22/1999	LTN013D	< 0.01	0.1	< 0.01	< 0.01	0.11	0.10	0.01	3	12	3.0	< 1.0
	06/21/1999	LTN013B	< 0.01	0.1	0.02	< 0.01	0.11	0.08	0.03	11	21	1.0	
	06/21/1999	LTN013C	< 0.01	0.1	0.02	< 0.01	0.11	0.08	0.03	7	23	3.0	
	06/21/1999	LTN013D	< 0.01	0.2	0.02	< 0.01	0.21	0.18	0.03	8	25	1.0	
	08/30/1994	LTN013B	0.02	0.1	< 0.01	0.02	0.12	0.10	0.03	< 1	25	1.0	2.1
	08/30/1994	LTN013C	0.03	0.2	< 0.01	0.04	0.24	0.20	0.05	< 1	48	23.0	9.2
	08/30/1994	LTN013D	0.01	0.2	< 0.01	0.02	0.22	0.20	0.03	< 1	15	1.0	< 1.0
04													
Lake Cheoah	08/09/1999	LTN032B	< 0.01	0.3	< 0.01	0.16	0.46	0.3	0.17	2	20	5	< 1.0
	08/09/1999	LTN032D	< 0.01	0.2	< 0.01	0.15	0.35	0.2	0.16	6	20	1	< 1.0
	08/09/1999	LTN032F	< 0.01	0.3	< 0.01	0.15	0.45	0.3	0.16	14	23	1	<.01
	08/10/1994	LTN032B	0.02	0.1	0.02	0.16	0.26	0.08	0.18	< 1	40	1	1.4
	08/10/1994	LTN032D	0.03	0.1	0.01	0.14	0.24	0.09	0.15	< 1	26	2	1.4
	08/10/1994	LTN032F	0.03	0.2	0.01	0.14	0.34	0.19	0.15	< 1	28	2	1.5
Santeetlah Lake	08/24/1999	LTN037B	0.02	0.2	0.01	< 0.01	0.21	0.19	0.02	2	27	2	1.6
	08/24/1999	LTN037D	0.02	0.3	< 0.01	< 0.01	0.31	0.30	0.01	12	30	< 1	< 1.0
	08/24/1999	LTN037E	0.02	0.2	0.06	< 0.01	0.21	0.14	0.07	6	26	1	< 1.0
	08/09/1999	LTN037B	< 0.01	0.3	< 0.01	< 0.01	0.31	0.30	0.01	14	12	3	3.0
	08/09/1999	LTN037D	< 0.01	0.3	< 0.01	< 0.01	0.31	0.30	0.01	10	17	1	1.0
	08/09/1999	LTN037E	< 0.01	0.2	< 0.01	< 0.01	0.21	0.20	0.01	14	13	1	1.0
	07/27/1999	LTN037B	< 0.01	0.4	0.05	0.09	0.49	0.35	0.14	10	28	1	1.3
	07/27/1999	LTN037D	< 0.01	0.2	0.01	< 0.01	0.21	0.19	0.02	21	40	< 1	< 1.0
	07/27/1999	LTN037E	< 0.01	0.3	0.03	< 0.01	0.31	0.27	0.04	18	37	< 1	< 1.0
	08/02/1995	LTN037B	0.01	0.1	< 0.01	0.02	0.12	0.10	0.03	6	19	3	< 1.0
	08/02/1995	LTN037D	0.01	0.1	0.02	< 0.01	0.11	0.08	0.03	6	15	4	< 1.0
	08/02/1995	LTN037E	0.01	0.1	0.01	0.07	0.17	0.09	0.08	4	17	3	< 1.0
	08/30/1994	LTN037B	< 0.01	0.2	0.02	0.01	0.21	0.18	0.03	2	33	1	< 1.0
	08/30/1994	LTN037D	0.01	0.2	0.03	0.02	0.22	0.17	0.05	2	31	2	< 1.0
	08/30/1994	LTN037E	0.02	0.2	0.05	0.06	0.26	0.15	0.11	1	31	2	< 1.0

[1] Abbreviations are TP = total phosphorus, TKN = total Kjeldahl nitrogen, NH_3 = ammonia nitrogen, No_x = nitrate + nitrite nitrogen, TON = total organic nitrogen, TIN = total inorganic nitrogen, and Chl *a* = chlorophyll *a*. Units of measure are mg/l, except for chlorophyll *a* which is µg/l and turbidity which is NTU.