BROAD RIVER BASINWIDE ASSESSMENT
MAY, 2006

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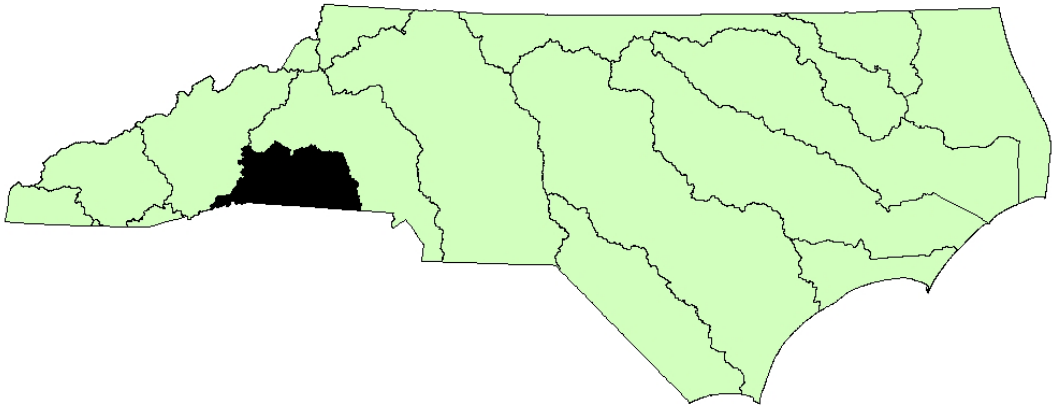

This document provides overviews from four program areas within the Environmental Sciences Section . They may be considered chapters or individual reports. The contributions from each unit are provided in the following order.

BASINWIDE ASSESSMENT –Provides basin and subbasin overviews of water quality and detailed information on collections of benthic macroinvertebrates, fish community structure, and fish tissue analyses.
Biological Assessment Unit 100 pages

LAKE & RESERVOIR ASSESSMENT-Provides lake & reservoir-specific information in the Broad River Basin, and an overview of assessment methodology.
Intensive Survey Unit 4 pages

AMBIENT MONITORING SYSTEM ASSESSMENT-Provides results of analyses from DWQ fixed station Ambient Monitoring System and Coalition Data, including temporal and spatial trends of chemical, hydrological, and physical data where appropriate.
Ecosystems Analysis Unit 38 pages

WHOLE EFFLUENT TOXICITY PROGRAM-Provides an overview of permits requiring (WET), compliance information, and brief summaries of actions by individual facilities and/or DWQ in response to WET limit failures.
Aquatic Toxicology Unit 4 pages

BASINWIDE ASSESSMENT REPORT

BROAD RIVER BASIN

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

April 2006

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BASIN DESCRIPTION

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

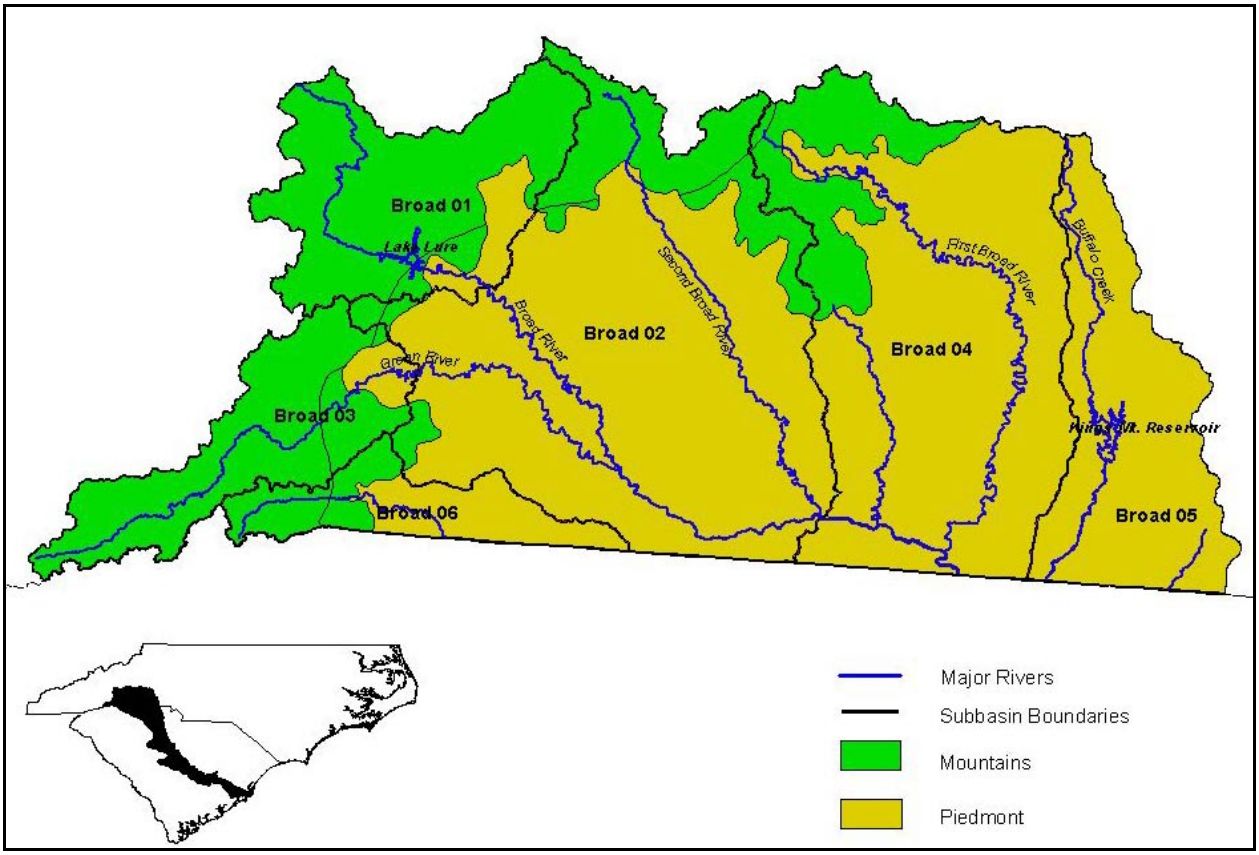


Figure 1. Geographical relationships and physiographic regions of the Broad River basin in North Carolina.

Most of the streams and rivers in Subbasins 01 - 03 originate and flow through the Southern Crystalline Ridges and Mountains and Southern Inner Piedmont ecoregions (Griffith *et al.* 2002) found in large portions of Polk and Rutherford counties. The streams in the lower portion of the basin (Subbasins 04 - 06) originate and flows through multiple Level IV ecoregions – the Eastern Blue Ridge Foothills, Northern Inner Piedmont, Southern Outer Piedmont, Southern Crystalline Ridges and Mountains, and Southern Inner Piedmont (Griffith *et al.* 2002). These subbasins are located in western portions of Polk, eastern Rutherford, and all of Cleveland counties.

There are 24 streams listed as High Quality Waters (HQW) in the basin. Seventeen of these HQW streams are located in subbasin 03, 11 of which are tributaries to the Green River in southwestern Henderson County. Six of the remaining seven HQW streams are located in Subbasin 06 in

southwestern Polk County, while only one HQW stream (unnamed tributary to Lake Montonia) is located in Subbasin 05. Five Natural Heritage Program Priority Areas are found in this basin: the Rollins/South Mountains Natural Area, Hickory Nut Gorge, Green River Gorge, Pacolet River Gorge, and Pinnacle Mountain.

The Broad River (Rocky Broad River) originates upstream of Lake Lure. Flat, Hickory, and Reedypatch Creeks are the largest tributaries above the lake. Buffalo Creek forms a major arm of the lake and Cove Creek is a large tributary to the Broad River below the lake. Land use within the lake's watershed is predominantly forested with some urban and agricultural uses.

The middle and lower portion of the Broad River covers approximately 40 river miles from Lake Lure to the confluence of the Second Broad River near the Cleveland/Rutherford county line. Major tributaries in this section include the Green and the Second Broad Rivers. These begin in the Mountains, but flow into the Piedmont ecoregion. Smaller tributary catchments of the Broad River include Mountain and Cleghorn Creeks.

The headwater reaches of the Green River are in Henderson County. The Green has been impounded at two locations to form Lakes Summit and Adger. Both reservoirs are used to produce hydroelectric power. Lake Summit is used extensively for primary and secondary recreational purposes. Tributary streams are often high gradient and are capable of supporting trout populations. Apple orchards are a significant land use in upper reaches of many tributary catchments, including the Hungry River. As the topography flattens, the lower reaches of many catchments are farmed.

The First Broad River originates in Rutherford County and flows into the Broad River in Cleveland County, just above the South Carolina border. This geographic area is a transitional zone between ecoregions, with some streams exhibiting Mountain characteristics and other streams are more Piedmont in nature.

Buffalo Creek and its tributaries, Muddy Fork, Beason Creek, and Kings Creek are in North Carolina, but flow into the Broad River in South Carolina. Although a few streams in the northern portion of the watershed exhibit some montane characteristics, this area is considered to be in the Piedmont ecoregion. The North Pacolet River in Polk County has a small watershed in North Carolina before flowing directly into South Carolina.

INTRODUCTION TO PROGRAM METHODS

The Division of Water Quality 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 re-assessed every five years. The Broad River basin has been sampled by the Environmental Sciences Section (ESS) three times for basinwide monitoring: 1995, 2000, and 2005.

The ESS 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 program areas there may be adequate data 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 Broad River basin include benthic macroinvertebrates, fish community, ambient monitoring, lake assessments, and aquatic toxicity monitoring for the period 2000 - 2005. Details of biological sampling methods (including habitat evaluation) and rating criteria can be found in Appendices B-1 and Appendices F-1 – F-9). Technical terms are defined in the Glossary. Studies conducted prior to 2000 were summarized in NCDENR (2001c).

The document is structured with physical, geographical, and biological data discussions presented by subbasin. General water quality conditions are given in an upstream to downstream format. Subbasins within the basin are described by a six-digit code (030801– 030806), but are often referred to by their last two digits (e.g. Subbasin 01). Lakes data, ambient chemistry data and aquatic toxicity data, with summaries, are presented in separate chapters.

BROAD RIVER SUBBASIN 01

Description

This subbasin is located primarily in the Southern Crystalline Ridges and Mountains Level IV ecoregion; the eastern edge of the subbasin lies within the Southern Inner Piedmont ecoregion (Griffith *et al*. 2002). The subbasin contains the headwaters of the Broad River, including Lake Lure to approximately five river miles below Lake Lure (Figure 2). Major tributaries to the river include Flat, Hickory, Reedypatch, and Cove Creeks.

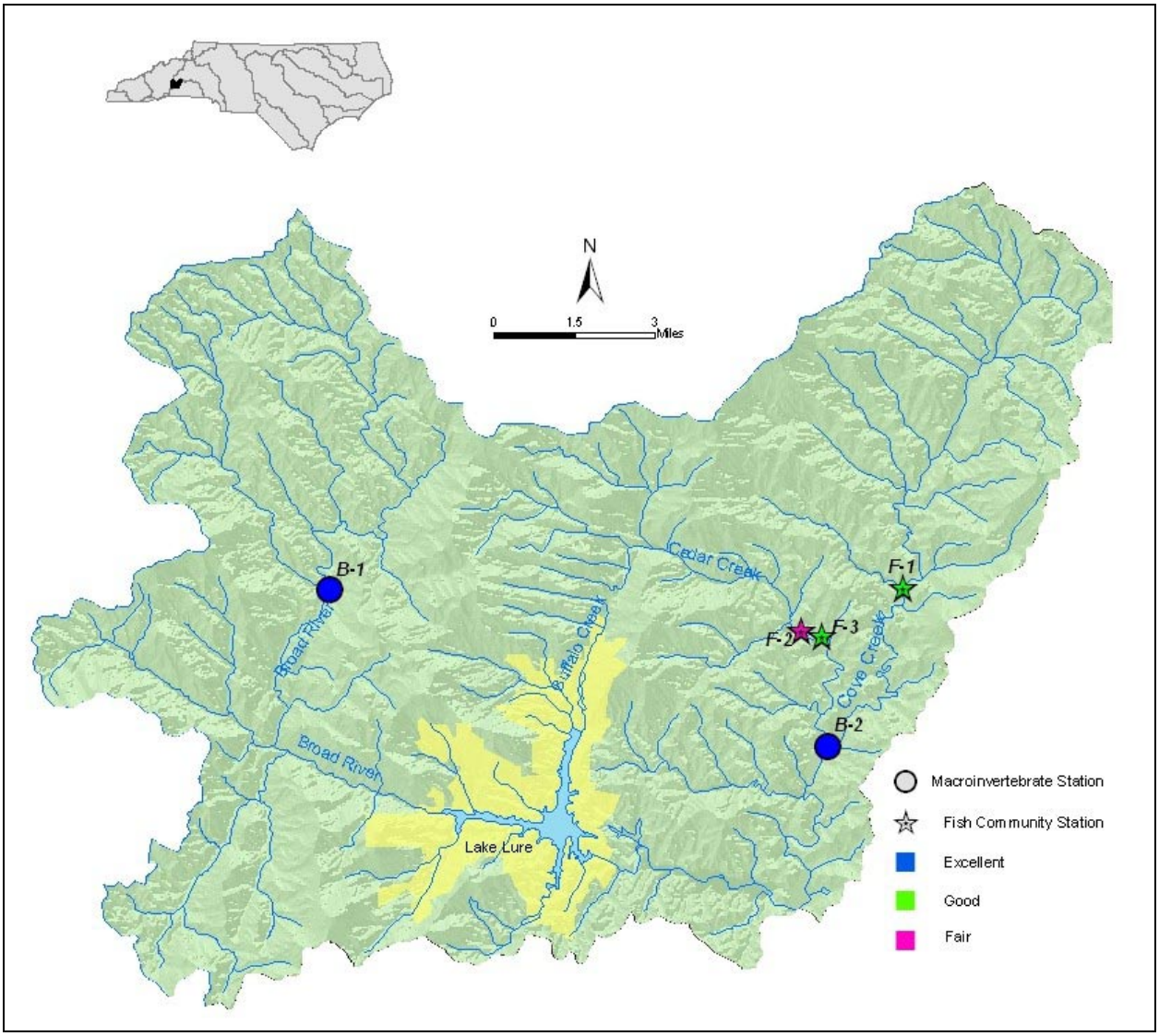


Figure 2. Sampling sites in Subbasin 01 in the Broad River basin. Monitoring sites are listed in Table 1.

More than 90 percent of the 183 square mile subbasin is forested (NCDENR 2003a), but more and more areas are being developed for residential and tourism uses in the vicinity of Lake Lure. The Town of Lake Lure's wastewater treatment plant is the only NPDES permitted discharger in the subbasin (Basinwide Information Management System query November 07, 2005). The facility is permitted to discharge 1 MGD into the Broad River below Lake Lure.

Overview of Water Quality

The two macroinvertebrate basinwide sites in this subbasin rated Excellent (Table 1), as they have in past collections, and this was most likely due to the high percentage of land that remains forested. However, sedimentation is a growing concern. The Cove Creek site appeared to show the effects of sedimentation more readily than the higher gradient Broad River site, which has maintained its rocky substrate.

Two of the three fish community sites were sampled for the first time in 2005. At the two fish community sites on Cedar Creek, the waterbodies are supplementally classified as trout waters (Tr). Difference in NCIBI ratings between the two sites on Cedar Creek were related to pronounced instream habitat differences.

Table 1. Waterbodies monitored in Subbasin 01 in the Broad River basin for basinwide assessment, 2000 and 2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	Broad R	Buncombe	SR 2808	Excellent	Excellent
B-2	Cove Cr	Rutherford	SR 1381	Excellent	Excellent
F-1	Cove Cr	Rutherford	SR 1001	---	Good
F-2	Cedar Cr	Rutherford	SR 1008	---	Fair
F-3	Cedar Cr	Rutherford	SR 1371	Good-Fair	Good

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

River and Stream Assessment

Broad River, SR 2802, Buncombe County

The Broad River at this site was 15 meters wide with a good substrate mix of boulder (40%), rubble (30%), gravel (20%), and sand (10%). The drainage area is 34 square miles. Overall, the habitat was favorable and received a score of 87. The scarcity of pools, removal of the riparian zone on one side for agriculture, and moderate stream bank erosion lessened the total score. The conductivity was 24 µmhos/cm. Heavy rainfall from Hurricane Dennis occurred the week preceding sampling and on the day of sampling. At SR 2802, Flat Creek flows into the Broad River. The picture below (right) shows the turbidity in the Broad River at the confluence with Flat Creek after heavy rainfall.

Broad River at SR 2802, Buncombe County.

This site has been sampled for benthos three times: in 1995, in 2000, and in 2005. All three samples received Excellent ratings. Total taxa, EPT S, and BI increased from 1995 to 2000 (82 to 99, 43 to 49, and 3.4 to 4.1, respectively). These numbers were attributed to recolonization following a period of low rainfall, reduced scour, and improved expertise in taxonomy. The 2005 numbers were similar to 1995

numbers. In 2005, the Total S was 77, the EPT S was 43, and the BI was 3.2. The 2005 BI was the lowest of the three samples collected at this location. This most upstream location was the only Broad River site to rate Excellent for macroinvertebrates in 2005. To date, this site has maintained its Excellent rating and supported an intolerant benthic community, however, sedimentation is a concern throughout the river basin.

Cove Creek, SR 1001, Rutherford County
Draining northwestern Rutherford and southwestern McDowell counties, Cove Creek is a tributary to the Broad River. At this crossing, the instream, riparian, and watershed characteristics were of exceptionally high quality (habitat score = 85; Appendix F-6) and qualified the site as a new fish community regional reference site.

Cove Creek at SR 1001, Rutherford County.

This stream was sampled (at the next bridge upstream) in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al*. 1965). Ten species were collected and the dominant species was the margined madtom. In 2005, 13 species were collected and the dominant species was the bluehead chub. The fish community was rated Good in 2005. Even though this site had a watershed drainage area of 32.5 square miles, this headwater stream may have a naturally low diversity. Species absent included white sucker, northern hog sucker, and tessellated darter. If these three species had been present, the reference site would have rated Excellent.

Cove Creek, SR 1381, Rutherford County
This macroinvertebrate site on Cove Creek is downstream of the fish community site at SR 1001. The substrate at this 12 meter wide location was almost entirely sand (70%) with filled in pools and infrequent riffles. Sand had greatly increased from 20% in 2000 to 70% in 2005. The habitat score (60) reflected the sandy substrate, infrequent pools and riffles, and narrow riparian zones due to agriculture. The drainage area is approximately 43 square miles. When sampled in September 2005 the conductivity was 36 μmhos/cm.


Cove Creek at SR 1381, Rutherford County.

The three collections at this site, in 1995, 2000, and 2005 have all yielded Excellent bioclassifications. EPT S has been similar for the three samples collected at this site (36-40). However, the 2005 EPT BI was the highest yet. The EPT BI has increased from 3.1 in 1995, to 3.4 in 2000, to 4.7 in 2005. This indicates that the benthic community of Cove Creek is becoming more tolerant over time. Sedimentation and agricultural stressors are two concerns in this watershed. Cove Creek should be closely monitored in the future for adverse impacts.

Cedar Creek, SR 1008, Rutherford County

The Cedar Creek watershed drains northern Rutherford, southwestern McDowell, and the extreme southeastern corner of Buncombe counties. This site is located approximately 0.7 miles upstream of the other Cedar Creek site at SR 1371. It was added as a new basinwide site because in 1998 and 2000 it was observed that the creek changes its instream habitat characteristics between the two crossings. Sampling at the SR 1008 site was recommended to document any differences in the fish communities between two reaches of the creek that differed greatly in their habitat characteristics within a short distance of one another (NCDENR 2001c).

In 2005 it was documented that within this short distance the creek changes its characteristics from a slow moving stream with sandy and gravely runs (habitat score = 61) at SR 1008 to one with high gradient, swift flow, boulder and bedrock shelves, plunge pools, and riffles (habitat score = 90) at SR 1371 (Appendix F-6). The main differences between the two sites were in the quality of instream habitats, substrates, and the quantity and quality of the pools and riffles (Table 2).


Cedar Creek at SR 1008, Rutherford County.

Table 2. Habitat evaluations at two locations on Cedar Creek, Rutherford County, June 22, 2005.

Habitat Metric	Location		Maximum Possible Score
	SR 1008	SR 1371	
Channel	5	5	5
Instream habitat	12	19	20
Substrate	4	13	15
Pools	4	8	10
Riffles	5	16	16
Bank stability			
Left	6	7	7
Right	6	7	7
Shade	9	7	10
Riparian zone			
Left	5	5	5
Right	5	3	5
Total score	61	90	100

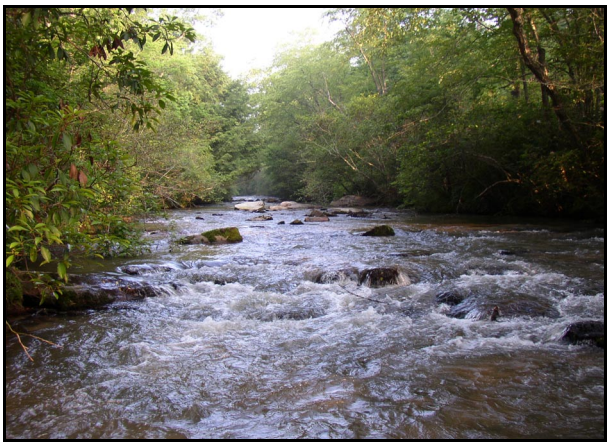
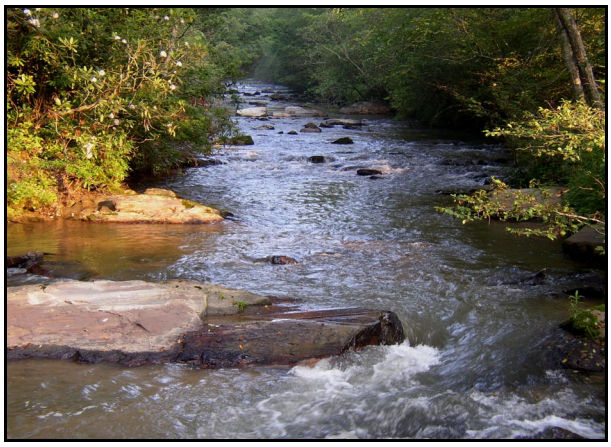
The fish community at the SR 1008 site was rated Fair (NCIBI = 38) in 2005. The number of fish and diversity metrics were lower than expected and the percentage of omnivores+herbivores was greater than expected. The bluehead chub was the most abundant species present, it comprised almost 50 percent of all the fish collected. Even though this site had a watershed drainage area of 21.3 square miles, this headwater stream may have a naturally low diversity. The stream is supplementally classified as Tr, but a reproducing population of trout (i.e., one with multiple age classes and sizes) was not documented in this reach even though two individuals were collected.

Cedar Creek, SR 1371, Rutherford County

In 2000, this site was identified as a fish community regional reference site based upon its watershed and instream and riparian habitat characteristics. However, the fish community was rated, unexpectedly, Good-Fair (NCIBI = 44). In 2005, the community was rated Good (NCIBI = 48) because of a more balanced trophic structure than in 2000. Bluehead chub which had comprised 41 percent of all the fish collected in 2000, comprised only 29 percent in 2005.

The same 11 species which were collected in 2000 were again collected in 2005. Even though this site had a watershed drainage area of 22 square miles, this headwater stream may have a naturally low diversity. Species absent included white sucker, northern hog sucker, and tessellated darter. Like at Cove Creek, another headwater stream, if these three species had been present at Cedar Creek, this reference site would have rated Excellent.

This stream supported very abundant populations of two intolerant species – the seagreen darter and the fieryblack shiner. More specimens of these two species were collected from this site in 2005 than from any fish community site ever sampled in the Catawba or Broad River basins, except for a site on the Green River (Polk County) which was sampled once in 1995. Cedar Creek is supplementally classified as Tr and a reproducing population of naturalized, wild, rainbow trout was documented to reside in this reach of the stream.

Cedar Creek at SR 1371, Rutherford County.

The more diverse, complex, and higher quality instream habitats at the SR 1371 site (Appendix F-6) supported three times more total fish than at the site just upstream at SR 1008 (Table 3). Species showing pronounced population increases with higher quality habitats included fieryblack shiner, rosyside dace, bluehead chub, striped jumprock, and seagreen darter. At the lower site, the gradient may have been too great to support a large population of the Piedmont shiner, bluegill, and fantail darter. The downstream site also had a more balanced trophic structure than did the upstream site.

Table 3. Abundance of fish and NCIBI metrics at two locations on Cedar Creek, Rutherford County, June 22, 2005.

	Location	
Scientific Name	**SR 1008**	**SR 1371**
Clinostomus funduloides	9	48
Cyprinella pyrrhomelas	8	108
Nocomis leptocephalus	95	172
Notropis sp. cf. *chlorocephalus*	13	4
Semotilus atromaculatus	3	6
Scartomyzon rupiscartes	21	80
Lepomis auritus	16	53
L. macrochirus	1	---
Noturus insignis	1	13
Oncorhynchus mykiss	2	7
Etheostoma flabellare	---	3
E. thalassinum	30	101

	Location	
Metric	**SR 1008**	**SR 1371**
No. Species	11	11
No. Fish	199	595
No. Darters	1	2
No. SBT	3	2
No. Suckers	1	1
No. Intolerants	3	3
% Tolerants	10	10
% Omnivores+Herbivores	48	29
% Insectivores	52	71
% Piscivores	0.00	0.00
% Diseased	0.00	0.00
% Multiple Ages	64	91
NCIBI Score	38	48
NCIBI Rating	Fair	Good

Special Studies

Buffalo Creek at SR 1314, Rutherford County

The Asheville Regional Office and DWQ Planning Section requested a sample from this tributary to the northern arm of Lake Lure in response to residential development concerns. Buffalo Creek rated Good (31 taxa) based on EPT criteria for mountain streams. Numerous intolerant taxa were collected, producing a very low EPT BI (1.6). Notable intolerant taxa included *Danella lita, Drunella conestee*, *Stenonema meririvulanum,* and *Parapsyche cardis.* Sediment sensitive caddisflies (*Glossosoma*, *Goera*, *Neophylax mitchelli*, *N. oligius*, and *N. ornatus*) were collected on rocks. Considering the intolerant taxa collected and the Good rating, this site was not adversely affected by stressors in the watershed at the time of sampling. However, it is evident that extensive residential growth is occurring in this area. In addition, the rapid increase in turbidity that occurred in the stream shortly after a rain event indicated land

disturbance in the watershed. Future sampling is recommended to insure that watershed development does not adversely affect this small tributary to Lake Lure (Biological Assessment Unit Memorandum B-051214).

BROAD RIVER SUBBASIN 02

Description

This subbasin is located in three Level IV ecoregions -- the Eastern Blue Ridge Foothills, the Southern Inner Piedmont, and the Southern Outer Piedmont (Griffith *et al*. 2002). This subbasin includes the middle portion of the Broad River, from about five miles below the Lake Lure dam to the confluence of the Second Broad River near the Cleveland/Rutherford county line, and the tributaries Mountain, Cleghorn, and Floyd Creeks (Figure 3). The entire Second Broad River drainage, including Catheys and Roberson Creeks, and the lower drainage of the Green River are also included in this subbasin.

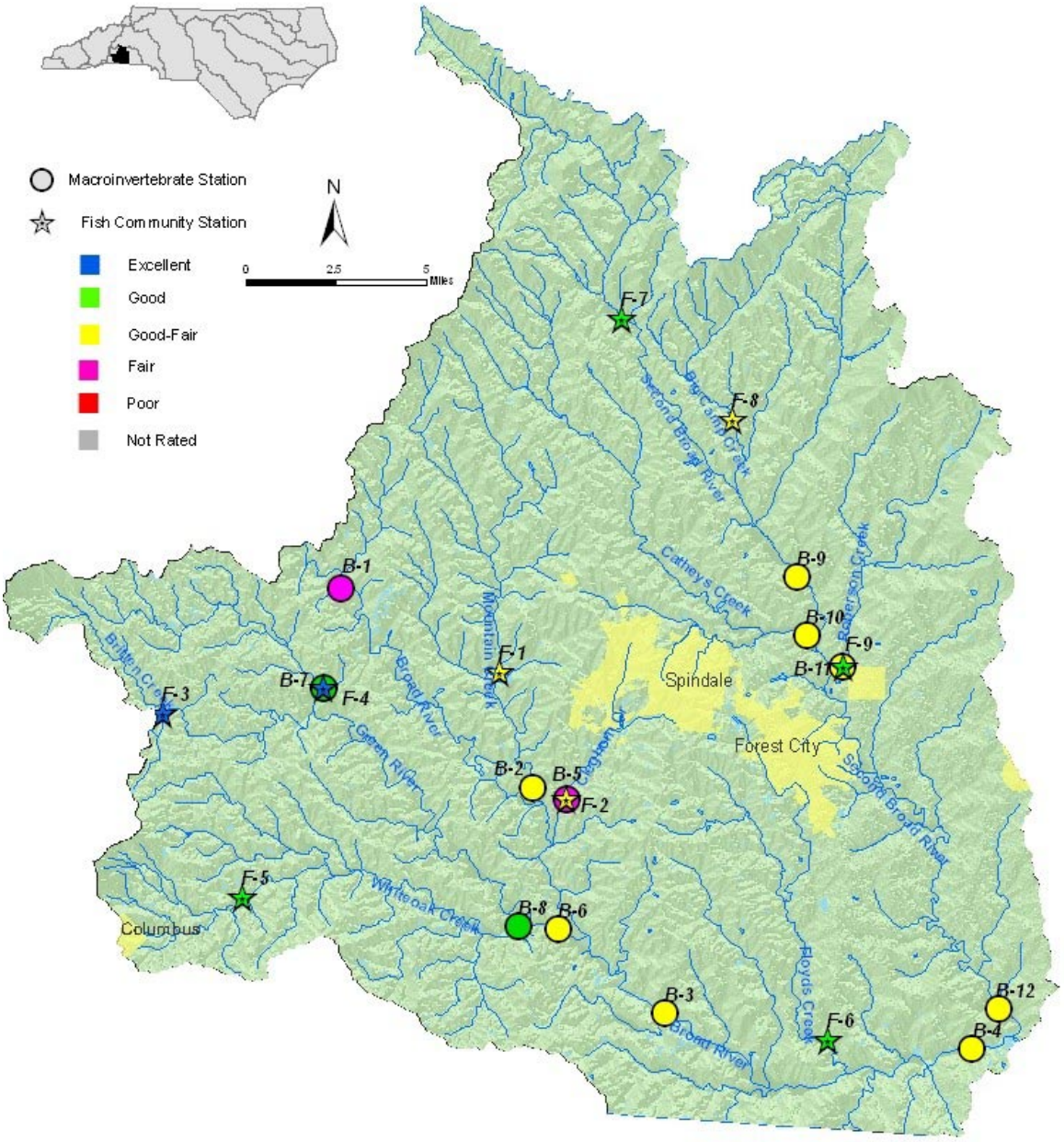


Figure 3. Sampling sites in Subbasin 02 in the Broad River basin. Monitoring sites are listed in Table 4.

Approximately 75 percent of the 512 square mile subbasin is forested with about 20 percent in pasture (NCDENR 2003a). The largest urbanized area is the Rutherfordton-Spindale-Forest City municipal area. There are 16 permitted dischargers in the subbasin; six of them have permitted discharges greater than 0.5 MGD. Three of these facilities discharge within the Second Broad River watershed (the wastewater treatment plants for the Towns of Spindale and Forest City and Cone Denim LLC) and three facilities discharge within the Broad River watershed (the wastewater treatment plants for the Towns of Columbus and Rutherfordton and Dan River, Inc.).

Overview of Water Quality

Twelve macroinvertebrate sites and nine fish community assessment sites were sampled during 2005 basinwide sampling. Based on the macroinvertebrate collections, the overall water quality at the benthic sites was Good-Fair. Eight of the 12 sites (67 percent) sampled (Catheys Creek data from 2003), rated Good-Fair. Of the remaining 4 sites, 2 rated Fair and 2 rated Good. This showed a decline in water quality from the 2000 basinwide sampling. In 2000, 7 sites rated Good-Fair, 1 rated Fair, 3 rated Good, and 1 rated Excellent. Many of the streams are low gradient, extremely sandy, and often lacking rocky riffle areas. Most of the stream fauna in these streams was associated with woody debris, leaf packs, and root mats.

Fish community ratings ranged from Good-Fair to Excellent. If petitioned, Britten and Walnut Creeks could be reclassified from Class C to Class C, High Quality Waters based upon the Excellent fish community ratings and the high quality instream and riparian habitats.

Eight of the 16 NPDES dischargers in this subbasin are required to perform toxicity testing. Since January 2000, the Town of Columbus's WWTP, Duke Power's Cliffside Steam Station, and the Forest City-Riverside Industrial Park WWTP reported no permit violations. The Cone Denim LLC-Cliffside Plant reported 4 permit violations, Dan River, Inc. reported 1 violation, and the Town of Forest City's WWTP reported 5 violations. The Town of Spindale's WWTP reported seven permit violations and the City of Rutherfordton's WWTP has had 22 violations.

Table 4. Waterbodies monitored in Subbasin 02 in the Broad River basin for basinwide assessment, 2000 and 2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	Broad R	Rutherford	SR 1181	Good	Fair
B-2	Mountain Cr	Rutherford	SR 1149	Good-Fair	Good-Fair
B-3	Broad R	Rutherford	SR 1106	Good-Fair	Good-Fair
B-4	Broad R	Rutherford	US 221	Good	Good-Fair
B-5	Cleghorn Cr	Rutherford	SR 1149	Good-Fair	Fair
B-6	Green R	Rutherford	SR 1302	Good-Fair	Good-Fair
B-7	Walnut Cr	Polk	SR 1315	Excellent	Good
B-8	Whiteoak Cr	Polk	SR 1352	Good	Good
B-9	Second Broad R	Rutherford	SR 1538	Good-Fair	Good-Fair
B-10	Catheys Cr	Rutherford	SR 1549	Fair	Good-Fair[2]
B-11	Roberson Cr	Rutherford	SR 1561	Good-Fair	Good-Fair
B-12	Second Broad R	Rutherford	SR 1973	Good-Fair	Good-Fair
F-1	Mountain Cr	Rutherford	SR 1178	---	Good-Fair
F-2	Cleghorn Cr	Rutherford	SR 1149	---	Good-Fair
F-3	Britten Cr	Polk	NC 9	---	Excellent
F-4	Walnut Cr	Polk	SR 1315	Excellent	Excellent
F-5	Whiteoak Cr	Polk	SR 1526	Good-Fair	Good
F-6	Floyds Cr	Rutherford	SR 1116	---	Good
F-7	Second Broad R	Rutherford	SR 1500	Good	Good
F-8	Big Camp Cr	Rutherford	SR 1504	---	Good-Fair
F-9	Roberson Cr	Rutherford	SR 1561	Good	Good

[1] B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.
[2] = benthic sampling was conducted in 2003

Five of the nine fish community sites were sampled for the first time in 2005 (Table 4). There are no NPDES facilities within the watersheds above the fish community sites on Mountain, Walnut, Floyds, Big Camp and Roberson Creeks or on the Second Broad River (Basinwide Information Management System query November 07, 2005).

A fish community sample could not be collected from Cane Creek at SR 1558 in Rutherford County when the site was visited on June 09 and June 21, 2005. Strong thunderstorms across this watershed the previous days lead to high flows and excessive turbidities.

Upstream views of turbidity in Cane Creek at SR 1558, Rutherford County, June 09 and 21, 2005.

Broad River at SR 1181, Rutherford County

This benthic site, about six miles below Lake Lure, was 22 meters wide with a sand dipping operation just upstream on the right bank. The same sand operation was noted in 2000. The stream bottom was very sandy (65%) with the remaining substrate comprised of gravel (25%) and rubble (10%). Riffles were absent, pools were infrequent, and the minimal canopy lowered the overall habitat score (41). The conductivity was 34 µmhos/cm. At this location, the drainage area is approximately 190 square miles.

This site rated Fair in 2005, Good in 2000, and Good-Fair in 1995. In 2005, the EPT S declined from 31 in 2000 to 18. The 2005 EPT S was the lowest ever recorded at this site and the BI was the highest (5.5). Only one stonefly taxon was collected in 2005; four taxa were collected in both previous sampling collections. The 2005 sample was collected in late September and previous samples were collected in July. Seasonal differences could influence the taxa, but such an overall decline in EPT taxa from 2000 and 1995 indicates a decline in water quality. The highest BI (5.5) to date also indicates a decline in water quality and a more tolerant benthic fauna. In addition, only the exotic Asiatic clam, *Corbicula fluminea*, was collected in 2005, while seven taxa were collected in 2000. A mussel bed containing hundreds of *Elliptio icterina* was observed in 2000, but was not located in 2005. Overall, this site indicated a decline in water quality and future sampling is warranted.

Mountain Creek, SR 1178, Rutherford County

Mountain Creek is a tributary to the Broad River and drains the west-central portion of Rutherford County. Like many streams within the basin that carry a heavy sand and sediment bed load, there was a sand-dipping operation at the site, below the bridge.

Mountain Creek at SR 1178, Rutherford County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Few fish were collected then and of the 12 species represented, the bluehead chub was the most abundant. In 2005, the least number of fish (n = 98) were collected at this site than at any of the other sites. Of the 59 fish community samples ever collected from the basin, this sample had the second fewest fish collected. The diversity of fish met expectations, but the number of fish and the percentage of species with multiple age groups were well below expectations. The low number of fish and the absence of age classes has been observed at other sites where the flow has fluctuated dramatically (i.e., from extremely low flows to extremely high flows). This may happen repeatedly in Mountain Creek. The site was rated Good-Fair. The bluehead chub was the most abundant species, 55 percent of all the fish collected were of this species.

Mountain Creek, SR 1149, Rutherford County

The substrate at this eight meter wide location on Mountain Creek was almost entirely sand (80%) with filled in pools and no riffles. The low habitat score (52) reflected the homogeneous substrate, narrow riparian zone on the left bank, and erosional areas on the stream banks. The drainage area is approximately 47 square miles. When sampled in September 2005 the conductivity was 39 μmhos/cm.

There have been three collections at the SR 1149 location: in 1995 (Good), 2000 (Good-Fair), and 2005 (Good-Fair). The 2005 sample (EPT S = 19; EPT BI = 4.6) and the 2000 sample (EPT S = 19; EPT BI = 4.1) were similar. However, these samples showed a decline in the benthic community from 1995. In 1995, the EPT S was 28 and the EPT BI was 3.8. The Full Scale method used in 2000 would have theoretically produced more EPT taxa than the abbreviated EPT methodology used in 1995 and 2005. In all three years, the taxa collected have been a mixture of moderately tolerant and intolerant fauna. The long-lived Perlid stonefly, *Acroneuria abnormis*, was been abundant in all three collections, but some intolerants such as the mayfly, *Leucrocuta*, was not collected in 2005 as in previous years. Since 1995, the benthic community at this site has shifted slightly towards more tolerant.

Broad River, SR 1106, Rutherford County

The Broad River was 32 meters wide at this location. The substrate was mostly sand (80%) with a small amount of boulder (10%) and rubble (10%). The habitat received a low score (44) due to substrate composition, absence of riffles, and infrequent pools. The riparian zones were wide and intact. The drainage area is approximately 539 square miles at this site. The conductivity was 24 μmhos/cm.

This site has been sampled three times since 1995 and has consistently rated Good-Fair. A new bridge was under construction during the 2000 sampling. It was noted at that time the flow had been significantly reduced. Taxa changes between 1995 and 2000 included a decrease in fauna that require adequate flow year round (*Acroneuria abnormis*, *Pteronarcys dorsata*) and increases in fauna adaptive to low flows (*Caenis, Stenacron pallidum*, and *Oecetis persimilis*). The 2005 sample indicated that the faunal changes were not permanent and most of the taxa absent in 2000 were collected in 2005. This site has rated Good-Fair since 1995, indicating impacted water quality for 10 years.

Broad River, US 221, Rutherford County

The Broad River near Cliffside was 30 meters wide. Substrate was mostly rubble (35%) and gravel (40%) with smaller amounts of sand (20%) and silt (5%). The habitat scored 51 as a result of the embedded substrate, absence of pools, and riffles filled in with sediment. The drainage area is approximately 609 square miles. In 2005, the conductivity measured 42 μmhos/cm. This site experiences considerable diurnal flow fluctuations from power plant operations located upstream and the current can be very swift and dangerous.

This site is the most downstream basinwide location on the Broad River and has been sampled nine times since 1983. Seven of the nine samples resulted in a Good-Fair rating, with the exception of 1983 (Fair) and 2000 (Good). The 2005 sample rated Good-Fair. Of the nine samples, the 2000 sample had the highest EPT S (32) and the lowest BI (4.9). The 2005 sample had one of the lowest EPT S (20) and highest BI (5.3). Although this site has rated Good-Fair since 1984, the 2005 sample was lower within the Good-Fair range suggesting declining water quality over time.

Cleghorn Creek, SR 1149, Rutherford County

Cleghorn Creek is a tributary to the Broad River and drains the southwestern portion of Rutherford County including the Towns of Rutherfordton and Spindale. This site was approximately four miles below the Town of Rutherfordton's wastewater treatment plant (NC0025909) outfall. The facility is permitted to discharge up to 3 MGD to the creek. Between July 01, 2001 and July 01, 2005, there were at least 36 months whereby the facility had at least one permit limit violation for ammonia, total suspended solids, and total residual chlorine, monitoring violations, reporting violations, and toxicity test failures (Basinwide Information Management System query November 07, 2005). The violations led to enforcement actions by DWQ many times and resulted in monetary penalties being assessed. The facility is under a Special Order of Consent (SO4-003) effective August 01, 2005 until August 01, 2007.


Cleghorn Creek at SR 1149, Rutherford County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Ten species were represented and the bluehead chub was the most abundant species. In 2005, the community was rated Good-Fair. Diversity and tolerance metrics were within expectations, but the percentage of omnivores+herbivores (65 percent), an indicator of nutrient enrichment, was the highest of any of the sites in the basin in 2004/2005. Almost two-thirds of all the fish collected were bluehead chubs, also an indicator of nutrient enrichment.

At the time of macroinvertebrate sampling, the stream was seven meters wide and continued to show problems with sedimentation. The substrate was mostly sand (60%) and gravel (30%), with a small amount of rubble (10%). The habitat received a score of 57. There were sections of vertical eroding banks, most of the pools were filled in, and the riffles were small and infrequent. The drainage area of Cleghorn Creek at this road crossing is 13.6 square miles. This site had a high conductivity measurement (78 μmhos/cm), which was probably a result of the Town of Rutherfordton WWTP discharge.

This site rated Fair in 2005, Good-Fair in 2000, and Fair in 1995. The EPT S in 2005 (21) was comparable to past years (2000 EPT S = 24 and 1995 EPT S = 17). The BI was the same for 2000 and 2005 (6.2). The long-lived stonefly, *Acroneuria abnormis,* has been collected at this site since 1995, indicating a stable habitat. In addition, *Eccoptura xanthenes*, another long-lived perlid stonefly was collected for the first time in 2005. Caddisfly taxa did experience a decline in the 2005 sample. Eleven caddisfly taxa were collected in 2000 and only 6 in 2005. The samples were very similar for this site in 2000 and 2005, indicating borderline Good-Fair and Fair conditions for both years. The overall Total S was higher in 2000 than in 2005; this could be attributed to low rainfall, resulting in reduced scour and less impact from nonpoint sources.

Green River, SR 1302, Rutherford County

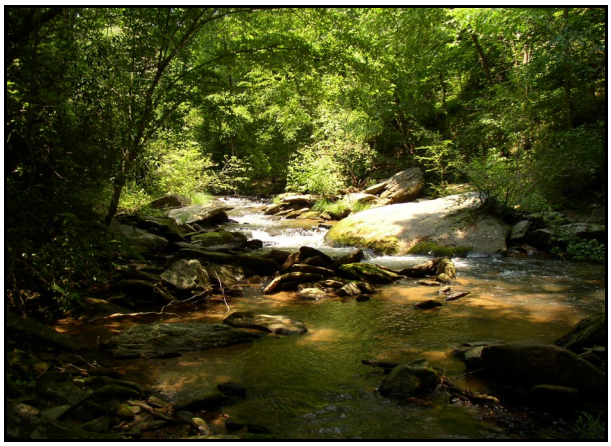
This site near the mouth of the Green River was 20 meters wide. The substrate was comprised of rubble (45%), boulder (20%), sand (20%), gravel (10%), silt (5%) and a trace of bedrock. The habitat scored 68. Although the riparian zone was not intact and bank erosion was present, riffles were frequent, and sticks, leafpacks, and undercut banks were abundant. The drainage area is approximately 243 square miles. The conductivity was 40 μmhos/cm.

The site at SR 1302 has been sampled five times, beginning in 1987. In 1987 and 1989, the site rated Good. Since 1995, the site has consistently rated Good-Fair, including the 2005 sample. The 2005 sample had the lowest EPT S (23) recorded and the highest BI (4.8) since 1995, indicating a decline in water quality over time. This decline may be related to increased nutrient input and other stressors from development around Lake Adger, which is located upstream.

Britten Creek, NC 9, Polk County

Britten Creek is a tributary to the Green River and drains northwestern Polk County. The monitoring site was approximately 400 yards upstream of the creek's confluence with the Green River. At this crossing, the instream, riparian, and watershed characteristics were of exceptionally high quality (habitat score = 97; Appendix F-6) and qualified the site as a new fish community regional reference site. The habitat score was the highest of any fish community site in the basin and the second highest of any of the approximately 1,100 fish community samples evaluated across the state.

There is one permitted discharger within the creek's watershed. The Pavilion International facility (NC0085294) is located approximately four miles upstream of the monitoring site. It is permitted to discharge up to 0.0059 MGD to the creek. Between July 01, 2001 and July 01, 2005, there where no limit or monitoring violations for this facility (Basinwide Information Management System query November 07, 2005).



Britten Creek at NC 9, Polk County.

As expected at a site with high quality instream and riparian habitats and downstream from a discharger in compliance, the fish community was rated Excellent (NCIBI = 54). The intolerant, fieryblack shiner was the most abundant species collected. Other intolerant species present were the seagreen darter and the Piedmont darter, a species uncommon in the Broad River basin.

Walnut Creek, SR 1315, Polk County
Walnut Creek is tributary to the Green River and drains the extreme northeast corner of Polk County. The monitoring site was approximately one mile above the creek's confluence with the Green River. Diverse habitats characterize Walnut Creek at SR 1315. The lower one-third of the reach has a cobble and boulder substrate with riffles and a swift current; the upper two-thirds of the reach is shallower, slower moving, and the substrate is sand.


Walnut Creek at SR 1315, Polk County.

The fish community was rated Excellent in 2000 and 2005. There was a slight increase in the percentage of tolerant fish between 2000 and 2005 due to a slight increase in the abundance of the tolerant creek chub, white sucker, and redbreast sunfish. The percentage of piscivores also decreased due to an absence of largemouth bass. These slight changes were offset by a more balanced percentage of omnivores+herbivores (due to a decrease in the omnivorous bluehead chub) and insectivores in 2005 than in 2000.

Based upon samples from 2000 and 2005, the fish community is very diverse; 25 species have been collected from the creek, including 10 species of minnows, 5 species of suckers, and 4 species of darters. The creek and the community were unique in other respects:

- Walnut Creek was only 1 of 2 streams in the basin where 23 species have been collected at any particular time;
- Walnut Creek was only 1 of 2 streams in the basin where 4 species of darters have been found;
- Walnut Creek was the only stream in the basin where 5 species of suckers have been found; and
- Walnut Creek was only 1 of 3 streams in the basin where 6 intolerant species have been found.
- Regional endemics inhabiting the stream include the thicklip chub, Santee chub, highback chub, striped jumprock, and seagreen darter.
- Based upon DWQ data and records from other researchers, two species found in Walnut Creek, the brassy jumprock and Piedmont darter, are uncommon and rare to uncommon, respectively in the basin.
- The only non-native (exotic) species collected from this creek has been the green sunfish and only one specimen was collected in 2005.

This location was also sampled for benthic fauna in 2005. Although the substrate was mixed, it was embedded and siltier than in 2000. The habitat scored 79, which reflected the frequent riffles and overall favorable habitat. The drainage area is approximately 17 square miles. The conductivity at the time of sampling was 33 µmhos/cm.

Benthic macroinvertebrates rating have yielded varying results. In 2005, the rating was Good, in 2000 Excellent, and in 1995 Fair. It is unclear why the diversity was so low in 1995 (EPT S = 14). In 2000, the EPT S was 38 and the EPT BI was 3.4 indicating intolerant fauna and good water quality. In 2005, the

EPT S decreased to 33, causing the rating to decline to Good; the EPT N also decreased. Fewer baetid mayflies, an absence of *Serratella*, philopotamid caddisflies, and *Neophylax* were the main differences between 2000 and 2005. Overall, the 2005 taxa still were indicative of a minimally impacted stream. Seasonality and scour from heavy rains due to hurricanes in 2005 may have contributed to the differences in taxa between the two samples.

Whiteoak Creek, SR 1526, Polk County

Whiteoak Creek is a tributary to the Green River and drains central Polk County, including the Town of Columbus. There is one permitted discharger within the creek's watershed. The town's wastewater treatment plant is located approximately three miles upstream of the monitoring site. It is permitted to discharge up to 0.8 MGD to the creek. Between July 01, 2001 and July 01, 2005, there where 15 permit limit violations (for fecal coliforms, biochemical oxygen demand, and total suspended solids), monitoring violations, and reporting violations for the facility. Three Notices of Violations (NOV) were issued in 2004 (Basinwide Information Management System query November 07, 2005).

Whiteoak Creek at SR 1526, Polk County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Ten species were represented and the bluehead chub was the most abundant species. In 2005, the community was rated Good (NCIBI = 48), it had been rated Good-Fair (NCIBI = 46) in 2000. Except for the collection of 12 intolerant seagreen darters in 2005, the community did not change substantially between 2000 and 2005. The elevated percentage of omnivores+herbivores and the dominance of bluehead chubs in 2000 and 2005, approximately 50 percent of the fauna, was indicative of an abundance of nutrients in the stream.

Whiteoak Creek, SR 1352, Polk County

This benthic site on Whiteoak Creek is approximately 0.5 mile above the confluence with the Green River. The effects of sediment filling in pools and riffles were evident at this 12 meter wide location. The creek is adversely affected by nonpoint source impacts. The substrate was rubble (30%) with a small amount of boulder(10%) and gravel (10%). Sand and silt made up 50% of the substrate. The overall habitat score was 73. The drainage area is 52 square miles; conductivity was 48 μmhos/cm.

This site has been sampled five times since 1986. In 1986 the rating was Good-Fair; it has been Good since then, including 2005. In 2005 an EPT sample was collected; previously, all samples had been Full

Scale. The EPT S of the 2005 sample was 28, which was borderline Good. One fewer taxon would have produced a Good-Fair rating. With the exception of 1986, the 2005 sample contained the lowest number of EPT taxa. Although the sampling technique in 2005 differed from 2000, 12 fewer EPT indicated a stressor or decline in water quality.

Floyds Creek, SR 1116,, Rutherford County

Floyds Creek is a tributary to the Broad River and drains southern Rutherford County including the Towns of Spindale and Forest City and the US 74 corridor. Indications of high flows in 2004, for example the presence of large, coarse woody debris snags in the channel and severely eroded stream banks in places, was still evident in 2005.

Floyds Creek at SR 1116, Rutherford County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Only 43 fish representing eight species were collected; darters were absent. In 2005 four species of darters were present along with 16 other species. Four of the 20 species were intolerant species. The community was rated Good, but fewer fish were collected and a greater number of tolerant species, primarily redbreast sunfish and green sunfish, were present than what was expected.

Second Broad River, SR 1500, Rutherford County
This site is in the headwaters of the Second Broad River. Here the river drains southern McDowell County, including the rural development along the US 221 corridor, and a smaller portion of northern Rutherford County. This high gradient site is a fish community regional reference site.


Second Broad River at SR 1500, Rutherford County.

The site was rated Good in 2000 and in 2005. There were no substantial changes in the fish community or the metrics between the two monitoring periods. Twenty species of fish are known from the site, including two recent exotics – the green sunfish and the redear sunfish. The fantail darter is the only species of darter that has ever been collected at this site. The other species of darter found in the basin, the seagreen darter, tessellated darter, and piedmont darter, are not known from this part of the watershed, so the low diversity of darters may be natural. The dominant species in 2000 was the bluehead chub; in 2005 it was the fantail darter and the bluehead chub.

Second Broad River, SR 1538, Rutherford County

The Second Broad River near Logan was 10 meters wide. The substrate was mostly sand (70%) with small amounts of rubble (5%), gravel (15%), and silt (10%). There were no riffles due to heavy sedimentation, so woody debris, leafpacks, and undercut banks provided the best habitat. Bank erosion was severe and the riparian zones were not intact. The overall habitat scored 51. The drainage area is 87 square miles. Conductivity measured 33 µmhos/cm.

This site rated Good-Fair in 2005, the same rating it received in 2000 and 1995. The EPT S (26) has remained constant since 1995, although the BI has slightly increased since 1995 (4.4) and 2000 (4.7); the BI in 2005 was 5.2. For the past ten years, the benthic assemblage at this site has been a mixture of mostly moderately tolerant taxa (*Isonychia, Hexagenia, Stenonema modestum*, and *Cheumatopsyche*) with some intolerants (*Paragnetina fumosa, Acroneuria abnormis*, and *Brachycentrus nigrosoma*). This site has rated Good-Fair since 1995, indicating impacted water quality for 10 years.

Big Camp Creek, SR 1504, Rutherford County
Big Camp Creek is a tributary to the Second Broad River and drains rural northern Rutherford County. The stream was very turbid on June 09, 2005 and could not be sampled. The site was sampled on June 21, 2005. The water became very turbid (orange) when walking in the channel. Even though the watershed is rural, the source of the excessive turbidity should be investigated.


Big Camp Creek at SR 1504, Rutherford County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Only eight species were collected, including one species of darter and no sunfish. In 2005, only one species of darter (fantail darter) and sunfish (redbreast sunfish) were collected. The redbreast sunfish was represented by only one specimen, which is usually a common species. The diversity metrics (total number of species, number of species of darters and sunfish, bass, and trout, and the number of intolerant species) were all lower than expected. The Piedmont shiner was the dominant species and the community was rated Good-Fair.

Catheys Creek, SR 1549, Rutherford County

Catheys Creek at SR 1549 was sampled in June 2003 as part of a Wetlands Restoration Project (WRP) (Biological Assessment Unit Memorandum 030815) and was not resampled during 2005 basinwide assessment. The WRP study was initiated based on Fair benthic ratings for Catheys and Hollands Creek. Catheys Creek originates in a forested and agricultural area upstream of the Spindale-Rutherford area. The drainage area at this site is 44 square miles. At the time of sampling, Catheys Creek had been severely scoured by recent rains. The habitat scored low (38), reflecting the unstable coarse sand substrate and severely eroded stream banks. Large snags were the only substrate that produced benthic macroinvertebrates. In 2003, the conductivity was 66 µmhos/cm.

This site has been sampled five times since 1988 and has remained on the borderline between Fair and Good-Fair. The 2003 bioclassification was Good-Fair, suggesting no significant change in water quality. One fewer EPT taxon in the 2003 sample would have produced a Fair rating. All baetid taxa were sparse at this site, suggesting that the coarse sandy habitat led to significant scour. There was a diverse and abundant stonefly fauna in all years, although one of the more intolerant taxa (*Acroneuria abnormis*) was less common in 2000 and 2003.

Roberson (Robinson) Creek, SR 1561, Rutherford County

Roberson Creek is also a tributary to the Second Broad River and drains east central Rutherford County.


Roberson Creek at SR 1561, Rutherford County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Eleven species were collected and more than 80 percent of all the fish collected were the bluehead chub. This site has been sampled by DWQ staff in 2000 and in 2005. Both times, the community has been rated Good (NCIBI = 52 and 50, respectively). Twenty-one species of fish are known from the site, but the tessellated darter and the seagreen darter are absent from the watershed. In both years the bluehead chub was the most abundant species.

Although the ratings and most of the metrics were not different between years, the total number of fish collected and the number of species with multiple ages decreased substantially between 2000 and 2005. There was an approximately 75 percent decline in the number of fish collected, the second greatest of any fish community site in the basin. Of the 21 species known from the site, 17 of them declined in abundance and four species were not collected in 2005. Less than 30 percent of the species were represented by multiple age groups, the lowest percentage of any fish community site in the basin in 2005. The decline in abundance and the loss of age classes has been observed at other sites where the flow has fluctuated dramatically (i.e., from extremely low flows to extremely high flows; Appendix F-8). This may have happened at Roberson Creek.

The drainage area of Roberson Creek at SR 1561 is 26 square miles. Similar to other streams in the basin, Roberson Creek had a mostly sandy substrate (50%), with some gravel (40%), and silt (10%) comprising the remaining substrate. The habitat was characterized by infrequent riffles and pools, but good snags and undercut banks. The habitat score was 65. The conductivity was 44 µmhos/cm at the time of sampling.

The Good-Fair bioclassification for benthos has remained unchanged since 1995, although there were indications in 2000 that impacts were increasing in this watershed. While most streams in this subbasin had more taxa in 2000 than in 1995 due to reduced scour from low rainfall conditions, Roberson Creek's EPT S and EPT N declined, and the EPT BI increased between 1995 and 2000. The 2005 EPT S (24) and EPT BI (4.4) were similar to 2000 (EPT S = 21 and EPT BI = 4.6). These numbers may indicate decreasing biological integrity in the benthic fauna. Regardless, this site has rated Good-Fair since 1995, indicating impacted water quality for 10 years.

Second Broad River, SR 1973, Rutherford County

This site near Cliffside was just upstream of the Cone Mills-Cliffside WWTP discharge. The drainage area is approximately 220 square miles. The conductivity (226 μmhos/cm) was very high at this site and the water was red in color. The substrate was mostly rubble (55%) with the remainder comprised of gravel (20%), sand (10%), boulder (10%) and silt (5%). Infrequent pools, some erosional areas on the banks, and a narrow riparian zone on one bank lessened the final habitat score (72).

This site has been sampled eight times since 1983. Over that time, water quality has improved, but not above a Good-Fair rating. This location was rated Poor in 1983, Fair in 1985 and 1989, and Good-Fair in 1987, 1991, 1995, 2000, and 2005. Similar to many streams in the Broad Basin, the total taxa number was greater in 2000 (83) than in 2005 (62), but this was mostly due to a greater number of midges in 2000 (26 versus 11). A notable difference in the 2000 and 2005 sample was the decrease in Trichoptera taxa in 2005. The 2000 sample contained 16 caddisfly taxa, while the 2005 sample contained 11. Several of these taxa (*Nectopsyche pavida*, and *Oecetis persimilis*) are considered summer taxa, so seasonal differences may partially account for the decrease. Overall, the 2005 sample (EPT S=26, BI= 5.6) was similar to the 2000 (EPT S=29, BI= 5.8). This site has had stable Good-Fair water quality since 1987.

Special Studies

Catheys Creek and Hollands Creek WRP/EEP Study, Rutherford County

Catheys Creek and Hollands Creek were selected as a WRP/EEP study area based on Fair macroinvertebrate ratings assigned to some sections of these streams, especially below the Spindale wastewater treatment plant. The Town of Spindale originally discharged to Hollands Creek and was found to have problems with chronic toxicity and mercury concentrations. The wastewater plant relocated the discharge further downstream to Catheys Creek in 1999 in order to achieve greater dilution. The June 2003 study included three sites on Catheys Creek, including the basinwide site at SR 1549, three sites on Hollands Creek, and four other sites on tributaries and reference sites. All six sites on Catheys Creek and Hollands Creek rated Good-Fair. Taxa collected in Catheys and Hollands Creek compared with habitat assessments suggested both habitat and water quality problems exist in these streams (Biological Assessment Unit Memorandum B-030815).

The fish communities in Catheys Creek at US 221 and at SR 1549 and in Hollands Creek at SR 1547 and SR 1548 were sampled on March 23, 2004 at the request of staff from the Ecosystems Enhancement Program. The two upstream sites on each creek, at US 221 and at SR 1547, had better instream and riparian habitats and rated higher (Good and Good-Fair, respectively) than the lower sites on each creek which both rated Fair. The habitat score (25) for Hollands Creek at SR 1548 was one of the lowest scores ever recorded for the approximately 1,100 fish community samples evaluated across the state. Sedimentation from the Towns of Rutherfordton and Spindale contributed to the poor instream habitats at the downstream sites and restoration efforts were recommended to improve the habitat qualities at both of these sites (Biological Assessment Unit Memorandum F-20040430).

Little Whiteoak Creek at SR 1324, Polk County

A benthic sample was requested by the Asheville Regional Office (ARO) due to development concerns in the Little Whiteoak Creek watershed, which is located southeast of Lake Adger. Little Whiteoak Creek rated Good-Fair (19 EPT taxa). For the most part, the taxa collected were moderately tolerant to tolerant (EPT BI = 5.2); however, several fairly intolerant taxa (*Eccoptura xanthenes, Pteronarcys*, and *Brachycentrus nigrosoma*) were collected in the sample.

The presence of animal waste from cattle confounded the analysis of stressors. It is recommended that cow access to the stream be addressed by the appropriate agency. In addition, Polk Central High School discharges to Little Whiteoak Creek (as of 2003). The discharge is considered minor (<1 MGD per day) and is 100 percent domestic waste. Although the source or combination of sources was unclear, the conductivity (55 μmhos/cm) at this location was slightly elevated compared to other sites in subbasin 02 (Biological Assessment Unit Memorandum B-051214).

BROAD RIVER SUBBASIN 03

Description

This subbasin is located primarily in the Southern Crystalline Ridges and Mountains Level IV ecoregion; the northeastern edge of the subbasin lies within the Southern Inner Piedmont ecoregion (Griffith *et al*. 2002). Within this subbasin lies the headwaters of the Green River; it has been impounded at two locations to form Lakes Summit and Adger (Figure 4). The Hungry River is the only large tributary to the river in this subbasin. A section of the Green River watershed from its source to the downstream side of the mouth of Little Rock Creek is designated High Quality Waters. The Green River Game Land between Lake Summit and Lake Adger on the Green and Hungry Rivers also provides important protected areas. The Green River Preserve, on the headwaters of the Green River, serves a similar function.

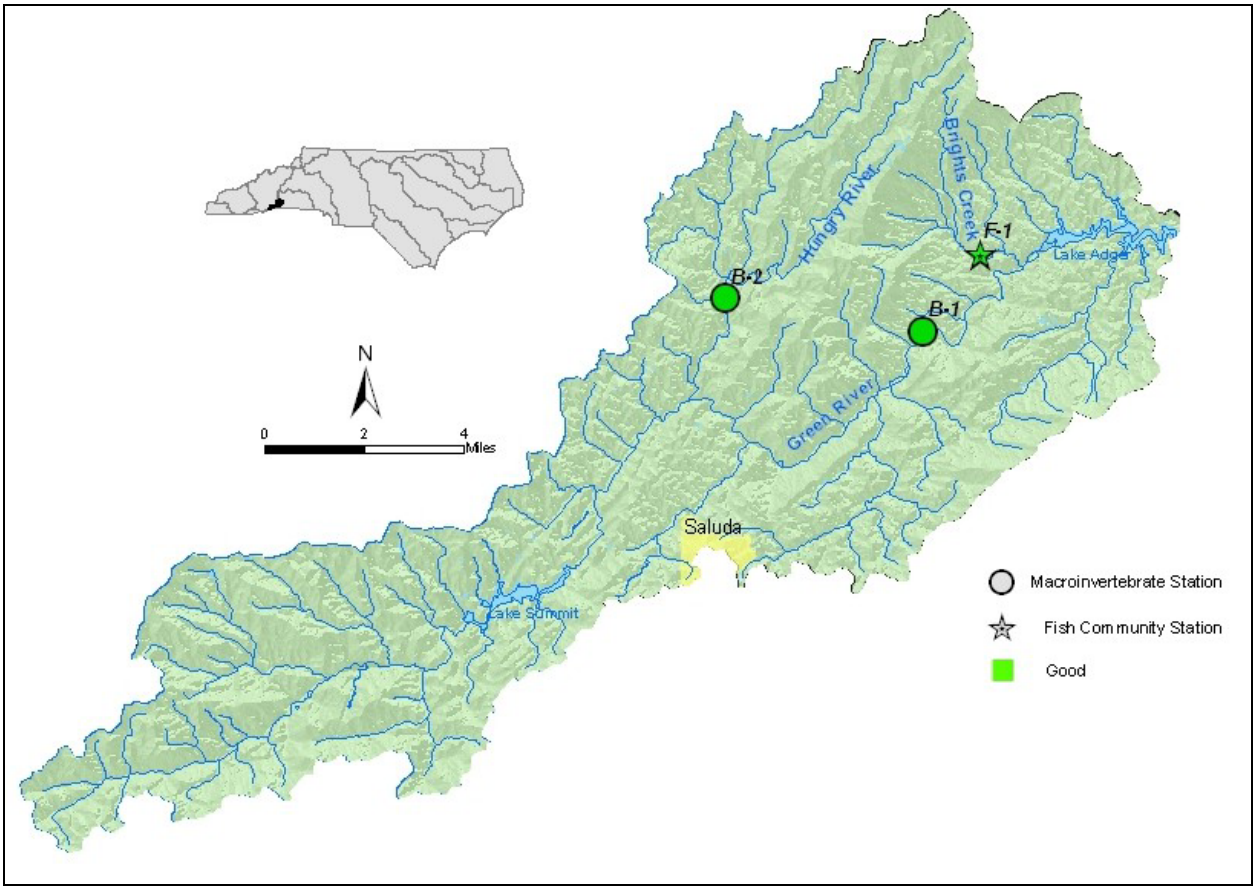


Figure 4. Sampling sites in Subbasin 03 in the Broad River basin. Monitoring sites are listed in Table 5.

More than 90 percent of the 137 square mile subbasin is forested (NCDENR 2003a). There is one existing permitted discharger in this subbasin (Basinwide Information Management System query November 07, 2005). R. J. G. Inc.'s Six Oaks Complex has a permitted discharge of 0.02 MGD to the Green River above Lake Summit. A second permitted facility is being built at the Bright's Creek Golf Club development. When the facility is operational, it will have a non-discharge permit (WQ0024694) to spray 0.12 MGD effluent with UV disinfection on the development's golf course.

Overview of Water Quality

The two macroinvertebrate sites in this subbasin rated Good during 2005 basinwide sampling (Table 5). The Green River at SR 1151 improved from a Good-Fair rating in 2000 and the Hungry River maintained its Good rating. Similar to other areas in the Broad basin, development is rapidly occurring and sedimentation is impacting the streams. A special study sample collected approximately one mile below the HQW designated section of the Green River rated Good-Fair. This rating is of concern due to its close proximity to HQW waters and warrants future sampling. The fish community on Brights Creeks which rated Good and is supplementally classified as tout waters (Tr) is within the Bright's Creek Golf Club residential development and has the potential to be impacted by upstream runoff from the development.

Table 5. Waterbodies monitored in Subbasin 03 in the Broad River basin for basinwide assessment, 2000 and 2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	Green R	Polk	SR 1151	Good-Fair	Good
B-2	Hungry R	Henderson	SR 1799	Good	Good
F-1	Brights Cr	Polk	SR 1155	---	Good

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

River and Stream Assessment

Green River, SR 1151, Polk County

This Green River basinwide site is located between Lake Summit and Lake Adger. The width was 16 meters wide and the substrate was a mix of rubble (35%), boulder (20%), gravel (20%), and sand (25%). The habitat score was 88, due to abundant leafpacks, snags, undercut banks, frequent pools and riffles as well as wide, intact riparian zones. The conductivity was 40 μmhos/cm. The drainage area at this site is 105 square miles.

This site has been sampled three times since 1995. The bioclassification was Good-Fair in 1995 and 2000, but improved to Good in 2005. The 2005 EPT S (37) was significantly higher than 2000 (29) and 1995 (25). In addition, the EPT BI was lower in 2005 (3.4) than in 2000 (3.5) and in 1995 (4.0). In 2005, the dominant mayflies were moderately tolerant taxa such as *Stenonema modestum*, *Baetis intercalaris,* and *B. anoka*. A diverse mix of seven stonefly taxa were collected including long-lived perlids (*Acroneuria abnormis, Paragnetina ichusa, P. immarginata*). In addition, fifteen caddisfly taxa were collected and there was a varied assemblage of beetles. The benthic community at this site has improved slightly since 1995.

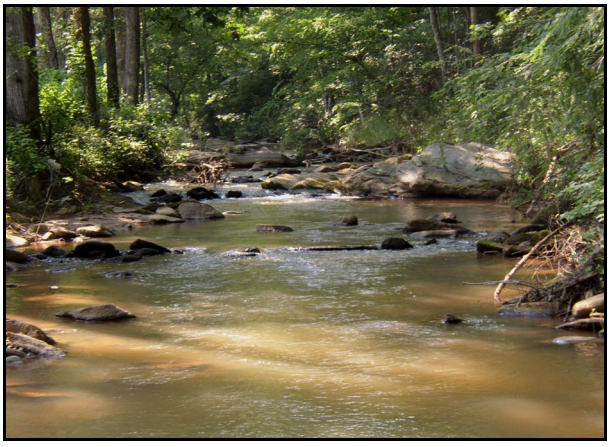
Hungry River, SR 1799, Henderson County

This site on the Hungry River is just below the confluence with Tumblebug Creek. The width was eight meters and instream habitat was a mix of boulder (20%), rubble (50%), gravel (10%), and sand (20%). Sedimentation had caused some riffle embeddedness and filled in pools. The riparian zone was less than 12 meters on both banks and the overall habitat score was 70. The drainage area at this location is 18 square miles. Conductivity was 47 µmhos/cm.

This location has been sampled four times; once in 1995, twice in 2000 (July and September), and once in 2005. The rating in 1995 was Good-Fair; since that time the rating has been Good. The improved rating in 2000 was attributed to a low flow year with reduced scour that allowed recolonization. The EPT S was slightly lower in 2005 (31) than the two 2000 samples (34 for each sample), but the EPT BI was similar for July 2000, September 2000, and 2005 (2.7, 3.2, and 3.2 respectively). All samples since 1995 have included intolerant taxa. Abundant taxa collected in 2005 contained many intolerant stoneflies and caddisflies (*Rhyacophila fuscula, Dolophilodes, Acroneuria abnormis*, and *Malirekus hastatus*). Intolerant mayflies (*Epeorus rubidus, Neoephemera purpurea*, and *Drunella conestee*) were also collected in 2005, but in fewer numbers. This site has changed little since 2000 and has maintained its Good rating.

Brights Creek, SR 1155, Polk County

Brights Creek was sampled for the first time for fish community assessment in 2005. The creek is a tributary to the Green River/Lake Adger and drains northwest Polk County. The creek's watershed at 5.9 square miles was the smallest watershed of any fish community site monitored in 2005 in the basin. In 1998, the site was identified as a fish community regional reference site but a fish community sample could not be collected until 2005. Recently, the area nearby and immediately upstream of the site are being developed into the 4,500 acre (seven square miles) Bright's Creek Golf Club residential development. When sampled on June 23, 2005, it was observed that land clearing activities followed by storm events had contributed to excessive turbidity and thick sediment deposits in the creek. These observations and concerns were communicated to the Land Quality Staff in the Asheville Regional Office. According to staff the developer was adhering to all the environmental regulations regarding minimizing sediment entering the stream. As mentioned previously, the permitted facility will spray the effluent on the golf course. Because of the development of this watershed and potential runoff from the golf course, the stream is no longer considered as fish community regional reference site.



Brights Creek at SR 1155, Polk County.

The fish community was rated Good at this site. The diversity of fish was high for a small stream and included two species of suckers and three species of darters. There was an abundance of bluehead chubs which skewed the trophic metrics; the number of intolerant species was also lower than expected. Brights Creek is supplementally classified as Tr, but a reproducing population of trout was not documented to inhabit the stream. Only one, 207 mm TL brown trout was collected from the reach.

This site should continue as a basinwide monitoring site to document any impacts from sediment runoff as the development is built out and to document any impacts from the land application of the treated effluent. Because a reproducing population of trout was not documented, this site should also be resampled to determine if the supplemental classification of Tr is still warranted or if more strict mitigation measures are needed.

Special Studies

Green River off SR 1106, Henderson County

ARO requested a sample on the Green River in the upper portion of the watershed above Lake Summit. Five benthic samples have been collected at several locations above Lake Summit since 1989. All samples resulted in Good or Excellent bioclassifications. The Green River from its source to the downstream side of the mouth of Rock Creek was designated as High Quality Waters (HQW). The HQW section ends approximately one mile above the site sampled in 2005.

The Green River off SR 1106 upstream of Lake Summit rated Good-Fair (21 EPT S and EPT BI = 3.1). The 2005 sample contained the lowest number of EPT S (21) ever for this stretch of the river. Samples from 1989 and 1993 ranged from 38 to 51 EPT. Though the 1989 and 1993 samples were collected in winter (January and late October) and the fact that Full Scale sampling methods should produce more EPT taxa than EPT sampling methods, the 2005 EPT sample still showed a decline in taxa. The 2005 sample contained a combination of tolerant and intolerant taxa. Intolerant taxa included *Heptagenia pulla, Epeorus rubidus*, *Neoephemera purpurea, Beloneuria, Suwallia*, and *Brachycentrus spinae*. However, year round taxa (*Isonychia, Paragnetina immarginata, Rhyacophila fuscula*) and sediment sensitive caddisflies *(Glossosoma, Goera*) that were collected in previous years were not collected in 2005. Similar to other areas in the river basin, this subbasin is impacted by increasing development as mountain property continues to be desirable for commercial and residential development. Future sampling is warranted based on the close proximity to HQW waters and the 2005 Good-Fair rating (Biological Assessment Unit Memorandum B-051214). It is recommended to include this upper Green River site as a basinwide site.

Joe Creek at SR 1106, Henderson County

Joe Creek was sampled in 2005 as a follow-up to special studies conducted in 1989 and 2000 to determine if the stream was supporting its designated use. Joe Creek, a small tributary to the Green River above Lake Summit rated Good-Fair (27 EPT taxa) in 2005, missing a Good rating by one taxon. The same location was sampled in 1989 (Good-Fair rating, 28 EPT taxa, seasonal correction) and 2000 (Excellent rating, 38 EPT taxa) using EPT methods both years. The EPT BI was similar for all three years (2.9, 3.0, and 3.0). The July 2000 sample contained 19 mayfly taxa while only 7 mayfly taxa were collected in the September 2005 sample. This difference in numbers of EPT taxa would be affected partially by seasonality, but year round taxa (*Caenis, Isonychia, Baetis flavistriga*, and *B. intercalaris*) were not collected in 2005. In addition, sediment sensitive caddisflies (*Goera* and *Glossosoma*) were not as abundant in 2005 as in 2000. Similar to most of the Broad River Basin, this upper portion of the Green River watershed warrants future benthic sampling to monitor water quality (Biological Assessment Unit Memorandum B-051214).

BROAD RIVER SUBBASIN 04

Description

This subbasin is located in three Level IV ecoregions – the Eastern Blue Ridge Foothills, the Northern Inner Piedmont, and the Southern Outer Piedmont (Griffith *et al*. 2002). Within this subbasin lies the watershed of the First Broad River and to a lesser extent, the Broad River (Figure 5).

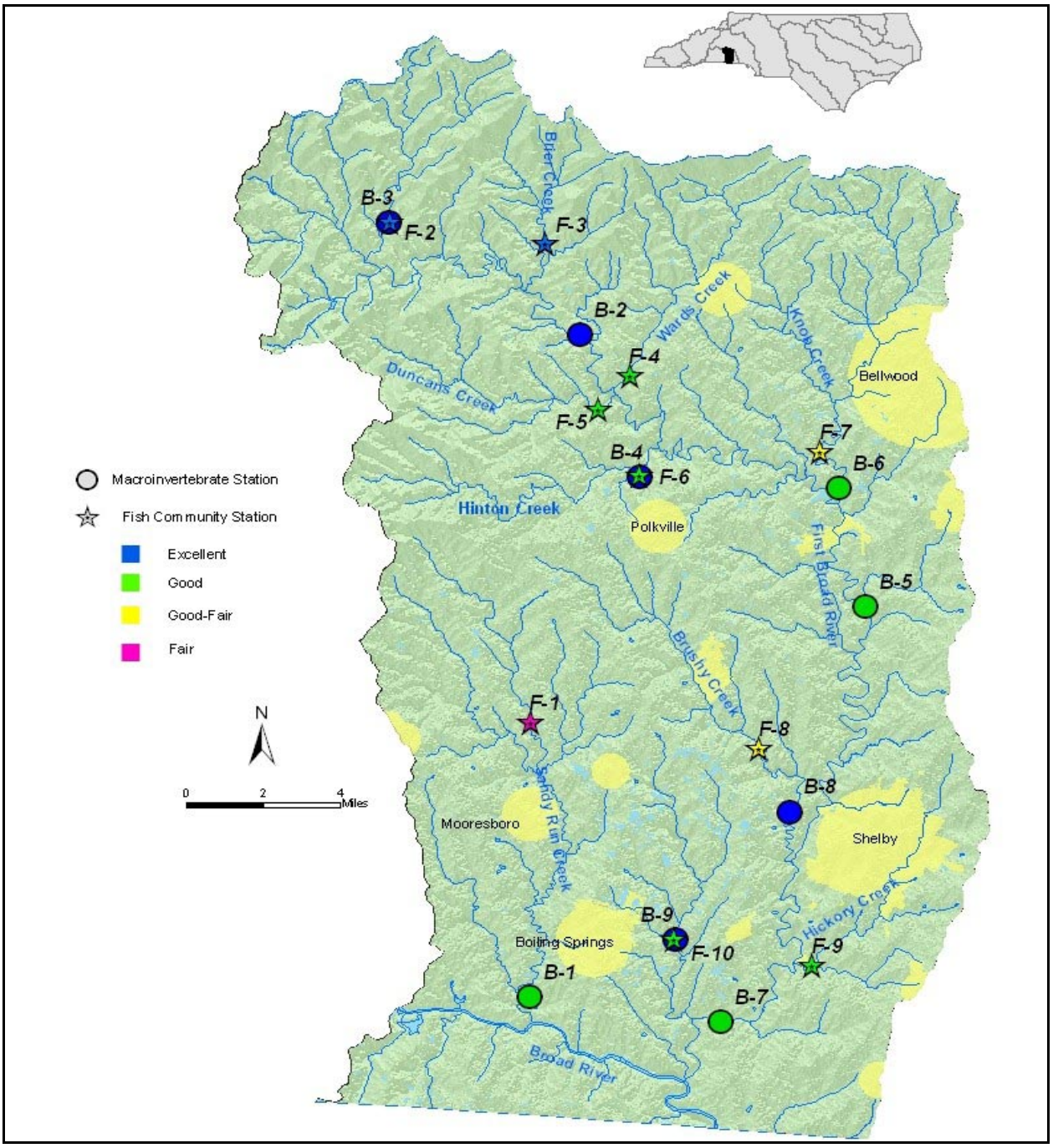


Figure 5. Sampling sites in Subbasin 04 in the Broad River basin. Monitoring sites are listed in Table 6.

The catchment of the North Fork First Broad River is contained in the Eastern Blue Ridge Foothills and is typified by open low mountain terrain with elevations ranging between 1,000 and 2,800 feet. Given the low elevations, this area contains a mix of both mountain and piedmont characters and most of the land is covered with mixed oak and oak-hickory-pine forests (Griffith *et al*. 2002). Extreme northeastern portions of Rutherford and northwestern areas of Cleveland County contain large intact forest areas associated with the South Mountains, and South Mountain State Park.

The First Broad River originates in northeastern Rutherford County and flows into the Broad River in Cleveland County, just above the North Carolina-South Carolina border. The First Broad River is contained in the Northern Inner Piedmont and has a rolling, hilly topography, but also contains mountain remnants known as monadnocks. Streams here are higher in gradient than most other piedmont Level IV ecoregions (Griffith *et al*. 2002). The Broad River and its tributary Sandy Run Creek drain the southwestern portion of the subbasin. These two waterbodies and all remaining streams in this subbasin are found in the Southern Outer Piedmont and landforms here are low relief with irregular plains.

Almost two-thirds of the 426 square mile subbasin is forested and one-third is in pasture (NCDENR 2003a). The largest urbanized areas are the Towns of Shelby and Boiling Springs. These municipalities are restricted to the southern third of the subbasin and are concentrated along the US 74 corridor. There are 11 permitted dischargers in the subbasin including the Towns of Shelby's and Boiling Springs' wastewater treatment plants and PPG Industries.

Overview of Water Quality

In this subbasin during 2005, 10 sites were sampled for fish community assessments and 9 for benthic macroinvertebrates (Table 6). At the benthic macroinvertebrate sites, most of the streams in the central and southern portion of this subbasin were evaluated with Piedmont criteria while those sites in the northern and western portion of the subbasin were evaluated using Mountain criteria. Sixteen of the 19 samples/sites monitored for fish or benthic macroinvertebrates were rated Good or Excellent. No sites were rated Poor and only one site was rated Fair (Sandy Run Creek). Except for the site on Sandy Run Creek, the seven fish community sites sampled previously did not change their ratings in 2005. Based upon benthic macroinvertebrates, Hinton Creek improved dramatically from Good-Fair in 2000 to Excellent in 2005, while Brushy and Beaverdam Creeks, and First Broad River at SR 1530 all improved from Good in 2000 to Excellent in 2005 (Table ---).

Table 6. Waterbodies monitored in Subbasin 04 in the Broad River basin for basinwide assessment, 2000 and 2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	Sandy Run Cr	Cleveland	SR 1195	Good	Good
B-2	First Broad R	Cleveland	SR 1530	Good	Excellent
B-3	N Fk First Broad R	Rutherford	SR 1728	Excellent	Excellent
B-4	Hinton Cr	Cleveland	NC 226	Good-Fair	Excellent
B-5	First Broad R	Cleveland	Off SR 1809	Good	Good
B-6	Knob Cr	Cleveland	SR 1004	Good	Good
B-7	First Broad R	Cleveland	SR 1140	Good	Good
B-8	Brushy Cr	Cleveland	SR 1308	Good	Excellent
B-9	Beaverdam Cr	Cleveland	NC 150	Good	Excellent
F-1	Sandy Run Cr	Cleveland	SR 1332	Good	Fair
F-2	N Fk First Broad R	Rutherford	SR 1728	Excellent (1999)	Excellent
F-3	Brier Cr	Rutherford	SR 1733	Excellent (1998)	Excellent
F-4	Wards Cr	Cleveland	SR 1525	Good	Good
F-5	Duncans Cr	Cleveland	NC 226	---	Good
F-6	Hinton Cr	Cleveland	NC 226	---	Good
F-7	Knob Cr	Cleveland	SR 1641	Good-Fair	Good-Fair
F-8	Brushy Cr	Cleveland	SR 1342	Good-Fair	Good-Fair
F-9	Hickory Cr	Cleveland	NC 18	Good	Good
F-10	Beaverdam Cr	Cleveland	NC 150	Good	Good

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

There are four NPDES dischargers in this subbasin that are required to perform Whole Effluent Toxicity (WET) testing. PPG-Shelby (NC0004685) which discharges 1.3 MGD to Brushy Creek and Shelby WWTP (NC0024538) which discharges 6.0 MGD to the First Broad River had no WET violations since 2000. E-flex LLC (formerly known as Cleveland Mills) (NC0004120) discharges 0.78 MGD to the First Broad River. This facility had one violation of its WET permit in December 2004 for a non-report. The last facility required to conduct WET testing, Jefferson Smurfit (NC0005061) had three WET violations since 2000. It discharges 0.01 MGD to the East Fork of Beaverdam Creek.

The six-month average stream discharge from April 2005 through September 2005 was 97 cubic feet per second (cfs) at the First Broad River near Casar (Figure 6). This monthly average was significantly greater than the six-month average stream discharge (49 cfs) measured from February 2000 through July 2000. In addition to WWTP upgrades and removals, the significantly higher six-month average discharge preceding the 2005 benthic macroinvertebrate collections relative to lower flows preceding the July 2000 collections can partially explain the improved bioclassifications observed at the First Broad River (SR 1530) and at Hinton, Brushy, and Beaverdam Creeks in 2005. In catchments primarily influenced by point sources of pollution (Beaverdam and Brushy Creeks) increased stream flow can dilute point sources of pollution and can result in short-term improvements in bioclassification. In mostly protected catchments (First Broad River at SR 1530 and Hinton Creek) increased stream flow can produce improved bioclassifications as instream physical conditions (such as increased availability of wetted habitat and increased dissolved oxygen levels) result in more favorable conditions for invertebrate colonization.

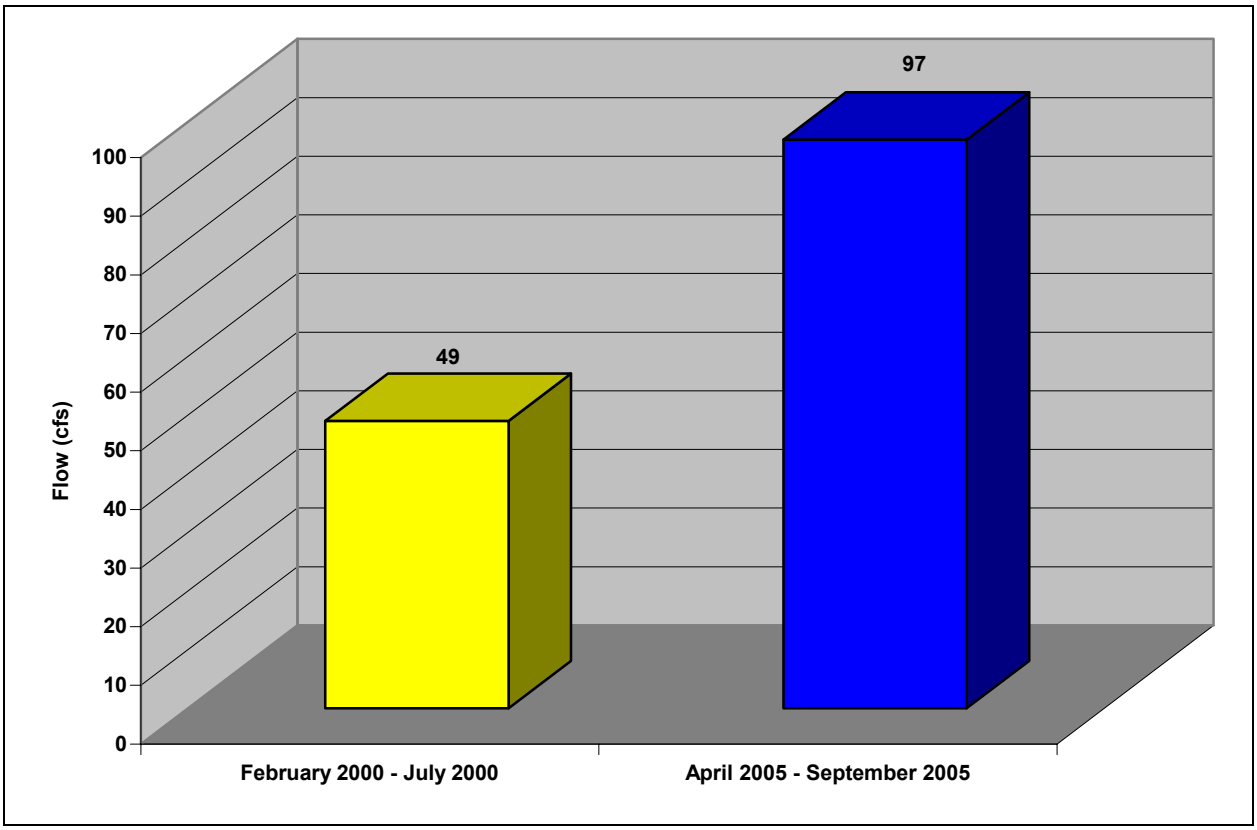


Figure 6. Six month average stream discharge (cfs) for the First Broad River near Casar, February 2000 - July 2000 and April 2005 - September 2005.

If petitioned, Brier Creek could be reclassified from Class C, Tr to Class C, Tr, High Quality Waters based upon the Excellent fish community ratings and the high quality instream and riparian habitats. Reclassification of the North Fork First Broad River watershed from Class C, Tr to Class C, Tr,

Outstanding Resource Waters is currently being pursued (Biological Assessment Unit Memoranda F-20050302 and F-20050913).

River and Stream Assessment

There are no NPDES facilities within the watersheds above the fish community sites on Sandy Run, Brier, Wards, Duncans, Hinton, Knob, or Hickory Creeks or on the North Fork First Broad River (Basinwide Information Management System query November 07, 2005). Two of the eight fish community sites were sampled for the first time in 2005 (Table 6).

Sandy Run Creek, SR 1332, Cleveland County
Sandy Run Creek is a tributary to the Broad River and drains western Cleveland and eastern Rutherford counties. The previous assessment report (NCDENR 2001c) described the creek as: "*Aptly named, Sandy Run Creek at SR 1332 has a sandy substrate, an absence of riffles, unstable banks, and a narrow riparian zone. In the upper part of the monitored reach, there are breaks in the riparian zone and livestock have access to the stream. The lower end of the reach had a slightly wider riparian zone with more stable banks than did the upper part of the reach*." The habitat score was 39. In 2005, cattle continued to have access to the stream and continued to cause substantial bank erosion. The habitat score was 35, the lowest of any fish community basinwide site in the basin in 2004/2005. It appeared there was more sediment (sand) in the channel in 2005 than in 2000. Even though there was evidence of cattle waste in the stream, the conductivity was not unusually elevated either in 2000 or 2005 (40 and 36 µmhos/cm, respectively).

Sandy Run Creek at SR 1332, Cleveland County.

This stream was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Only four species were collected and more than 60 percent of all the fish collected were bluehead chubs. The stream was described as having a sandy substrate and subject to flash flooding.

In 2005, there was almost an 80 percent decline in the number of fish collected compared to the number collected in 2000 (n = 722 vs. n = 165, respectively) (Appendix F-2). This decline was the greatest of any fish community site in the basin in 2005. The site also had the fewest number of species having declined from 15 in 2000 to 8 in 2005. Species that were absent included the sandbar shiner, white sucker, bluegill, largemouth bass, and fantail darter, and two intolerant species, the fieryblack shiner and the seagreen darter. The most abundant species was the bluehead chub which constituted almost 60 percent of all the fish collected. The dominance of this species and the abundance of periphyton suggested nutrient enrichment from the cattle waste. The community was rated a low Fair in 2005 (NCIBI = 36); it was rated a low Good in 2000 (NCIBI = 48). The fish community is potentially impacted by the agricultural practices within the watershed and by recent hydrological events, including the 1998 – 2002 drought and the subsequent flooding effects from the 2004 hurricanes (Appendix F-8).

Sandy Run Creek, SR 1195, Cleveland County

Sandy Run Creek along this segment is approximately 18 meters in width and has a drainage area of 64.9 square miles. Land use in the immediate area of this site is completely forested. However, the upstream portion of the catchment receives runoff from the Town of Boiling Springs and the US 74 corridor. In addition, this site is approximately 2.5 miles downstream from the Boiling Springs WWTP (NC0071943; 0.6 MGD), which underwent an expansion from 0.3 MDG to 0.6 MGD since the last sample in 2000. In addition, this facility upgraded its treatment process during the expansion. Substrate here is comprised of a generally unembedded mix of boulder (20%), rubble (40%), gravel (20%) and sand (30%). The primary habitat problems were the lack of pool habitat and some areas of stream bank erosion. Conductivity was 46 μmhos/cm during the 2005 sample, 53 μmhos/cm in 2000, and 68 μmhos/cm in 1995. Habitat received a score of 80.

This site has been sampled twice previously for benthos with a 1995 sample resulting in a Good-Fair bioclassification (BI=5.1, EPT BI=4.3, EPT S=28) and a 2000 sample producing a Good bioclassification (BI=4.7, EPT BI=4.0, EPT S=38). The 2005 sample also resulted in a Good bioclassification with a BI of 4.6, an EPT BI of 3.9, and a total EPT richness (EPT S) of 37. Since 1995, the biological data suggest steadily improving water quality at this site as the EPT BI and BI have both decreased at each successive sampling. There were several intolerant EPT taxa collected for the first time at this location in 2005 and included the mayflies *Epeorus dispar*, *Serratella serratoides*, the stonefly *Tallaperla*, and the caddisflies *Brachycentrus nigrosoma* and *Lepidostoma*. The treatment upgrades at the Boiling Springs WWTP may be contributing to the improving invertebrate metrics observed at this location.

First Broad River, SR 1530, Cleveland County

This location on the First Broad River has a drainage area of 60.2 square miles and is approximately 12 meters wide. The dominant landuse in this upper portion of the Broad River catchment is forest and row crops with only sparse areas of scattered residences. Substrate was an unembedded mix of boulder (10%), rubble (20%), gravel (40%) and sand (30%). No major habitat problems were noted along this reach and the habitat received a score of 88. Conductivity was 37 μmhos/cm.

This portion of the First Broad River has been sampled six times since 1986 with all six samples producing Good bioclassifications. The 2005 sample improved in bioclassification to Excellent with an EPT S of 54, which bettered the previous high EPT S of 47 recorded in 2000. There were several intolerant EPT taxa collected for the first time at this location in 2005 and included the mayflies *Acentrella*, *Baetisca carolina*, the stoneflies *Acroneuria lycorias*, *Beloneuria*, *Helopicus subvarians*, *Eccoptura xanthenes*, and the caddisflies *Micrasema bennetti*, *Oecetis morsei*, and *Rhyacophila nigrita*. The improvement at this site could possibly be the result of higher flows in 2005 versus those measured in 2000 (Figure 6). In protected catchments increased stream discharge can result in better instream physical conditions (such as increased availability of wetted habitat and increased dissolved oxygen levels), which can result in more favorable conditions for invertebrate colonization.

North Fork First Broad River, SR 1728, Rutherford County
The North Fork First Broad River is in the headwaters of the First Broad River watershed and drains the northeastern corner of Rutherford County. GIS landuse data based upon 1993 coverage showed that more than 90 percent of the watershed was forested with very small amounts of pasture and managed herbaceous lands. The specific conductance has always been low at this site (< 30 µmhos/cm). This site is a fish community regional reference site.


North Fork First Broad River at SR 1728, Rutherford County.

Nineteen species of fish are known from this watershed, 17 of which have been collected in recent years. The most commonly collected species include rosyside dace, fieryblack shiner, bluehead chub, Piedmont shiner, margined madtom, striped jumprock, and fantail darter. Rainbow trout and smallmouth bass, two species preferring cold to cool water and low turbidity, have been introduced into this watershed and are now sustained by wild, naturalized, reproducing populations. Intolerant species collected from this site include the thicklip chub, fieryblack shiner, highback chub, rainbow trout, smallmouth bass, and seagreen darter. The percentage of tolerant fish in the river has always been very low (1 - 2 percent) and is the lowest of any stream in the basin. The river is supplementally classified as Tr and a reproducing population of rainbow trout has always been documented in the stream. The fish community was rated Excellent again in 2005; it was rated Excellent in 1999 and Good in 1995. Reclassification of the North Fork First Broad River watershed from Class C, Tr to Class C, Tr, Outstanding Resource Waters is currently being pursued (Biological Assessment Unit Memoranda F-20050302 and F-20050913).

During benthic macroinvertebrate monitoring, this site was approximately eight meters wide. Substrate was an unembedded mix of boulder (10%), rubble (40%), gravel (30%) and sand (20%). The only habitat problem noted was a small disruption of the riparian zone on the left bank. Conductivity was measured at 29 µmhos/cm and the habitat received a score of 90. The North Fork First Broad River has been sampled for benthos at this road crossing on three previous occasions with one sample (1989) resulting in a Good bioclassification and two samples (1995, 2000) resulting in Excellent bioclassifications. The 2005 sample also received an Excellent bioclassification and produced both the highest EPT S (49) and lowest EPT BI (3.2) ever measured at this site. There were several intolerant EPT taxa collected for the first time at this location in 2005 and included the mayflies *Acentrella*, *Baetisca carolina*, *Drunella conestee*, *Drunella cornutella*, *Ephemerella catawba*, *Ephemerella invaria*, the stoneflies *Isoperla holochlora*, *Malirekus hastatus*, and the caddisflies *Diplectrona modesta*, *Lepidostoma*, *Rhyacophila carolina, R. nigrita*, and *R. vuphipes*.

Brier Creek, SR 1733, Rutherford County
Brier Creek is a tributary to the First Broad River and drains the northeastern corner of Rutherford County and the extreme northwestern corner of Cleveland County. Effects from the extremely high water from the 2004 hurricanes were evident in the upper reaches where the creek channel was now encroaching towards SR 1735. Like the North Fork First Broad River, the conductivity in the creek is very low (< 30 µmhos/cm). This site is a fish community regional reference site.


Brier Creek at SR 1733, Rutherford County.

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Twelve species were present and the bluehead chub was the most abundant species collected. The fish community did not seem to have changed appreciably in 40 years. In 1998 and 2005, 15 and 14 species were collected, respectively and the dominant species were the bluehead chub and the Piedmont shiner. The creek is supplementally classified as Tr and a reproducing population of rainbow trout were documented inhabiting the stream. The community was rated Excellent in 1998 and 2005.

Wards Creek, SR 1525, Cleveland County

Wards Creek is a tributary to the First Broad River and drains the rural northwestern corner of Cleveland County. Effects from the extremely high water from the 2004 hurricanes were not as evident at this site as compared to many other fish community sites in the basin. Even though there are no municipalities within the watershed, the conductivity increased between 2000 and 2005, from 24 to 39 µmhos/cm. This site continued to be a fish community regional reference site.


Wards Creek at SR 1525, Cleveland County.

The fish community was rated Good in 2000 and 2005 (NCIBI = 52). Only one species of sunfish, bass, and trout (redbreast sunfish) has ever been collected at this site, so this low diversity may be natural. The dominant species in 2005 was the bluehead chub and the highback chub.

Duncans Creek, NC 226, Cleveland County

Duncans Creek is a tributary to the First Broad River and drains rural northeastern Rutherford County and small region of northwestern Cleveland County. Duncans and Hinton Creeks were sampled in 2005

because they were adjacent to one another, had similar size watersheds, had no NPDES permitted dischargers within the watersheds, and had the potential to be new regional references sites. The habitat scores for each site (61), however, failed to qualify them as reference sites. Physical effects from the extremely high water from the 2004 hurricanes were evident at both sites.


Duncans Creek at NC 226, Cleveland County.

The fish community was rated Good (NCIBI = 48), but the diversities of suckers and of sunfish, bass, and trout were low as was the percentage of species with multiple age groups. Five intolerant species, thicklip chub, fiery shiner, Santee chub, highback chub, and seagreen darter, were present. The dominant species were the bluehead chub and the Piedmont shiner.

Hinton Creek, NC 226, Cleveland County

The Hinton Creek watershed is south of and adjacent to Duncans Creek. It is also a tributary to the First Broad River and drains rural northeastern Rutherford County and small region of northwestern Cleveland County.


Hinton Creek at NC 226, Cleveland County.

This creek was sampled (at the next bridge upstream) in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Twelve species were collected but only one species of darter (fantail darter) and one species of sunfish (redbreast sunfish). The bluehead chub was the dominant species. In 2005, the fish community was rated Good (NCIBI = 52). Sixteen species were collected, including three species of darters, but again only one species of sunfish (redbreast sunfish). The dominant species continued to be the bluehead chub. More fish were collected and the

catch per unit effort was greater at Hinton Creek than at Duncans Creek, but the species lists were almost identical.

During benthic macroinvertebrate monitoring, Hinton Creek was seven meters wide. Substrate was comprised mostly of gravel (40%), sand (50%), and silt (10%). The notable habitat problems at this location included a lack of well-developed pool habitat and a lack of boulder and rubble riffles. The habitat received a score of 70 and the conductivity was 32 μmhos/cm.

Hinton Creek was sampled for benthic macroinvertebrates during past basinwide surveys receiving Good-Fair bioclassifications in 1995 and 2000. For 2005, this site improved dramatically receiving an Excellent bioclassification. The 2005 sample had an EPT richness of 40 and an EPT BI (3.3). These metrics were dramatically improved from the 1995 metrics EPT S, 22 and EPT BI, 3.5, as well as the 2000 EPT S (26) and EPT BI (3.9). There were several intolerant EPT taxa collected for the first time at this location in 2005 and included the mayflies *Acentrella*, *Brachycercus*, *Heptagenia marginalis*, *Neoephemera purprea*, the stoneflies *Eccoptura xanthenes*, *Leuctra*, *Tallaperla*, and the caddisflies, *Diplectrona modesta*, *Glossosoma*, *Lepidostoma*, and *Neophylax oligius*. The improvement at this site could possibly be the result of higher flows in 2005 versus those measured in 2000 (Figure 6). In protected catchments increased stream discharge can result in better instream physical conditions (such as increased availability of wetted habitat and increased dissolved oxygen levels), which can result in more favorable conditions for invertebrate colonization.

First Broad River, off SR 1809, Cleveland County

This segment of the First Broad River is about halfway down the watershed. At this location, most of the upstream watershed is a mix of scattered residences, row crop agriculture, and patches of forest. Here, the First Broad River is approximately 22 meters wide and has a drainage area of 121.9 square miles. The primary NPDES discharger upstream of this location is E-Flex, LLC and has had no WET, permit violations since 2000. Substrate was a slightly embedded combination of rubble (10%) and gravel (10%) with sand (20%), silt (20%), and bedrock (30%) comprising the remainder. Habitat problems noted here included areas of bank erosion and a lack of well-developed riffles. The habitat scored 80 and the conductivity was 43 μmhos/cm.

Prior basinwide sampling in 1995 and 2000 produced Good bioclassifications as did the 2005 sample. was no different as it also receiving a Good bioclassification. The abundant presence (from current and previous collections) of the pollution intolerant and long-lived stoneflies *Acroneuria abnormis*, *Paragnetina fumosa*, and *Pteronarcys* suggests both stable and overall favorable water quality conditions through time. *Neotrichia*, a micro-caddisfly rarely collected in North Carolina, was collected from this location. *Neotrichia* has never before been collected from the Broad basin, and has only been collected by DWQ biologists on 14 previous occasions (out of nearly 6,000 collections) since invertebrate collecting started in 1983.

Knob Creek, SR 1641, Cleveland County

Knob Creek is a tributary to the First Broad River and drains north central Cleveland County.


Knob Creek at SR 1641, Cleveland County.

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). It was described as being turbid along its entire length and only seven species of fish were collected. Based upon the 1964 data and DWQ's 2000 and 2005 data, only 15 species of fish are known from this site. As observed at other sites in the basin that were affected by the drought and the 2004 high water events, the number of fish and the percentage of species with multiple age classes were less in 2005 than in 2000. However, an additional species of darter (the intolerant seagreen darter) and sunfish (bluegill) were collected in 2005. There was more balance to the trophic structure in 2005 than in 2000 even though the bluehead chub continued to be the most abundant species at the site. The fish community was rated Good-Fair in 2000 and 2005 (NCIBI = 42 and 46, respectively).

Knob Creek, SR 1004, Cleveland County

This segment of Knob Creek is approximately seven meters wide and has a drainage area of 34.9 square miles. Substrate is nearly all sand (90%) with only a small amount of gravel (10%) present. Landuse in this catchment is primarily row crop agriculture, forest, and sparse areas of residences. Several obvious habitat problems were noted at this location and included a lack of riffles and pools, severe bank erosion, and significant breaks in the riparian zone on the right bank. Conductivity was 36 μmhos/cm. The habitat problems noted above resulted in a score of 50.

All three basinwide samples (1995, 2000, 20005) from this location of Knob Creek have all resulted in Good bioclassifications. However, EPT S declined from 31 in 1995 and 30 in 2000 to 25 in 2005. This was the only site in Subbasin 04 in which the EPT S declined from both 2000 and 1995 levels. This decline included the loss of the mayflies *Hexagenia*, *Serratella deficiens*, *S. serrata*, the stoneflies *Neoperla*, *Perlesta*, and the caddisflies *Glossosoma* and *Micrasema wataga*. Although the 2005 collection was conducted in September, and the 1995 and 2000 samples were collected in July, there were four other sites in this subbasin where no decrease in EPT S were measured despite the later sampling. Therefore, seasonal effects are likely not the reason for the decline in EPT taxa at Knob Creek. The increased flows measured in this catchment in 2005 (Figure 6) may be the cause for the lowered EPT S. The Knob Creek catchment is predominately nonpoint agriculture. In periods of increased precipitation, catchments dominated by nonpoint runoff tend to experience increased pollutant runoff.

First Broad River, SR 1140, Cleveland County

This is the furthest downstream benthos station on the First Broad River and the catchment here includes most of the City of Shelby. The Shelby WWTP discharges approximately six miles upstream of this site and has had no WET permit violations since 2000. This segment of the First Broad River is approximately 35 meters wide and has a drainage area of 294.8 square miles. Substrate was primarily comprised of sand (80%) with lesser amounts of gravel (10%) and silt (10%). Primary habitat deficiencies included a lack of riffle and pool habitats, bank erosion, and riparian breaks on both banks. These problems are reflected in the low habitat score (47). The conductivity was 71 μmhos/cm.

This location of the First Broad River has been sampled on six previous occasions receiving one Fair rating (1985), three Good-Fair bioclassifications (1983, 1989, 1995) and two Good bioclassifications (1987 and 2000). The 2005 sample also resulted in a Good bioclassification and produced the highest EPT S (30) ever measured this location and included several intolerant EPT taxa collected for the first time including the mayflies *Acentrella*, *Heterocloeon curiosum*, the stonefly *Neoperla*, and the caddisflies *Pycnopsyche lepida*, *Psychomyia nomada*, and the rare microcaddisfly *Neotrichia*. This is only the second collection (both in 2005) of *Neotrichia* in the Broad basin since collections started in 1983.

Brushy Creek, SR 1342, Cleveland County

Brushy Creek is a tributary to the First Broad River and drains west central Cleveland County. The greatest decrease (37 percent) in conductivity between 2000 and 2005 in the basin was observed in Brushy and Hickory Creeks (Appendix F-7). As observed at other sites in the basin, physical effects from the 2004 high water events were evident at this site.

There are two permitted dischargers in the watershed upstream from the monitoring site. PPG Industries (NC0004685), located approximately 2.1 miles upstream, has a permitted discharge of up to 1.3 MGD. Between July 01, 2001 and July 01, 2005, the facility had 41 permit violations and three Notices of Violations (NOV) were issued in April, August, and October 2004 (Basinwide Information Management System query November 07, 2005). Ramseur Washerette (NC0030481), located approximately 3.8 miles upstream on Little Creek (a tributary to Brushy Creek), has a permitted discharge of up to 0.0056 MGD. Between July 01, 2001 and July 01, 2005, the facility had 26 permit violations and two NOVs were issued in October 2004 and May 2005 (Basinwide Information Management System query November 07, 2005).

Brushy Creek SR 1342, Cleveland County.

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer,, *et al.* 1965). It was described as having a shifting sand bottom which is typical of many streams in the basin. Only five species of fish were collected. Based upon DWQ's efforts in 2000 and 2005, 19 species are currently known from the creek of which 18 were collected in 2005 and 16 in 2000. An abundance of bluehead chubs in 2000 and 2005 led to a high percentage of omnivores+herbivores and a NCIBI rating of Good-Fair in both years. The diversity of darters and sunfish, bass, and trout were also lower than expected.

Brushy Creek, SR 1308, Cleveland County

This reach of Brushy Creek is approximately five meters in width and has a drainage area of 26.8 square miles. Substrate was a slightly embedded mix of rubble (10%), gravel (10%), sand (70%), and silt (10%). The primary habitat problems included a lack of pool and riffle habitat and moderate bank erosion. These issues lowered the habitat score to 66. While the conductivity in 2005 was 107 µmhos/cm, it was far less than the level measured here in 2000 (279 µmhos/cm). The only major discharger in this catchment (PPG-Shelby) has had no WET permit violations since 2000.

Brushy Creek was sampled at this road crossing in 2000 resulting in a Good bioclassification with 24 EPT taxa collected. The 2005 sample produced a noticeable increase in EPT taxa (31) resulting in an improved Excellent bioclassification. Several intolerant EPT taxa were collected for the first time here and included the mayflies *Acentrella*, *Baetisca*, *Heptagenia pulla*, *Neoephemera purprea*, the stonefly *Eccoptura xanthenes*, and the caddisflies *Oecetis persimilis* and *Pycnopsyche*. Of particular significance, the 2000 sample was collected using more intensive Full-Scale methods while the 2005 sample used less-intensive EPT methods. The fact that seven more EPT were collected using less intensive collection methods may reflect improving water quality as the drastically lower conductivity from 2000 to 2005 suggests. In addition, the increased flows in this catchment in 2005 relative to previous collections (Figure 6) likely diluted the effects of the PPG discharge. Moreover, the PPG plant started a pilot program in August 2002 whereby up to 100% of their discharge is recovered and filtered and used in their non-contact cooling process. As a result, there has been a significant reduction in the volume of their discharge.

Hickory Creek, NC 18

The Hickory Creek watershed drains the eastern half of the Town of Shelby in south central Cleveland County; the creek is also a tributary to the First Broad River. The greatest decrease (37 percent) in conductivity between 2000 and 2005 was observed in Hickory and Brushy Creeks. Hickory Creek drains an urbanized area of Shelby and Brushy Creek draining a more rural watershed but also with dischargers upstream (Appendix F-6).

The previous assessment report (NCDENR 2001c) described the creek as: ". . . *generally typical of the basin -- sandy substrate, shallow runs, infrequent and small side pools, shallow gravelly riffles, but also having a wide riparian zone. Discarded automobile tires and beverage cans deposited in the stream and along the shoreline attest to the stream's urban and suburban drainage*". In 2005, the instream and riparian habitats did not appear to have changed and continued to show severe bank erosion in places.


Hickory Creek at NC 18, Cleveland County.

This creek was sampled in 1964 (at the next bridge upstream) as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Only seven species were collected and the bluehead chub made up almost 80 percent of the total fauna. Since then, 24 species are known from the creek of which 23 have been collected by DWQ in 2000 or 2005; 18 of those have been collected during each monitoring period. The two dominant species have been the bluehead chub and the greenfin shiner. These two species constituted 60 and 70 percent of the fauna in 2000 and 2005, respectively and the abundance of omnivores+herbivores indicated nutrient enrichment. Three additional species of sunfish were collected in 2005, including 25 specimens of the green sunfish which were the first records for this exotic species in Cleveland County. Three intolerant species were absent in 2005 – fieryblack shiner, Santee chub, and seagreen darter. Despite the loss of these three species, the community continued to be rated Good.

Beaverdam Creek, NC 150, Cleveland County

The Beaverdam Creek watershed drains southwestern Cleveland County; the creek is also a tributary to the First Broad River.


Beaverdam Creek at NC 150, Cleveland County.

There are three NPDES permitted dischargers in the watershed upstream from the monitoring site. All three dischargers (NC0042293 (Specialty Lighting Inc), NC0005061 (Jefferson Smurfit Corp.-Shelby), and NC0004685 (PPG Industries, stormwater and non-contact cooling water)) are in the creek's headwaters, more than 5.5 miles upstream and discharge to unnamed tributaries to Beaverdam Creek. Between July 01, 2001 and July 01, 2005, there where 38 permit violations for the Specialty Lighting facility and four Notices of Violations (NOV) were issued between October 2003 and October 2005 (for

June 2005 violations) (Basinwide Information Management System query November 07, 2005). The Jefferson Smurfit facility has had 17 permit violations and one NOV which was issued in June 2005 for a total suspended solids limit violation (Basinwide Information Management System query November 07, 2005). The violations for PPG Industries were previously listed under the discussion for Brushy Creek.

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Similar to Hickory Creek, only eight species were collected from Beaverdam Creek and the bluehead chub again made up almost 80 percent of the total fauna. This site has been sampled by DWQ during every basinwide monitoring cycle. The ratings have not changed, Good (NCIBI = 48 or 50) and most of the metric values have varied little among the years. Twenty three species are known from the site of which 17 or 18 have been collected every year. The bluehead chub continues to be the dominant species constituting approximately 40 percent of the fauna; other commonly collected species include the Piedmont shiner and the greenfin shiner.

The abundance of the bluehead chub and the elevated percentage of omnivores+herbivores indicates nonpoint nutrient enrichment and the lack of predators may be due to the absence of deep pools with submerged cover. The one metric that has changed over time is the number of intolerant species. This metric has decreased from 5 in 1995 to 4 in 2000 to 2 in 2005. Intolerant species that have been gradually lost include the Santee chub, thicklip chub, and fieryblack shiner.

During benthic macroinvertebrate sampling, this reach of Beaverdam Creek was approximately eight meters in width. Substrate was an uneven distribution of rubble (10%), gravel (30%), and sand (60%). Landuse in this catchment is primarily scattered commercial and residential areas associated with the US 74 corridor with remaining uses comprised of scattered areas of forest and row crops. Three months after the July 2000 sample, Crest High School and Crest Middle School ceased their discharges to Beaverdam Creek and commenced pumping to the Cherryville WWTP which discharges to Indian Creek in the Catawba River Basin. The remaining NPDES discharger in this catchment required to perform WET testing (Jefferson Smurfit) has had three WET violations since 2000, but has a very small permitted discharge to a small tributary stream (East Fork Beaverdam Creek). The primary habitat problems observed at this location included the lack of riffles and pools, and impacts to the riparian zone. The habitat scored 62 and the conductivity was 44 μmhos/cm.

Beaverdam Creek has been sampled at this location twice before with a Good-Fair bioclassification in 1995 and a Good bioclassification in 2000. The 2005 sample resulted in yet another improvement in bioclassification (Excellent) clearly reflecting the removal of the Crest High School and Crest Middle School discharges. The 2005 sample had the lowest BI (5.2), lowest EPT BI (4.1), and the highest EPT S (35) and Total S (85) versus 1995 and 2000 levels. There were several intolerant EPT taxa collected for the first time at this location in 2005 and included the mayflies *Acentrella*, *Heptagenia marginalis*, the stoneflies *Eccoptura xanthenes*, and the caddisflies *Brachycentrus nigrosoma*, *Glossosoma*, and *Hydroptila*. In addition, the increased flows in this catchment in 2005 relative to previous collections (Figure 6) likely diluted the effects of the Jefferson Smurfit discharge.

Special Studies

Fish Community Urbanization Study

Brushy Creek at SR 1308, Cleveland County, was sampled by DWQ in 2004 as part of a North Carolina State University fish community urbanization study (unpublished data). The watershed size difference between Brushy Creek at SR 1342 and Brushy Creek at SR 1308 was 6.5 square miles and the sites were 4.1 miles apart. Unlike the upstream site at SR 1342 which was rated Good-Fair, this downstream site at SR 1308 was rated Excellent. The difference in the ratings was due to an additional species of

sunfish, bass, and trout being collected, a more balanced trophic structure, including the presence of piscivores, and a greater percentage of species with multiple age groups. The bluehead chub which constituted 54 percent of the fauna upstream, constituted only 24 percent of the fauna downstream. It was replaced by the greenfin shiner which made up 33 percent of the fauna downstream, but only four percent upstream. The instream habitats, pools, and canopy were of greater quality downstream than upstream.

BROAD RIVER SUBBASIN 05

Description

This subbasin is located in three Level IV ecoregions – the Northern Inner Piedmont, the Southern Outer Piedmont and Kings Mountain (Griffith *et al*. 2002). Major waterbodies draining the subbasin include Muddy Fork and Buffalo, Beason, and Kings Creeks (Figure 7).

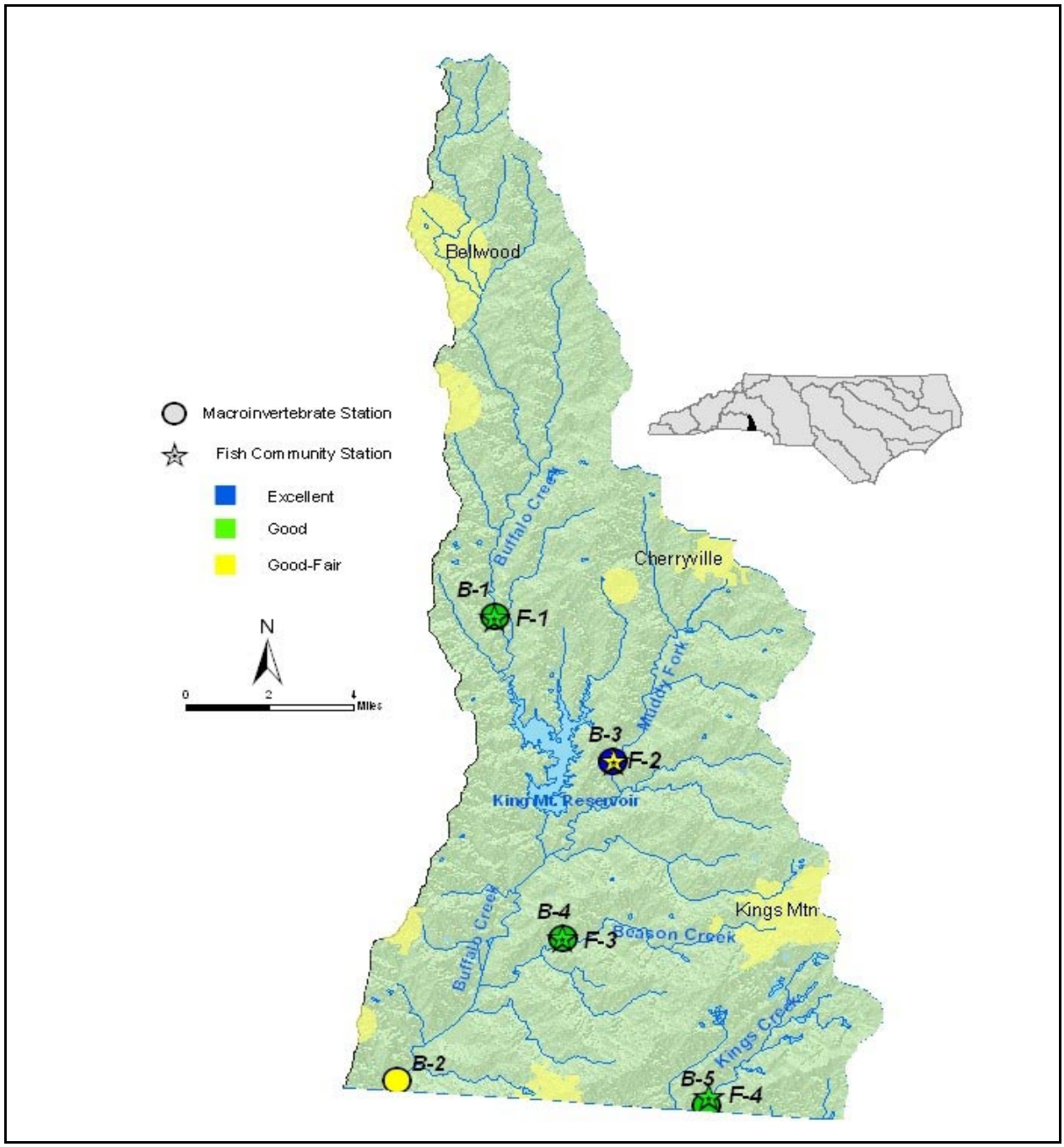


Figure 7. Sampling sites in Subbasin 05 in the Broad River basin. Monitoring sites are listed in Table 7.

Approximately 40 percent of the 181 square mile subbasin is in pasture – a percentage greater than in any other subbasins in the Broad River watershed (NCDENR 2003a). Almost 50 percent of the subbasin continues to be forested. The largest urbanized area is the City of Kings Mountain. There are nine permitted dischargers in the subbasin including the wastewater treatment plants for the City of Kings Mountain and the Town of Grover.

Overview of Water Quality

In this subbasin during 2004 and 2005, five sites were sampled for benthic macroinvertebrates and four for fish community assessments (Table 7). All streams sampled for benthic macroinvertebrates were classified using Piedmont criteria. Seven of the nine samples/sites monitored for fish or benthic macroinvertebrates were rated Excellent or Good. No sites were rated Poor.

Table 7. Waterbodies monitored in Subbasin 05 in the Broad River basin for basinwide assessment, 2000 and 2004/2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	Buffalo Cr	Cleveland	SR 1908	Excellent	Good
B-2	Buffalo Cr	Cleveland	NC 198	Good	Good-Fair
B-3	Muddy Fk	Cleveland	SR 2012	Good	Excellent
B-4	Beason Cr	Cleveland	SR 2246	Good-Fair	Good
B-5	Kings Cr	Cleveland	SR 2286	Good	Good
F-1	Buffalo Cr	Cleveland	SR 1906 (SR 1908)	Good-Fair	Good (2004)
F-2	Muddy Fk	Cleveland	SR 1001 (SR 2012)	Good	Good-Fair (2004)
F-3	Beason Cr	Cleveland	SR 2246	---	Good (2004)
F-4	Kings Cr	Cleveland	SR 2286	---	Good (2004)

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

Based on benthic macroinvertebrate data, only Kings Creek maintained its Good bioclassification from 2000 to 2005. Two sites improved in bioclassification from 2000 to 2005 -- Beason Creek went from Good-Fair to Good and Muddy Creek went from Good to Excellent. The two locations on Buffalo Creek (SR 1908 and NC 198) declined in bioclassification from Excellent to Good and Good to Good-Fair, respectively between 2000 and 2005.

There are two NPDES dischargers in this subbasin that are required to perform Whole Effluent Toxicity (WET) testing. King's Mountain WWTP (NC0020737; 6.0 MGD) has had two WET permit violations since 2000. CNA Holdings, Inc. (NC0004952; 0.8 MGD) has had no WET violations since 2000. Both facilities discharge to Buffalo Creek.

The six-month average stream discharge from April 2005 through September 2005 was 97 cubic feet per second (cfs) at the First Broad River near Casar (Figure 6). This monthly average was significantly greater than the six-month average stream discharge (49 cfs) measured from February 2000 through July 2000. The increased stream discharge in this subbasin in 2005 may partially explain the lowered bioclassifications on both Buffalo Creek locations due to increased non-point pollution inputs. Explanations for the improvement in bioclassification at locations dominated by non-point pollution inputs (Beason and Muddy Creeks) were unclear.

River and Stream Assessment

There are no NPDES facilities within the watersheds above the fish community sites on Buffalo and Beason Creeks or on Muddy Fork (Basinwide Information Management System query November 07, 2005). Two of the four fish community sites (Table 7) were sampled for the first time in 2004 as part of a North Carolina State University fish community urbanization study (unpublished data).

Buffalo Creek, SR 1908 (SR 1906), Cleveland County

Buffalo Creek drains eastern Cleveland, southwestern Lincoln, and northwestern Gaston counties. The site sampled in 2004 at SR 1908 was approximately three miles upstream of Kings Mountain Reservoir

and 2.5 miles below the fish community site monitored in 2000 at SR 1906. No major tributaries joined the stream between the two sites and the difference in watershed size was three square miles. This was the largest watershed at 43.3 square miles of any fish community site evaluated in 2004/2005.

Upstream Reach

The water became very turbid, even more so than at most other sites, when walking in the stream channel. Even though there are no municipalities within the watershed, the conductivity increased from 35 to 58 µmhos/cm between 2000 and 2004 (Appendix F-7).

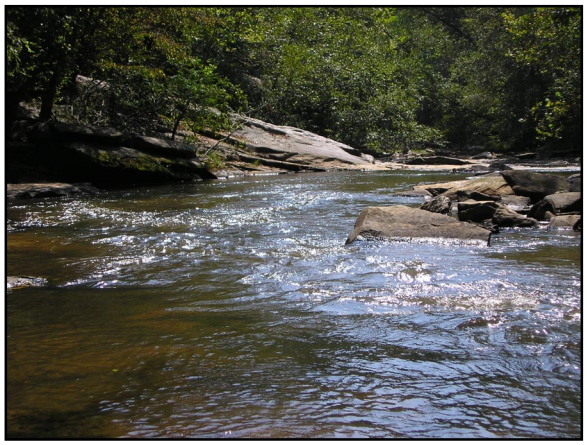
Buffalo Creek at SR 1908, Cleveland County. Views are upstream of bridge

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). It was described as being turbid then. Only eight species were collected, darters were absent, and the dominant species was the bluehead chub.

This creek was sampled by DWQ in 2000 (at SR 1906) and in 2004 (at SR 1908) and 17 species were documented from the creek. This creek was the only creek monitored in 2000 and 2004/2005 where at least one species of darter was not collected. It was also the only creek in 2004/2005 where the Piedmont shiner was not collected. The overall diversity of the creek was slightly lower than expected.

The fish community was rated Good-Fair in 2000 and Good in 2004 (NCIBI = 46 and 50, respectively). The slight difference between the two ratings occurred because was there was a lower percentage of omnivores+herbivores (i.e., bluehead chubs) and a higher percentage of insectivores (greenfin shiner and sandbar shiner) in 2004 than in 2000.

Downstream Reach



At this location, Buffalo Creek is 12 meters wide and has a drainage area of 43.7 square miles. This reach of Buffalo Creek was comprised primarily of bedrock (50%) and sand (20%) with boulder (10%), rubble (10%), and gravel (10%) making up the remainder of the available substrate. This catchment is partially forested, but mostly agriculture with some scattered rural residences also present. The primary habitat drawbacks at this site were a lack of root mats and undercut banks and impacts to the riparian zone on the right bank. Conductivity was 51 µmhos/cm and the habitat received a score of 83. Of note, conductivity has been very stable at this site through time as measurements in 1995 and 2000 were 51 µmhos/cm and 57 µmhos/cm respectively.

This site was sampled in 1995 and 2000 using Full-Scale methods receiving a Good and Excellent bioclassification respectively. For 2005, this site was sampled using EPT methods and received a Good bioclassification. Although the bioclassification declined in 2005 from 2000, the EPT community metrics are similar between all three samples. For example, the EPT S was 29 in 1995, 35 in 2000, and 27 in 2005. Moreover, the EPT BI was extremely stable at 4.7 in 1995, 4.2 in 2000, and 4.6 in 2005 and demonstrates a stable, pollution intolerant community at this location and is consistent with the conductivity data. The fact that the 1995 and 2000 samples were collected in mid-July, while the 2005 sample was collected in mid September may explain the slight decline in EPT diversity at this site. An additional explanation for the lower EPT diversity may be the result of increased flows measured in this catchment in 2005 (Figure 6). Much of the catchment upstream of this location is agriculture. In periods of increased precipitation, there is the potential for increased pollution runoff.

Buffalo Creek, NC 198, Cleveland County

This segment of Buffalo Creek was 12 meters in width and the drainage area was 160 square miles. Substrate was almost all sand (80%), with lesser amounts of gravel (10%), and silt (10%). Landuse in the catchment includes residential and commercial areas associated with the US 74 corridor as well as scattered areas of agriculture and forest. The chief habitat problems observed were a lack of riffles, pools, and extensive bank erosion. Conductivity was elevated at 180 μmhos/cm and the habitat received a score of 60. There are two NPDES dischargers upstream of this site required to perform WET testing: CNA Holdings and King's Mountain WWTP. The King's Mountain facility recorded one WET violation (7/04).

This site has been sampled on five previous occasions using Full-Scale methods resulting in two Fair bioclassifications (1983 and 1988), one Good-Fair bioclassification (1984), and two Good bioclassifications (1995 and 2000). In 2005, this site declined slightly to Good-Fair. While the 2005 sample was collected using EPT methods, the EPT S and EPT BI have been quite stable at this site since 1995. For example, the EPT S was 24 in 1995, 27 in 2000, and 21 in 2005. Moreover, the EPT BI was extremely stable at 4.8 in 1995, 4.5 in 2000, and 4.7 in 2005 suggesting a stable benthic community at this location. The reduction in the number of EPT taxa collected in 2005 may be due to a combination of late-season sampling (September versus July) and less intensive EPT collecting methods. Although increased flows in 2005 likely diluted the two dischargers effluent, the fact that this catchment includes large portions of the US 74 corridor as well as the City of King's Mountain, the increased flows likely resulted in an increase in non-point pollution from these areas (Figure 6).

Muddy Fork, SR 2012 (SR 1001), Cleveland County

Muddy Fork is a tributary to Buffalo Creek below Kings Mountain Reservoir and drains eastern Cleveland and western Gaston counties, west of the Town of Cherryville. The site sampled in 2004 was approximately 1.7 miles upstream from the site sampled in 2000; the difference in watershed size was 9.7 square miles due to the subtraction of the Persimmon Creek drainage.


Muddy Fork at SR 2012, Cleveland County.

This creek was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Fourteen species were collected of which 55 percent of the fish were bluehead chubs. Since then, the creek has been sampled by DWQ in 2000 and 2004. Eighteen species are now known from the creek, of which 16 have been collected in each sampling period. Even though the rating declined from Good in 2000 to Good-Fair in 2004 (NCIBI = 48 and 46, respectively), the slight difference was due to the absence of bluegill in 2004; one bluegill had been collected in 2000. The bluehead chub continued to dominate the fauna constituting 44 and 43 percent of the fauna in 2000 and 2004, respectively and indicated some nutrient enrichment from nonpoint sources.

This reach is approximately seven meters in width and has a drainage area of 21.7 square miles. The watershed upstream of this road crossing is comprised mostly of residential areas as well as scattered tracts of agriculture and forest. Substrate was mostly sand (60%), with rubble (20%) and gravel (20%) making up the rest. The primary habitat problems included a lack of riffles, pools, and moderate bank erosion. The habitat received a score of 64. Conductivity was 61 µmhos/cm.

This location of has been sampled on four previous occasions resulting in two Good-Fair bioclassifications (1983 and 1990) and two Good bioclassifications (1995 and 2000). This site improved in 2005 and received an Excellent bioclassification. The 1995 and 2000 samples produced 23 and 25 EPT taxa respectively while the 2005 sample produced an EPT S of 35. There were several intolerant EPT taxa collected for the first time here in 2005 and included the mayflies *Acentrella*, *Eurylophella verisimilis,* the stoneflies *Acroneuria abnormis, Leuctra, Pteronarcys proteus*, and the caddisflies *Dolophilodes, Glossosoma, Lype diversa,* and *Rhyacophila fuscula*. Of particular note, the stoneflies *Acroneuria abnormis* and *Pteronarcys proteus* are pollution intolerant and long-lived suggesting both stable and overall favorable water quality conditions. Given the largely non-point makeup of this catchment (including portions of the town of Cherryville), it is unclear why this site improved in light of the higher discharges measured in 2005 (Figure 6).

Beason Creek, SR 2246, Cleveland County

Beason Creek is a tributary to Buffalo Creek and drains southeastern Cleveland County, including the Town of Kings Mountain. This creek (at the next bridge downstream) was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Eleven species of fish were collected even though the creek was discolored by textile mill dyes.

June 2004

Beason Creek at SR 2246, Cleveland County.

Fourteen species of fish were collected in 2004 and the fish community was rated Good. The bluehead chub was the dominant species in 2004 just as it was in 1964. Its dominance, almost one-half of all the fish collected, pointed towards nonpoint source nutrient enrichment. Only the fantail darter was collected, thus the diversity of darters was lower than expected.

July 2005

During benthic macroinvertebrate sampling the stream width was eight meters. The substrate was nearly all sand (80%) with lesser amounts of rubble (10%), and gravel (10%). Beason Creek's catchment is urban and includes the city of Kings Mountain, with lesser amounts of agriculture and broken tracts of forest comprising the remainder of its watershed. The primary habitat deficiencies included a lack of pool habitat, lack of riffles, severe bank erosion, and a poor riparian zone. These problems are reflected by the low habitat score (49). The conductivity was measured at 77 µmhos/cm.

Beason Creek has been sampled at this road crossing in 1987, 1995 and 2000 all resulting in Good-Fair bioclassifications. The 2005 sample resulted in an improvement in bioclassification to Good with an EPT S of 23 surpassing the previous EPT S levels seen in 1987 (17), 1995 (18) and 2000 (15). Given the largely non-point makeup of this catchment (including portions of King's Mountain), it is unclear why this site improved during the higher discharges measured in 2005 (Figure 6).

Kings Creek, SR 2286, Cleveland County

Kings Creek is a large tributary to the Broad River in South Carolina. This headwater site in North Carolina drains southeastern Cleveland County, including the Town of Kings Mountain. There are two NPDES permitted dischargers in the creek's headwaters upstream from the monitoring site. Chemetall Foote Corporation (NC0033570, no flow limit in permit) discharges condensate/non-contact cooling water/blowdown and the Phoenix Minerals Processing Facility (NC0087742) discharges 0.29 MGD to Kings Creek. Neither facility had any permit violations between July 01, 2001 and July 01, 2005 (Basinwide Information Management System query November 07, 2005). This creek (at the next bridge upstream) was sampled in 1964 as part of the NCWRC's survey and classification of streams in the Broad River (Messer *et al.* 1965). Ten species of fish were collected and the dominant species was the bluegill.

June 2004 (above bridge)
The conductivity in Kings Creek, 181 µmhos/cm, was the greatest of any fish community site in the basin in 2004/2005 (Appendix F-7). The water became very turbid, even more so than at most other sites, when walking in the stream channel.


Kings Creek at SR 2286, Cleveland County.

In 2005 the dominant species was the redbreast sunfish; it constituted 44 percent of all the fish collected. Tolerant species (redbreast sunfish, white sucker, creek chub, and flat bullhead) made up 48 percent of the fauna, the greatest percentage at any site in the basin in 2004 or 2005. Only one specimen of one intolerant species (seagreen darter) was collected. Although 16 species were collected, 9 of the 16 species were represented by only 1 or 2 fish per species and hence were not represented by multiple age classes. Because of the size of its watershed, approximately 11 square miles, the stream may have gone dry during the drought and has yet to be fully colonized by all expected species with assorted age groups. Except for the elevated percentage of tolerant fish and the low percentage of species with multiple ages, the remaining 10 metrics all scored what would be observed at a regional reference site. The community was rated Good (NCIBI = 52).

July 2005 (below bridge)

This segment of King's Creek is roughly five meters in width and has a drainage area of 11.8 square miles. Substrate was a generally unembedded mix of boulder (10%), rubble (20%), gravel (30%), sand (20%) and silt (10%). Landuse in the catchment includes commercial and residential development associated with the I-85 corridor as well as scattered areas of agriculture and forest. No significant habitat deficiencies were observed and this site received a habitat score of 82. The conductivity was 54 µmhos/cm although it was far less than levels measured in 1995 (225 µmhos/cm) and 2000 (482 µmhos/cm).

King's Creek has been sampled here on two previous occasions with a 1995 sample producing a Good-Fair bioclassification and a 2000 sample resulting in a Good bioclassification. This site also received a Good bioclassification in 2005. Although the bioclassification is unchanged relative to the 2000 rating, this site's EPT BI has been steadily declining (5.7 in 1995, 5.4 in 2000, and 4.6 in 2005) which may suggest improving water chemistry.

Special Studies

Fish Community Urbanization Study

Buffalo Creek at SR 1908, Muddy Fork at SR 2012, Beason Creek at SR 2246, and Kings Creek at SR 2286, all in Cleveland County, were sampled by DWQ in 2004 as part of a North Carolina State University fish community urbanization study (unpublished data). The ratings at each of these creeks was discussed above and these four sites are also considered as basinwide sites.

Potts Creek, SR 1001, Cleveland County

Staff at the Mooresville Regional Office requested a macroinvertebrate sample on Potts Creek. Potts Creek at SR 1001 is approximately four stream miles downstream of the former Cinderella Mills site where a recent release of tetrachloroethylene (also know as PERC, PCE, perchloroethylene, and tetrachlorothene) was detected. The tetrachloroethylene was released into several tributaries of Potts Creek and this sample was conducted in order to see if there were any deleterious effects on Potts Creek. The 2005 EPT sample resulted in an EPT S of 26, an EPT BI of 4.4, and a Good bioclassification. Based on benthic data, there seem to be no adverse effects on Potts Creek as a result of the PCE release (Biological Assessment Unit Memorandum B-060208).

BROAD RIVER SUBBASIN 06

Description

This subbasin is located in three Level IV ecoregions – the Southern Crystalline Ridges and Mountains, the Southern Inner Piedmont, and the Southern Outer Piedmont (Griffith *et al*. 2002). The elevation in the Ridges and Mountains ecoregion may ranges from 1,200 to 4,500 feet (Griffith *et al*. 2002). This subbasin contains the headwaters of the North Pacolet River and many small tributaries which flow into South Carolina (Figure 8). Almost 80 percent of the 181 square mile subbasin is forested (NCDENR 2003a) with another 20 percent in pasture, including horse farms. The only urbanized areas are in the vicinity of the Towns of Columbus and Tryon along the US 176 corridor. There are eight permitted dischargers including the wastewater treatment plants for the Towns of Tryon and Saluda.

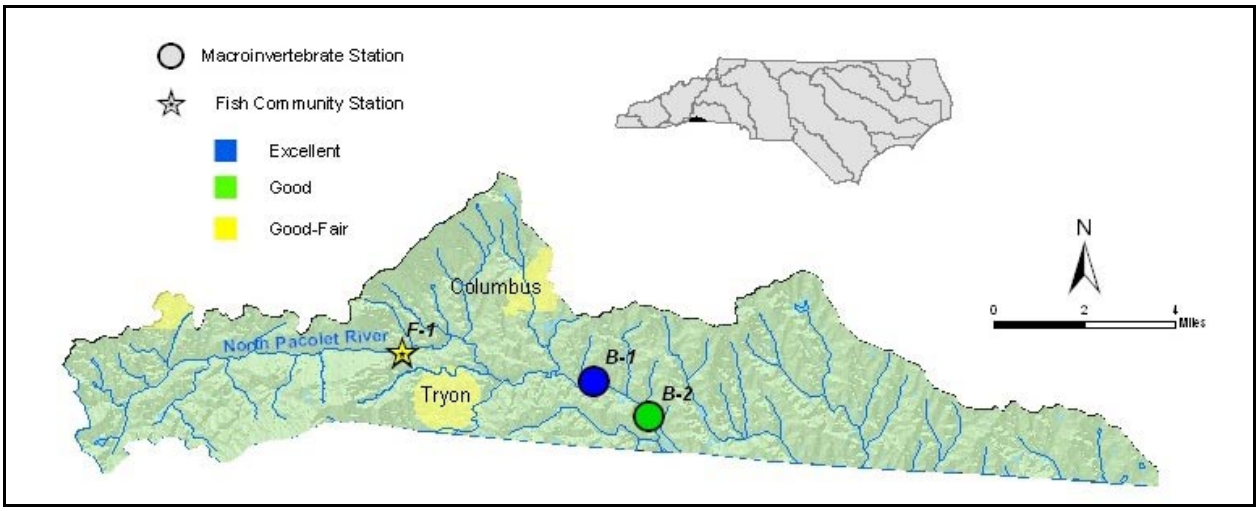


Figure 8. Sampling sites in Subbasin 06 in the Broad River basin. Monitoring sites are listed in Table 8.

Overview of Water Quality

In this subbasin during 2005, two sites were sampled for benthic macroinvertebrates and one for fish community assessments (Table 8). All streams sampled for benthic macroinvertebrates were classified using Mountain criteria. One site was rated as Excellent and no sites were rated as Fair or Poor. Based on benthic macroinvertebrate data, both locations on the North Pacolet River improved in bioclassification from 2000 to 2005.

Table 8. Waterbodies monitored in Subbasin 06 in the Broad River basin for basinwide assessment, 2000 and 2005.

Map #[1]	Waterbody	County	Location	2000	2005
B-1	N Pacolet R	Polk	SR 1179	Good	Excellent
B-2	N Pacolet R	Polk	SR 1501	Good-Fair	Good
F-1	N Pacolet R	Polk	US 176/SR 1125	---	Good-Fair

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

There are two NPDES dischargers in this subbasin that are required to perform Whole Effluent Toxicity (WET) testing. Grover Industries (NC0004391) discharges 0.45 MGD to the North Pacolet River and has had no WET permit violations since 2000. The Tryon WWTP (NC0021601) discharges 1.5 MGD to Vaughn Creek, a tributary to the North Pacolet River, and has had no WET violations since 2000.

The six-month average stream discharge from February 2005 through July 2005 was 183 cubic feet per second (cfs) at Cove Creek near Lake Lure (Figure 9). This average was significantly greater than the six-month average stream discharge (82 cfs) measured from the same duration in 2000. In addition to WWTP upgrades and removals, the significantly greater six-month average discharge preceding the 2005 collections relative to lower flows preceding the 2000 collections can partially explain the improved bioclassification observed at the site at SR 1501 on the North Pacolet River. In catchments strongly influenced by point sources of pollution increased stream flow can dilute point sources of pollution and can result in short-term improvements in bioclassification. In protected catchments such as the site at SR 1179 on the North Pacolet River increased stream flow can produce improved bioclassifications as instream physical conditions (such as increased availability of wetted habitat and increased dissolved oxygen levels) result in more favorable conditions for invertebrate colonization.

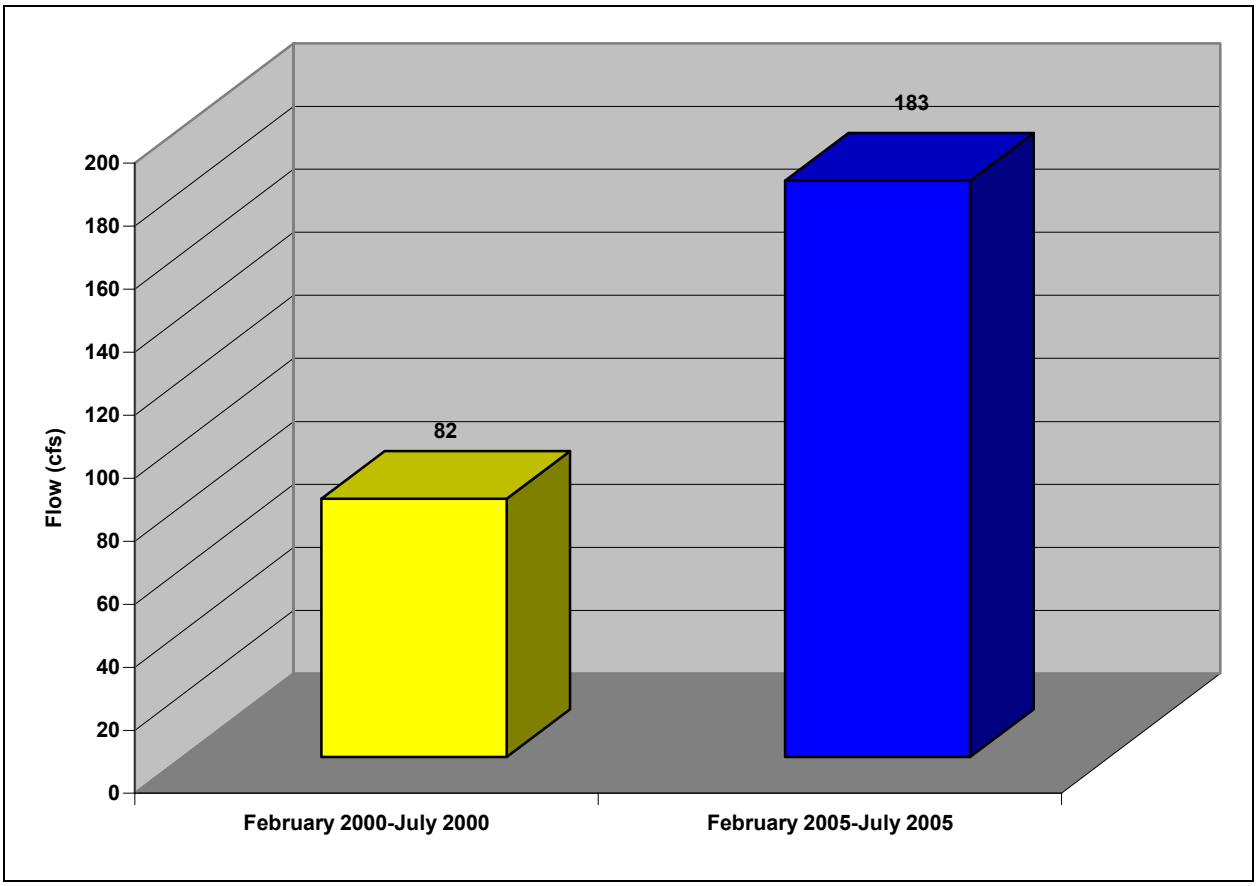


Figure 9. Six month average stream discharge (cfs) at Cove Creek near Lake Lure, February - July 2000 and 2005.

River and Stream Assessment

North Pacolet River, US 176/SR 1125, Polk County

This site on the North Pacolet River was sampled for the first time for fish community assessment in 2005. The North Pacolet River drains the southwest corner of Polk County, west of the Town of Tryon, and the extreme southeastern corner of Henderson County. Most of the habitat characteristics were of moderate to high quality. However, the riparian zones along both shorelines were altered by the residential landuse resulting in a fairly open canopy, bank erosion, grassy lawns down to the stream bank, and bank armoring.

There is one NPDES permitted discharger upstream from the monitoring site. The City of Saluda's wastewater treatment plant (NC0028975), located approximately 7.5 miles upstream, discharges up to 0.1 MGD to Joels Creek, a tributary to the river. Between July 01, 2001 and July 01, 2005, the facility had 14 permit violations and one Notice of Violation (NOV) was issued (Basinwide Information Management System query November 07, 2005). In June and July 2005, the facility was discharging more than 64 times the permitted limit for total residual chlorine; ammonia-nitrogen and fecal coliform bacteria also exceeded the permitted levels.

North Pacolet River at US 176 and SR 1125, Polk County.

The fish community was rated Good-Fair. More fish were collected at this site (n = 962) than from any other site in the basin that has ever been monitored. Bluehead chubs were extremely abundant; more than 60 percent of all the fish collected were of this species. The number of bluehead chubs (n = 587) was the most ever collected anywhere in the state (representing 651 collections) where this species has been found. This abundance clearly indicated the downstream transport of point and nonpoint sources of nutrients in this watershed. More specimens of striped jumprock (n = 102) were collected from this site than at any other site (except for Cedar Creek, Rutherford County in 2000) in the Broad, Catawba, and Yadkin River basins where the species has been found. The percentage of tolerant fish, two percent, however, was as low as one other site in the basin (North Fork First Broad River).

The North Pacolet River is supplementally classified as Tr and a reproducing population of naturalized, rainbow trout was documented to reside in this reach of the stream. The stream is also stocked periodically by the North Carolina Wildlife Resources Commission with three species of trout. Stocked specimens of all three trout species were collected in 2005.

North Pacolet River, SR 1179, Polk County

At this location, the North Pacolet River is 11 meters wide and has a drainage area of 37.3 square miles. Landuse in this catchment is mostly forest although some residential, commercial, and agricultural uses can be found adjacent to the US 176 corridor. Substrate was an unembedded mix of boulder (20%), rubble (40%), gravel (30%) and sand (10%). The primary habitat problems here included severe bank erosion, poor riparian areas on both banks, and a lack of pool habitat. Conductivity was 35 μmhos/cm. The habitat received a score of 66.

Prior basinwide sampling in 1995 and 2000 resulted in Good bioclassifications with 31 and 37 EPT taxa collected and BIs of 4.3 and 4.6 respectively. In 2005,

this segment of the North Pacolet River improved to Excellent with the highest EPT S (52) and the lowest BI (3.9) ever recorded at this site. Not only did the EPT S dramatically increase, but also the overall taxa diversity increased from 68 in 1995, 83 in 2000, to 108 in 2005. Intolerant EPT taxa not previously collected included the mayflies *Drunella conestee, Ephemerella catawba, E. invaria, Epeorus dispar*, the stoneflies *Eccoptura xanthenes, Malirekus hastatus*, *Leuctra, Isoperla holochlora, Suwallia*, and the caddisflies *Dolophilodes, Lepidostoma, Lype diversa, Neophylax consimilis, N. mitchelli, N. ornatus,* and *Rhyacophila carolina*. The improved bioclassification may be the result of increased stream discharge measured in 2005 versus flows observed in 2000 (Figure 9). In protected catchments, increased stream discharge can produce improved bioclassifications as instream physical conditions (such as increased availability of wetted habitat and increased dissolved oxygen levels) can result in more favorable conditions for invertebrate colonization.

North Pacolet River, SR 1501, Polk County

This reach of the North Pacolet River is approximately eight river miles downstream from the SR 1179 location. At this location stream width is 12 meters and drainage area is 49.3 square miles. Landuse here includes all of the suburban areas associated with the towns of Tryon and Columbus as well as development associated with the US 74 corridor. The remainder of land use includes extensive horse farms, row crops, and scattered residences. This site is also downstream of two NPDES dischargers (Grover Industries; NC0004391; 0.45 MGD and the Tryon WWTP; NC0021601; 1.5 MGD) neither, of which have had any WET permit violations since 2000. Substrate was mostly sand (70%) with lesser amounts of gravel (20%) and silt (10%). The most notable primary habitat shortcoming at this location was a lack of large diameter riffle substrates, poor riparian coverage on the right bank, and infrequent pools. The conductivity was 72 μmhos/cm and the habitat received a score of 65.

This site has been sampled on two previous occasions receiving one Fair bioclassification (1995), and one Good-Fair bioclassifications (2000). In 2005, this site improved to Good, up very slightly from the high (i.e., borderline) Good-Fair rating in 2000. The 2000 sample had an EPT S of 33, Total S of 97, a BI of 5.5, and an EPT BI of 4.4, while the 2005 sample had a slight improvement in EPT S (35), an identical EPT BI (4.4) and a virtually identical BI (5.6). Nevertheless, the addition of a few intolerant EPT taxa in 2005 not previously collected was enough to improve the bioclassification and included the mayfly *Leucrocuta*, the stoneflies *Eccoptura xanthenes*, *Helopicus subvarians*, *Paragnetina immarginata*, and the caddisflies *Dolophilodes* and *Ceratopsyche morose.* Since the 2000 sample, Grover Industries ceased its yarn dyeing operation. As a result, their discharge is currently reduced in overall volume and is now 100% domestic and non-process in nature. These facts, combined with the dilution of the Tryon WWTP due to the increase in stream flows (Figure 9) may account for the improved bioclassification seen at this location in 2005.

SPECIAL STUDIES
North Pacolet River, SR 1102, Polk County

An additional sample on the North Pacolet River was taken well upstream of the SR 1179 location in order to establish a reference condition on this waterbody. A location at SR 1102 was sampled using EPT methodology and the collection resulted in an Excellent bioclassification with 37 EPT taxa present. Numerous intolerant taxa present at this site included the mayflies *Drunella conestee*, *Epeorus rubidus*, the stoneflies *Paragnetina immarginata*, *Tallaperla*, *Isoperla holochlora*, *Pteronarcys*, and the caddisflies *Dolophiloides*, *Glossosoma*, *Lepidostoma*, *Parapsyche cardis*, and *Neophylax mitchelli*. Although the SR 1102 reach received an Excellent bioclassification, there were no community metrics at this location significantly better than those recorded in 2005 from the next closest downstream site at SR 1179. However, the SR 1102 location is suitable as a habitat reference site for the North Pacolet River as the habitat received a score of 94 out of 100 points. The next highest habitat score on the North Pacolet River (66 out of 100 points) was recorded in 2005 at SR 1179 location (Biological Assessment Unit Memorandum B-060208).

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GLOSSARY

$7Q_{10}$	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. $7Q_{10}$ flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass or Bioclassification	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*.
Class C Waters	Freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum.
Conductivity	In this report, synonymous with specific conductance and reported in the units of µmhos/cm at 25 ^{o}C. Conductivity is a measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts.
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, vegetation, and soil type. Examples include Mountains, Piedmont, Coastal Plain, Sand Hills, and Carolina 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. Waters which are rated Excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and all Class SA waters.
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. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs.
NTU	Nephelometric Turbidity Unit.
ORW	Outstanding Resource Waters. Unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.
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

Appendix B-1. Summary of benthic macroinvertebrate data, sampling methods, and criteria.

Macroinvertebrates were sampled throughout the entire Broad River Basin in 2005 and a total of 32 basinwide collections were made in all six subbasins. This was the same number of collections made in 2000 during the previous basinwide sampling period. From these totals 28% of the sites received Excellent bioclassifications in 2005 which represented an improvement from 2000 when only (16%) of the ratings were Excellent. In 2005, 38% of the sties received Good bioclassifications, which was a decrease from 2000 when 50% of the locations received Good bioclassifications. However, there were five Good bioclassifications in 2000 that improved to Excellent in 2005. In 2005, 31% of the basinwide sites received Good-Fair ratings, which was nearly identical to the 31% measured in 2000. In 2005, 3% of the sites received Fair bioclassification which is essentially identical to the 3% observed in 2000. There were no Poor bioclassifications in 2000 or 2005. Clearly, the most significant trend observed from 2000 to 2005 was the almost doubling in Excellent bioclassifications from five to nine. While Good sites represented most of the Good to Excellent improvements seen between 2000 and 2005, one site (Hinton Creek in Subbasin 04) improved drastically from Good-Fair in 2000 to Excellent in 2005. Remaining bioclassifications remained basically static through the same time period. Historic summaries of bioclassifications from the Broad River Basin (1995 - 2005) can be found in Table 1 and in NCDENR 2001.

Historic summaries of bioclassifications at Broad basinwide benthos sites (2005 to 1995) are presented in Figure 1. Through this time period the most significant trends are the reduction in Good-fair bioclassifications, and the increase in Good and Excellent ratings.

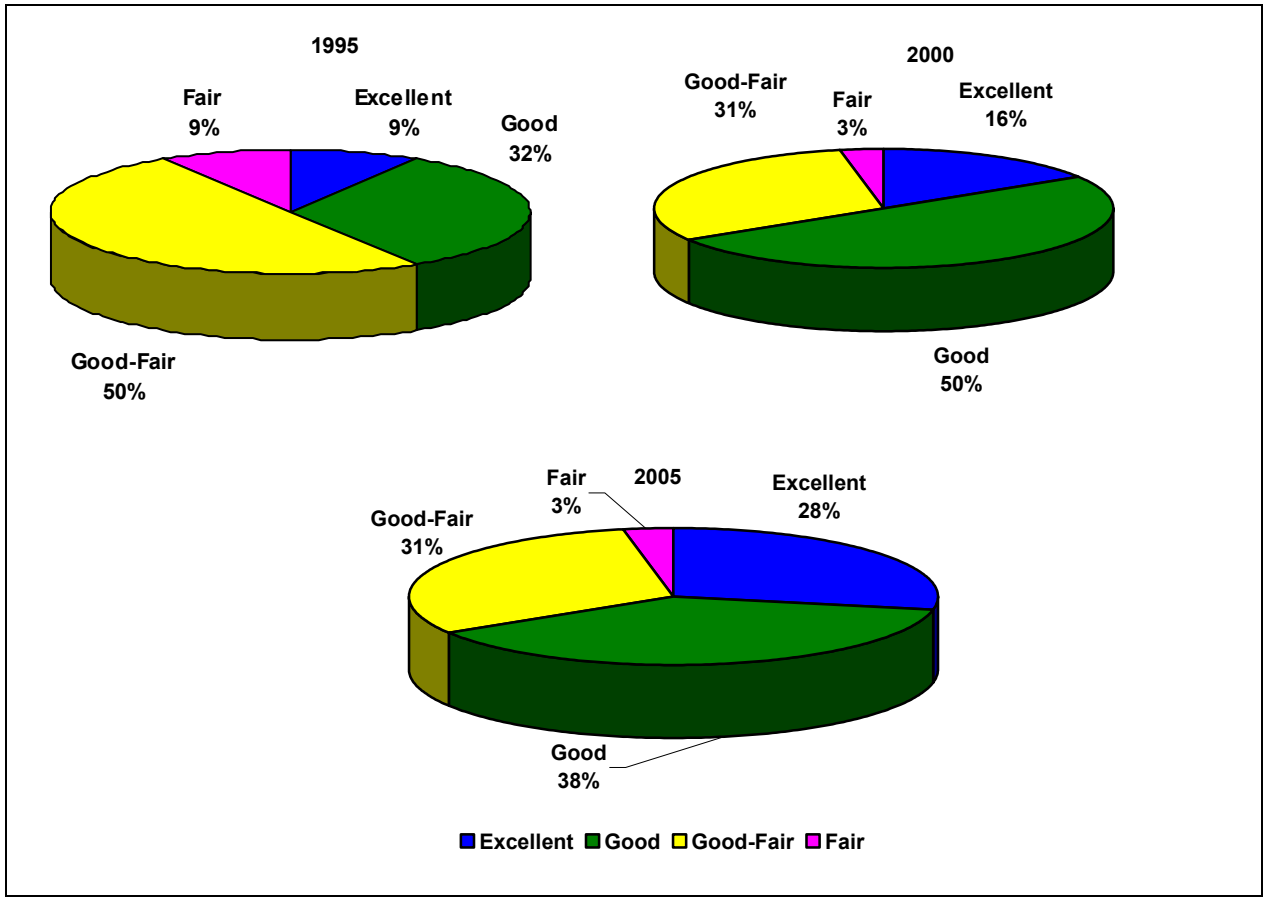

Figure 1. Broad River Basin benthic macroinvertebrate bioclassifications, 1995 – 2005.

Significantly rare invertebrate taxa collected in the Broad River basin in 2005 included the mayfly *Danella lita* (Broad River at SR 2802), the caddisflies *Neophylax ornatus* (Broad River SR 2802, North Pacolet River SR 1179), *Rhyacophila vuphipes* (North Fork First Broad River SR 1728), *Neotrichia* (First Broad River SR 1140, SR 1809), and the stoneflies *Beloneuria* (Broad River US 221, Second Broad River SR 1538, Walnut Creek SR 1315, Green River SR 1106), and *Acroneuria lycorias* (North Fork First Broad River, SR 1728. Of particular note, the micro-caddisfly *Neotrichia* has only been collected a total of 16 times (out of nearly 6,000 collections) and was collected at two locations in the Broad River Basin for the first time in 2005.

Sampling Methods

Standard Qualitative (Full Scale) and EPT Methods

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Biological Assessment Unit's standard qualitative (Full Scale) 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 (NCDENR 2003). The samples are picked on-site. 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).

Benthic macroinvertebrates can also be collected using the EPT sampling procedure. Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT taxa are collected and identified and only EPT criteria are used to assign a bioclassification.

Habitat Evaluation

An assessment form has been developed by the Biological Assessment Unit to better evaluate the physical habitat of a stream. The habitat score, which ranges between 1 and 100, is based on the evaluation of channel modification, amount of instream habitat, and 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. In general, sites with scores greater than 65 indicate moderate to high quality habitat while sites scoring less than 65 are generally poor to low quality.

Data Analysis

Criteria for bioclassifications for standard qualitative samples in mountain and piedmont ecoregions are given below and are based on EPT S and the NCBI.

Tolerance values for individual species and biotic index values have a range of 0 - 10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality scores (5 = Excellent, 4 = Good, 3 = Good-Fair, 2 = Fair and 1 = Poor) assigned with the biotic index numbers are averaged with EPT taxa richness scores to produce a final bioclassification. Criteria for piedmont and mountain streams are used for the Broad River basin. EPT abundance and total taxa richness calculations also are used to help examine between-site differences in water quality.

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

Criteria for Standard Qualitative (Full Scale) Samples.

Score	BI Values Mountain	BI Values Piedmont	EPT Values Mountain	EPT Values Piedmont
5	<4.00	<5.14	>43	>33
4.6	4.00 – 4.04	5.14-5.18	42-43	32-33
4.4	4.05 – 4.09	5.19-5.23	40-41	30-31
4	4.10 – 4.83	5.24-5.73	34-39	26-29
3.6	4.84 – 4.88	5.74-5.78	32-33	24-25
3.4	4.89 – 4.93	5.79-5.83	30-31	22-23
3	4.94 – 5.69	5.84-6.43	24-29	18-21
2.6	5.70 – 5.74	6.44-6.48	22-23	16-17
2.4	5.75 – 5.79	6.49-6.53	20-21	14-15
2	5.80 – 6.95	6.54-7.43	14-19	10-13
1.6	6.96 – 7.00	7.44-7.48	12-13	8-9
1.4	7.01 – 7.05	7.49-7.53	10-11	6-7
1	> 7.05	>7.53	0-9	0-5

Criteria for bioclassifications for EPT samples in piedmont and mountain ecoregions are given below and are based on EPT S.

Criteria for EPT Samples.

Score	EPT Values Mountain	EPT Values Piedmont
Excellent	>35	>27
Good	28-35	21-27
Good-Fair	19-27	14-20
Fair	11-18	7-13
Poor	0-10	0-6

Table 1. Benthic macroinvertebrate monitoring data collected in the Broad River basin, 2000-2005. Basin sites are in bold.

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
030801									
Broad R	SR 2802	Buncombe	9-(1)	07/11/05	77	43	3.21	2.74	Excellent
				07/10/00	99	49	4.10	3.26	Excellent
Buffalo Cr	SR 1314	Rutherford	9-20	07/11/05	31	31	1.56	1.56	Good
Cove Cr	SR 1381	Rutherford	9-23-(9)	09/21/05	36	36	4.67	4.67	Excellent
				07/12/00	40	40	3.39	3.39	Excellent
Taylors Cr	SR 1314	Rutherford	9-23-14-3	06/11/03	43	43	2.69	2.69	Excellent
030802									
Broad R	SR 1181	Rutherford	9-(22)	09/21/05	59	18	5.52	5.23	Fair
				07/12/00	81	31	4.78	3.40	Good
E Fk Mountain Cr	SR 1331	Rutherford	9-25-2	06/10/03	31	31	4.06	4.06	Not Rated
Mountain Cr	SR 1149	Rutherford	9-25-(5)	09/21/05	19	19	4.59	4.59	Good-Fair
				08/17/00	53	19	4.96	4.09	Good-Fair
Broad R	SR 1106	Rutherford	9-(25.5)	09/20/05	48	19	4.85	4.28	Good-Fair
				07/11/00	71	24	5.43	4.69	Good-Fair
Broad R	US 221	Rutherford	9-(25.5)	09/20/05	48	20	5.34	4.45	Good-Fair
				07/19/00	79	32	4.89	3.97	Good
Cleghorn Cr	SR 1149	Rutherford	9-26	09/21/05	55	21	6.19	5.37	Fair
				07/13/00	84	24	6.19	5.43	Good-Fair
Green R	SR 1302	Polk	9-29-(33)	09/20/05	57	23	4.78	4.05	Good-Fair
				07/12/00	70	29	4.50	3.65	Good-Fair
Walnut Cr	SR 1315	Polk	9-29-44	09/21/05	33	33	4.07	4.07	Good
				07/11/00	38	38	3.36	3.36	Excellent
Whiteoak Cr	SR 1352	Polk	9-29-46	09/20/05	28	28	4.24	4.24	Good
				07/11/00	96	40	4.63	3.79	Good
L Whiteoak Cr	SR 1324	Polk	9-29-46-1	09/23/05	19	19	5.21	5.21	Good-Fair
Second Broad R	SR 1538	Rutherford	9-41-(10.5)	09/19/05	66	26	5.15	4.40	Good-Fair
				08/16/00	64	26	4.71	3.73	Good-Fair
Catheys Cr	US 221	Rutherford	9-41-13-(0.5)	06/10/03	19	19	3.99	3.99	Good-Fair
Mill Cr	SR 1327	Rutherford	9-41-13-3	06/10/03	11	11	4.78	4.78	Fair
Catheys Cr	SR 1549	Rutherford	9-41-13-(6)	06/12/03	48	20	5.19	4.57	Good-Fair
				08/16/00	18	18	4.59	4.59	Fair
Catheys Cr	SR 1547	Rutherford	9-41-13-(6)	06/12/03	57	26	4.94	4.36	Good-Fair
Hollands Cr	SR 1520	Rutherford	9-41-13-7-(3)	06/10/03	40	13	4.70	3.63	Not Rated
Hollands Cr	SR 1547	Rutherford	9-41-13-7-(3)	06/11/03	62	23	5.17	4.13	Good-Fair
Hollands Cr	SR 1548	Rutherford	9-41-13-7-(3)	06/11/03	65	20	5.51	4.23	Good-Fair
Case Br	SR 1547	Rutherford	9-41-13-7-4	06/11/03	40	16	4.56	3.81	Not Rated
Roberson Cr	SR 1561	Rutherford	9-41-14	09/19/05	24	24	4.44	4.44	Good-Fair
				07/13/00	21	21	4.56	4.56	Good-Fair
Second Broad R	SR 1973	Rutherford	9-41-(24.7)	09/19/05	62	26	5.55	4.51	Good-Fair
				07/19/00	83	29	5.80	4.69	Good-Fair
030803									
Green R	off SR 1106	Henderson	9-29-(1)	09/22/05	21	21	3.08	3.08	Good-Fair
Joe Cr	SR 1106	Henderson	9-29-14	09/22/05	27	27	2.95	2.95	Good-Fair
Green R	SR 1151	Polk	9-29-(22)	09/22/05	87	37	4.57	3.40	Good
				07/11/00	71	29	4.46	3.54	Good-Fair
Hungry R	SR 1799	Henderson	9-29-30	07/10/00	34	34	2.74	2.74	Good
				09/12/00	34	34	3.20	3.20	Good
				09/22/05	31	31	3.18	3.18	Good
30804									
Sandy Run Cr	SR 1195	Cleveland	9-46	07/12/05	79	37	4.6	3.9	Good
				07/19/00	80	38	4.7	4.0	Good
First Broad R	SR 1530	Cleveland	9-50-(1)	09/19/05	118	54	4.8	3.9	Excellent
				07/17/00	110	47	4.4	3.6	Good
N Fk First Broad R	SR 1728	Rutherford	9-50-4	07/13/05	-----	49	-----	3.1	Excellent
				07/17/00	-----	36	-----	3.5	Excellent
Hinton Cr	NC 226	Cleveland	9-50-15	07/13/05	-----	40	-----	3.3	Excellent
				07/17/00	-----	26	-----	3.9	Good-Fair
First Broad R	Off SR 1809	Cleveland	9-5-(15.5)	09/20/05	111	38	5.1	4.0	Good
				07/18/00	83	32	4.7	3.9	Good

Table 1 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Knob Cr	SR 1004	Cleveland	9-50-19-(4)	09/20/05	-----	25	-----	4.8	Good
				07/17/00	-----	30	-----	3.9	Good
First Broad R	SR 1140	Cleveland	9-50-(28)	09/20/05	82	30	5.8	4.7	Good
				07/20/00	70	23	5.3	4.1	Good
Brushy Cr	SR 1308	Cleveland	9-50-29	09/21/05	-----	31	-----	4.8	Excellent
				07/20/00	62	24	5.0	3.9	Good
Beaverdam Cr	NC 150	Cleveland	9-50-32	07/12/05	85	35	5.2	4.1	Excellent
				07/19/00	68	24	5.7	5.0	Good
30805									
Buffalo Cr	SR 1908	Cleveland	9-53-(1)	09/19/05	-----	27	-----	4.6	Good
				07/20/00	79	35	5.0	4.4	Excellent
Buffalo Cr	NC 198	Cleveland	9-53-(5)	09/20/05	-----	21	-----	4.7	Good-Fair
				07/20/00	75	27	5.2	4.5	Good
Muddy Cr	SR 2012	Cleveland	9-53-6	07/12/05	87	35	5.5	4.9	Excellent
				07/18/00	72	25	5.5	4.8	Good
Potts Cr	SR 1001	Cleveland	9-53-6-3	07/14/05	----	26	----	4.4	Good
Beason Cr	SR 2246	Cleveland	9-53-8	07/12/05	----	23	----	5.0	Good
				07/18/00	----	15	-----	5.1	Good-Fair
Kings Cr	SR 2286	Cleveland	9-54	09/19/05	-----	22	-----	5.4	Good
				07/21/00	72	24	5.7	4.8	Good
30806									
N Pacolet R	SR 1102	Polk	9-55-1-(1)	07/15/05	----	37	----	2.5	Excellent
N Pacolet R	SR 1179	Polk	9-55-1-(1)	07/14/05	108	52	3.9	3.2	Excellent
				07/11/00	83	37	4.5	3.9	Good
N Pacolet R	SR 1501	Polk	9-55-1-(10)	09/21/05	93	35	5.6	4.4	Good
				07/11/00	97	33	5.5	4.4	Good-Fair

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Appendix F-1. Fish community sampling methods and criteria.

Sampling Methods
At each sample site, a 600 ft. section of stream was selected and measured. The fish in the delineated stretch of stream were then collected using two backpack electrofishing units and usually, two persons netting the stunned fish. A seine was also used where there were substantial riffles. In 2004 and 2005 Biological Assessment Unit Staff were assisted by staff from the NC DWQ and North Carolina State University (NCSU) and summer interns from NCSU. After collection, all readily identifiable fish were examined for sores, lesions, fin damage, or skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Those fish that were not readily identifiable were preserved and returned to the laboratory for identification, examination, and total length measurement.

NCIBI Analysis
The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr, *et al*. (1986). The IBI method was developed for assessing a stream's biological integrity by examining the structure and health of its fish community. The scores derived from this index are a measure of the ecological health of the waterbody and may not directly correlate to water quality. For example, a stream with excellent water quality, but with poor or fair fish habitat, would not be rated excellent with this index. However, in many instances, a stream which rated excellent on the NCIBI should be expected to have excellent water quality.

The Index of Biological Integrity incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities (water quality, energy source, habitat quality, flow regime, and biotic interactions). While any change in a fish community can be caused by many factors, certain aspects of the community are generally more responsive to specific influences. Species composition measurements reflect habitat quality effects. Information on trophic composition reflects the effect of biotic interactions and energy supply. Fish abundance and condition information indicate additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

The assessment of biological integrity using the North Carolina Index of Biotic Integrity (NCIBI) is provided by the cumulative assessment of 12 parameters or metrics (Table 1). The values provided by the metrics are converted into scores on a 1, 3, or 5 scale. A score of 5 represents conditions which would be expected for undisturbed reference streams in the specific river basin or ecoregion, while a score of 1 indicates that the conditions deviate greatly from those expected in undisturbed streams of the region. Each metric is designed to contribute unique information to the overall assessment. The scores for all metrics are then summed to obtain the overall NCIBI score. Finally, the score (an even number between 12 and 60) is then used to determine the ecological integrity class of the stream from which the sample was collected.

The NCIBI has been revised (NCDENR 2001b). Currently, the focus of using and applying the NCIBI has been restricted to wadeable streams that can be sampled by a crew of four persons. The bioclassifications and criteria have also been recalibrated against regional reference site data (Biological Assessment Unit Memorandum F-20010922) (Tables 2 – 5). To qualify as a reference site, the site had to satisfy all seven criteria in the order listed in Table 2. Reference sites represented the least impacted or the most minimally impacted streams and the overall biological conditions of the fish communities that could be attained.

Table 2. Reference site selection hierarchy -- a watershed-based approach for streams.

Criterion	Qualification
1 -- Habitat	Total habitat score ≥ 65
2 – NPDES dischargers	No NPDES dischargers ≥ 0.01 MGD above the site or if there are small dischargers (~≤ 0.01 MGD), the dischargers are more than one mile upstream
3 – Percent urbanization	< 10% of the watershed is urban or residential areas
4 – Percent forested	≥ 70% of the watershed is forested or in natural vegetation
5 – Channel incision	At the site, the stream is not incised beyond natural conditions
6 – Riparian zone integrity	No breaks in the riparian zones or, if there are breaks, the breaks are rare
7 – Riparian zone width	Mountain streams -- width of the riparian zone along both banks is ≥ 6m Piedmont streams – width of the riparian zone along both banks is ≥ 12 m
Exception 1	If the site satisfied Criteria 1 - 6, except one of the two riparian widths was less than one unit optimal, then the site still qualified as a reference site
Exception 2	If the site satisfied Criteria 1 - 3 and 5 - 7, but the percentage of the watershed in forest or natural vegetations was ≥ 60% (rather than ≥ 70%), then the site still qualified as a reference site. [Note: in the New River Basin this last exception is ≥ 50%.]

Table 3. Regional reference sites/samples used in calibrating the North Carolina Index of Biotic Integrity in the Broad River basin.

Subbasin/Waterbody	Station	County	Date
030801			
Flat Cr	SR 2802	Buncombe	09/29/1998
Cedar Cr	SR 1371	Rutherford	05/11/2000
030802			
Second Broad R	SR 1500	Rutherford	05/11/2000
030804			
N Fk First Broad R	SR 1728	Rutherford	06/20/1995
N Fk First Broad R	SR 1728	Rutherford	09/28/1998
Brier Cr	SR 1733	Rutherford	09/28/1998
Wards Cr	SR 1525	Cleveland	05/09/2000

Table 5. Revised scores and classes for evaluating the fish community of a wadeable stream using the North Carolina Index of Biotic Integrity in the Inner Piedmont, Foothills, and Eastern Mountains of the Broad, Catawba, Savannah, and Yadkin River basins.

NCIBI Scores	NCIBI Classes
54, 56, 58, or 60	Excellent
48, 50, or 52	Good
42, 44, or 46	Good-Fair
36, 38, or 40	Fair
≤ 34	Poor

Criteria and ratings applicable only to wadeable streams in the mountain and piedmont regions of the Broad River basin are the same as those for the Catawba, Savannah, and Yadkin River basins (Tables 3 and 5) . The definition of mountain and piedmont for these four river basins is based on a map of North Carolina watersheds by Fels (1997) and Griffith *et al*. (2002). Metrics and ratings should not be applied to non-wadeable streams nor to small, wadeable Southern Appalachian type trout streams in each of these basins. Characteristics of Southern Appalachian type trout streams include gradient, visual aspects of the stream and riparian zones, presence of plunge pools, overall fish faunal characteristics, specific conductance, temperature, clarity, elevation, and stream order. These streams, along with streams draining the Sandhills ecoregion in the southeast corner of the Yadkin River basin, are currently not rated.

Table 1 **Scoring criteria for the NCIBI for wadeable streams in the mountain and piedmont ecoregions of the Broad, Catawba, Savannah, and Yadkin River basins with watershed drainage areas ranging between 2.8 and 245 mi^2.**

No.	Metric		Score
1	**No. of species**		
	where Y is the number of species in the sample and X is the stream's drainage area in mi^2:		
	$Y \geq 9.5*Log_{10}X+1.6$		5
	$4.8*Log_{10}X+0.8 \leq Y < 9.5*Log_{10}X+1.6$		3
	$Y < 4.8*Log_{10}X+0.8$		1
2	**No. of fish**		
	Mountains	Piedmont	
	≥ 300 fish	≥ 150 fish	5
	200-299 fish	100-149 fish	3
	< 200 fish	< 100 fish	1
3	**No. of species of darters**		
	where Y is the number of species of darters in the sample and X is the stream's drainage area in mi^2.		
	$Y \geq 1.6*Log_{10}X$		5
	$0.8*Log_{10}X \leq Y < 1.6*Log_{10}X$		3
	$Y < 0.8*Log_{10}X$		1
	If the drainage area is > 70 mi^2, then ≥ 3 species = 5		
4	**No. of species of sunfish, bass, and trout**		
	≥ 3 species		5
	2 species		3
	0 or 1 species		1
5	**No. of species of suckers**		
	≥ 2 species		5
	1 species		3
	0 species		1
6	**No. of intolerant species**		
	Mountains	Piedmont	
	≥ 3 species	≥ 1 species	5
	1or 2 species	(no middle criteria or score)	3
	0 species	0 species	1
7	**Percentage of tolerant individuals**		
	Mountains	Piedmont	
	≤ 12%	≤ 25%	5
	13-25%	26-35%	3
	> 25%	> 35%	1
8	**Percentage of omnivorous and herbivorous individuals**		
	10-35%		5
	36-50%		3
	> 50%		1
	< 10%		1
9	**Percentage of insectivorous individuals**		
	60-90%		5
	45-59%		3
	< 45%		1
	> 90%		1
10	**Percentage of piscivorous individuals**		
	≥ 1.0%		5
	0.25-1.0%		3
	≤ 0.24%		1
11	**Percentage of diseased fish (DELT = diseased, fin erosion, lesions, and tumors)**		
	< 0.75%		5
	0.76-1.25%		3
	> 1.25%		1
12	**Percentage of species with multiple age groups**		
	Mountains	Piedmont	
	≥ 65% of all species have multiple age groups	≥ 55% of all species have multiple age groups	5
	45-64% all species have multiple age groups	35-54% all species have multiple age groups	3
	< 45% all species have multiple age groups	< 35% all species have multiple age groups	1

Table 4. Tolerance ratings and adult trophic guild assignments for fish in the Broad River basin. Species collected in 2004 and 2005 are highlighted in blue. Common and scientific names follow Nelson, *et al*. (2004), except for *Scartomyzon*.

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Clupeidae	**herrings and shads**		
Alosa aestivalis	blueback herring	Intermediate	Insectivore
Dorosoma cepedianum	gizzard shad	Intermediate	Omnivore
D. petenense	threadfin shad	Intermediate	Omnivore
Cyprinidae	**carps and minnows**		
Campostoma anomalum	stoneroller	Intermediate	Herbivore
Carassius auratus	goldfish	Tolerant	Omnivore
Clinostomus funduloides	rosyside dace	Intermediate	Insectivore
Ctenopharyngodon idella	grass carp	Tolerant	Herbivore
Cyprinella chloristia	greenfin shiner	Intermediate	Insectivore
C. galactura	whitetail shiner	Intermediate	Insectivore
C. labrosa	thicklip chub	Intolerant	Insectivore
C. nivea	whitefin shiner	Intermediate	Insectivore
C. pyrrhomelas	fieryblack shiner	Intolerant	Insectivore
C. zanema	Santee chub	Intolerant	Insectivore
Cyprinus carpio	common carp	Tolerant	Omnivore
Hybognathus regius	silvery minnow	Intermediate	Herbivore
Hybopsis hypsinotus	highback chub	Intolerant	Insectivore
Luxilus coccogenis	warpaint shiner	Intermediate	Insectivore
Nocomis leptocephalus	bluehead chub	Intermediate	Omnivore
Notemigonus crysoleucas	golden shiner	Tolerant	Omnivore
Notropis sp. cf. chlorocephalus	piedmont shiner	Intermediate	Insectivore
N. hudsonius	spottail shiner	Intermediate	Omnivore
N. procne	swallowtail shiner	Intermediate	Insectivore
N. rubricroceus	saffron shiner	Intermediate	Insectivore
N. scepticus	sandbar shiner	Intermediate	Insectivore
N. spectrunculus	mirror shiner	Intermediate	Insectivore
Pimephales promelas	fathead minnow	Tolerant	Omnivore
Rhinichthys obtusus	western blacknose dace	Intermediate	Insectivore
Semotilus atromaculatus	creek chub	Tolerant	Insectivore
Catostomidae	**suckers**		
Carpiodes cyprinus	quillback	Intermediate	Omnivore
Catostomus commersonii	white sucker	Tolerant	Omnivore
Hypentelium nigricans	northern hogsucker	Intermediate	Insectivore
Moxostoma collapsum	notchlip redhorse	Intermediate	Insectivore
M. duquesnei	black redhorse	Intermediate	Insectivore
M. pappillosum	v-lip redhorse	Intermediate	Insectivore
Scartomyzon rupiscartes	striped jumprock	Intermediate	Insectivore
S. sp. cf. *lachneri*	brassy jumprock	Intermediate	Insectivore
Ictaluridae	**North American catfishes**		
Ameiurus brunneus	snail bullhead	Intermediate	Insectivore
A. catus	white catfish	Tolerant	Omnivore
A. nebulosus	brown bullhead	Tolerant	Omnivore
A. platycephalus	flat bullhead	Tolerant	Insectivore
Ictalurus punctatus	channel catfish	Intermediate	Omnivore
Noturus insignis	margined madtom	Intermediate	Insectivore
Esocidae	**pikes**		
Esox masquinongy	muskellunge	Intermediate	Piscivore
Salmonidae	**trouts and salmons**		
Oncorhynchus mykiss	rainbow trout	Intolerant	Insectivore
Salmo trutta	brown trout	Intermediate	Piscivore
Salvelinus fontinalis	brook trout	Intolerant	Insectivore
Poeciliidae	**livebearers**		
Gambusia holbrooki	eastern mosquitofish	Tolerant	Insectivore
Cottidae	**sculpins**		
Cottus bairdii	mottled sculpin	Intermediate	Insectivore

Table 4 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Moronidae	**temperate basses**		
Morone chrysops	white bass	Intermediate	Piscivore
Centrarchidae	**sunfishes and black basses**		
Ambloplites rupestris	rock bass	Intolerant	Piscivore
Lepomis auritus	redbreast sunfish	Tolerant	Insectivore
L. cyanellus	green sunfish	Tolerant	Insectivore
L. gibbosus	pumpkinseed	Intermediate	Insectivore
L. gulosus	warmouth	Intermediate	Insectivore
L. macrochirus	bluegill	Intermediate	Insectivore
L. microlophus	redear sunfish	Intermediate	Insectivore
Lepomis sp.	hybrid sunfish	Tolerant	Insectivore
Micropterus dolomieu	smallmouth bass	Intolerant	Piscivore
M. salmoides	largemouth bass	Intermediate	Piscivore
Pomoxis annularis	white crappie	Intermediate	Piscivore
P. nigromaculatus	black crappie	Intermediate	Piscivore
Percidae	**darters and perches**		
Etheostoma flabellare	fantail darter	Intermediate	Insectivore
E. olmstedi	tessellated darter	Intermediate	Insectivore
E. thalassinum	seagreen darter	Intolerant	Insectivore
Perca flavescens	yellow perch	Intermediate	Piscivore
Percina crassa	piedmont darter	Intolerant	Insectivore
Stizostedion vitreus	walleye	Intermediate	Piscivore

Blackspot and Other Diseases

Blackspot and yellow grub diseases are naturally occurring, common infections of fish by an immature stage of flukes. The life cycle involves fish, snails, and piscivorous birds. Although heavy, acute infections can be fatal, especially to small fish, fish can carry amazingly high worm burdens without any apparent ill effects (Noga 1996). The infections may often be disfiguring and render the fish aesthetically unpleasing (Figure 1).

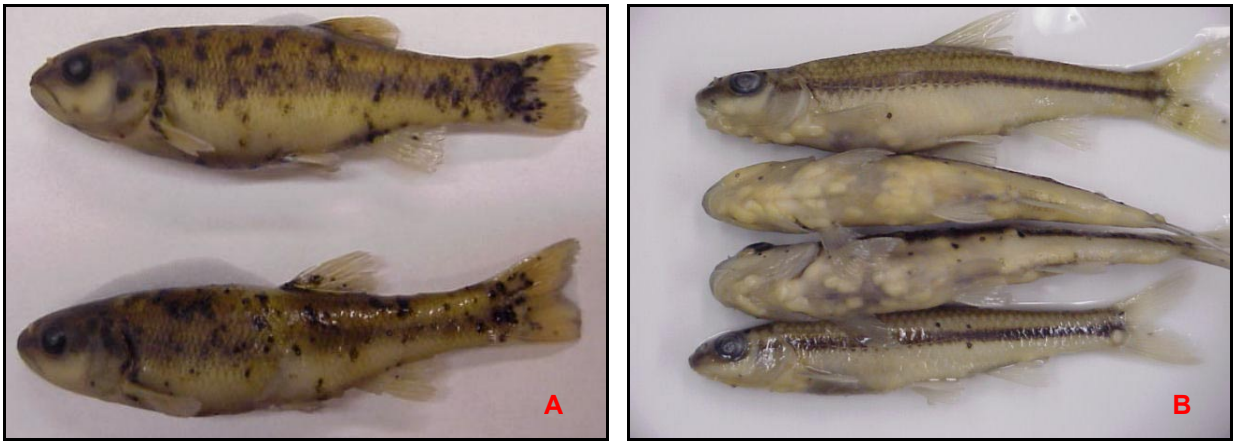

Figure 1. Heavy infestation of blackspot disease in creek chub (A) and yellow grub in bigeye chub (B).

Although some researchers incorporate the incidence of black spot and yellow grub into indices of biotic integrity (e.g., Steedman 1991), others, because of a lack of a consistent, inverse relationship to environmental quality, do not (e.g., Sanders *et al*. 1999). The diseases are not considered in the NCIBI because it is widespread, affecting fish in all types of streams. This disease was noted in Beason Creek in spottail shiner. Other diseases observed in 2004 included "fungus" on bluehead chubs in Muddy Fork, Hickory, and Brushy Creeks; and "Ich" on margined madtom in Brights Creek. Overall, the incidence of diseases in fish in the Broad River Basin was very low.

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Appendix F-2. A summary of fish community assessment data.

Monitoring efforts in 2004 and 2005 can be summarized as:

- Twenty eight sites were sampled in June and July 2004 (n = 4) and in early and late June 2005 (n = 24) as part of the current Broad River basinwide monitoring cycle.
- None of the sites sampled in 2004 or 2005 were on the 303 (d) impaired streams list.
- Nine sites were in the Mountains and 19 sites were in the Piedmont Level III ecoregions.
- Thirteen of the 28 sites had not been previously sampled.
- Some of these unassessed sites were in rural watersheds where there were no NPDES dischargers and were selected as potential candidates for fish community regional reference sites (e.g. Cove, Big Camp, Mountain, Britten, Brights, Duncans, and Hinton Creeks). Only Cove and Britten Creeks possessed the instream, riparian, and watershed characteristics of exceptionally high quality to qualify the sites as new fish community regional reference sites.
- The remaining 15 sites had been sampled during the last basinwide cycle in 2000 or as part of special studies conducted in 1998 and 1999.
- The four sites sampled in 2004 were part of a larger study on the impact of urbanization on aquatic communities in the Piedmont of North Carolina.
- A special study was also completed in 2004 at four sites within the Catheys-Hollands Creek watershed for the Ecosystems Enhancement Program.
- The drainage areas of the assessed watersheds ranged from 5.9 to 43.3 square miles.
- The most commonly collected species during basinwide monitoring were the bluehead chub, Piedmont shiner, striped jumprock, and redbreast sunfish; the most abundant species was the bluehead chub.
- All streams were evaluated and rated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendix F-1). The NCIBI scores ranged from 38 to 58 and the NCIBI ratings ranged from Fair to Excellent (Figures 1 and 2; Appendix F-3); 26 of the 28 sites were rated Good-Fair or better.

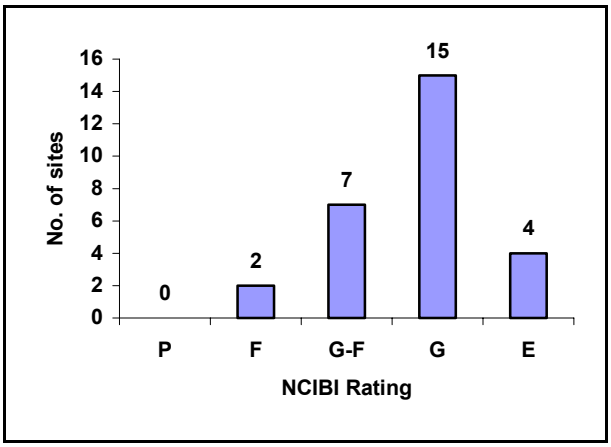

Figure 1. Distribution of the ratings of 28 fish community basinwide sites in the Broad River basin, 2004 and 2005. Abbreviations are: P = Poor, F = Fair, G-F = Good-Fair, G = Good, and E = Excellent.

- Based upon watershed and instream and riparian habitat characteristics Cove and Britten Creeks qualified as new fish community regional reference sites. Cove Creek was rated Good and Britten Creek was rated Excellent. The three other streams rated Excellent were Walnut and Brier Creeks and the North Fork First Broad River.
- Based upon the fish community ratings, degraded streams (a bioclassification of Fair) included Cedar (the upper site) and Sandy Run Creeks.

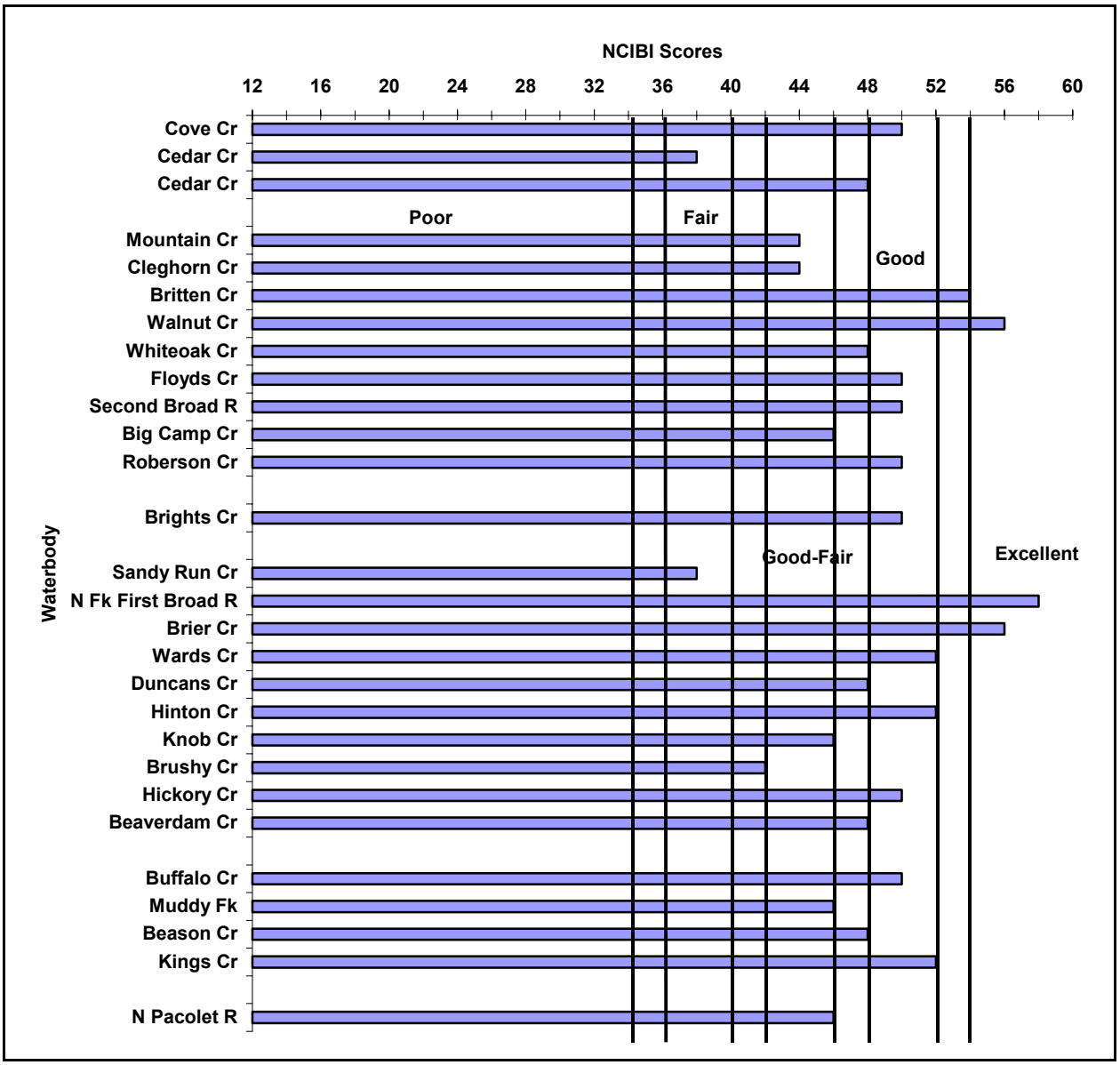

Figure 2. NCIBI scores and ratings of 28 fish community basinwide sites in the Broad River basin, 2004 and 2005.

- Fifteen of the 28 sites had been sampled more than once either in the previous basinwide monitoring cycles or as special studies (Figure 3).
- Of these 15 sites, 5 sites had scores that did not change, 4 sites had scores that increased, and 6 sites had scores that decreased between years (Figure 4). The range in the difference in the scores was 4 points or less, except at one site where the score decreased by 10 points. The bioclassifications did not change at 11 sites, increased 1 rating at 3 sites (from Good-Fair to Good), and decreased 2 ratings at 1 site (Figure 4). The decline was most pronounced at Sandy Run Creek which declined from Good to Fair and which was attributed to lingering effects from the early 2000s drought followed by extremely high water events in fall 2004 (Appendix F-8).

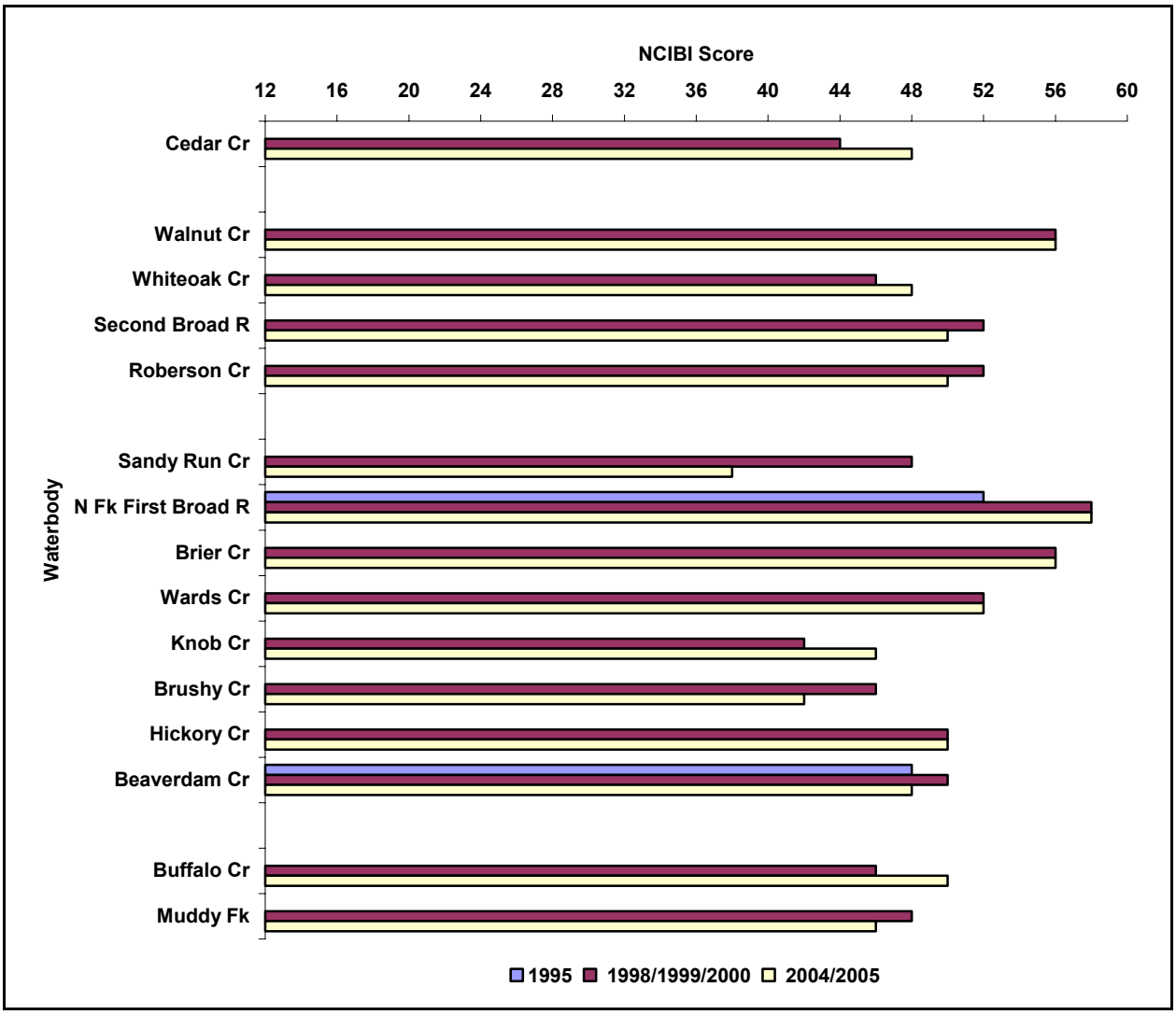

Figure 3. NCIBI scores and ratings of 15 repeat fish community sites in the Broad River basin, 1995 - 2005.

- These two environmental events may have contributed to the declines in the number of fish collected at 12 of the 15 sites (Figure 5); the declines ranged from 19 percent at North Fork First Broad River to 77 percent at Sandy Run Creek. At three-fourths of these sites, the number of fish collected was still within the range of what was to be expected compared to the regional fish community reference site. Fewer fish also led to a loss of age classes and a decline in the number of species with multiple age groups at these 12 sites. The declines in species diversity were most pronounced at Roberson and Sandy Run Creeks. Most other sites experienced either no change or a net loss or increase of only one or two species.
- Habitat characteristics and examples of high and low quality habitats at fish community sites in the basin are described and summarized in Appendix F-6. The instream and riparian habitat assessment scores at the 29 sites ranged from 35 to 97. Fish communities rated Excellent were found where the habitats were of moderate to high quality; communities rated Good-Fair or Fair were found where the habitats were of lower quality. Even though many of the fish communities were rated Good, there were substantial habitat problems stemming from long-term nonpoint erosion, sedimentation, and bank instability.

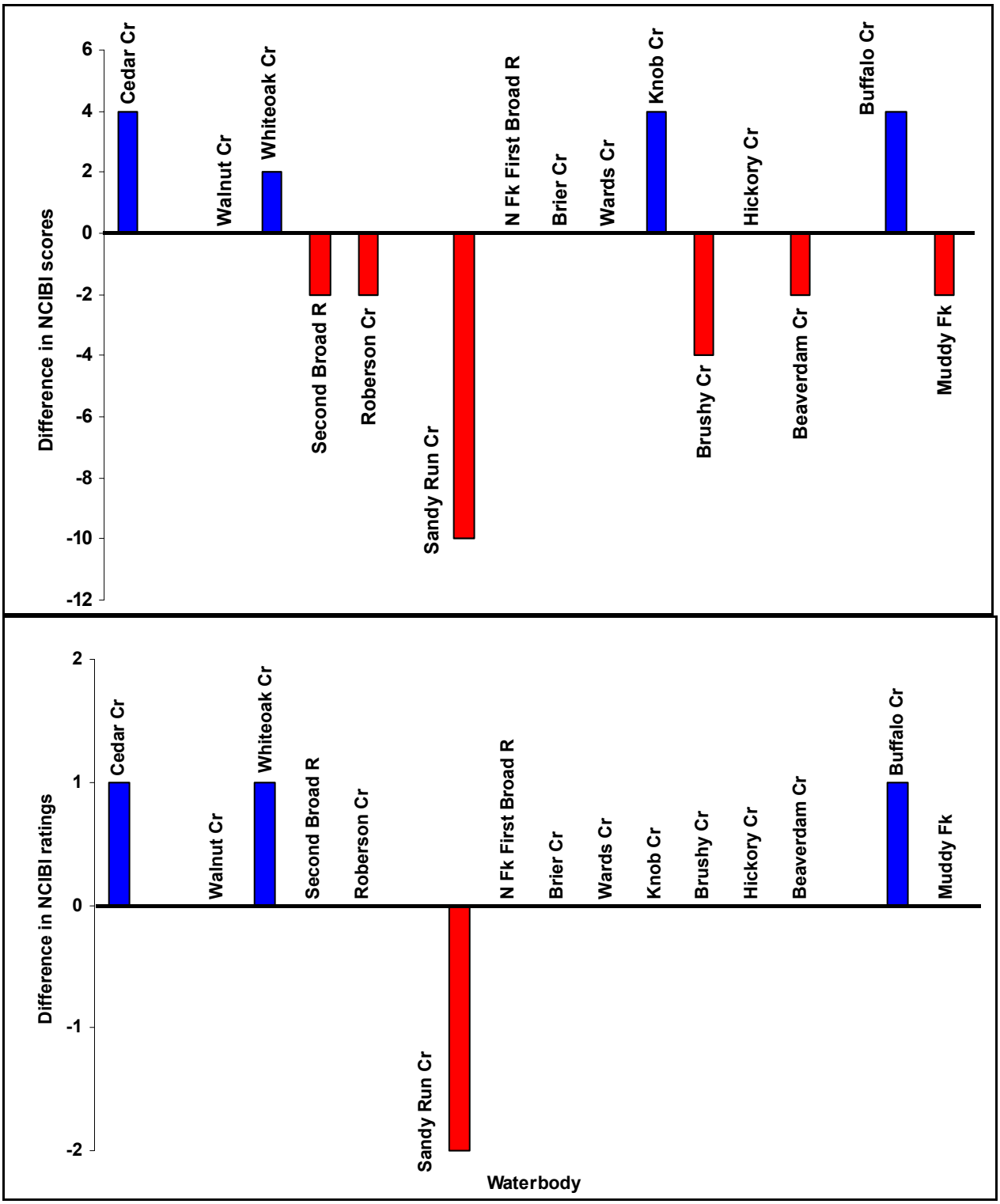

Figure 4. **A comparison of the NCIBI scores (top) and the bioclassifications (bottom)at 15 rateable fish community sites in the Broad River basin between 1998/1999/2000 and 2004/2005. For waterbodies with neither a red or blue bar, the difference was zero. A positive difference (blue) meant that the NCIBI score or rating was greater in 2004/2005 than in 1998/1999/2000; a negative difference (red) meant that the NCIBI score or rating was greater in 1998/1999/2000 than in 2004/2005.**

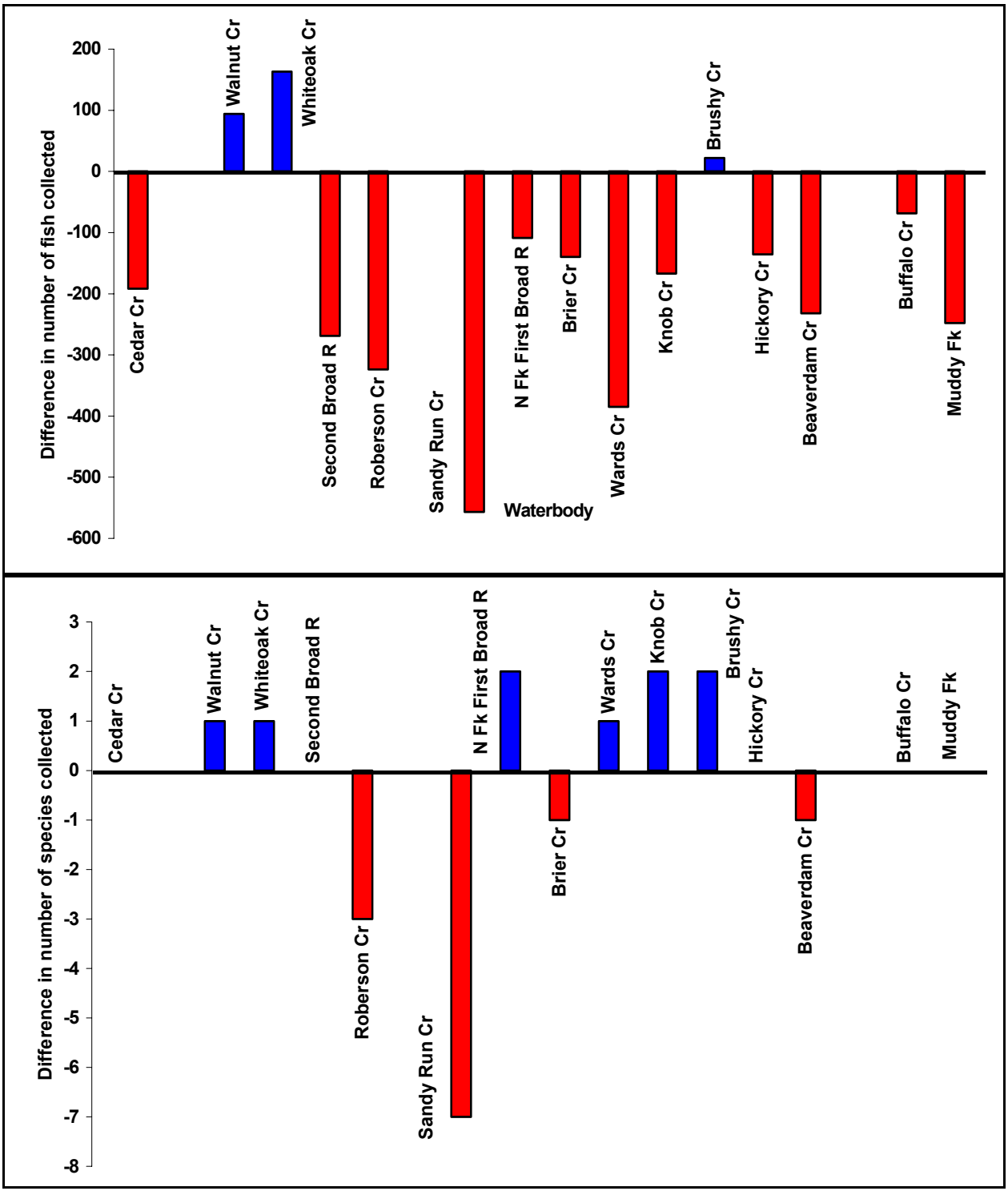

Figure 5. **A comparison of the number of fish and number of species collected at 15 community sites in the Broad River basin between 1998/1999/2000 and 2004/2005. For waterbodies with neither a red or blue bar, the difference was zero. A positive difference (blue) meant that the number of fish or number of species was greater in 2004/2005 than in 1998/1999/2000; a negative difference (red) meant that the number of fish or number of species was greater in 1998/1999/2000 than in 2004/2005.**

Appendix F-3-. Fish community data collected from the Broad River basin, 1994 – 2005. Current basinwide sites are in bold font.

Subbasin/Waterbody	Station	County	Index No.	Date	NCIBI Score	NCIBI Rating
030801						
Flat Cr	SR 2802	Buncombe	9-12	09/29/98	---	Not Rated
Cove Cr	SR 1001	Rutherford	9-23-(9)	06/22/05	50	Good
Cedar Cr	SR 1008	Rutherford	9-23-14	06/22/05	38	Fair
Cedar Cr	SR 1371	Rutherford	9-23-14	06/22/05	48	Good
				05/11/00	44	Good-Fair
030802						
Mountain Cr	SR 1178	Rutherford	9-25-(3.5)	06/21/05	44	Good-Fair
Cleghorn Cr	SR 1149	Rutherford	9-26	06/08/05	44	Good-Fair
Green R	SR 1302	Polk	9-29-(33)	06/19/95	46	Good-Fair
Britten Cr	NC 9	Polk	9-29-43	06/23/05	54	Excellent
Walnut Cr	SR 1315	Polk	9-29-44	06/23/05	56	Excellent
				05/12/00	56	Excellent
Whiteoak Cr	SR 1526	Polk	9-29-46	06/23/05	48	Good
				05/12/00	46	Good-Fair
Floyds Cr	SR 1116	Rutherford	9-37	6/8/2005	50	Good
Second Broad R	SR 1500	Rutherford	9-41-(0.5)	06/21/05	50	Good
				05/11/00	52	Good
Second Broad R	SR 1538	Rutherford	9-41-(10.5)	06/20/94	56	Excellent
Second Broad R	US 74 Bus	Rutherford	9-41-(21.5)	06/20/94	50	Good
Second Broad R	US 221A	Rutherford	9-41-(24.7)	06/20/94	50	Good
Big Camp Cr	SR 1504	Rutherford	9-41-11-(2.5)	06/21/05	46	Good-Fair
Cane Cr	SR 1558	Rutherford	9-41-12-(5.5)	05/10/00	44	Good-Fair
Catheys Cr	US 221	Rutherford	9-41-13-(0.5)	03/23/04	52	Good
Catheys Cr	SR 1549	Rutherford	9-41-13-(6)	03/23/04	36	Fair
				05/10/00	32	Poor
				06/20/94	46	Good-Fair
Hollands Cr	SR 1547	Rutherford	9-41-13-7-(3)	03/23/04	46	Good-Fair
Hollands Cr	SR 1548	Rutherford	9-41-13-7-(3)	03/23/04	40	Fair
Roberson Cr	SR 1561	Rutherford	9-41-14	06/09/05	50	Good
				05/10/00	52	Good
030803						
Brights Cr	SR 1155	Polk	9-29-38-1	06/23/05	50	Good
030804						
Sandy Run Cr	SR 1332	Cleveland	9-46	06/07/05	38	Fair
				05/10/00	48	Good
N Fk First Broad R	SR 1728	Rutherford	9-50-4	06/20/05	58	Excellent
				06/07/99	58	Excellent
				06/20/95	52	Good
Brier Cr	SR 1733	Rutherford	9-50-8	06/20/05	56	Excellent
				09/28/98	56	Excellent
Wards Cr	SR 1525	Cleveland	9-50-12	06/07/05	52	Good
				05/09/00	52	Good
Duncans Cr	NC 226	Cleveland	9-50-13	06/08/05	48	Good
Hinton Cr	NC 226	Cleveland	9-50-15	06/08/05	52	Good
Knob Cr	SR 1641	Cleveland	9-50-19-(2.5)	06/07/05	46	Good-Fair
				05/09/00	42	Good-Fair
Brushy Cr	SR 1342	Cleveland	9-50-29	06/07/05	42	Good-Fair
				05/09/00	46	Good-Fair
Brushy Cr	SR 1308	Cleveland	9-50-29	07/15/04	58	Excellent
Hickory Cr	NC 18	Cleveland	9-50-30	06/06/05	50	Good
				05/08/00	50	Good
Beaverdam Cr	NC 150	Cleveland	9-50-32	06/06/05	48	Good
				05/08/00	50	Good
				06/20/95	48	Good
030805						
Buffalo Cr	SR 1906	Cleveland	9-53-(1)	05/09/00	46	Good-Fair
Buffalo Cr	SR 1908	Cleveland	9-53-(1)	07/14/04	50	Good
Muddy Fk	SR 2012	Cleveland	9-53-6	06/22/04	46	Good-Fair
Muddy Fk	SR 1001	Cleveland	9-53-6	05/08/00	48	Good
Beason Cr	SR 2246	Cleveland	9-53-8	06/21/04	48	Good
Kings Cr	SR 2286	Cleveland	9-54	06/22/04	52	Good
030806						
N Pacolet R	US 176 & SR 1125	Polk	9-55-1-(1)	06/24/05	46	Good-Fair
N Pacolet R	SR 1501	Polk	9-55-1-(10)	06/19/95	48	Good

Appendix F-4. Fish community metric values from 28 wadeable streams in the Broad River basinwide monitoring program, 2004 and 2005.[1]

Subbasin Waterbody	Location	County	d. a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. SBT	No. Sp. Suckers	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
030801																
Cove Cr	SR 1001	Rutherford	32.5	06/22/05	13	441	2	3	1	3	13	29	71	0.45	0.00	77
Cedar Cr	SR 1008	Rutherford	21.3	06/22/05	11	199	1	3	1	3	10	48	52	0.00	0.00	64
Cedar Cr	SR 1371	Rutherford	22.0	06/22/05	11	595	2	2	1	3	10	29	71	0.00	0.00	91
030802																
Mountain Cr	SR 1178	Rutherford	28.7	06/21/05	16	98	3	4	3	3	11	56	43	1.02	0.00	31
Cleghorn Cr	SR 1149	Rutherford	13.6	06/08/05	15	173	2	2	2	3	10	65	35	0.00	0.00	40
Britten Cr	NC 9	Polk	6.8	06/23/05	15	406	3	2	2	3	12	32	68	0.00	0.00	73
Walnut Cr	SR 1315	Polk	16.9	06/23/05	23	522	4	3	5	5	11	29	71	0.00	0.00	57
Whiteoak Cr	SR 1526	Polk	11.3	06/23/05	14	508	2	2	3	2	17	54	46	0.00	0.00	93
Floyds Cr	SR 1116	Rutherford	27.0	06/08/05	20	148	4	2	3	4	26	27	73	0.00	0.00	60
Second Broad R	SR 1500	Rutherford	25.9	06/21/05	18	458	1	5	3	3	6	29	71	0.00	0.00	61
Big Camp Cr	SR 1504	Rutherford	12.2	06/21/05	10	441	1	1	2	1	5	27	73	0.00	0.00	80
Roberson Cr	SR 1561	Rutherford	26.0	06/09/05	17	116	1	4	2	3	16	29	69	1.72	0.00	29
030803																
Brights Cr	SR 1155	Polk	5.9	06/23/05	15	343	3	2	2	2	8	42	57	0.29	0.29	73
030804																
Sandy Run Cr	SR 1332	Cleveland	11.2	06/07/05	8	165	1	1	1	1	13	58	42	0.00	0.00	63
N Fk First Broad R	SR 1728	Rutherford	12.3	06/20/05	16	475	3	3	2	6	2	26	73	0.63	0.00	75
Brier Cr	SR 1733	Rutherford	8.9	06/20/05	14	361	3	3	1	5	3	28	72	0.28	0.00	79
Wards Cr	SR 1525	Cleveland	17.5	06/07/05	17	415	3	1	3	4	13	24	76	0.00	0.00	76
Duncans Cr	NC 226	Cleveland	19.7	06/08/05	16	150	3	1	1	5	3	25	75	0.00	0.00	50
Hinton Cr	NC 226	Cleveland	18.7	06/08/05	16	256	3	1	2	4	7	34	66	0.00	0.00	69
Knob Cr	SR 1641	Cleveland	33.3	06/07/05	15	138	3	2	2	3	12	37	63	0.00	0.00	47
Brushy Cr	SR 1342	Cleveland	20.0	06/07/05	18	309	2	2	3	3	10	57	43	0.00	0.32	50
Hickory Cr	NC 18	Cleveland	18.6	06/06/05	18	470	2	4	3	1	11	45	55	0.00	0.21	50
Beaverdam Cr	NC 150	Cleveland	16.9	06/06/05	17	494	3	2	2	2	3	49	51	0.20	0.00	53
030805																
Buffalo Cr	SR 1908	Cleveland	43.3	07/14/04	14	181	0	4	2	1	23	23	77	0.00	0.00	57
Muddy Fk	SR 2012	Cleveland	21.6	06/22/04	16	563	2	1	2	2	22	44	56	0.00	0.18	56
Beason Cr	SR 2246	Cleveland	9.8	06/21/04	14	410	1	3	2	1	13	57	40	2.20	0.00	43
Kings Cr	SR 2286	Cleveland	10.9	06/22/04	16	200	2	4	4	1	48	26	74	0.5	0.00	38
030806																
N Pacolet R	US 176 & SR 1125	Polk	17.7	06/24/05	15	962	1	3	2	4	2	61	38	0.10	0.00	80

[1]Abbreviations are d. a. = drainage area, No. = number, Sp. = species, SBT = sunfish, bass, and trout, Intol. = intolerants, Omni. + Herb. = omnivores+herbivores, Insect. = insectivores, Pisc. = piscivores, DELT = disease, erosion, lesions, and tumors, and MA = species with multiple age groups.

Appendix F-5. Fish distributional records for the Broad River basin.

Based upon Menhinick (1991), NC DWQ's data, and data from other researchers, approximately 66 species have been collected from the Broad River basin in North Carolina (Table 5 in Appendix F-1). The known species assemblage includes 25 species of minnows, 8 species of suckers, 12 species of sunfish and bass, and 6 species of darters. At least 19 of the 66 species (about 29 percent of the total basin fauna) are exotics and were introduced either as sportfish, forage fish, baitfish, or for reasons unknown. In 2004 and 2005, 7 of the 40 species collected were exotic species. These seven species included common carp, fathead minnow, rainbow trout, brown trout, green sunfish, redear sunfish, and smallmouth bass. Other exotic species now found in the basin include blueback herring, threadfin shad, goldfish, grass carp, channel catfish, muskellunge, brook trout, white bass, rock bass, white crappie. yellow perch, and walleye. Streams that did not have any exotic species included Britten, Whiteoak, Big Camp, Sandy Run, Wards, Duncans, Hinton, Knob, Brushy, Muddy Fork, Beason, and Kings Creeks. Stream that did not have any exotic species prior to 2005, but now do include Roberson, Walnut, and Hickory Creeks (green sunfish) and Beaverdam Creek (fathead minnow).

None of the 66 species has required special protection by the U. S. 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, *et al*. 2004; Menhinick and Braswell 1997). There are no species found within the river basin that are considered to be federally or state endangered, threatened, or of special concern. The Natural Heritage Program, however, considers the Santee Chub, *Cyprinella zanema*, as a Significantly Rare and as a S3 type species (rare or uncommon in North Carolina with 21-100 extant populations) (LeGrand, *et al*. 2004). This species was collected at three sites in northern Rutherford and Cleveland counties during the 2004/2005 monitoring activities.

In 2004/2005, 40 of the 66 species were collected during DWQ's fish community monitoring program (Table 5 in Appendix F-1). The most commonly collected species were the bluehead chub, striped jumprock, and redbreast sunfish (collected at all 28 sites). The most abundant species was the bluehead chub which constituted approximately 37 percent of all the fish collected. It was also the numerically dominant species at 23 of the 28 sites.

New county distributional records in 2004/2005 from DWQ's fish community monitoring efforts were:

- Fathead minnow -- Beaverdam Creek (Cleveland County);
- Brassy jumprock. -- Kings Creek (Cleveland County);
- Redear sunfish -- Buffalo Creek (Cleveland County);
- Green sunfish -- Hickory and Walnut Creeks (Cleveland and Polk counties); and
- Piedmont darter -- Floyds Creek (Rutherford County).

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Appendix F-6. Habitat evaluations and stream and riparian habitats at 28 fish community monitoring sites in the Broad River basin, 2004/2005.

Habitat Assessments

A method has been developed by the Biological Assessment Unit to evaluate the physical habitats of a stream (NCDENR 2001). The narrative descriptions of eight habitat characteristics, including channel modification, amount of instream habitat, type of bottom substrate, pool variety, riffle frequency, length and width, bank stability, light penetration, and riparian zone width, are converted into numerical scores. The total habitat score ranges between 1 and 100. Higher numbers suggest better habitat quality, but criteria have not been developed to assign impairment ratings.

Fish community sampling was conducted in 2004/2005 at 28 sites; 9 in the Mountains and 19 within the Piedmont Level III ecoregions (Table 1). Habitat scores ranged from 35 (Sandy Run Creek) to 97 (Britten Creek) (Table 2). One-third of the streams had overall moderate to high quality habitats (score ≥ 65); whereas two-thirds of the streams had overall low to poor quality habitats (score < 65) (Figure 1). This distribution of total habitat scores was similar to that for all fish community sites which were sampled in the basin between 1995 and 2005 (Figure 2).

Major differences between the high to moderate and the low to poor quality habitat types were in the instream habitats, substrates, riffles, and bank stabilities (Table 3). Differences were not as pronounced in the abundance of pools, extent of canopy cover, or width of riparian zones. Low scores were attributable to chronic erosion of the easily eroded soils and nonpoint source sedimentation within the respective watersheds.

Table 2. Rankings of 28 waterbodies in Broad River basin according to the total habitat scores, 2004/2005.

Subbasin	Waterbody	Location	County	Score
High to Moderate Quality Habitats				
2	Britten Cr	NC 9	Polk	97
1	Cedar Cr	SR 1371	Rutherford	90
3	Brights Cr	SR 1155	Polk	88
4	N Fk First Broad R	SR 1728	Rutherford	88
2	Second Broad R	SR 1500	Rutherford	87
4	Brier Cr	SR 1733	Rutherford	85
1	Cove Cr	SR 1001	Rutherford	85
6	N Pacolet R	US 176/SR 1125	Polk	74
4	Wards Cr	SR 1525	Cleveland	69
Low to Poor Quality Habitats				
1	Cedar Cr	SR 1008	Rutherford	61
4	Duncans Cr	NC 266	Cleveland	61
4	Hinton Cr	NC 226	Cleveland	61
2	Floyd's Cr	SR 1116	Rutherford	60
2	Roberson Cr	SR 1561	Rutherford	58
2	Walnut Cr	SR 1315	Polk	56
5	Muddy Fk	SR 2012	Cleveland	54
2	Mountain Cr	SR 1178	Rutherford	53
4	Beaverdam Cr	NC 150	Cleveland	51
5	Kings Cr	SR 2286	Cleveland	51
2	Big Camp Cr	SR 1504	Rutherford	50
4	Brushy Cr	SR 1342	Cleveland	49
5	Buffalo Cr	SR 1908	Cleveland	48
4	Hickory Cr	NC 18	Cleveland	47
4	Knob Cr	SR 1641	Cleveland	47
2	Whiteoak Cr	SR 1526	Polk	45
5	Beason Cr	SR 2246	Cleveland	45
2	Cleghorn Cr	SR 1149	Rutherford	42
4	Sandy Run Cr	SR 1332	Cleveland	35

Table 1. Habitat evaluations at 28 basinwide fish community sites in the Broad River basin, 2004/2005.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030801															
	Cove Cr	SR 1001	Rutherford	15	5	18	11	6	14	6	7	9	4	5	85
	Cedar Cr	SR 1008	Rutherford	9	5	12	4	4	5	6	6	9	5	5	61
	Cedar Cr	SR 1371	Rutherford	12	5	19	13	8	16	7	7	7	5	3	90
030802															
	Mountain Cr	SR 1178	Rutherford	9	5	11	3	6	3	3	4	9	4	5	53
	Cleghorn Cr	SR 1149	Rutherford	8	5	9	3	4	2	3	3	7	3	3	42
	Britten Cr	NC 9	Polk	8	5	18	14	10	15	7	7	10	5	5	97
	Walnut Cr	SR 1315	Polk	8	5	13	7	4	3	6	6	6	4	2	56
	Whiteoak Cr	SR 1526	Polk	9	5	11	3	6	3	3	3	7	2	2	45
	Floyd's Cr	SR 1116	Rutherford	10	5	12	5	8	5	4	4	8	5	4	60
	Second Broad R	SR 1500	Rutherford	11	5	18	13	6	16	6	6	9	4	4	87
	Big Camp Cr	SR 1504	Rutherford	6	5	12	4	4	5	2	3	9	4	2	50
	Roberson Cr	SR 1561	Rutherford	12	5	12	4	6	5	4	4	8	5	5	58
030803															
	Brights Cr	SR 1155	Polk	6	5	18	13	8	15	6	7	9	2	5	88
030804															
	Sandy Run	SR 1332	Cleveland	9	5	10	3	2	2	2	2	9	0	0	35
	N Fk First Broad R	SR 1728	Rutherford	7	5	18	14	8	16	6	6	7	3	5	88
	Brier Cr	SR 1733	Rutherford	9	5	18	13	6	15	6	6	9	3	4	85
	Wards Cr	SR 1525	Cleveland	9	5	14	6	6	10	5	5	9	5	4	69
	Duncans Cr	NC 266	Cleveland	7	5	14	5	7	5	3	3	9	5	5	61
	Hinton Cr	NC 226	Cleveland	10	5	12	5	6	5	4	5	9	5	5	61
	Knob Cr	SR 1641	Cleveland	9	5	11	3	4	4	2	2	7	5	4	47
	Brushy Cr	SR 1342	Cleveland	9	5	9	3	4	5	3	3	7	5	5	49
	Hickory Cr	NC 18	Cleveland	8	5	12	3	4	2	2	2	7	5	5	47
	Beaverdam Cr	NC 150	Cleveland	9	5	14	4	4	4	3	3	6	4	4	51
030805															
	Buffalo Cr	SR 1908	Cleveland	11	5	12	2	10	1	3	3	5	5	2	48
	Muddy Fk	SR 2012	Cleveland	9	5	12	4	4	4	3	3	9	5	5	54
	Beason Cr	SR 2246	Cleveland	5	5	12	3	4	3	3	3	7	2	2	45
	Kings Cr	SR 2286	Cleveland	6	5	12	3	9	3	2	2	7	4	4	51
030806															
	N Pacolet R	US 176/SR 1125	Polk	16	5	16	12	8	16	3	3	7	2	2	74
Maximum possible scores					**5**	**20**	**15**	**10**	**16**	**7**	**7**	**10**	**5**	**5**	**100**

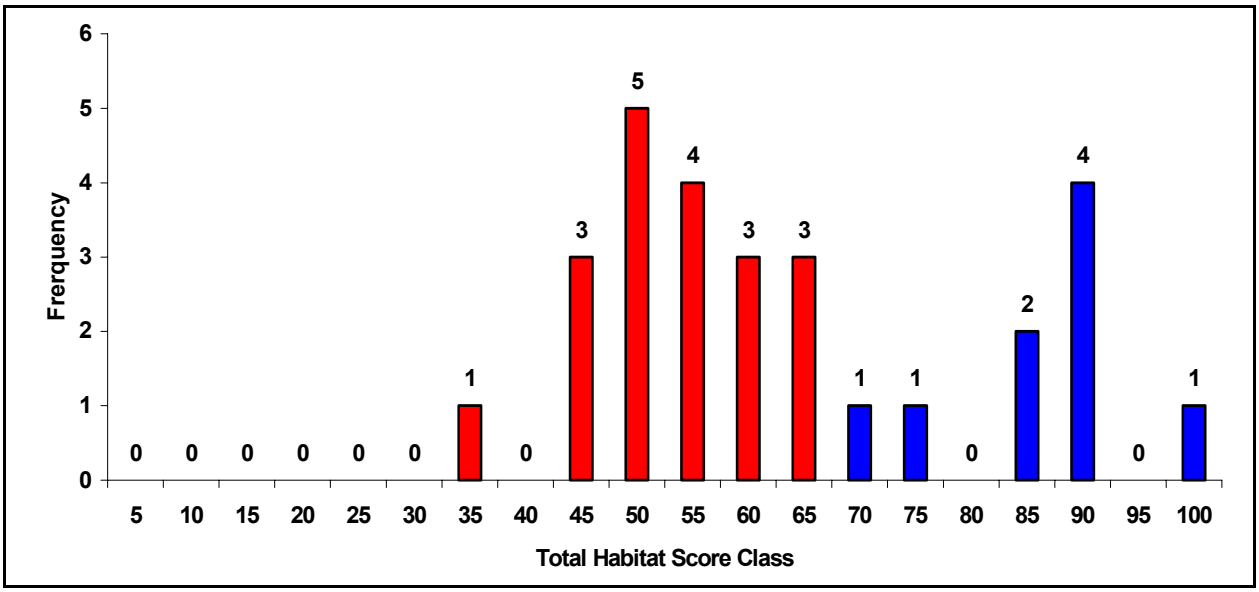

Figure 1. **Distribution of the total habitat scores at fish community sites in the Broad River, 2004/2005. High to moderate quality scores are shown in blue and low to poor quality habitat sites are shown in red.**

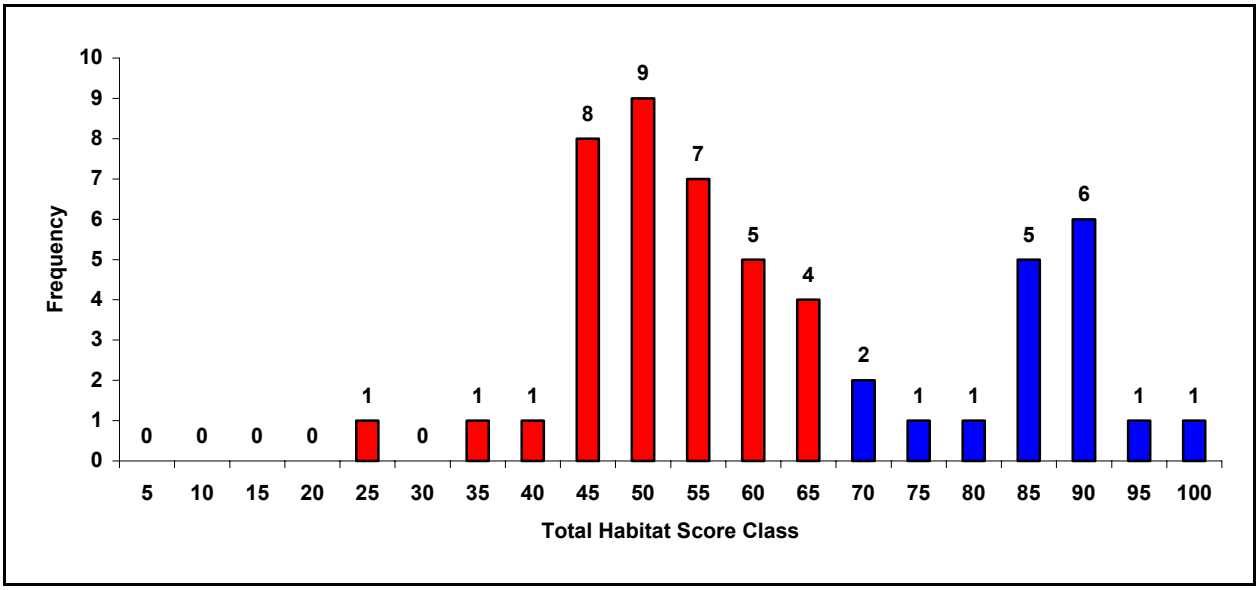

Figure 2. **Distribution of the total habitat scores at fish community sites in the Broad River, 1995 - 2005. High to moderate quality scores are shown in blue and low to poor quality habitat sites are shown in red.**

Table 3. **Mean habitat scores for 28 fish community sites in the Broad River basin, 2004/2005.**

Habitat characteristics	Low - Poor Quality Habitat	Moderate - High Quality Habitat	Maximum score
Instream habitat	11.7	17.4	20
Substrate	3.7	12.1	15
Riffle	3.6	14.8	16
Bank stability (right and left)	6.6	11.8	14

Characteristics of moderate to high quality habitat streams are (Figure 3):

- instream habitats composed of rocks, sticks, leafpacks, snags, logs, undercut banks and root mats;
- a substrate of cobble and gravel with low embeddedness;
- frequent pools and riffles of varying depths and widths; and
- stable banks with a good tree canopy and a medium to wide riparian zone with no or rare breaks.

Figure 3. Instream habitats composed of boulder, cobble, and gravel rocks; sticks, leafpacks, snags, logs, and root mats; and wide riparian zones offering a good tree canopy, Britten Creek at NC 9, Polk County.

Characteristics of low to poor quality habitat streams are (Figure 4):

- a substrate of primarily sand with instream bar development;
- an absence of riffles; if present, they are infrequent and usually caused by embedded, coarse woody debris; and
- a deeply entrenched channel with easily erodible and unstable, vertical, sparsely vegetated banks.

Figure 4. Livestock with access to the stream, sandy substrates with few riffles, and eroding and sloughing banks, Sandy Run Creek at SR 1332, Cleveland County.

There were minimal differences (± 7 points maximum) in the habitat scores at 15 sites that were sampled during the past two basinwide monitoring cycles (Figure 5). Even though there was a wide range in habitat qualities among the sites, overall, the habitats at these sites were very stable. Also the scoring/assessment method was very reproducible with small variability among trained staff.

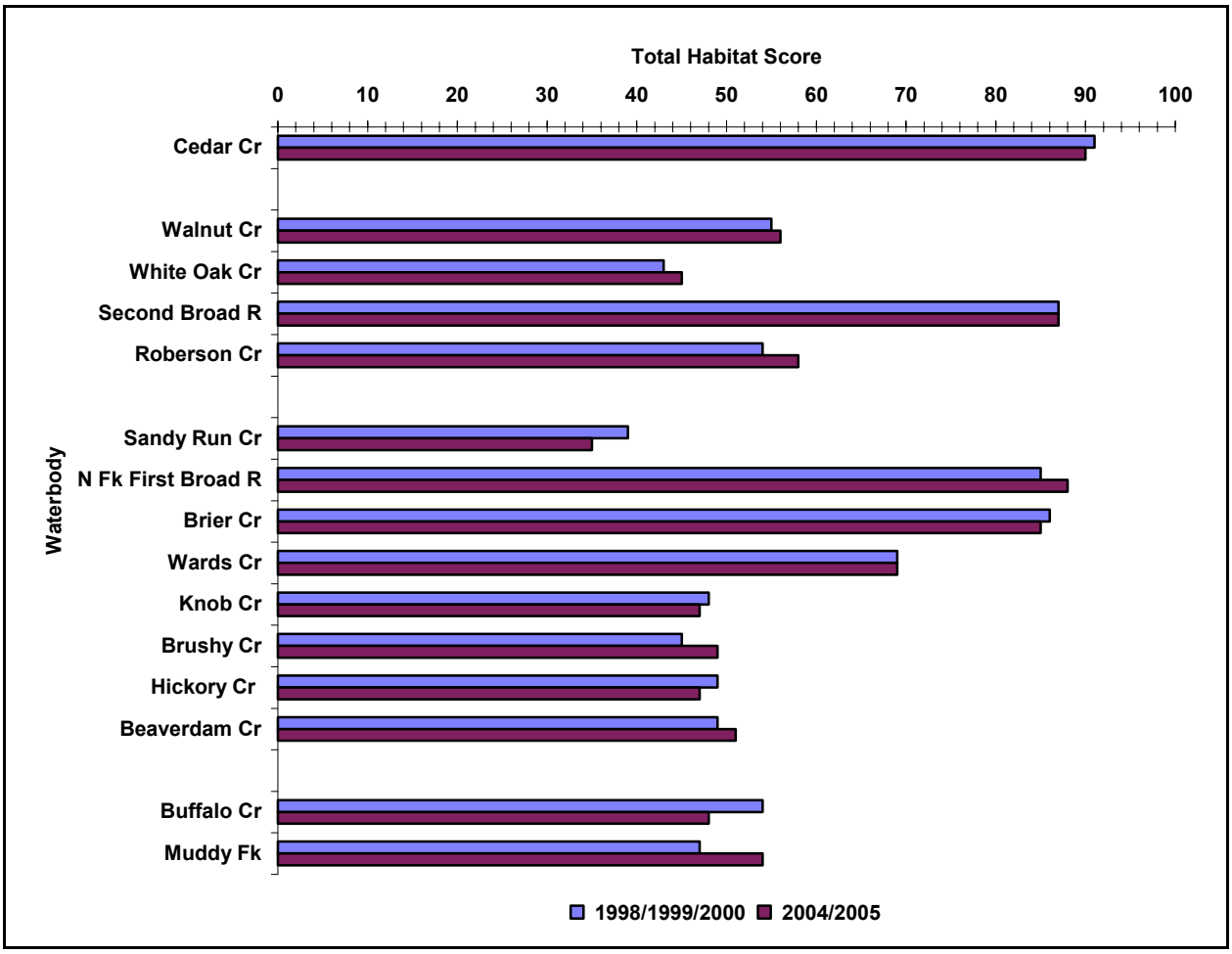

Figure 5. Total habitat scores at 15 fish community sites in the Broad River basin, 1998/1999/2000 and 2004/2005.

Habitat and NCIBI Relationships

Fish communities which were rated Excellent were found where the habitats were of moderate to high quality (Table 5); except for Walnut Creek. The overall habitats at Walnut Creek were scored a 56, but the lower one-third of the reach had moderate to high quality habitats. Communities rated Good-Fair or Fair were found where the habitats were of lower quality. It seems that many fish communities in the basin are still rated Good, even though there were substantial habitat problems stemming from easily eroded soils, long-term nonpoint erosion, sedimentation, and bank instability.

Table 5. NCIBI ratings and habitat quality for 29 streams in the Broad River basin, 2004/2005.[1]

NCIBI Rating	Waterbodies with Low to Poor Quality Habitat (Score < 65)	Waterbodies with Moderate to High Quality Habitat (Score ≥ 65)
Excellent	Walnut	Britten, North Fork First Broad, Brier
Good	Whiteoak, Floyds, Roberson, Duncans, Hinton, Hickory, Beaverdam, Buffalo, Beason, Kings	Cove, Cedar, Second Broad, Brights, Ward
Good-Fair	Mountain, Cleghorn, Big Camp, Knob, Muddy, Brushy	N Pacolet
Fair	Cedar, Sandy Run	---
Poor	---	---

[1]Blue denotes streams with moderate to high quality habitats and fish communities rated Good or Excellent. Red denotes streams with low to poor quality habitats and fish communities rated Fair or Poor.

Fifty-two rateable fish community samples with associated habitat evaluations have been collected throughout the basin since 1995. Although the size of the data set was limited, fish communities rated Excellent were found where high quality instream and riparian habitats existed as contrasted to communities rated Good to Poor (Figure 6). The median habitat score for Excellent sites was 85; communities rated Good to Poor had median scores ranging from 38 to 58.

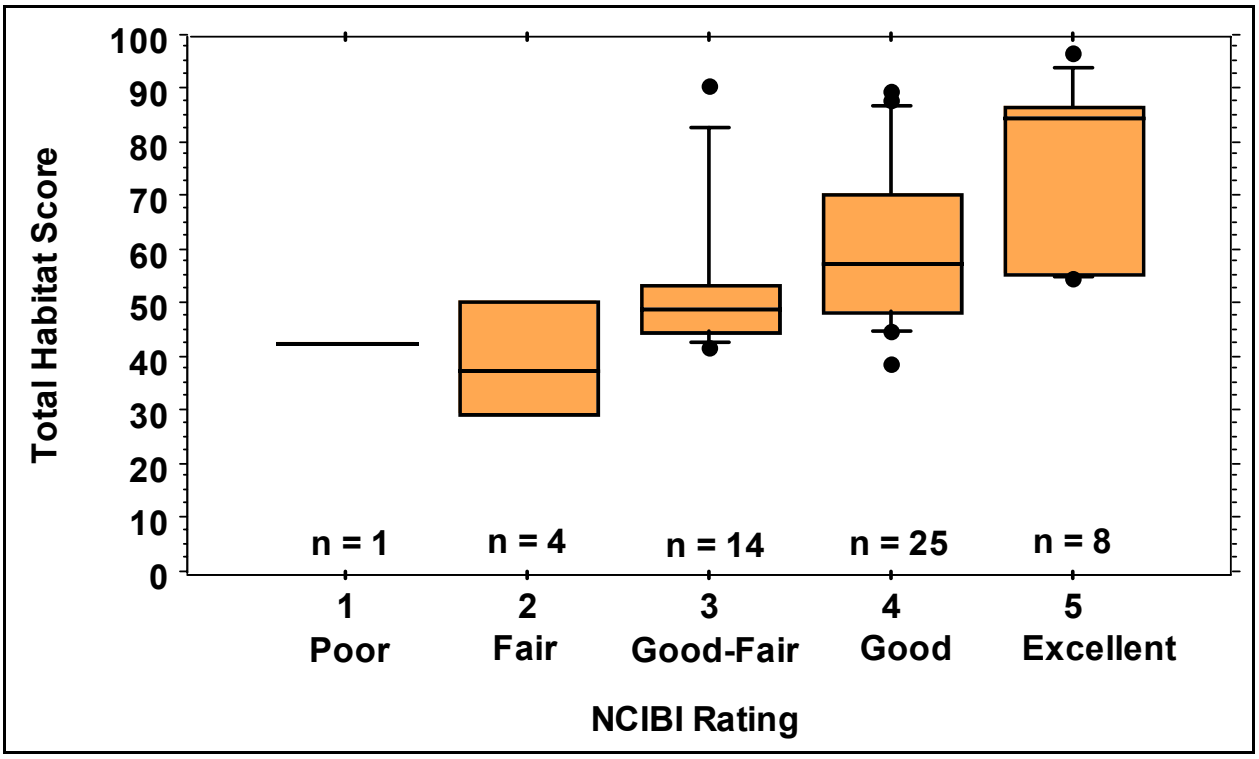

Figure 6. Relationships between habitat scores and NCIBI ratings in the Broad River basin, 1995 –2005.

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Appendix F-7. Water quality at 28 fish community sites in the Broad River basin, 2004 and 2005.

In 2004/2005 water quality data were collected at every site during fish community assessments (Table 1). All dissolved oxygen concentrations were greater than the water quality standard of 5 mg/L (NCAC 2004). Dissolved oxygen saturation ranged from 81 percent at Beaverdam Creek to 99 percent at North Fork First Broad River. All pH measurements were within the water quality standard for non-swamp waters and ranged from 6.1 s.u. at Brier Creek and North Fork First Broad River to 7.4 s.u. at Sandy Run Creek.

Table 1. Water quality measurements at 24 fish community sites in the Broad River basin, 2004 and 2005.

Subbasin/ Waterbody	Location	County	Date	Temperature (˚C)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	Saturation (%)	pH (s.u.)
030801								
Cove Cr	SR 1001	Rutherford	06/22/05	18.8	39	9.0	97	6.4
Cedar Cr	SR 1008	Rutherford	06/22/05	17.4	33	8.9	93	6.7
Cedar Cr	SR 1371	Rutherford	06/22/05	16.2	33	8.6	88	6.6
030802								
Mountain Cr	SR 1178	Rutherford	06/21/05	18.2	48	8.7	92	6.3
Cleghorn Cr	SR 1149	Rutherford	06/08/05	20.8	73	7.6	85	6.7
Britten Cr	NC 9	Polk	06/23/05	21.3	35	7.3	82	6.4
Walnut Cr	SR 1315	Polk	06/23/05	18.2	33	8.3	88	6.4
Whiteoak Cr	SR 1526	Polk	06/23/05	18.0	57	7.9	83	6.4
Floyds Cr	SR 1116	Rutherford	06/08/05	21.6	44	7.5	85	6.7
Second Broad R	SR 1500	Rutherford	06/21/05	16.5	51	8.9	91	6.7
Big Camp Cr	SR 1504	Rutherford	06/21/05	16.7	43	8.2	84	6.5
Roberson Cr	SR 1561	Rutherford	06/09/05	19.2	42	8.3	90	6.7
030803								
Brights Cr	SR 1155	Polk	06/23/05	23.7	33	6.9	82	6.2
030804								
Sandy Run Cr	SR 1332	Cleveland	06/07/05	18.5	36	8.2	88	7.4
N Fk First Broad R	SR 1728	Rutherford	06/20/05	17.2	28	9.5	99	6.1
Brier Cr	SR 1733	Rutherford	06/20/05	16.8	28	9.3	96	6.1
Wards Cr	SR 1525	Cleveland	06/07/05	19.7	39	8.7	95	7.2
Duncans Cr	NC 226	Cleveland	06/08/05	18.6	33	8.3	89	6.2
Hinton Cr	NC 226	Cleveland	06/08/05	18.4	32	8.1	86	6.8
Knob Cr	SR 1641	Cleveland	06/07/05	19.0	41	8.7	94	6.2
Brushy Cr	SR 1342	Cleveland	06/07/05	18.9	76	8.3	89	6.3
Hickory Cr	NC 18	Cleveland	06/06/05	20.3	50	7.9	87	6.6
Beaverdam Cr	NC 150	Cleveland	06/06/05	24.0	66	6.8	81	6.7
030805								
Buffalo Cr	SR 1908	Cleveland	07/14/04	25.0	58	7.1	86	6.2
Muddy Fk	SR 2012	Cleveland	06/22/04	20.6	65	7.8	87	---[1]
Beason Cr	SR 2246	Cleveland	06/21/04	21.3	78	7.4	84	---[1]
Kings Cr	SR 2286	Cleveland	06/22/04	19.3	181	8.4	91	---[1]
030806								
N Pacolet R	US 176 & SR 1125	Polk	06/24/05	17.2	31	8.5	88	6.3

[1]data not collected; instrument malfunction.

Conductivity (specific conductance) ranged from 28 µmhos/cm at Brier Creek and North Fork First Broad River to 181 µmhos/cm at Kings Creek (Figure 1). The elevated readings at Kings Creek may be due to the two permitted industrial dischargers upstream, although neither facility had any permit violations between July 01, 2001 and July 01, 2005 (Basinwide Information Management System query November 07, 2005).

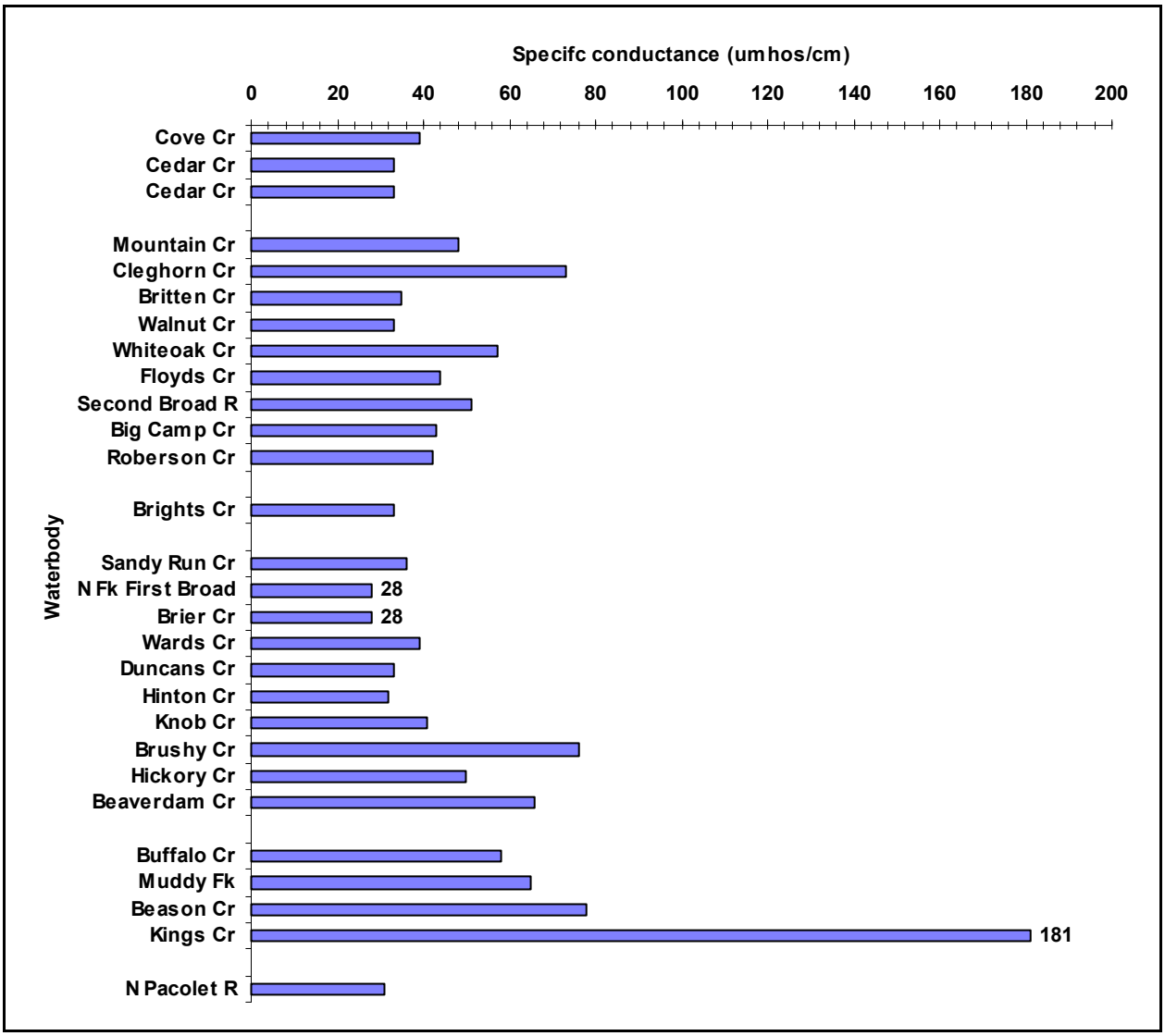


Figure 1. Specific conductance at 28 fish community sites in the Broad River basin, 2004/2005.

Fifteen fish community sites were sampled in 2000 and again in 2004/2005. The two greatest increases and percentage increases in conductivity were measured at Wards and Buffalo Creeks (Figure 2 and 3). The conductivity increased more than 60 percent at both of these sites. Although the conductivity continued to be low at Wards Creek and relatively low at Buffalo Creeks, the reason for the increases were unknown. There are no permitted dischargers or municipalities within either of these watersheds, thus the increases must have been due to nonpoint source runoff.

The greatest decreases and greatest percentage decreases in conductivity were measured at Brushy and Hickory Creeks. Hickory Creek drains a fairly developed area including a portion of the Town of Shelby. However, there are no permitted dischargers within its watershed. Thus, the decrease must have come from reduced nonpoint source runoff and urban stormwater. The watershed of Brushy Creek is rural but the monitoring site is below two permitted dischargers.

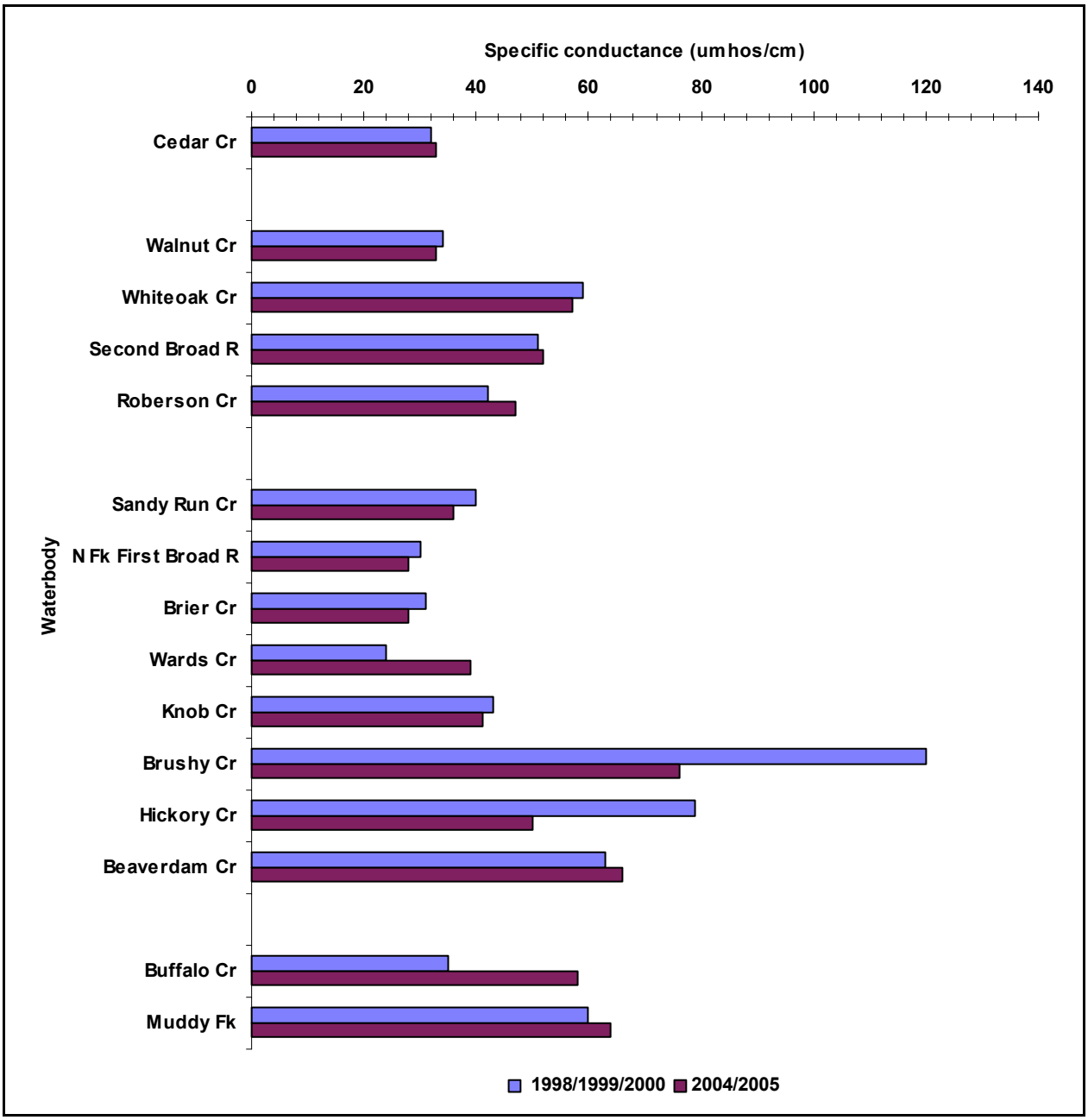


Figure 2. **Specific conductance at 15 repeat fish community sites in the Broad River basin, 1998 - 2005.**

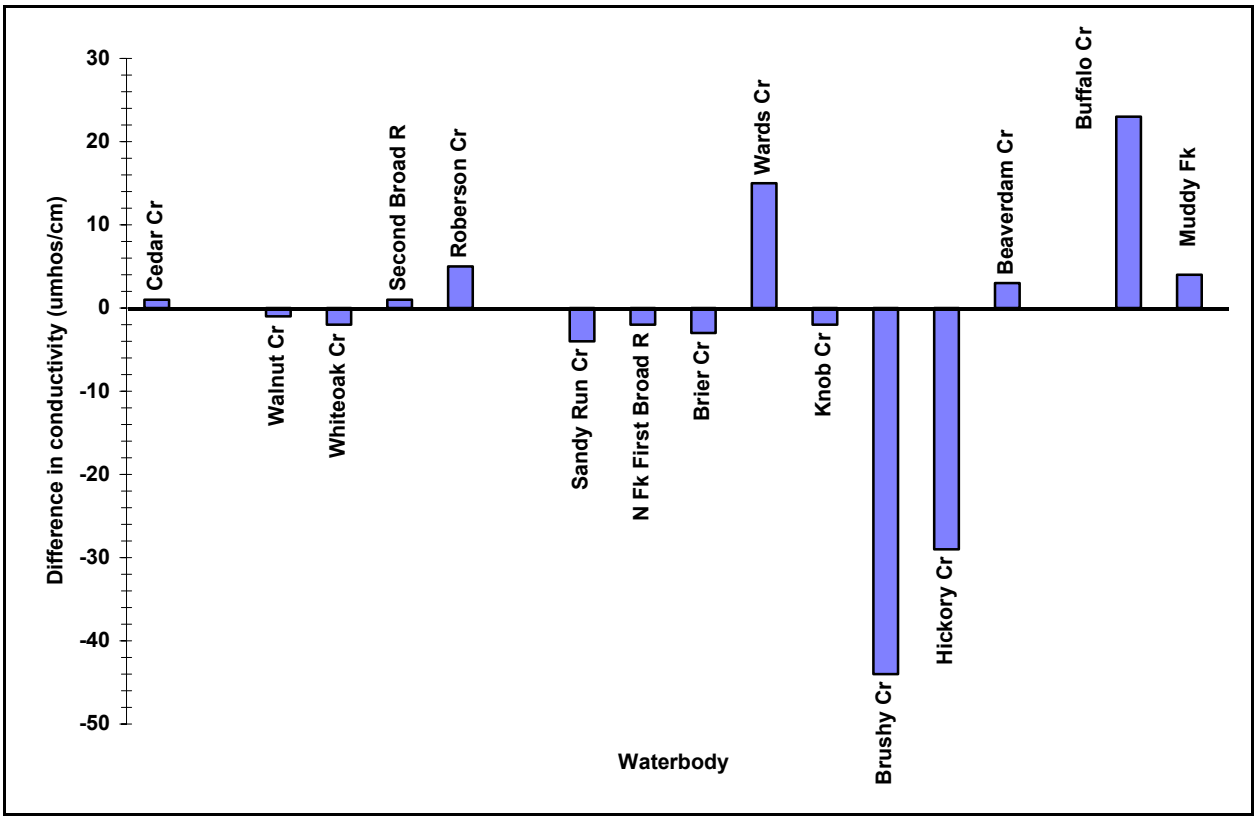


Figure 3. **A comparison of the conductivity at 15 fish community sites in the Broad River basin, 1998/1999/2000 vs. 2004/2005. A positive difference meant that conductivity was greater in 2004/2005 than in 1998/1999/2000; a negative difference meant that conductivity was greater in 1998/1999/2000 than in 2004/2005.**

REFERENCES

NCAC. 2004. North Carolina administrative code. Effective August 1, 2004. Environmental Management Commission. North Carolina Department of Environmental and Natural Resources. Division of Water Quality. Raleigh, NC.

Appendix F-8. Flow measurement and flow conditions in the Broad River basin.

Even before the last basinwide monitoring cycle was completed in 2000, the Broad River basin had been experiencing a prolonged drought which started in 1998 and continued through 2002 (Figures 1- 3). The drought was abruptly halted by above normal precipitation in late 2002 and into 2003. Extremely high flows were then recorded in 2004. The drought was most severe during summer 2002. The lowest daily mean discharges flows ever recorded occurred in August and September 2002. Daily mean discharges of 8.1, 3.9, and 83 cfs (cubic feet per second) occurred at Cove Creek, First Broad River, and Broad River, respectively. Annual 90 percent exceedance flows for these three sites were 48, 31, and 551 cfs, respectively (Weaver 2005). Many of the streams draining smaller watersheds in the basin undoubtedly went completely dry or became a series of isolated pools with subsurface flows.

Two years later, streams draining the northern part of the basin in Henderson, Polk, McDowell, Rutherford, and Burke counties experienced the highest flows ever recorded as a result of the remnants of Hurricanes, Frances, Ivan, and Jeanne. On September 8, 2004, the peak stream flow in the First Broad River near Casar was measured at 12,500 cfs; the previous record had been 7,790 cfs on January 14, 1995. Also on September 8, 2004, the peak stream flow in the Cove Creek near Lake Lure was measured at 6,550 cfs at a gauge height of 18.41 ft. This flow was the third greatest flow ever recorded at the site; the record gauge height is 23.00 ft. in 1916 (flow and date unknown). On September 9, 2004, the peak stream flow in the Broad River near Boiling Springs was measured at 37,000 cfs. This flow was the fourth greatest flow ever recorded at the site.

During fish community sampling in late June 2004 flows were well above median daily at nearby USGS gauge sites; by mid-July 2004 flows had decreased to median levels. In June 2005, flows were at median levels at most sites, except at Big Camp and Mountain Creeks and at the Second Broad River sites where flows were well above median levels.

REFERENCES

Weaver, J. C. 2005. The drought of 1998 – 2002 in North Carolina – precipitation and hydrologic conditions. U. S. Geological Survey. Scientific Investigations Report 2005-5053.

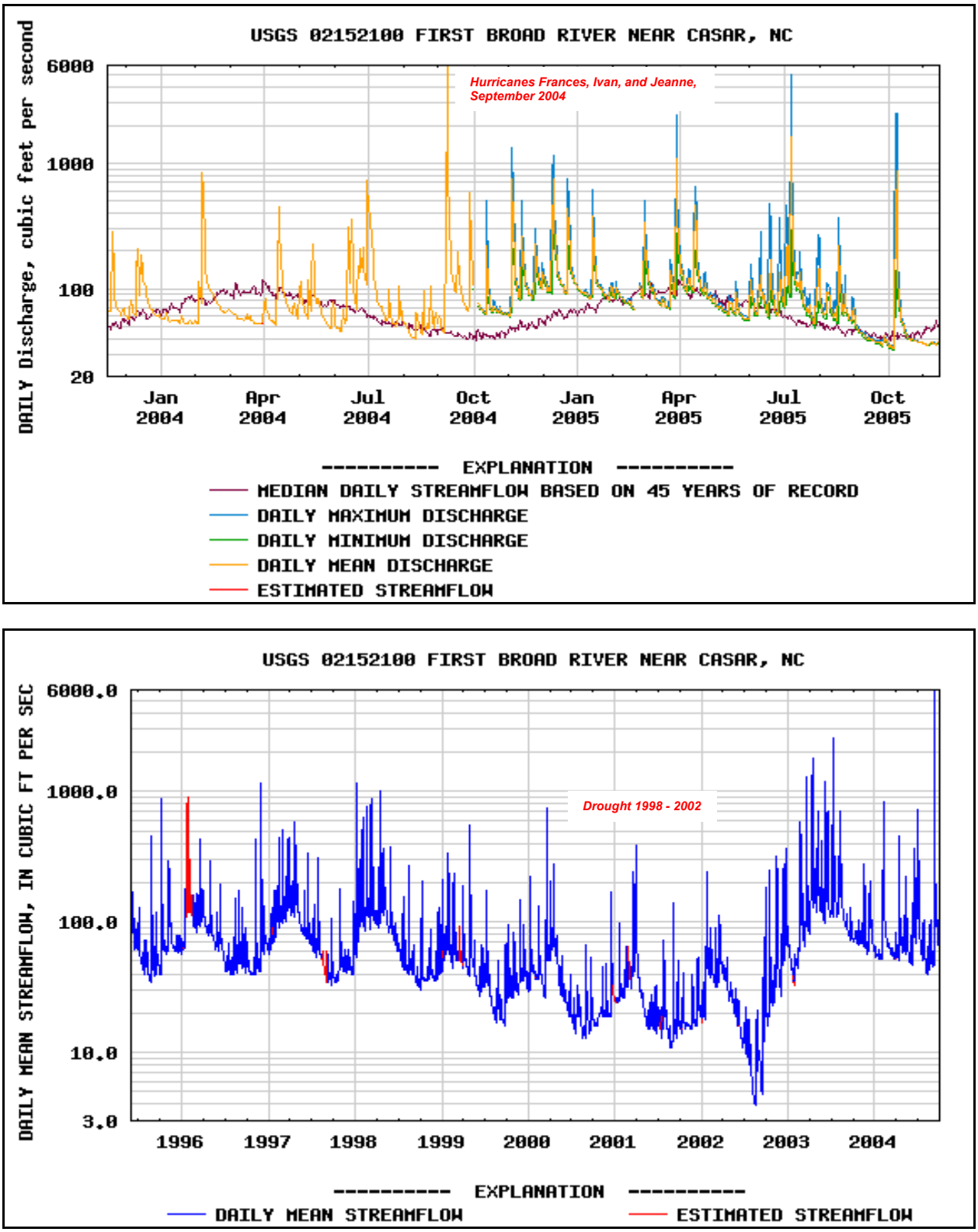


Figure 1. **Flows in the First Broad River near Casar, NC, , November 13, 2003 – November 13, 2005 (top) and June 01, 1995 – September 30, 2004 (bottom).**

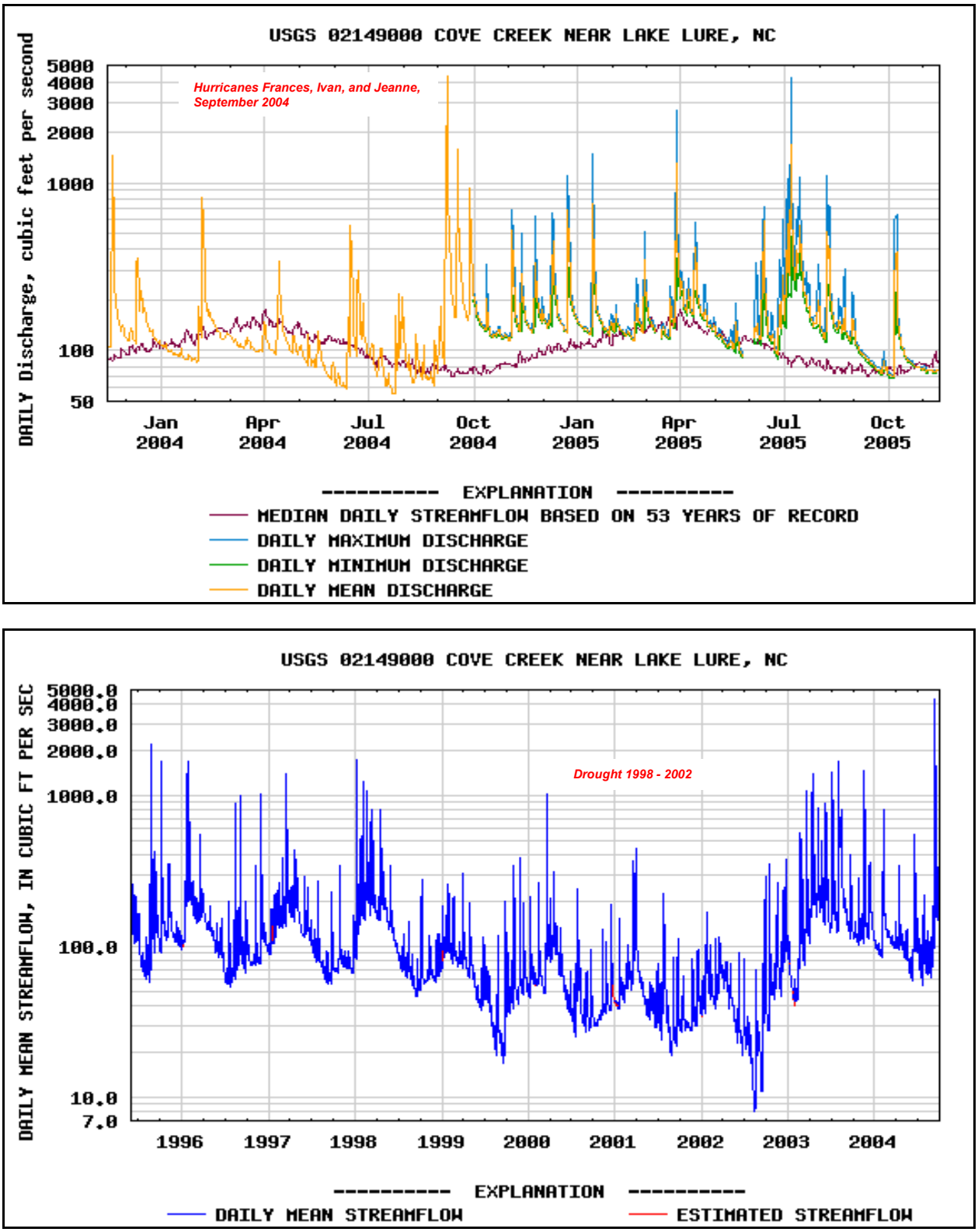


Figure 2. **Flows in Cove Creek near Lake Lure, NC, November 13, 2003 – November 13, 2005 (top) and June 01, 1995 – September 30, 2004 (bottom).**

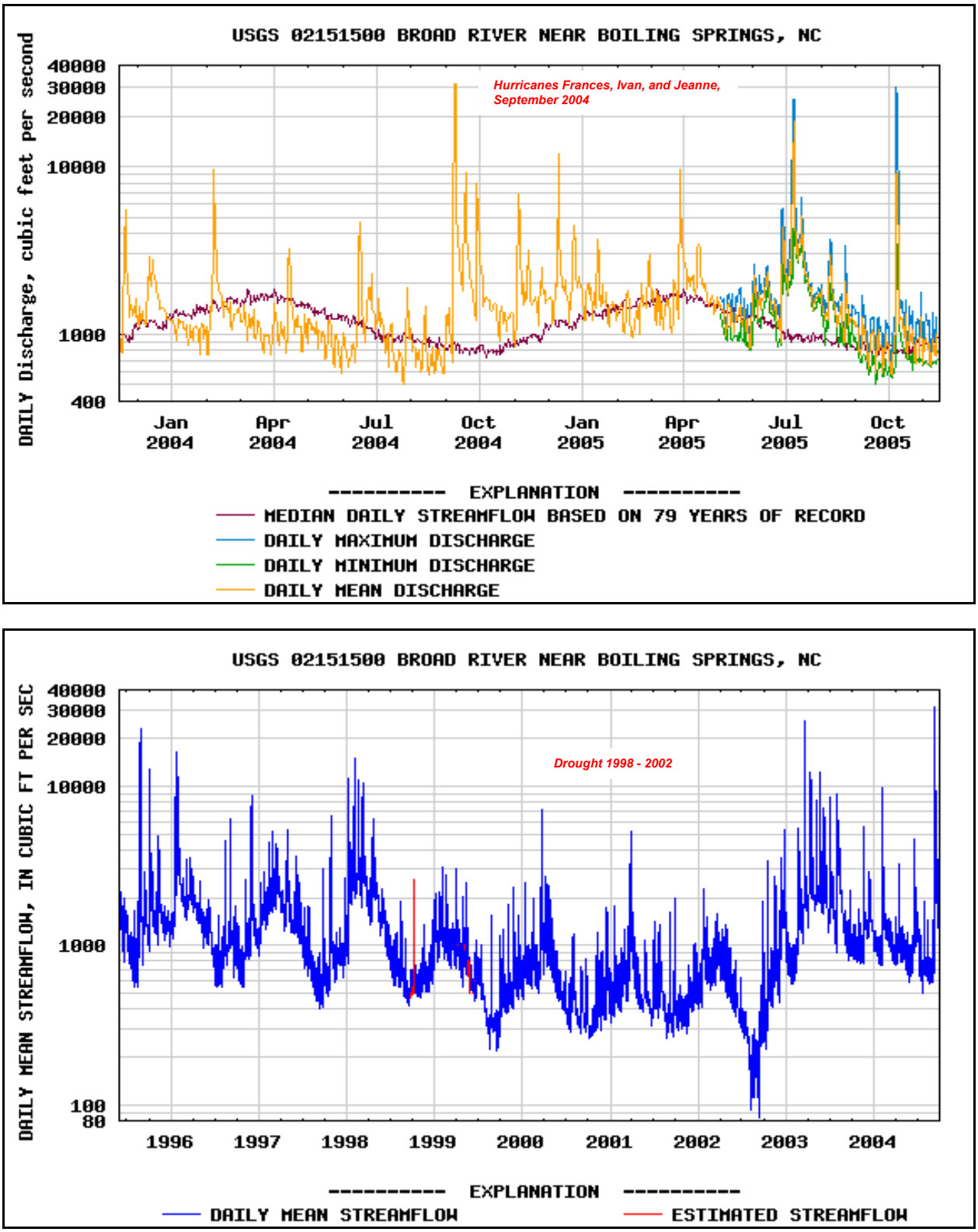


Figure 3. **Flows in the Broad River near Boiling springs, NC, November 13, 2003 – November 13, 2005 (top) and June 01, 1995 – September 30, 2004 (bottom).**

Appendix F-9. Web links.

NC Wildlife Resources Commission (stocking information)
http://www.ncwildlife.org/pg03_fishing/pg3b.htm

NC Division of Water Quality (fish community sampling methods)
http://h2o.enr.state.nc.us/esb/BAUwww/IBI%20Methods%202001.pdf

NC Division of Water Quality (fish community data)
http://h2o.enr.state.nc.us/esb/NCIBI.htm

NC Division of Water Quality (native and exotic freshwater fish in North Carolina)
http://www.esb.enr.state.nc.us/www.esb.enr.state.nc.us/Native and Introduced Freshwater Fish in North Carolina.2-1.htm

US Geological Survey (real-time streamflow data for North Carolina)
http://waterdata.usgs.gov/nc/nwis/current?type=flow

LAKE & RESERVOIR ASSESSMENTS – BROAD RIVER BASIN 2005

Intensive Survey Unit
Environmental Sciences Section
Division of Water Quality
March 23, 2006

Kings Mountain Reservoir

Overview

Kings Mountain Reservoir was the only lake sampled within the Broad River Basin between October 1, 2000 and September 30, 2005. Kings Mountain Reservoir (also known as Moss Lake) is a water supply for the Cities of Kings Mountain and Grover. The reservoir was constructed in 1963. Major tributaries to the lake include Buffalo Creek and Whiteoak Creek. The drainage area is characterized by rolling hills and rural areas. Access to the lake is strictly controlled to allow recreational use while protecting water quality. DWQ has sampled this reservoir 18 times beginning in 1989.

Assessment Methodology

For this basin, data from October 1, 2000 through September 30, 2005 were reviewed. Kings Mountain Reservoir was only sampled during the summer of 2005 in May through August. Data were assessed for excursions of the state's class C water quality standards for chlorophyll *a*, pH, dissolved oxygen and water temperature, turbidity, and surface metals. For Kings Mountain Reservoir, which is classified for use as a water supply (WS-III), there are additional parameters sampled related to water supply protection. The water supply standards sampled and evaluated were total suspended solids (TSS), nickel, manganese, chlorides and total hardness.

A water quality standard is exceeded (CE) if data values are above the state's water quality standard for more than 10% of the samples where the sample size consists of ten or more observations for the basinwide assessment period. Ideally, ten observations are needed to provide enough data to reasonably interpret water quality conditions within the lake or reservoir. Fewer observations increase the possibility of misinterpreting random unusual conditions as representative of ongoing water quality trends. If the water quality standard is exceeded, either in less than 10% of the data collected during the assessment period or if the sample observation size is less than ten for the basinwide assessment period, then the water quality standard for that parameter is designated exceeded (E).

Additional data considered as part of the use support assessment includes historic DWQ water quality data, documented algal blooms and/or fish kills, problematic aquatic macrophytes, or listing on the EPA's 303(d) List of Impaired Waters.

Lakes receive an overall rating of Supporting or Impaired when ten or more samples per water quality criteria are collected for evaluation within the basinwide assessment period. Otherwise, the lake is considered as Not Rated. The exceptions are for a lake listed on the 303(d) List of Impaired Waters or where additional data indicates water quality problems not captured during sampling. These lakes are listed as Impaired along with the reason for the impairment.

For a more complete discussion of lake ecology and assessment, please go to http://www.esb.enr.state.nc.us/. The 1990 North Carolina Lake Assessment Report (downloadable from this website) contains a detailed chapter on ecological concepts that clarifies how the parameters discussed in this review related to water quality and reservoir health.

Assessment

A data summary is presented in the use support matrix found at the end of this review. Surface water temperatures were elevated (greater than 29 degrees C per the standard for mountain and upper piedmont waters) in July. There are no thermal discharges to the lake. These elevated temperatures represent natural conditions at the mid-lake sampling stations and may explain the elevated percent dissolved oxygen saturation calculated. Percent dissolved oxygen saturation concentrations were greater than 120% at all four lake sampling sites on July 26th suggesting potential algal bloom conditions; however, none of the other data collected supported this conclusion.

Dissolved oxygen and pH values were within state water quality standards. In 2005, Secchi depths were similar to those previously observed at this reservoir and ranged from 1.4 meters to 2.6 meters. Phytoplankton analysis of samples collected on this date determined that the quantity of algas were not at bloom levels. The dominant algae were a filamentous blue-green, *Planktolyngbya* sp., and a unicellular green flagellate, *Chlamydomonas* sp. These algae are commonly found in reservoirs throughout North Carolina.

Total phosphorus concentrations were comparable to those previously observed in this reservoir, ranging from at or below detection level (0.02 mg/L) in 2005. Nitrogen concentrations were also similar to previous observations, suggesting that the general nutrient conditions in the lake have remained the same. Surface metals in Kings Mountain Reservoir were within applicable state water quality standards. Due to an error in laboratory analysis, chlorophyll *a* values were not available; therefore the lake trophic state score could not be calculated for 2005. Historically, DWQ monitoring has determined that this reservoir has ranged from very low biological productivity (oligotrophic) to moderate productivity (mesotrophic).

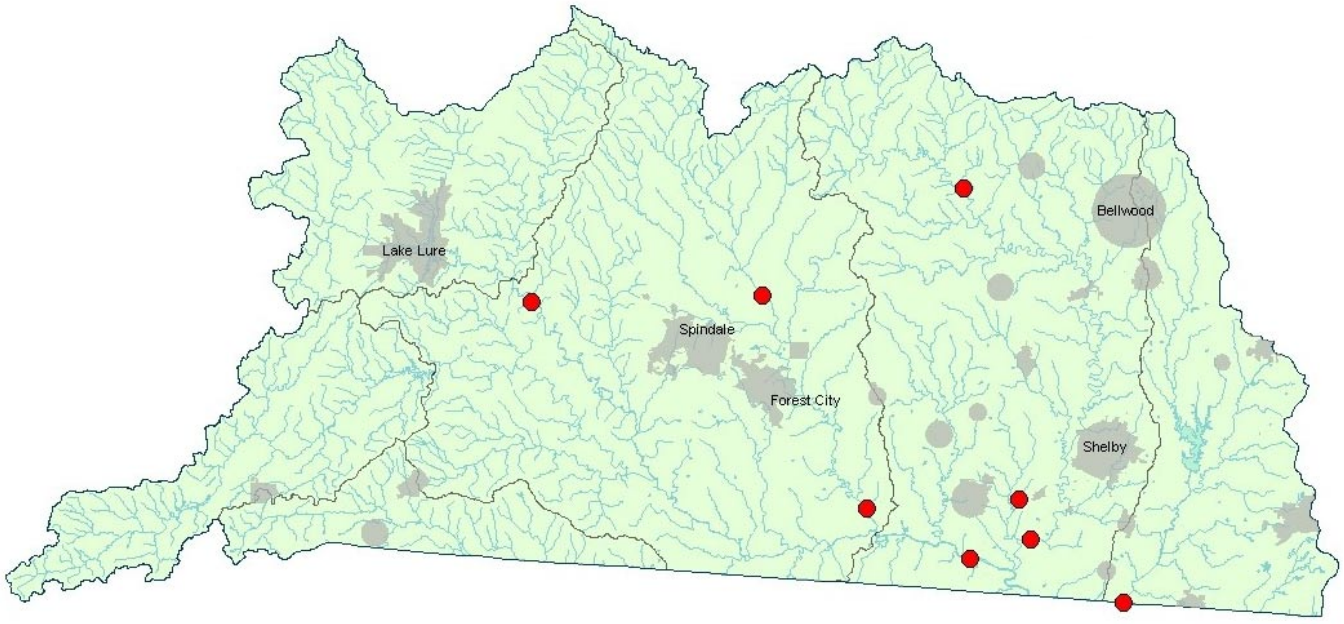
A review of other available data indicated no water quality problems had been observed.

Although Kings Mountain Reservoir appears to be supporting its designated uses as a water supply lake and for protection of aquatic life in 2005, insufficient data (less than 10 data points) was collected to rate the reservoir as Supporting. For further background information on this lake (including sampling data), please go to http://www.esb.enr.state.nc.us/.

BROAD RIVER BASIN AMBIENT LAKES USE SUPPORT MATRIX FOR 10/1/2000 – 9/31/2005

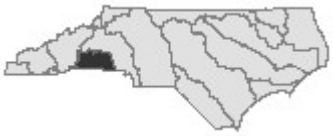
	Subbasin	***030805***
	Lakes Ambient Program Name	**Kings Mountain Reservoir**
	Mean Depth (meters)	45.9
	Volume ($10^6 m^3$)	7.4
	Watershed Area (mi^2)	65.3
	Assessment Unit Name	**Buffalo Creek (Kings Mountain Reservoir)**
	Classification	WS-III CA
	Assessment Unit	9-53-(2.9)
	Stations in Assessment Unit	BRD056C, BRD056E, BRD056G, BRD056J
	Number of Sampling Trips	8
Water Quality Standards		
Chlorophyll *a*	>40 ug/L	ND
Dissolved Oxygen	<4.0 mg/L	NCE
pH	<6 s.u. or > 9 s.u.	NCE
Turbidity	>25 mg/L	NCE
TSS	>500 mg/L	NCE
Temperature	>29°C Mountains and Upper Piedmont	E (38%)
Manganese	>200 ug/L	NCE
Chloride	>250 mg/L	NCE
Nickel	>25 ug/L	NCE
Metals	15A NCAC 2B .0211	NCE
Other Data		
% Saturation DO	>120%	E (13%)
Algae	Documented blooms during 2 or more sampling events in 1 year with historic blooms	N
Fish	Kills related to eutrophication	N
Chemically/Biologically Treated	For algal or macrophyte control - either chemicals or biologically by fish, etc.	N
Aesthetics complaints	Documented sheens, discoloration, etc. - written complaint and follow-up by a state	N
TSI	Increase of 2 trophic levels from one 5-yr period to next	N
Historic DWQ Data	Conclusions from other reports (link to other reports)	N
303(d)	Listed on 303(d) [year listed]	N
AGPT	Algal Growth Potential Test > 5 mg/L	ND
Macrophytes	Limiting access to public ramps, docks, swimming areas; reducing access by fish and other aquatic life to habitat	N
Taste and Odor	Public complaints or taste and odor causing algal species are dominant	N
Sediments	Clogging intakes – dredging program necessary; Frequent public/agency complaints - visual observation	N
	Rating:	**Not Rated (n<10)**

Key
E = Criteria is exceeded but n<10
ND = No data
NCE = No Criteria Exceeded
N = In Other Data portion, indicates that the parameter is within target or has not occurred per available information.



Broad River Basin
Ambient Monitoring System Report

September 1, 2000 through August 31, 2005



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Evaluation Levels

In order to assist the reader in developing a rapid understanding of the summary statistics provided throughout this data review, concentrations of water quality variables may be compared to an Evaluation Level (EL). Evaluation levels may be a water quality standard, an action level, an ecological threshold, or simply an arbitrary threshold that facilitates a rapid data review. Evaluation levels are further examined for frequency to determine if they have been exceeded in more than 10 percent of the observed samples. This summary approach facilitates a rapid and straightforward presentation of the data but may not be appropriate for making specific use support decisions necessary for identification of impaired waters under the Clean Water Act's requirements for 303(d) listings. The reader is advised to review the states 303(d) listing methodology for this purpose. (see http://h2o.enr.state.nc.us/tmdl/General_303d.htm).

TABLES

FIGURES

APPENDIXES

SUMMARY

A general understanding of human activities and natural forces that affect pollution loads and their potential impacts on water quality can be obtained through routine sampling from fixed water quality monitoring stations. During this assessment period (September 1, 2000 through August 31, 2005) chemical and physical measurements were obtained by DWQ from 8 stations located throughout the Broad River Basin.

In order to evaluate acceptable water quality criteria at least 10 observations are desired. If at least 10 results were collected for a given site for a given parameter, the results are then compared to water quality evaluation levels. The water quality evaluation level may be an ecological evaluation level, a narrative or numeric standard, or an action level as specified in 15A NCAC 2B .0200 (Table 3). If less then 10 results were collected, then no comparison to evaluation levels was made. When more than 10 percent of the results exceeded the evaluation level, a binomial statistical test was employed to determine if there was sufficient statistical confidence (95% confidence) to conclude that the results statistically exceed the 10% criteria. When that is found to be true, it is termed a *statistically significant exceedance* (SSE). This criterion was applied to all parameters with an evaluation level, except for fecal coliform bacteria. The criteria for fecal coliform varied based on the classification of the water body. See the Parameters section for an explanation of fecal coliform methods. The results of the data analysis are displayed in tables, box plots, scatter plots, and maps. For complete summaries on each station, reference the AMS Station Summary Sheets located in Appendix A.

All data were collected between September 1, 2000 and August 31, 2005. Stations with SSEs were found for iron (five sites), and fecal coliform (two sites). In addition to these SSEs, several locations exceeded the review criteria in more than 10% of the observed data; one for ph, three for turbidity, three for copper, one for iron, and two for fecal coliform.

A4700000, Broad River at NC 150 near Boiling Springs, A6400000, First Broad River at SR 1140 near Earl, A6450000, Sugar Branch at NC 150 near Boiling Springs, and A8600000, Buffalo Creek at NC 198 near Grover) are located near to each other in the southeast corner of the basin and appear to have the most significant issues in the basin. Out of 17 total 10% violations for the basin, 13 of them occurred at these four stations. Of particular note is that each of the four stations violated the fecal coliform evaluation level at least 20% of the time..

Two basinwide patterns of interest were identified: declining specific conductance and declining pH. Both of these parameters generally appear to have an inverse relationship with water flow, as is evident when compared to flow data from two stations in the basin. However between August 2003 and May 2004 pH deviated from this pattern and dropped significantly lower at 5 of 8 stations, resulting in 18 violations of the standard. No cause has been identified to explain this observation.

Five of seven SSEs and nine of 17 total 10% violations were for iron and copper. It should be noted that the samples were analyzed for *total* metals, which will include significant concentrations of metal from the iron-rich soil, not from pollution sources. Additionally, only a fraction of the total metals concentration is biologically available, so a violation of the standards does not necessarily represent a threat to aquatic life. We recommend that the metals standards be reviewed and updated to increase their accuracy and effectiveness.

The following table gives a summary of the problem areas using these criteria. While reading the table please note the following: The majority of the parameters listed are compared directly to water quality standards, and those are highlighted in blue. There are two exceptions, however. The fecal coliform standard requires that 5 samples be taken in the span of 30 days, which was not done for this data. Therefore any fecal coliform violations should be taken as a recommendation to collect the data required by the standard. The second exception is the dissolved oxygen (< 5 mg/l) standard. For fresh waters, the 5 mg/l standard is a daily average. The 4 mg/l standard applies to all waters and all samples.

Table 1. Exceedances in the Broad River Basin

Subbasin / Station ID		Class	Parameter / Evaluation Level	% Exceed	% Conf
BRD02	**Broad River, Second Broad River**				
A2700000	Second Broad Riv At Sr 1538 Nr Logan	WS-IV	Total Iron (>1000)	33.3%	99.9%
			Fecal Coliform (20% >400)*	14.5%	90.6%
A4400000	Second Broad Riv At Us 221 Alt At Cliffside	C	Fecal Coliform (20% >400)*	10.9%	69.0%
			Total Copper (>7)	19.0%	94.8%
			Total Iron (>1000)	61.9%	100.0%
BRD04	**Broad River, First Broad River**				
A4700000	Broad Riv At Nc 150 Nr Boiling Springs	C	Total Iron (>1000)	21.1%	96.5%
			Fecal Coliform (20% >400)*	26.4%	100.0%
			Turbidity (>50)	10.5%	65.7%
A4800000	First Broad Riv At Sr 1530 Nr Casar	WS-V	pH (<6)	14.0%	88.8%
A6400000	First Broad Riv At Sr 1140 Nr Earl	C	Total Copper (>7)	15.8%	88.5%
			Total Iron (>1000)	21.1%	96.5%
			Fecal Coliform (20% >400)*	30.2%	100.0%
			Fecal Coliform (Median >200)*	220	
A6400000	First Broad Riv At Sr 1140 Nr Earl	C	Turbidity (>50)	14.0%	88.8%
A6450000	Sugar Branch At Nc 150 Nr Boiling Springs	C	Total Iron (>1000)	15.8%	88.5%
			Fecal Coliform (20% >400)*	38.9%	100.0%
			Fecal Coliform (Median >200)*	344	
BRD05	**Buffalo Creek**				
A8600000	Buffalo Crk At Nc 198 Nr Grover	C	Total Copper (>7)	10.5%	70.5%
			Total Iron (>1000)	26.3%	99.1%
			Fecal Coliform (20% >400)*	20.4%	99.4%
			Turbidity (>50)	12.3%	79.3%

Blue entries indicate violations of standards. Black entries indicate violations of evaluation levels.

* The percentages, geomeans, and medians given are for the 5-year monitoring period, which does not meet the requirements of the fecal coliform standard. We recommend that intensive sampling be done for these sites in order to evaluate whether the standard has been violated.

INTRODUCTION

The DWQ's Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. The stations are located at convenient access points (e.g. bridge crossings) that are sampled on a monthly basis. These locations were chosen to characterize the effects of point source dischargers and nonpoint sources such as agriculture, animal operations, and urbanization within watersheds. Currently the DWQ does not conduct probabilistic (random) monitoring.

The data are used to identify long term trends within watersheds, to develop Total Maximum Daily Loads (TMDLs) and to compare measured values with water quality standards to identify possible areas of impairment. Parametric coverage is determined 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 added when justified (Table 2).

Within this document, an analysis of how monitoring results compare with water quality standards and evaluation levels is presented. A conceptual overview of water quality standards is provided at: http://www.epa.gov/waterscience/standards. Specific information on North Carolina water quality standards is provided at: http://h2o.enr.state.nc.us/csu/swstdsfaq.html.

Water quality data are evaluated in five year periods. Some stations have little or no data for several parameters over the period. However, for the purpose of standardization, data summaries for each station are included in this report. DWQ monitored water quality and collected samples at 8 stations throughout the basin.

Table 2. Parametric coverage for the Ambient Monitoring System.[1]

Parameter	All Waters	Water Supply
Dissolved oxygen (s)	✔	✔
pH (s)	✔	✔
Specific conductance	✔	✔
Temperature (s)	✔	✔
Total phosphorus[2]	✔	✔
Ammonia as N[2]	✔	✔
Total Kjeldahl as N[2]	✔	✔
Nitrate+nitrite as N[2] (s)	✔	✔
Total suspended solids	✔	✔
Turbidity (s)	✔	✔
Fecal coliform bacteria (s)	✔	✔
Aluminum	✔	✔
Arsenic (s)	✔	✔
Cadmium (s)	✔	✔
Chromium, total (s)	✔	✔
Copper, total (s)	✔	✔
Iron (s)	✔	✔
Lead (s)	✔	✔
Mercury (s)	✔	✔
Nickel (s)	✔	✔
Zinc (s)	✔	✔
Manganese (s)	---	✔
Chlorophyll *a*[2] (s)	✔	✔

[1]A check (✔) indicates the parameter is collected. 's' indicates the parameter has a standard.
[2]Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW) and some coastal areas. Since 2001, nutrient sampling likewise is only done in areas of concern, such as NSW, estuaries, and areas with known enrichment issues.

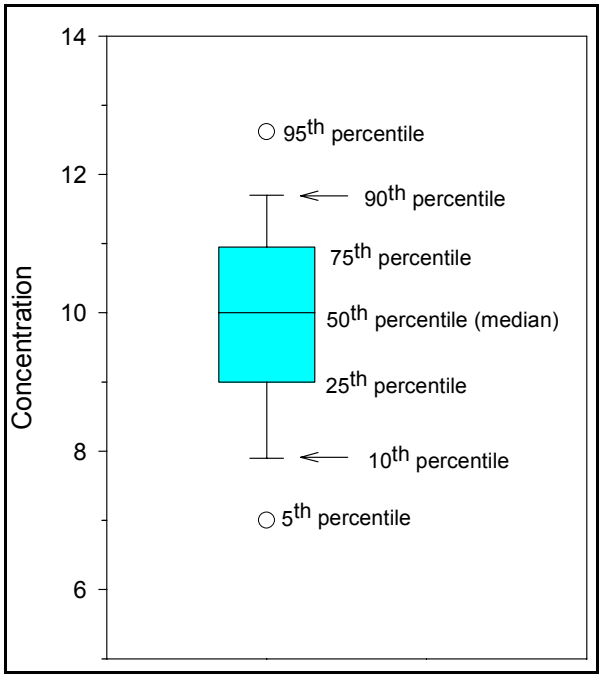


Figure 1. Explanation of box plots.

Table 3. Selected standards for parameters sampled as part of the Ambient Monitoring System.[1]

	Standards for All Freshwater			Standards to Support Additional Uses		
Parameter (µg/L, unless noted)	Aquatic Life	Human Health	Water Supply Classifications	Trout Water	HQW	Swamp Waters
Arsenic		10				
Cadmium	2.0			0.4		
Chloride (mg/l)	230		250			
Chlorophyll *a* (corrected)	40[2]			15[2]		
Chromium, total	50					
Coliform, total (MFTCC/100 ml)[3]			50[2] (WS-I only)			
Coliform, fecal (MFFCC/100 ml)[4]		200[2]				
Copper, total	7					
Dissolved oxygen (mg/L)	4.0[5,6]			6.0		[2, 6]
Hardness, total (mg/L)			100			
Iron	1,000					
Lead	25[2]					
Manganese			200			
Mercury	0.012					
Nickel	88		25			
Nitrate nitrogen			10,000			
pH (units)	6.0 - 9.0[2, 6]					[2, 6]
Solids, total suspended (mg/L)					10 Trout, 20 other[7]	
Turbidity (NTU)	50, 25[2]			10[2]		
Zinc	50					

[1]Standards apply to all classifications. For the protection of water supply and supplemental classifications, standards listed under Standards to Support Additional Uses should be used unless standards for aquatic life or human health are listed and are more stringent. Standards are the same for all water supply classifications (Administrative Code 15A NCAC 2B 0200, eff. August 1, 2004).
[2]Refer to 2B.0211 for narrative description of limits.
[3]Membrane filter total coliform count per 100 ml of sample.
[4]Membrane filter fecal coliform count per 100 ml of sample.
[5]An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.
[6]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3, if due to natural conditions.
[7]For effluent limits only, refer to 2B.0224(1)(b)(ii).

	Standards for All Saltwater			Standards To Support Additional Uses	
Parameter (µg/L, unless noted)	Aquatic Life	Human Health[1]	Class SA[2]	HQW	Swamp Waters
Arsenic		10			
Cadmium	5.0				
Chlorophyll *a* (corrected)	40[3]				
Chromium, total	20				
Coliform, fecal (MFFCC/100ml)[4]		200[3]	14[3]		
Copper, total	3[5]				
Dissolved oxygen (mg/L)	5.0[9]			6.0	[3, 6]
Lead	25[3]				
Mercury	0.025				
Nickel	8.3				
PH (units)	6.8 - 8.5[6]				[3, 6]
Selenium	71				
Silver	0.1[5]				
Solids, total suspended (mg/L)				10 PNA[7], 20 other[8]	
Turbidity (NTU)	25[3]				
Zinc	86[5]				

[1]Standards are based on consumption of fish only unless dermal contact studies are available, see 2B.0208 for equation.
[2]Class SA = shellfishing waters, see 2B.0101 for description.
[3]See 2B.0220 for narrative description of limits.
[4]MFFCC/100ml means membrane filter fecal coliform count per 100 ml of sample.
[5]Values represent action levels as specified in 2B.0220.
[6]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3 s.u., if due to natural conditions.
[7]PNA = Primary Nursery Areas.
[8]For effluent limits only, see 2B.0224.
[9]Swamp waters, poorly flushed tidally influenced streams, or embayments, or estuarine bottom waters may have lower values if caused by natural conditions.

Table 4. DWQ Monitoring stations in the Broad River Basin, 2000 - 2005.

Subbasin/ Station ID	Location	Class	Lat.	Long.
BRD01	**Lake Lure, Upper Broad River**			
No Stations				
BRD02	**Broad River, Second Broad River**			
A1520000	Broad River at SR 1181 near Rock Springs	C	35.39366	-82.09476
A2700000	Second Broad River at SR 1538 near Logan	WS-IV	35.40424	-81.87201
A4400000	Second Broad River at US 221 Alt at Cliffside	C	35.23872	-81.76667
BRD03	**Green River**			
No Stations				
BRD04	**Broad River, First Broad River**			
A4700000	Broad River at NC 150 near Boiling Springs	C	35.20131	-81.66553
A4800000	First Broad River at SR 1530 near Casar	WS-V	35.49331	-81.68133
A6400000	First Broad River at SR 1140 near Earl	C	35.21776	-81.60773
A6450000	Sugar Branch at NC 150 near Boiling Springs	C	35.24938	-81.62025
BRD05	**Buffalo Creek**			
A8600000	Buffalo Creek at NC 198 near Grover	C	35.17076	-81.51679
BRD06	**Pacolet River**			
No Stations				

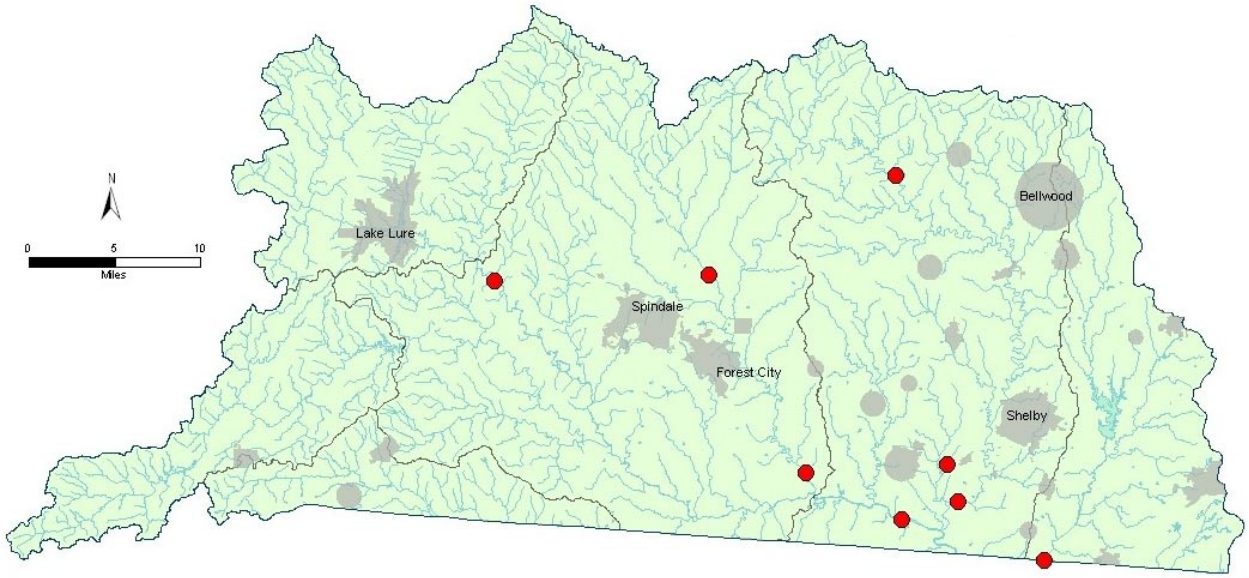


Figure 2. DWQ's Ambient Monitoring System in the Broad River Basin.

DATA ASSESSMENT AND INTERPRETATION

Monitoring and sampling results considered in this report represent samples collected or measurements taken at less than one-meter depth.

Percentile statistics were calculated for most of the data using JMP statistical software (version 5.01; SAS Institute, Cary, NC). Values less than the minimum reporting level (non-detected) were evaluated as equal to the reporting level. Box and whisker plots (constructed using SigmaPlot version 8.02) and maps are presented for most water quality parameters collected at each monitoring station. Significant trends in water quality parameters (constructed using Microsoft Excel) are illustrated as scatterplots. Significant trends are found by assessing the probability that the linear model explains the data no better then chance. If that chance is 5% or less (an observed significance probability of 0.05 or less) then that is considered evidence of a regression effect in this document. The strength of the regression effect is given as an r^2 value, the portion of the data that is explained by the linear model. There are many other types of modeling (non-linear) that can be used to explore trends, but they were not used in this document.

Analytical Considerations

Three issues were noted by the DWQ Laboratory Section as part of the analytical processes during this assessment period:

1) Between February and April 2001, improved analytical techniques and protocols for nutrient samples were implemented. No nutrient samples were processed during the period when the techniques and protocols were being implemented.
2) In early 2001 the Laboratory Section reviewed their internal QA/QC programs and some of the analytical methods. This effort resulted in a temporary increase in reporting levels for certain parameters. New analytical equipment and methods were subsequently acquired to establish more accurate reporting levels and rigorous quality assurance. Because of the improvements, the reporting levels quickly declined back down to or near the previous reporting levels. Nutrients were especially affected by these changes (Table 5).
3) Chlorophyll a samples collected between 4/11/05 and 8/23/05 were incorrectly prepared for analysis, to the extent that the accuracy of the results is unknown. Therefore, the chlorophyll a results for this period were omitted from the dataset.

Table 5. Changes in the Laboratory Section's reporting levels for nutrients.

	Reporting Level By Date (mg/l)			
Parameter	**Pre-2001**	**3/13/2001 to 3/29/2001**	**3/30/2001 to 7/24/2001**	**7/25/2001 to present**
NH_3	0.01	0.5	0.2	0.01
TKN	0.1	1.0	0.6	0.20
NO_2+NO_3	0.01	0.5	0.15	0.01
TP	0.01	0.5	0.1	0.02

Providing Confidence in the Exceedances of Water Quality Standards

NC DWQ uses guidance provided by the US EPA for determining when the number of results that exceed a water quality standard indicate potential water quality issues. Historically, the US EPA has suggested that management actions be implemented when 10 percent of the results exceeded a water quality standard. This interpretation is the same whether 1 out of 10, or 5 out of 50, or 25 out of 250 results exceed a standard. Evaluating exceedances in this manner is termed the "raw-score" approach. Although this "10 percent exceedance criterion" defines a point where potential water quality issues may be present, it does not consider uncertainty. Some results are subject to chance or other factors such as calibration errors or sample mishandling. Uncertainty levels change with sample size. The smaller the sample size, the greater the uncertainty.

This document uses a nonparametric procedure (Lin *et al.* 2000) to identify when a sufficient number of exceedances have occurred that indicate a true exceedance probability of 10 percent. Calculating the minimum number of exceedances needed for a particular sample size was done using the BINOMDIST function in Microsoft Excel®. This statistical function suggests that at least three exceedances need to be observed in a sample of 10 in order to be [about] 95 percent confident that the results statistically exceed the water quality standard more than 10% of the time. For example, there is less statistical confidence associated with a 1 exceedance out of 10 (73 percent) than when there are 3 exceedances out of 10 (93 percent confidence (Table 6).

Table 6. Exceedance Confidence

Number of Samples	Number of Exceedances																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10	74%	93%	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**							
12	66%	89%	**97%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**					
14	58%	84%	**96%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**			
16	51%	79%	93%	**98%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	
18	45%	73%	90%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
20	39%	68%	87%	**96%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
22	34%	62%	83%	94%	**98%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
24	29%	56%	79%	91%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
26	25%	51%	74%	89%	**96%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
28	22%	46%	69%	86%	94%	**98%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
30	18%	41%	65%	82%	93%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
32	16%	37%	60%	79%	91%	**96%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
34	13%	33%	55%	75%	88%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
36	11%	29%	51%	71%	85%	94%	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
38	10%	25%	46%	67%	83%	92%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
40	8%	22%	42%	63%	79%	90%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
42	7%	20%	38%	59%	76%	88%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
44	6%	17%	35%	55%	73%	85%	93%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
46	5%	15%	31%	51%	69%	83%	92%	**96%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
48	4%	13%	28%	47%	65%	80%	90%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
50	3%	11%	25%	43%	62%	77%	88%	94%	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
52	3%	10%	22%	40%	58%	74%	86%	93%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
54	2%	8%	20%	36%	54%	71%	83%	91%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
56	2%	7%	18%	33%	51%	67%	81%	90%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
58	2%	6%	16%	30%	47%	64%	78%	88%	94%	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
60	1%	5%	14%	27%	44%	61%	75%	86%	93%	**97%**	**99%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**
62	1%	5%	12%	24%	40%	57%	72%	84%	91%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**
64	1%	4%	11%	22%	37%	54%	69%	81%	90%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**	**100%**
66	1%	3%	9%	20%	34%	51%	66%	79%	88%	94%	**97%**	**99%**	**99%**	**100%**	**100%**	**100%**	**100%**
68	1%	3%	8%	18%	31%	47%	63%	76%	86%	93%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**
70	1%	2%	7%	16%	29%	44%	60%	74%	84%	91%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**	**100%**
72	0%	2%	6%	14%	26%	41%	57%	71%	82%	90%	**95%**	**97%**	**99%**	**100%**	**100%**	**100%**	**100%**
74	0%	2%	5%	13%	24%	38%	54%	68%	80%	88%	94%	**97%**	**99%**	**99%**	**100%**	**100%**	**100%**
76	0%	1%	5%	11%	22%	35%	51%	65%	77%	86%	93%	**96%**	**98%**	**99%**	**100%**	**100%**	**100%**
78	0%	1%	4%	10%	20%	33%	48%	62%	75%	85%	91%	**95%**	**98%**	**99%**	**100%**	**100%**	**100%**
80	0%	1%	4%	9%	18%	30%	45%	59%	72%	83%	90%	**95%**	**97%**	**99%**	**99%**	**100%**	**100%**

Note: Bold and shaded entries indicate that there is at least 95% confidence that at least 10% of the possible samples exceed the standard/action level.

Methods Used to Summarize Results

Methods used to summarize the results in this report encompass both tabular and graphical formats. Individual summary sheets for each station provide details on station location, stream classification, along with specifics on what parameters were measured, the number of samples taken (i.e. sample size), the number of results below reporting levels, the number of results exceeding a water quality standard or evaluation level, statistical confidence that 10% of results exceeded the evaluation level, and a general overview of the distribution of the results using percentiles. These station summary sheets provide the greatest details on a station-by-station basis. They are included as Appendix A to this report.

Use Support Assessment Considerations

1) The freshwater dissolved oxygen concentrations of 5.0 mg/L and 4.0 mg/L are presented as evaluation levels. Instantaneous concentrations of 4.0 mg/L or less (5.0 mg/L in salt water) are in violation of the standard unless caused by natural (e.g. swampy) conditions. The 5.0 mg/L evaluation level is based upon a freshwater standard which specifies "not less than a daily average of 5.0 mg/L" (15A NCAC 2B.0200).
2) The standards specify that action levels are to be used used for copper, iron, and zinc in salt waters. Where appropriate, follow-up toxicological work may need to be conducted.
3) The geometric mean and median statistics were calculated for fecal coliform results for each station as appropriate for stream class.

Specific information on water quality standards and action levels can be found in 15A NCAC 2B.0200 (August 1, 2004).

PARAMETERS

Dissolved Oxygen

Dissolved oxygen is one of the most important of all the chemical measurements. Dissolved oxygen provides valuable information about the ability of the water to support aquatic life and the capacity of water to assimilate point and nonpoint discharges. Water quality standards for dissolved oxygen vary depending on the classification of the body of water [see, for example: 15A NCAC 02B.0211(1)(b) and 15A NCAC 02B.0220 (1)(b)] but generally results less than 4.0 mg/L can be problematic. Consistent patterns of low concentrations of dissolved oxygen can be subject to intense management review and corrective actions, although patterns of low dissolved oxygen can occur naturally in and near swamp waters, in estuarine waters under salt wedge conditions, or during droughts.

pH

The pH of natural waters can vary throughout the state. Low values (<< 7.0 s.u.) can be found in waters rich in dissolved organic matter, such as swamp lands, whereas high values (>> 7.0 s.u.) may be found during algal blooms. Point source dischargers can also influence the pH of a stream. The measurement of pH is relatively easy; however the accuracy of field measurements is limited by the abilities of the field equipment, which is generally accurate to within 0.2 S.U. This is due, in part, because the scale for measuring pH is logarithmic (i.e. a pH of 8 is ten times less concentrated in hydrogen ions than a pH of 7).

The water quality standards for pH in freshwaters consider values less than 6.0 s.u. or greater than 9.0 s.u. to warrant attention; whereas in salt waters pH values less than 6.8 or greater than 8.5 warrant attention.

Conductivity

In this report, conductivity is synonymous with specific conductance. It is reported in micromhos per centimeter (µmhos/cm) at 25°C. Conductivity is a measure of the ability of water to conduct an electric

current. The presence of ions and temperature are major factors in the ability of water to conduct a current. Clean freshwater has a low conductivity, whereas high conductivities may indicate polluted water or saline conditions. Measurements reported are corrected for temperature, thus the range of values reported over a period of time indicate the relative presence of ions in water. Conductivities in US fresh waters commonly vary between 50 to 1,500 µmhos/cm (APHA 1998). North Carolina freshwater streams have a natural conductance range of 17-65 µmhos/cm, however (USGS 1992).

Conductivity can be used to evaluate variations in dissolved mineral concentrations (ions) among sites with varying degrees of impact resulting from point source discharges. Generally, impacted sites show elevated and widely ranging values for conductivity. However, water bodies that contain saltwater will also have high conductivities. Therefore those wishing to use conductivity as an indicator for problems must first account for salinity.

Turbidity

Turbidity data may denote episodic high values on particular dates or within narrow time periods. These can often be the result of intense or sustained rainfall events; however elevated values can occur at other times. Tidal surges can also disturb shallow estuarine sediments and naturally increase turbidity.

Metals

A number of metals are essential micronutrients for the support of aquatic life. However, there are threshold concentrations over which metals can be toxic. Currently the DWQ monitors total (not dissolved) concentrations for aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, manganese (Water Supply waters only), nickel, and zinc. Aluminum and iron are commonly found in North Carolina soils, therefore high aluminum and iron concentrations are typically correlated with high turbidity.

Nutrients

Compounds of nitrogen and phosphorus are major components of living organisms and thus are essential to maintain life. These compounds are collectively referred to as “nutrients.” Nitrogen compounds include ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN) and nitrite+nitrate nitrogen (NO_2+NO_3-N). Phosphorus is measured as total phosphorus. When nutrients are introduced to an aquatic ecosystem from municipal and industrial treatment processes, or runoff from urban or agricultural land, the excessive growth of algae (algal blooms) and other plants may be accelerated.

In addition to the possibility of causing algal blooms, ammonia-nitrogen may combine with high pH water to form NH_4OH, a form toxic to fish and other aquatic organisms.

Bacteria

Concentrations of fecal coliform bacteria can vary greatly. The descriptive statistics used to evaluate fecal coliform bacteria data include the geometric mean and the median depending on the classification of the waterbody. For all sites in the Broad River Basin, the standard specified in Administrative Code 15A NCAC 02B.0211 (3)(e) (August 1, 2005) is applicable:

"Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method."

The application of the standard is often hindered because the monthly (*circa* 30 day) sampling frequency employed for water quality monitoring usually does not provide more than one sample per 30-day period. However, water quality problems can be discerned using monthly sampling.

There are no SA class waters in the Broad River Basin. Non-SA class sites where the geometric mean was greater than 200 colonies/100ml, or where greater than 20 percent of the results exceed 400 colonies/100ml are indicated on the respective station summary sheets.

Table 7. Summary of Evaluation Level Exceedances at DWQ Stations

Subbasin / Station	Class	Percentage of Results that Exceeded the Evaluation Limit									
		Dissolved Oxygen (<5)[1]	Dissolved Oxygen (<4)	pH (combined)[2]	Water Temperature	Chlorophyll A	Turbidity	Arsenic	Copper	Iron	Fecal Coliform
BRD02	**Broad River, Second Broad River**										
A1520000	C	0%	0%	0%	0%	0%	2%	0%	0%	10%	2%
A2700000	WS-IV	0%	0%	0%	0%	BT	6%	0%	0%	**33%**	15%
A4400000	C	0%	0%	0%	0%	BT	4%	0%	**19%**	**62%**	11%
BRD04	**Broad River, First Broad River**										
A4700000	C	0%	0%	5%	5%	BT	**11%**	0%	5%	**21%**	**26%**
A4800000	WS-V	0%	0%	**14%**	0%	BT	4%	0%	0%	5%	8%
A6400000	C	0%	0%	5%	0%	BT	**14%**	5%	**16%**	**21%**	**30%**
A6450000	C	0%	0%	7%	0%	BT	7%	0%	5%	**16%**	**39%**
BRD05	**Buffalo Creek**										
A8600000	C	0%	0%	4%	0%	BT	**12%**	0%	**11%**	**26%**	**20%**

Notes:

Bold entries indicate at least 10% (at least 20% for fecal coliform) of results exceeded the evaluation level.

Underlined entries indicate 95% confidence that site conditions exceed the evaluation level at least 10% of the time (are SSEs), with a minimum of 10 results required before determination.

NA: Not Applicable. The evaluation level is not applicable to this station.

BT: Below Threshhold. This station was not evaluated because less than 10 samples/measurements were collected for this paramter.

[1] Applies to freshwater (class B, C, and WS) as a daily average.

[2] If both the maximum pH (9) and the minimum pH (6) were exceeded at a site, the total of the two is displayed.

WATER QUALITY PATTERNS IN THE BROAD RIVER BASIN

Box and whisker plots, scatterplots, and maps were used to depict data for a variety of water quality parameters throughout the basin. While graphs portray information visually, specific and accurate details can only be conveyed in tables. Individual station summary sheets should be consulted when exact information is needed. For the box plots, stations with fewer then 10 data points for a given parameter were not included.

Box and whisker plots were generated for each station for each water quality parameter that has an evaluation level, plus specific conductance, total nitrate/nitrite, total kjeldahl nitrogen, total ammonia, and total phosphorus. Maps were also generated for parameters with the most exceedances. In addition, a series of change over time graphs were generated for stations that exhibit trends of interest.

Basinwide Trends and Distributions

Two basinwide patterns of interest were identified: declining specific conductance and declining pH. Both of these parameters generally appear to have an inverse relationship with water flow, as is evident when compared to flow data from two stations in the basin. However between August 2003 and May 2004 pH deviated from this pattern and dropped significantly lower at 5 of 8 stations, resulting in 18 violations of the standard. No cause has been identified to explain this observation.

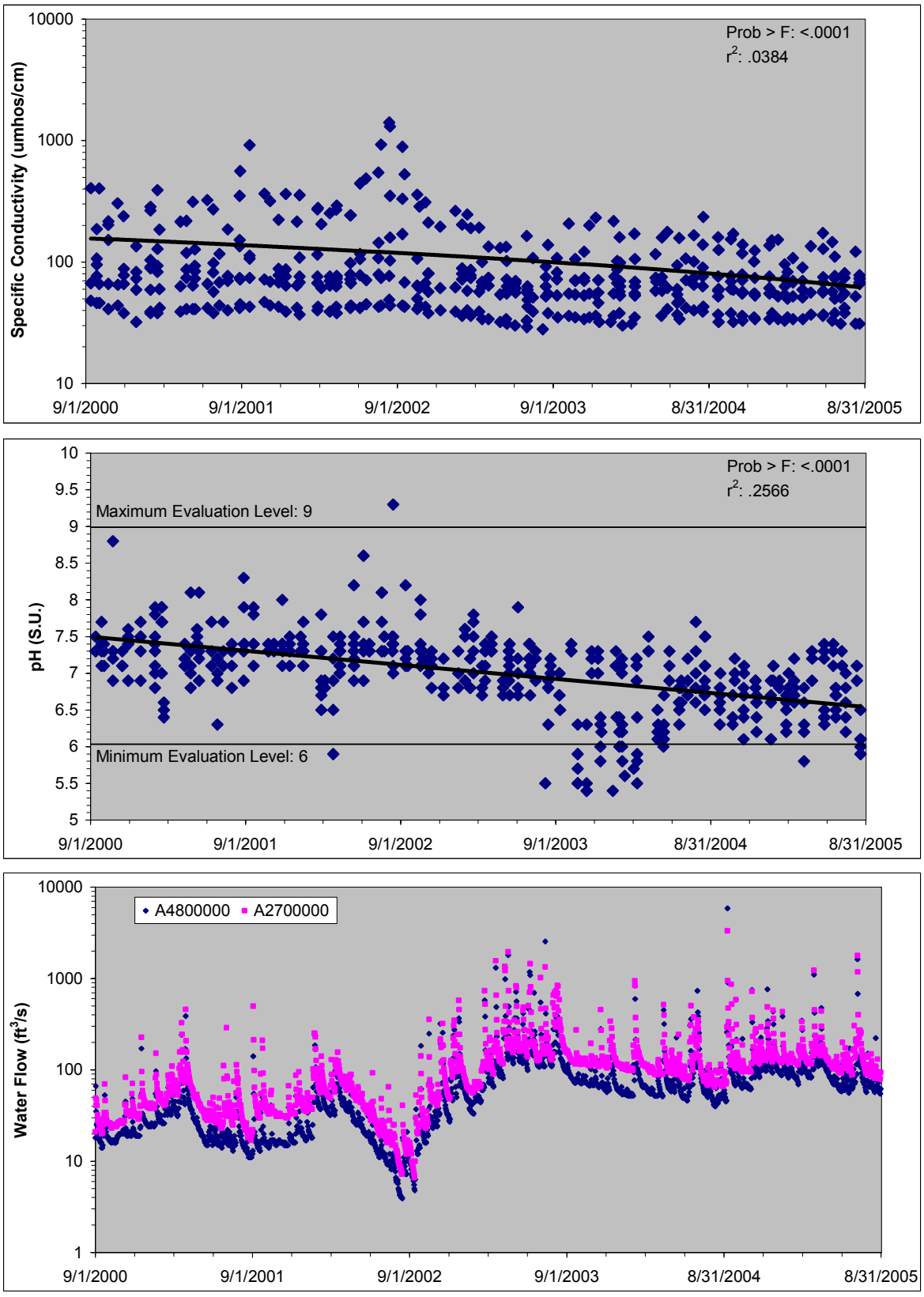


Figure 3. Specific Conductance, pH, and Water Flow in the Broad Basin.

Maps were used to display the geographic distribution of evaluation level exceedances for pH, turbidity, fecal coliform, copper, and iron.

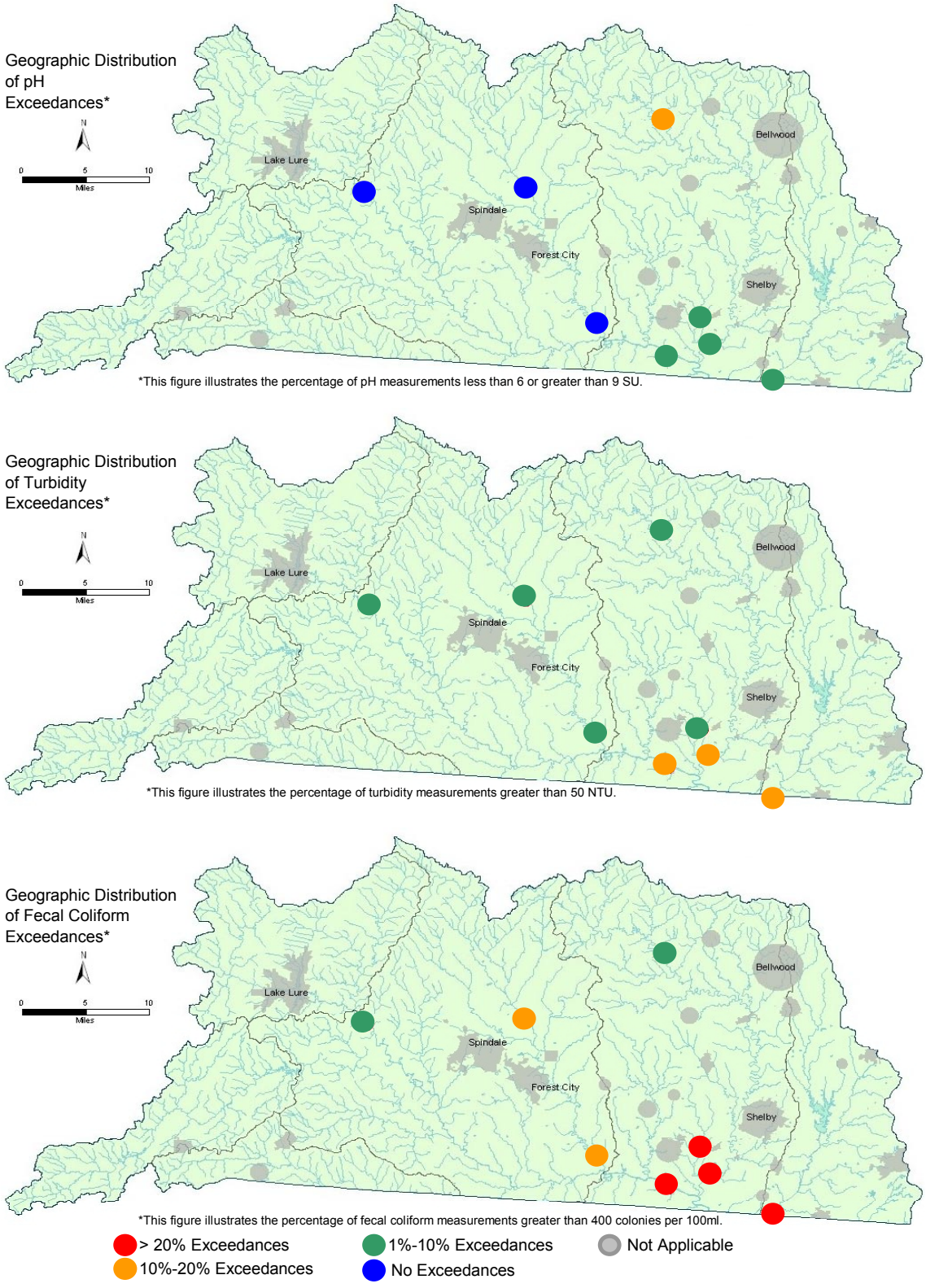


Figure 4. Geographic Distribution of pH, Turbidity, and Fecal Coliform.

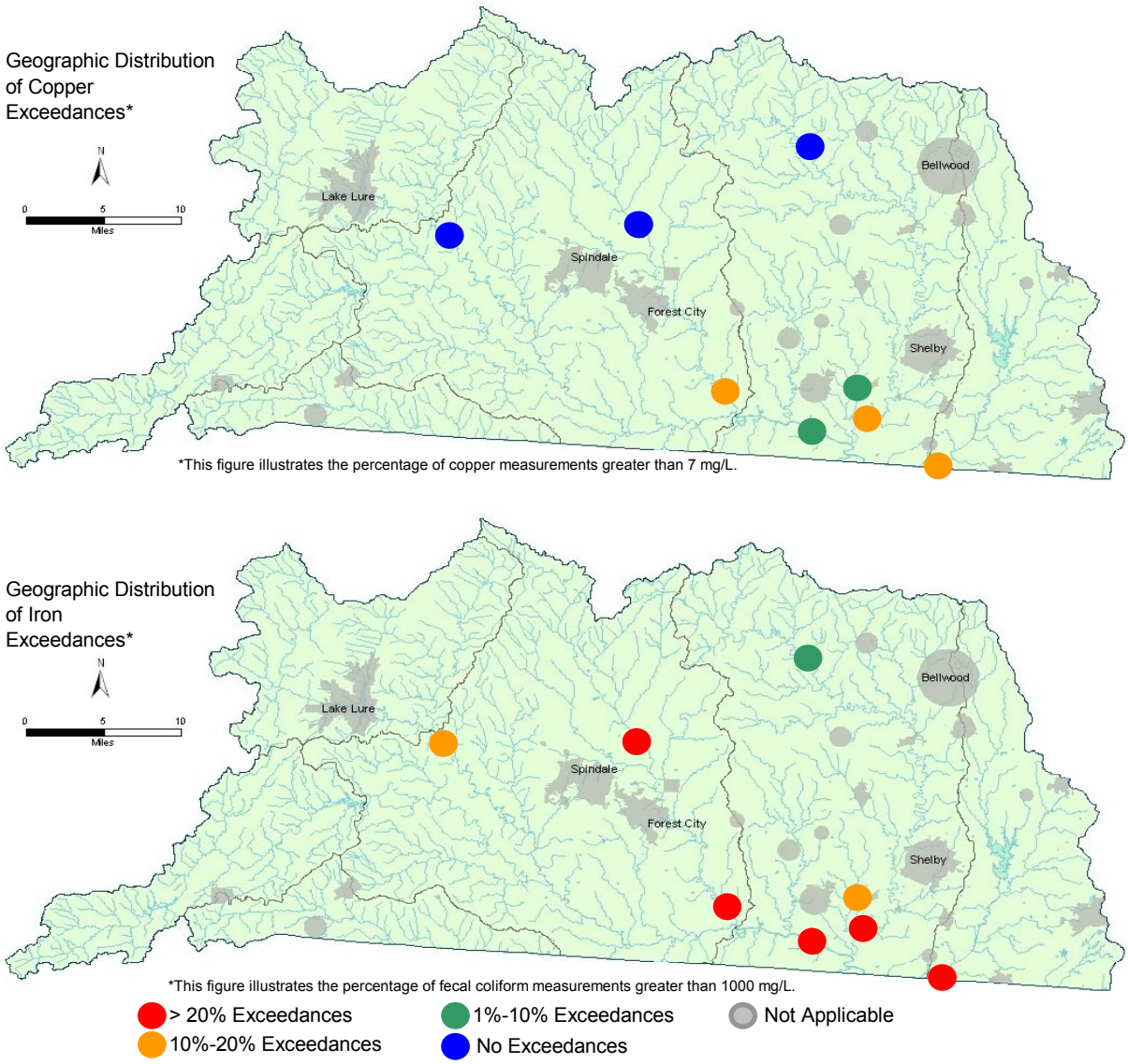


Figure 5. Geographic Distribution of Copper and Iron.

Individual Stations

The 8 stations were compared using box plots to evaluate whether any stations are particularly troubled by comparison. Box plots are included in Appendix B of this report. A4700000, Broad River at NC 150 near Boiling Springs, A6400000, First Broad River at SR 1140 near Earl, A6450000, Sugar Branch at NC 150 near Boiling Springs, and A8600000, Buffalo Creek at NC 198 near Grover) are located near to each other in the southeast corner of the basin and appear to have the most significant issues in the basin. Out of 17 total 10% violations for the basin, 13 of them occurred at these four stations. Of particular note is that each of the four stations violated the fecal coliform evaluation level at least 20% of the time.

Five of seven SSEs and nine of 17 total 10% violations were for iron and copper. It should be noted that the samples were analyzed for *total* metals, which will include significant concentrations of metal from the iron-rich soil, not from pollution sources. Additionally, only a fraction of the total metals concentration is biologically available, so a violation of the standards does not necessarily represent a threat to aquatic life. We recommend that the metals standards be reviewed and updated to increase their accuracy and effectiveness.

Appendix A: Station Summary Sheets

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: BROAD RIV AT SR 1181 NR ROCK SPRINGS
Station #: A1520000 **Subbasin:** BRD02
Latitude: 35.39366 **Longitude:** -82.09476 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-(22)

Time period: 09/12/2000 to 08/09/2005

	# result	# ND	EL	Results not meeting EL #	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		6.8	8.5	9.4	10.9	12.1	13	16.1
	54	0	<5	0	0		6.8	8.5	9.4	10.9	12.1	13	16.1
pH (SU)	55	0	<6	0	0		6.5	6.8	6.9	7.3	7.4	7.5	7.7
	55	0	>9	0	0		6.5	6.8	6.9	7.3	7.4	7.5	7.7
Spec. conductance (umhos/cm at 25°C)	53	0	N/A				31	32	35	39	43	45	49
Water Temperature (°C)	55	0	>29	0	0		4	6	9	17	23	25.4	27
Other													
Chlorophyll A (ug/L)	1	0	>40	0	0		8	8	8	8	8	8	8
TSS (mg/L)	20	5	N/A				2	3	3	5	12	15	23
Turbidity (NTU)	55	0	>50	1	1.8		1	2	3	4	8	19	120
Nutrients (mg/L)													
NH3 as N	9	6	N/A				0.01	0.01	0.01	0.02	0.18	0.5	0.5
NO2 + NO3 as N	9	2	N/A				0.05	0.05	0.05	0.08	0.14	0.5	0.5
TKN as N	8	4	N/A				0.1	0.1	0.2	0.29	0.53	1	1
Total Phosphorus	9	3	N/A				0.01	0.01	0.02	0.03	0.07	0.5	0.5
Metals (ug/L)													
Aluminum, total (Al)	21	1	N/A				50	77	115	200	510	1106	1200
Arsenic, total (As)	21	21	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	21	21	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	21	21	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	21	17	>7	0	0		2	2	2	2	2	2	3
Iron, total (Fe)	21	0	>1000	2	9.5		180	184	235	330	610	1072	1200
Lead, total (Pb)	21	21	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	21	21	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	21	21	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	21	19	>50	0	0		10	10	10	10	10	11	14

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
55	17	1	2	

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: SECOND BROAD RIV AT SR 1538 NR LOGAN
Station #: A2700000 **Subbasin:** BRD02
Latitude: 35.40424 **Longitude:** -81.87201 **Stream class:** WS-IV
Agency: NCAMBNT **NC stream index:** 9-41-(10.5)

Time period: 09/12/2000 to 08/09/2005

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		7.3	8.5	9.3	10.7	11.7	13.2	16
	54	0	<5	0	0		7.3	8.5	9.3	10.7	11.7	13.2	16
pH (SU)	55	0	<6	0	0		6.4	6.7	6.8	7.1	7.3	7.3	7.5
	55	0	>9	0	0		6.4	6.7	6.8	7.1	7.3	7.3	7.5
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				43	52	55	60	66	71	77
Water Temperature (°C)	55	0	>29	0	0		4	5.6	10	16	21	22.7	25
Other													
Hardness (mg/L as CaCO3)	5	0	>100	0	0		20	20	20	24	33	33	33
TSS (mg/L)	21	4	N/A				2	2	5	8	14	31	42
Turbidity (NTU)	55	0	>50	3	5.5		2	4	6	8	15	27	160
Nutrients (mg/L)													
NH3 as N	9	6	N/A				0.01	0.01	0.01	0.03	0.13	0.5	0.5
NO2 + NO3 as N	9	2	>10	0	0		0.05	0.05	0.07	0.12	0.17	0.5	0.5
TKN as N	8	4	N/A				0.1	0.1	0.13	0.25	0.58	1	1
Total Phosphorus	9	2	N/A				0.01	0.01	0.02	0.03	0.15	0.5	0.5
Metals (ug/L)													
Aluminum, total (Al)	21	0	N/A				75	95	190	380	695	1708	2700
Arsenic, total (As)	21	21	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	21	21	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	21	21	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	21	12	>7	0	0		2	2	2	2	2	3	4
Iron, total (Fe)	21	0	>1000	7	33.3	Yes	600	618	735	960	1200	2240	3900
Lead, total (Pb)	21	21	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	15	0	>200	0	0		48	50	57	67	76	134	140
Mercury, total (Hg)	21	21	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	21	21	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	21	17	>50	0	0		10	10	10	10	10	12	12

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
55	93	8	15	

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: SECOND BROAD RIV AT US 221 ALT AT CLIFFSIDE
Station #: A4400000 **Subbasin:** BRD02
Latitude: 35.23872 **Longitude:** -81.76667 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-41-(24.7)

Time period: 09/12/2000 to 08/09/2005

	# result	# ND	Results not meeting EL: EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		5.3	7	9	10.5	12	13.5	16.4
	54	0	<5	0	0		5.3	7	9	10.5	12	13.5	16.4
pH (SU)	55	0	<6	0	0		6.5	6.9	7	7.2	7.3	7.4	7.6
	55	0	>9	0	0		6.5	6.9	7	7.2	7.3	7.4	7.6
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				63	112	144	202	290	446	1408
Water Temperature (°C)	55	0	>29	0	0		3	5.6	8.9	17	22	24	27
Other													
TSS (mg/L)	21	2	N/A				2	3	4	8	12	25	140
Turbidity (NTU)	54	0	>50	2	3.7		4	6	9	12	20	36	150
Nutrients (mg/L)													
NH3 as N	33	4	N/A				0.01	0.02	0.02	0.03	0.06	0.11	0.5
NO2 + NO3 as N	33	1	N/A				0.14	0.31	0.34	0.4	0.47	0.52	0.58
TKN as N	32	4	N/A				0.2	0.2	0.2	0.27	0.36	0.58	1
Total Phosphorus	33	1	N/A				0.02	0.08	0.1	0.12	0.21	0.41	0.56
Metals (ug/L)													
Aluminum, total (Al)	21	0	N/A				160	182	325	470	955	1200	7500
Arsenic, total (As)	21	21	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	21	21	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	21	21	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	21	3	>7	4	19	No	2	2	2	4	6	8	25
Iron, total (Fe)	21	0	>1000	13	61.9	Yes	640	704	875	1100	1500	2200	8600
Lead, total (Pb)	21	21	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	21	21	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	21	21	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	21	15	>50	0	0		10	10	10	10	10	24	26

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
55	111	6	11	

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: BROAD RIV AT NC 150 NR BOILING SPRINGS
Station #: A4700000 **Subbasin:** BRD04
Latitude: 35.20131 **Longitude:** -81.66553 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-(25.5)

Time period: 09/26/2000 to 08/18/2005

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	57	0	<4	0	0		6.7	7.7	8.4	9.6	11.1	11.9	14.2
	57	0	<5	0	0		6.7	7.7	8.4	9.6	11.1	11.9	14.2
pH (SU)	57	0	<6	2	3.5		5.8	6.3	6.5	7.2	7.8	8.2	9.3
	57	0	>9	1	1.8		5.8	6.3	6.5	7.2	7.8	8.2	9.3
Spec. conductance (umhos/cm at 25°C)	57	0	N/A				43	56	64	73	98	124	170
Water Temperature (°C)	57	0	>29	3	5.3		4	6	10.3	17.3	23.2	26.5	33.1
Other													
TSS (mg/L)	19	2	N/A				1	1	3	9	16	64	190
Turbidity (NTU)	57	0	>50	6	10.5	No	2	3	5	10	22	71	370
Nutrients (mg/L)													
NH3 as N	35	21	N/A				0.01	0.01	0.02	0.02	0.02	0.15	0.5
NO2 + NO3 as N	35	1	N/A				0.07	0.21	0.26	0.3	0.33	0.36	0.5
TKN as N	35	16	N/A				0.2	0.2	0.2	0.2	0.27	0.39	1
Total Phosphorus	35	2	N/A				0.04	0.05	0.06	0.09	0.13	0.18	0.5
Metals (ug/L)													
Aluminum, total (Al)	19	0	N/A				100	110	220	350	730	4600	28000
Arsenic, total (As)	19	19	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	19	19	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	19	19	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	19	11	>7	1	5.3		2	2	2	2	3	7	13
Iron, total (Fe)	19	0	>1000	4	21.1	Yes	260	370	500	660	820	4100	20000
Lead, total (Pb)	19	19	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	19	19	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	19	19	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	19	12	>50	0	0		10	10	10	10	12	35	48

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
53	103	14	26	No

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: FIRST BROAD RIV AT SR 1530 NR CASAR
Station #: A4800000 **Subbasin:** BRD04
Latitude: 35.49331 **Longitude:** -81.68133 **Stream class:** WS-V
Agency: NCAMBNT **NC stream index:** 9-50-(11)

Time period: 09/26/2000 to 08/18/2005

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	57	0	<4	0	0		6.7	7.9	8.4	9.6	10.8	12.3	14.4
	57	0	<5	0	0		6.7	7.9	8.4	9.6	10.8	12.3	14.4
pH (SU)	57	0	<6	8	14	No	5.4	5.7	6.2	7.2	7.4	7.7	8.1
	57	0	>9	0	0		5.4	5.7	6.2	7.2	7.4	7.7	8.1
Spec. conductance (umhos/cm at 25°C)	57	0	N/A				28	31	34	38	40	43	74
Water Temperature (°C)	57	0	>29	0	0		0	4.8	9.5	15.4	19.8	22.4	26.9
Other													
Hardness (mg/L as CaCO3)	4	0	>100	0	0		12	12	12	14	23	26	26
TSS (mg/L)	19	11	N/A				1	1	2	2	5	12	26
Turbidity (NTU)	57	0	>50	2	3.5		1	2	2	4	7	24	110
Nutrients (mg/L)													
NH3 as N	9	6	N/A				0.01	0.01	0.01	0.01	0.14	0.5	0.5
NO2 + NO3 as N	9	4	>10	0	0		0.01	0.01	0.02	0.09	0.14	0.5	0.5
TKN as N	8	4	N/A				0.1	0.1	0.2	0.2	0.5	1	1
Total Phosphorus	9	4	N/A				0.01	0.01	0.01	0.02	0.08	0.5	0.5
Metals (ug/L)													
Aluminum, total (Al)	19	2	N/A				50	50	68	110	240	550	2400
Arsenic, total (As)	19	19	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	19	19	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	19	19	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	19	15	>7	0	0		2	2	2	2	2	3	5
Iron, total (Fe)	19	0	>1000	1	5.3		140	180	210	270	560	760	2200
Lead, total (Pb)	19	19	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	18	1	>200	0	0		10	12	15	18	26	37	48
Mercury, total (Hg)	19	19	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	19	19	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	19	19	>50	0	0		10	10	10	10	10	10	10

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
53	68	4	8	

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: FIRST BROAD RIV AT SR 1140 NR EARL
Station #: A6400000 **Subbasin:** BRD04
Latitude: 35.21776 **Longitude:** -81.60773 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-50-(28)

Time period: 09/26/2000 to 08/18/2005

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	57	0	<4	0	0		5.4	6.9	8.1	9.2	11	12.5	14.5
	57	0	<5	0	0		5.4	6.9	8.1	9.2	11	12.5	14.5
pH (SU)	57	0	<6	3	5.3		5.4	6.2	6.6	7	7.3	7.4	7.9
	57	0	>9	0	0		5.4	6.2	6.6	7	7.3	7.4	7.9
Spec. conductance (umhos/cm at 25°C)	57	0	N/A				42	50	54	64	81	116	351
Water Temperature (°C)	57	0	>29	0	0		1	4.2	9.7	17	21.2	24.6	28.6
Other													
TSS (mg/L)	19	1	N/A				3	4	6	10	24	200	380
Turbidity (NTU)	57	0	>50	8	14	No	2	5	7	12	22	122	550
Nutrients (mg/L)													
NH3 as N	34	12	N/A				0.01	0.02	0.02	0.03	0.08	0.2	0.5
NO2 + NO3 as N	34	0	N/A				0.44	0.47	0.51	0.62	0.71	0.85	1.5
TKN as N	34	11	N/A				0.2	0.2	0.2	0.27	0.37	0.6	1.5
Total Phosphorus	34	1	N/A				0.04	0.04	0.05	0.07	0.14	0.23	0.5
Metals (ug/L)													
Aluminum, total (Al)	19	0	N/A				190	190	250	420	570	8500	54000
Arsenic, total (As)	19	18	>10	1	5.3		5	5	10	10	10	10	11
Cadmium, total (Cd)	19	19	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	19	18	>50	0	0		25	25	25	25	25	25	32
Copper, total (Cu)	19	9	>7	3	15.8	No	2	2	2	2	4	11	34
Iron, total (Fe)	19	0	>1000	4	21.1	Yes	510	530	560	750	920	8900	23000
Lead, total (Pb)	19	18	>25	0	0		10	10	10	10	10	10	20
Mercury, total (Hg)	19	19	>0.012	0	0		0	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	19	17	>88	0	0		10	10	10	10	10	16	63
Zinc, total (Zn)	19	14	>50	0	0		10	10	10	10	13	21	32

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
53	220	16	30	Yes

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: SUGAR BRANCH AT NC 150 NR BOILING SPRINGS
Station #: A6450000 **Subbasin:** BRD04
Latitude: 35.24938 **Longitude:** -81.62025 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-50-32-3

Time period: 09/26/2000 to 08/18/2005

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	56	0	<4	0	0		5.1	6.9	7.6	8.8	9.8	11.8	14.9
	56	0	<5	0	0		5.1	6.9	7.6	8.8	9.8	11.8	14.9
pH (SU)	56	0	<6	4	7.1		5.4	6.1	6.3	6.8	6.9	7.1	7.7
	56	0	>9	0	0		5.4	6.1	6.3	6.8	6.9	7.1	7.7
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				57	67	71	74	78	83	107
Water Temperature (°C)	56	0	>29	0	0		2	4.9	9.9	15.9	19.7	22.5	27.2
Other													
TSS (mg/L)	19	11	N/A				1	1	2	2	4	19	31
Turbidity (NTU)	56	0	>50	4	7.1		2	2	2	3	8	31	130
Nutrients (mg/L)													
NH3 as N	9	4	N/A				0.01	0.01	0.01	0.09	0.35	0.61	0.61
NO2 + NO3 as N	9	1	N/A				0.4	0.4	0.53	0.72	1	1.5	1.5
TKN as N	9	4	N/A				0.1	0.1	0.2	0.3	0.8	1.4	1.4
Total Phosphorus	9	3	N/A				0.01	0.01	0.01	0.02	0.14	0.5	0.5
Metals (ug/L)													
Aluminum, total (Al)	19	0	N/A				51	69	99	130	150	1800	5800
Arsenic, total (As)	19	19	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	19	19	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	19	19	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	19	14	>7	1	5.3		2	2	2	2	3	3	9
Iron, total (Fe)	19	0	>1000	3	15.8	No	180	200	250	290	420	2000	5200
Lead, total (Pb)	19	19	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	19	19	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	19	18	>88	0	0		10	10	10	10	10	10	13
Zinc, total (Zn)	19	17	>50	0	0		10	10	10	10	10	11	17

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
54	344	21	39	Yes

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station Summaries
NCDENR, Division of Water Quality
Basinwide Assessment Report

Location: BUFFALO CRK AT NC 198 NR GROVER
Station #: A8600000 **Subbasin:** BRD05
Latitude: 35.17076 **Longitude:** -81.51679 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 9-53-(5)

Time period: 09/26/2000 to 08/18/2005

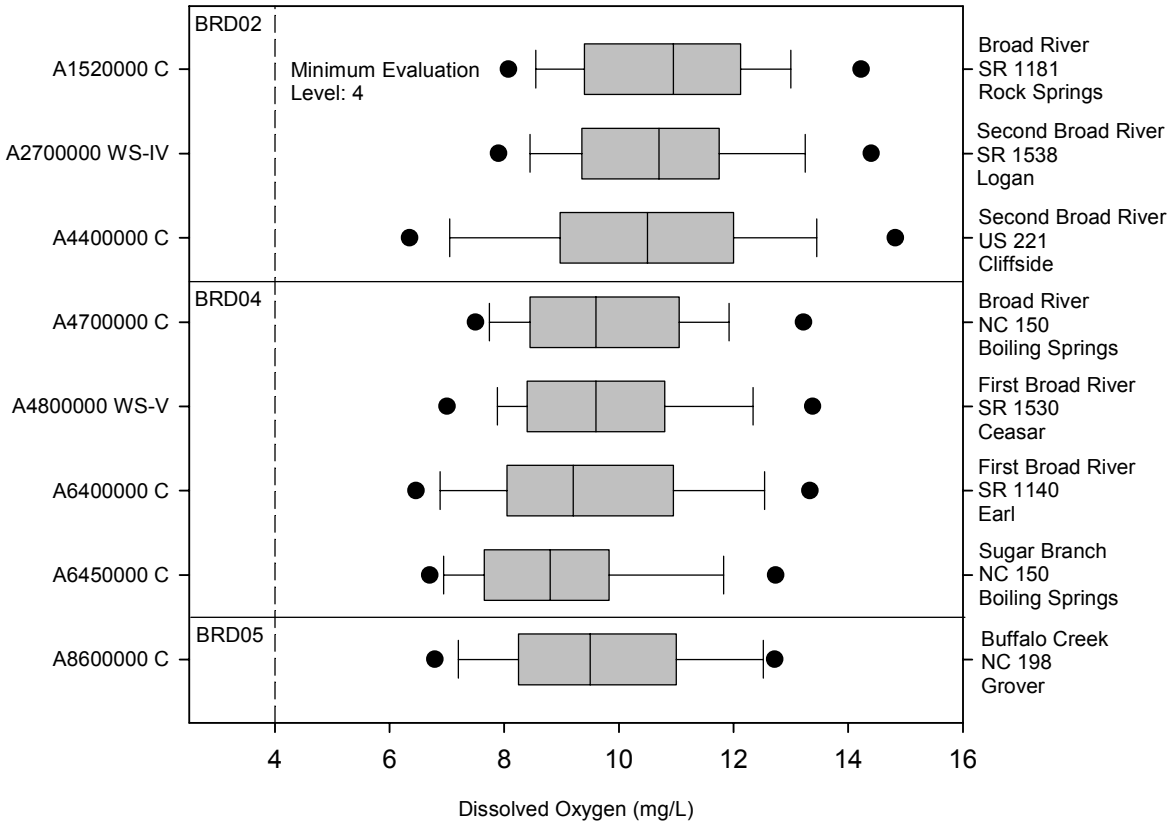
	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	57	0	<4	0	0		5.7	7.2	8.2	9.5	11	12.5	13
	57	0	<5	0	0		5.7	7.2	8.2	9.5	11	12.5	13
pH (SU)	57	0	<6	2	3.5		5.9	6.1	6.6	7.2	7.3	7.5	8
	57	0	>9	0	0		5.9	6.1	6.6	7.2	7.3	7.5	8
Spec. conductance (umhos/cm at 25°C)	57	0	N/A				59	87	106	154	262	401	1305
Water Temperature (°C)	57	0	>29	0	0		2.4	5	10	16	20.7	24.6	26.6
Other													
TSS (mg/L)	19	0	N/A				3	6	6	8	16	104	190
Turbidity (NTU)	57	0	>50	7	12.3	No	3	4	6	10	18	79	550
Nutrients (mg/L)													
NH3 as N	9	4	N/A				0.01	0.01	0.03	0.08	0.24	0.5	0.5
NO2 + NO3 as N	9	0	N/A				0.51	0.51	0.67	0.79	1.05	1.3	1.3
TKN as N	9	2	N/A				0.22	0.22	0.29	0.3	0.6	1	1
Total Phosphorus	9	1	N/A				0.1	0.1	0.16	0.19	0.36	0.5	0.5
Metals (ug/L)													
Aluminum, total (Al)	19	0	N/A				110	170	190	320	1200	4300	7800
Arsenic, total (As)	19	19	>10	0	0		5	5	10	10	10	10	10
Cadmium, total (Cd)	19	19	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	19	19	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	19	6	>7	2	10.5	No	2	2	2	3	6	7	9
Iron, total (Fe)	19	0	>1000	5	26.3	Yes	370	630	690	820	1200	3900	7500
Lead, total (Pb)	19	19	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	19	19	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	19	19	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	19	12	>50	0	0		10	10	10	10	15	23	25

Fecal coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
54	191	11	20	No

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Appendix B: Box Plots



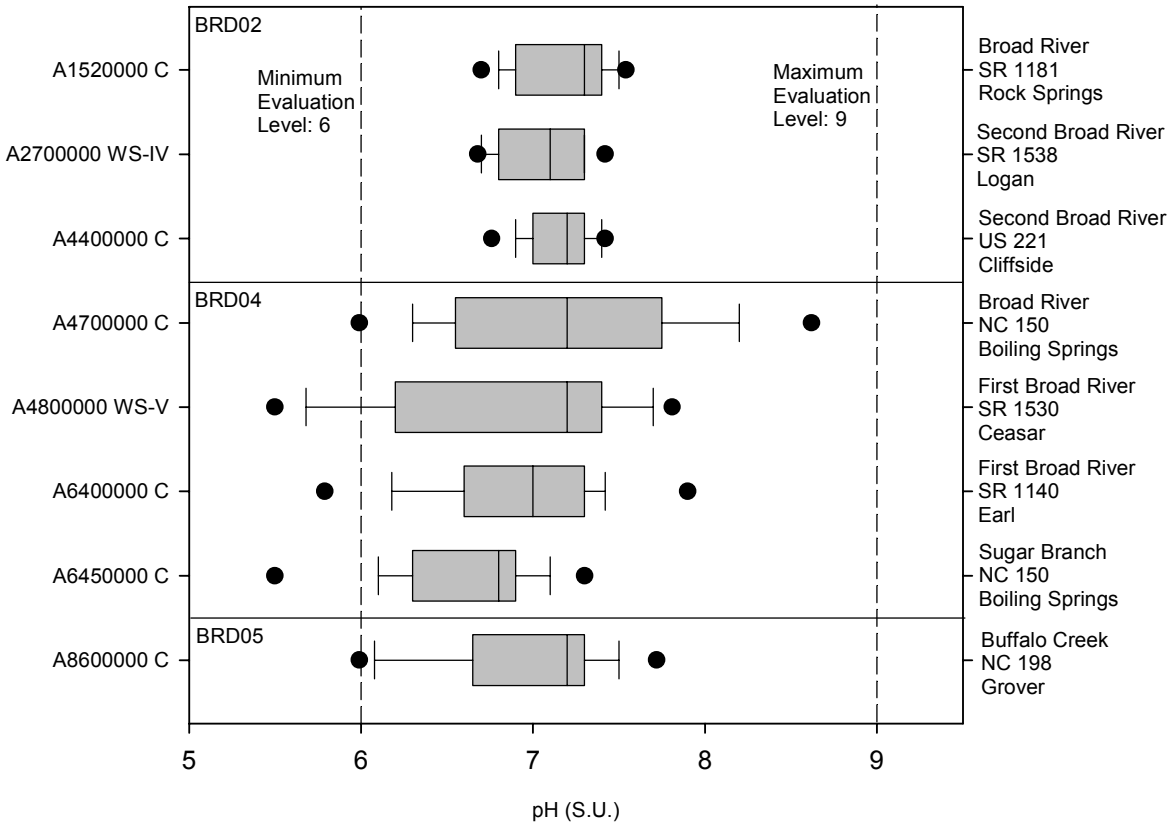


Figure 6. Box Plots of Dissolved Oxygen and pH in the Broad River Basin

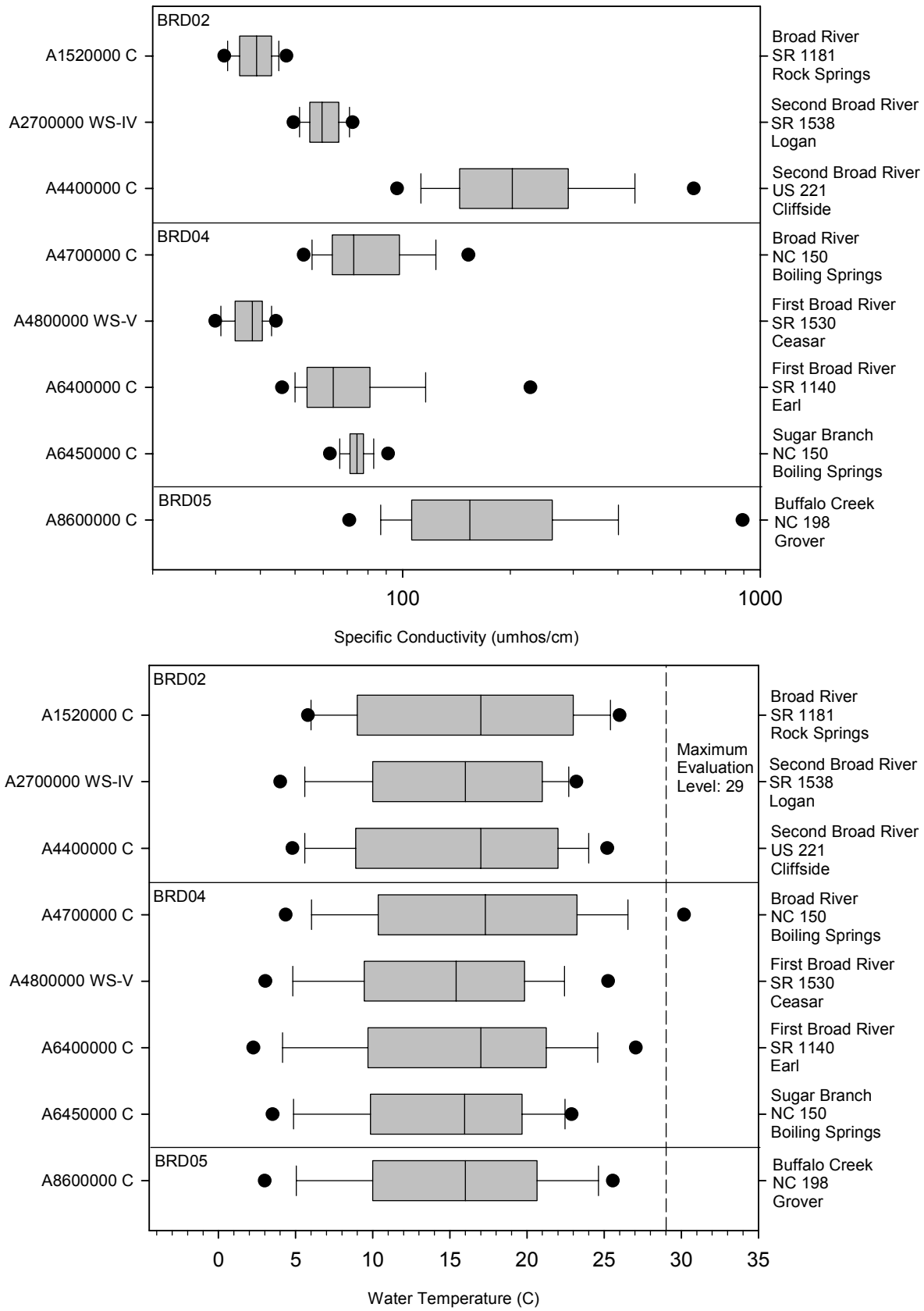
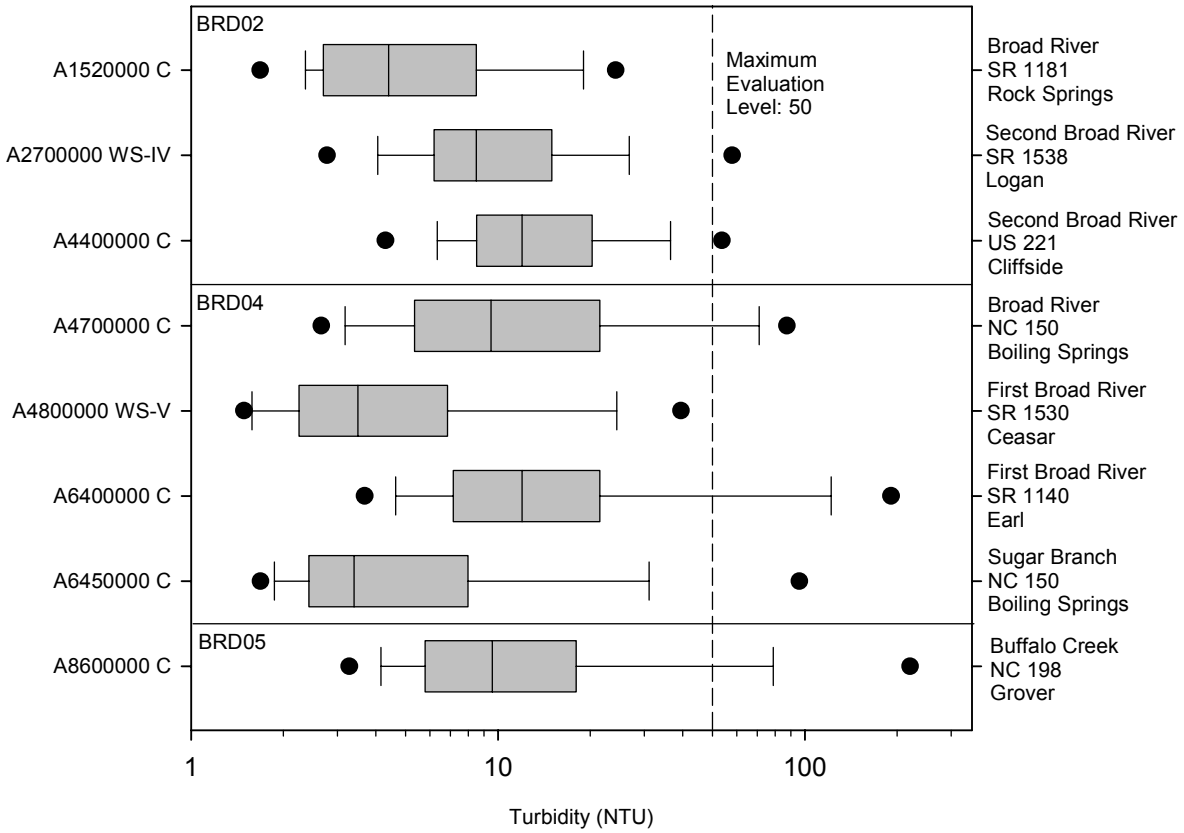


Figure 7. Box Plots of Specific Conductivity and Water Temperature in the Broad River Basin



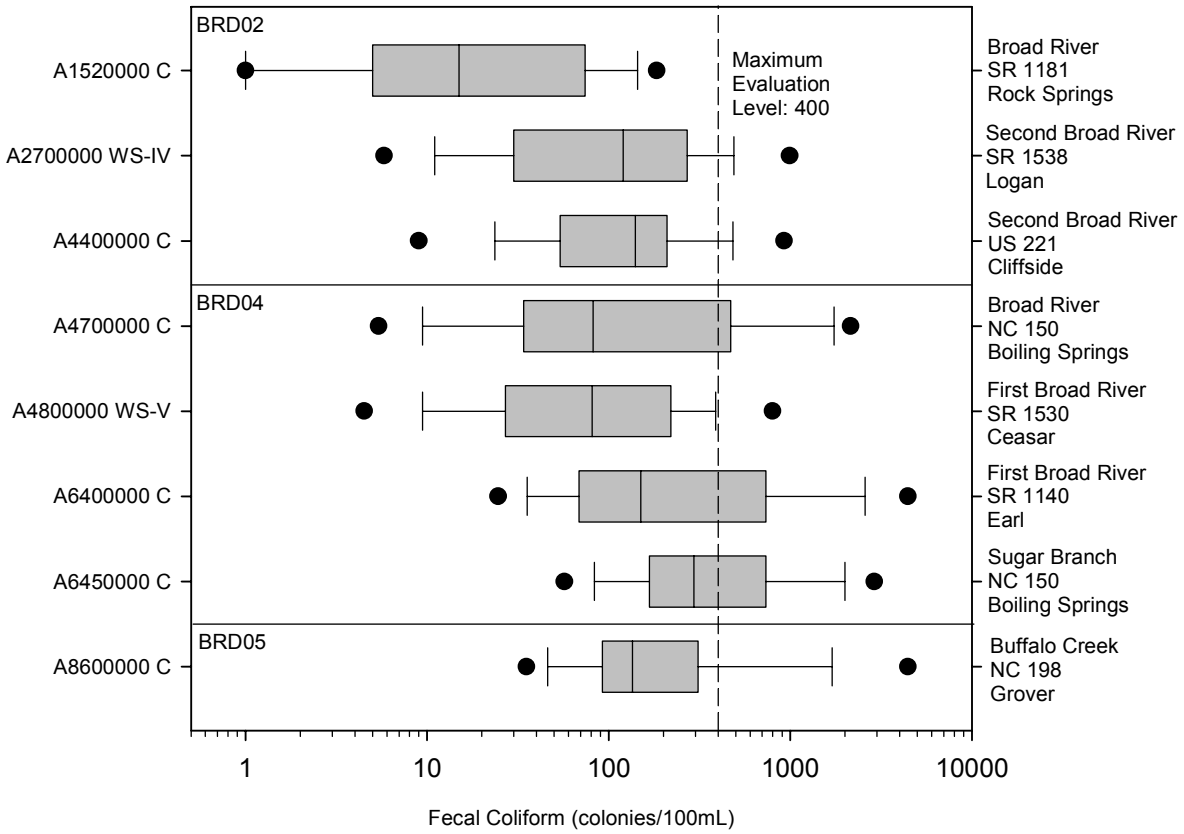
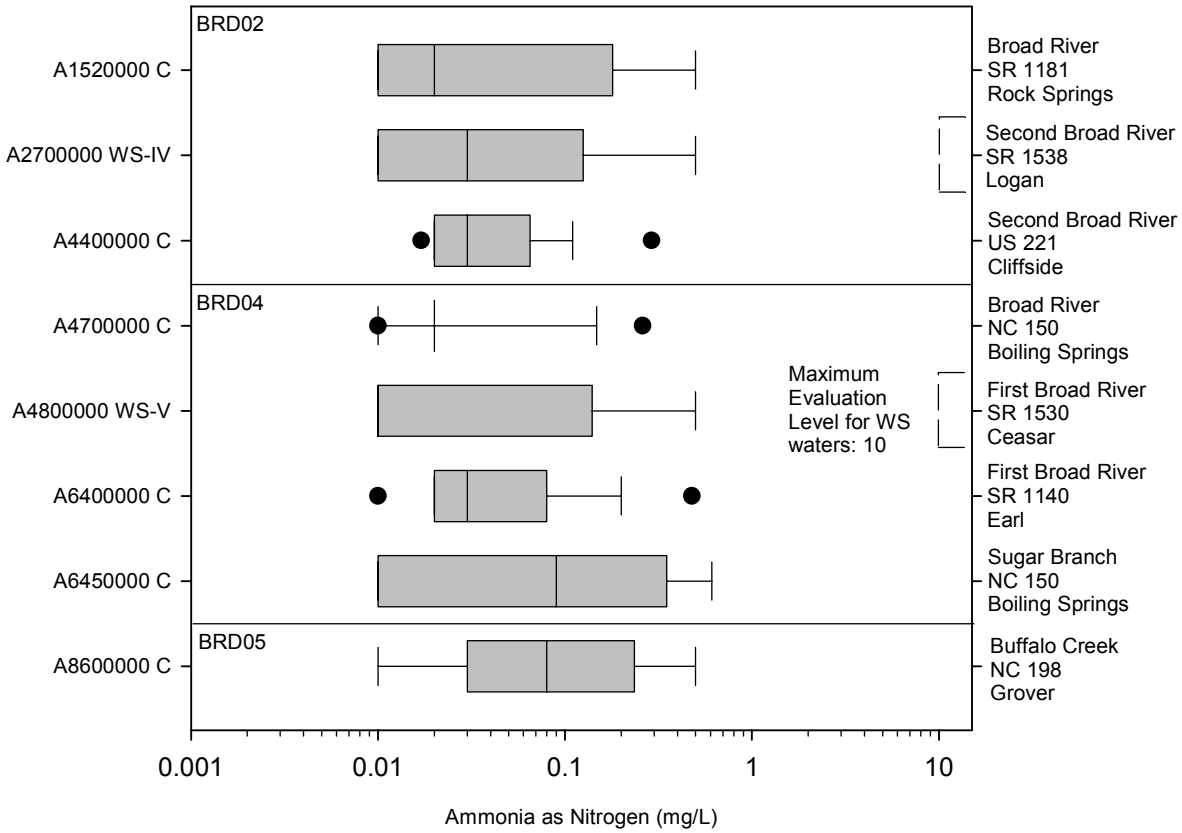


Figure 8. Box Plots of Turbidity and Fecal Coliform in the Broad River Basin



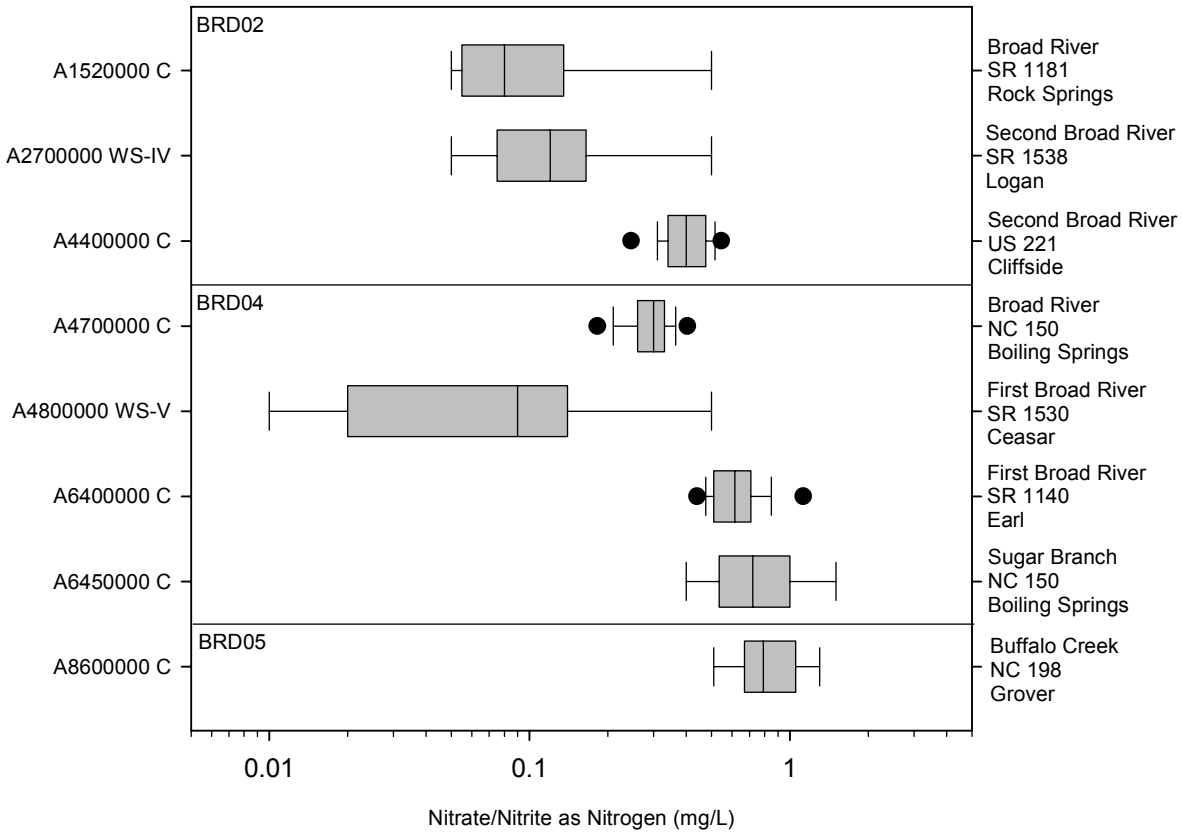
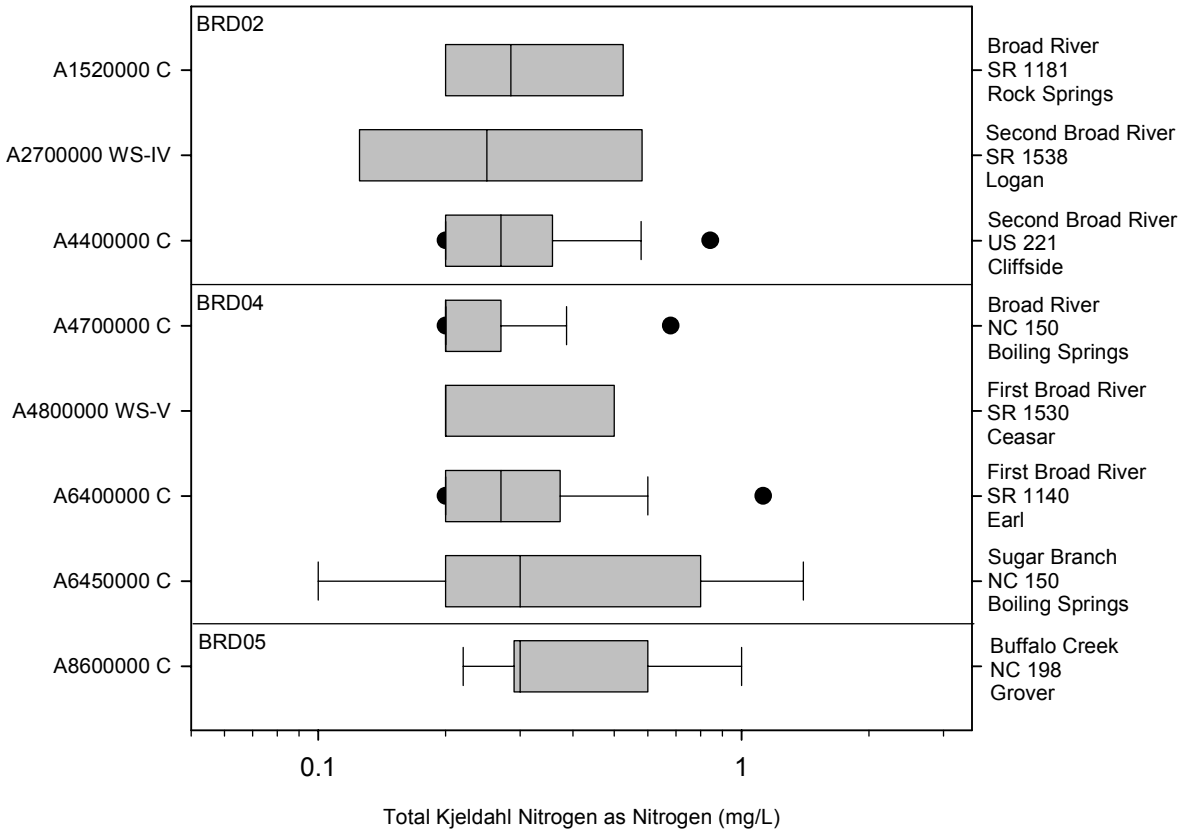


Figure 9. Box Plots of Ammonia and Nitrate/Nitrite in the Broad River Basin



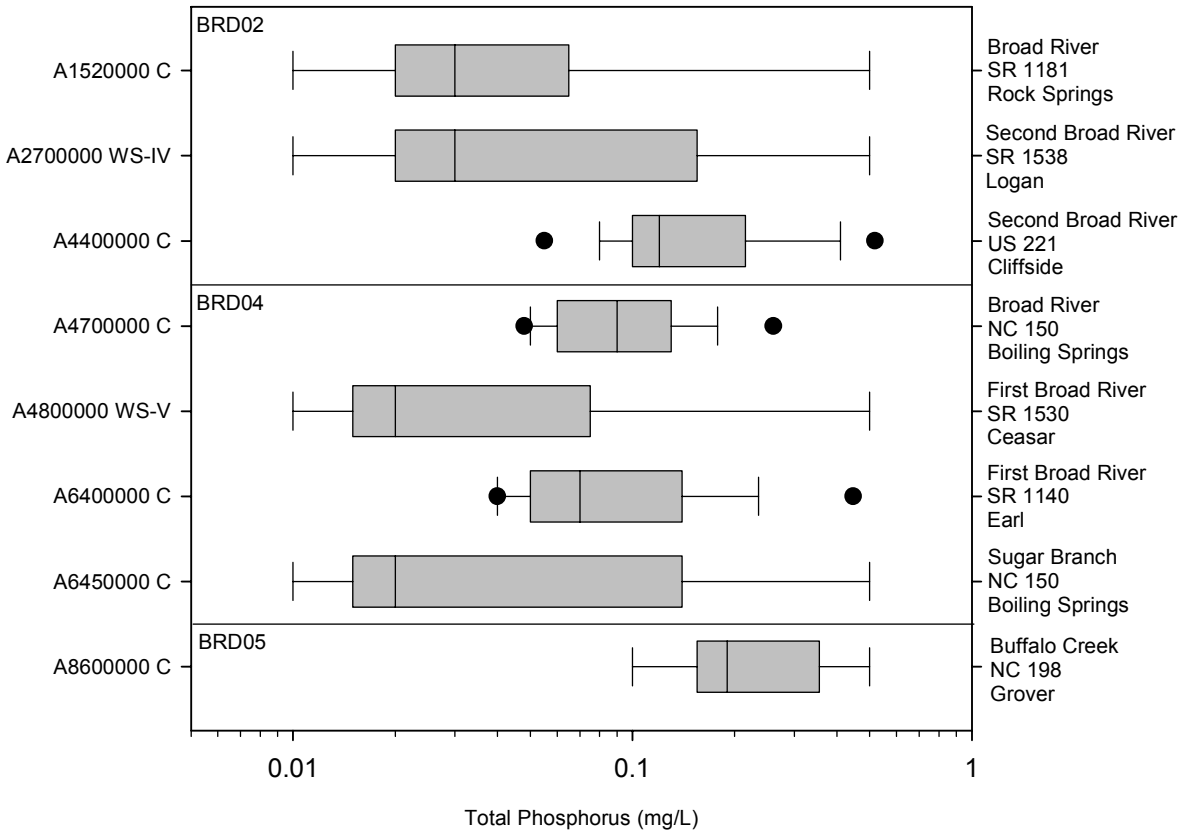
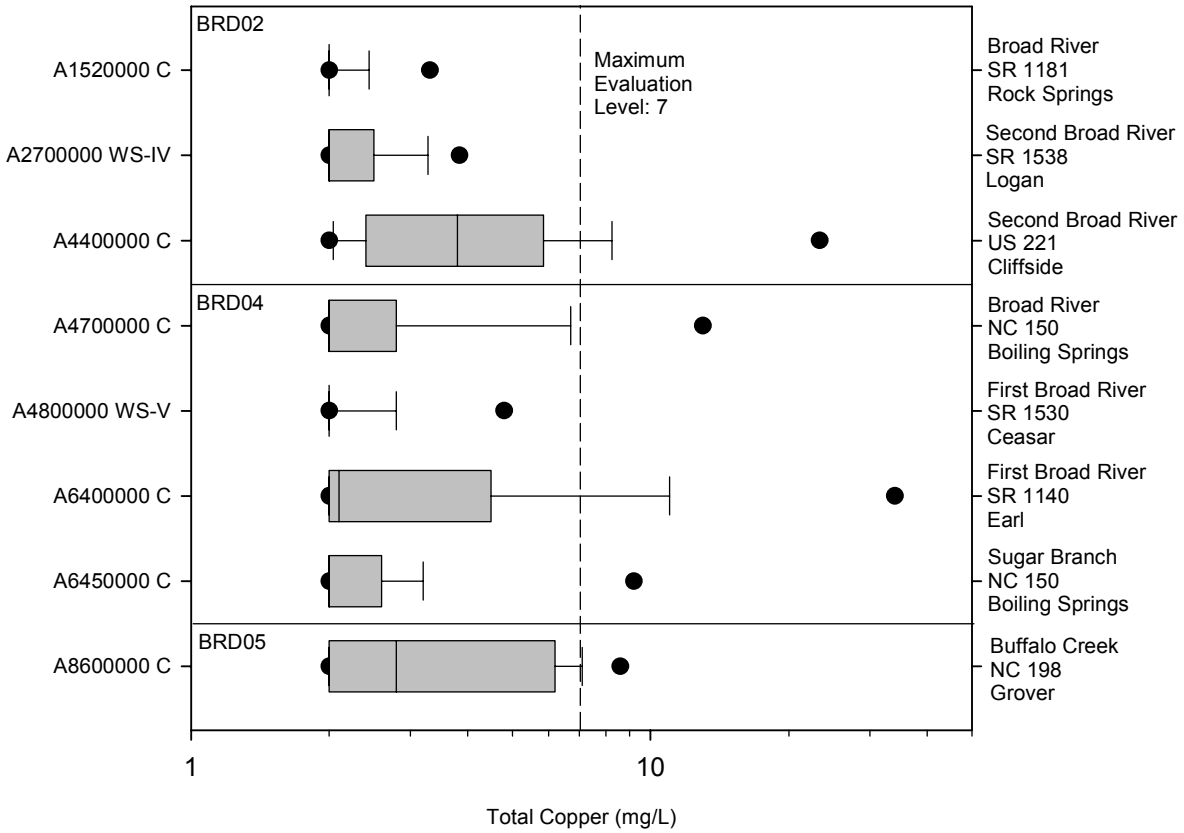


Figure 10. Box Plots of Total Kjeldahl Nitrogen and Total Phosphorus in the Broad River Basin



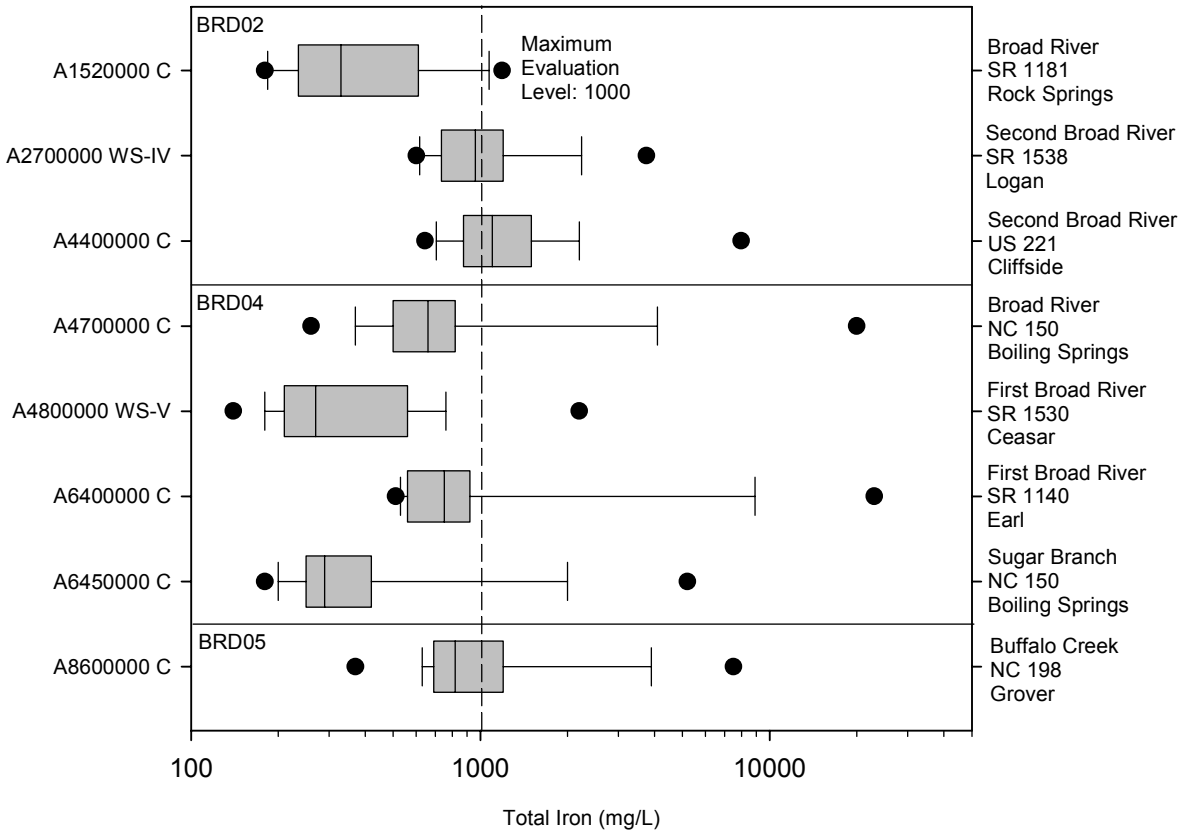
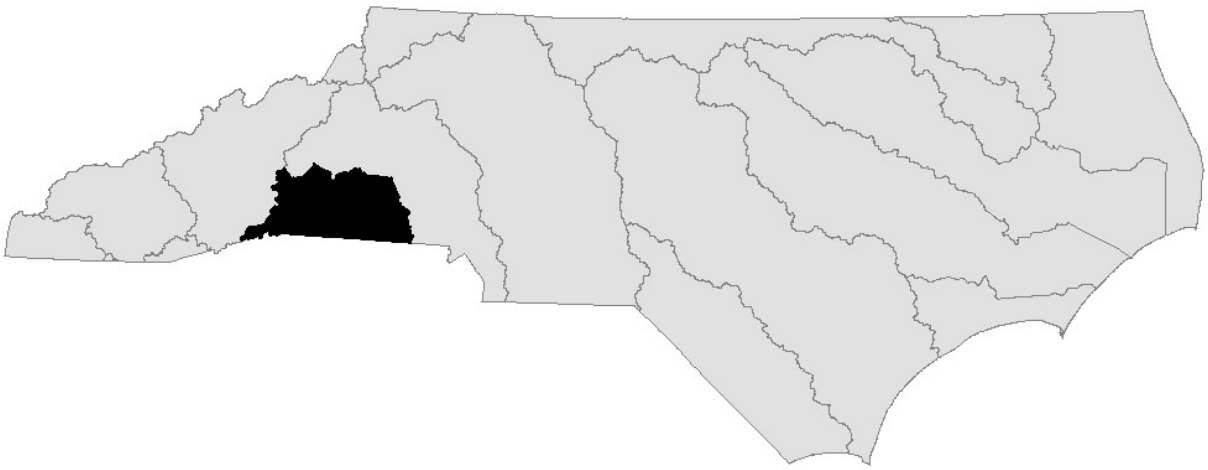


Figure 11. Box Plots of Copper ad Iron in the Broad River Basin

Broad River Basin
Basinwide Assessment Report
Whole Effluent Toxicity Program

2001-2005



The Division of Water Quality's Whole Effluent Toxicity Monitoring Program

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 researchers to be predictive of discharge effects to receiving stream populations.

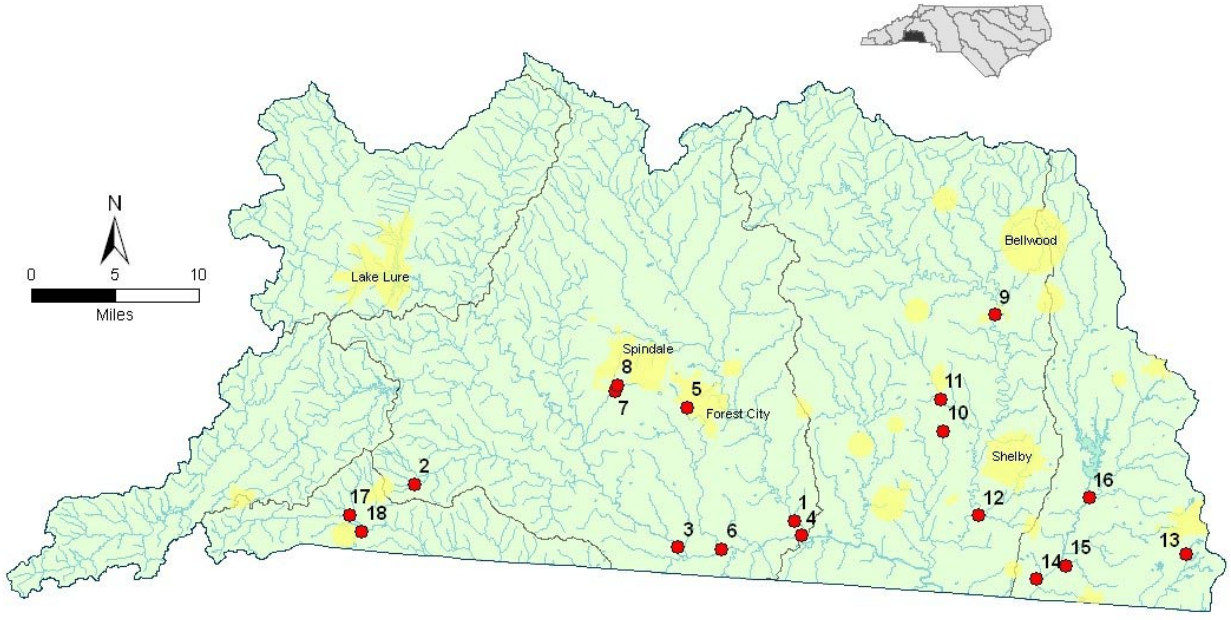
Many facilities are required to monitor whole effluent toxicity (WET) by their NPDES permit. Facilities without monitoring requirements may have their effluents evaluated for toxicity by DWQ's Aquatic Toxicology Laboratory. If toxicity is detected, DWQ may include aquatic toxicity testing upon permit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

DWQ's 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 WQ administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

WET Monitoring in the Broad River Basin – 2001-2005

Eighteen facility permits in the Broad River basin currently require whole effluent toxicity (WET) monitoring (Figure 1 and Table 1). Seventeen facility permits have a WET limit while one requires monitoring without a limit.

Figure 1. Broad River basin facilities required to conduct whole effluent toxicity testing



Key

1	Cliffside Plant WWTP	**7**	Rutherfordton WWTP	**13**	Chemetall Foote Corporation
2	Columbus WWTP	**8**	Spindale WWTP	**14**	CNA Holdings, Inc.
3	Dan River Inc. Harris Plant WWTP	**9**	E-flex, LLC WWTP	**15**	Grover Industries, Inc.- Cleveland
4	Duke Power - Cliffside	**10**	Jefferson Smurfit Corp.	**16**	King's Mtn.-Pilot Cr. WWTP
5	Forest City WWTP	**11**	PPG - Shelby	**17**	Grover Industries, Inc.- Polk
6	Forest City-Riverstone Ind Park WWTP	**12**	Shelby WWTP	**18**	Tryon WWTP

Table 1. Broad River basin facilities required to conduct whole effluent toxicity testing

Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	7Q10 (cfs)
03-08-02						
Cliffside Plant WWTP	NC0004405/001	Second Broad R.	Rutherford	1.75	4.19	62.10
Columbus WWTP	NC0021369/001	UT White Oak Cr.	Polk	0.8	37.08	2.1
Dan River Inc. Harris Plant WWTP	NC0083275/001	Broad R.	Rutherford	0.91	0.75	186
Duke Power - Cliffside	NC0005088/002	Broad R.	Rutherford	NA	7.14	287
Forest City WWTP	NC0025984/001	Second Broad R.	Rutherford	4.95	18.0	34.8
Forest City-Riverstone Ind Pk WWTP	NC0087084/001	Broad R.	Rutherford	0.1	0.08	195
Rutherfordton WWTP	NC0025909/001	Cleghorn Cr.	Rutherford	3.0	71	1.7
Spindale WWTP	NC0020664/001	Cathy's Cr.	Rutherford	3.0	19	20
03-08-04						
E-flex, LLC WWTP	NC0004120/001	First Broad R.	Cleveland	0.78	2.4	76
Jefferson Smurfit Corp.	NC0005061/001	E. Fk Beaverdam Cr.	Cleveland	0.010	11.0	0.12
PPG - Shelby	NC0004685/001	Brushy Cr.	Cleveland	1.3	33	4.0
Shelby WWTP	NC0024538/001	First Broad R.	Cleveland	6.0	17.0	44.3
03-08-05						
Chemetall Foote Corporation	NC0033570/001	Kings Cr.	Cleveland	NA	17	0.9
CNA Holdings, Inc.	NC0004952/001	Buffalo Cr.	Cleveland	0.8	5.8	20.0
Grover Industries, Inc. - Cleveland	NC0083984/001	Buffalo Cr.	Cleveland	0.38	1.8	32
King's Mtn.-Pilot Cr. WWTP	NC0020737/001	Buffalo Cr	Cleveland	6.0	33	19.0
03-08-06						
Grover Industries, Inc.- Polk	NC0004391/001	N. Pacolet R.	Polk	0.45	6.0	10.8
Tryon WWTP	NC0021601/001	Vaughn Cr.	Polk	1.5	37.0	4.00

The number of facilities in this basin with whole effluent toxicity limits has increased from 1985 (first year monitoring required) to 1994. The compliance rate of those facilities has generally risen since the inception of the program. Around 1998 the compliance rate stabilized in the range of 91-96% (Figure 2 and Table 2).

The Rutherfordton WWTP, discharging to Cleghorn Creek (subbasin 02), began to experience frequent WET non-compliances in 2000. Evaluation of the facility's copper and zinc monitoring data indicated that the effluent had reasonable potential to produce levels of these two metals above their Action Level standards in Cleghorn Creek. Acting in response to the Division's Action Level Policy, the facility undertook toxicity identification evaluation studies to determine whether copper and/or zinc were contributing to the observed toxicity. These studies indicated that these metals were contributing to toxicity; per the Action Level Policy, limits for these metals were included in the facility's permit, effective May 1, 2004.

Concurrent with the toxicity issues, the facility also experienced problems meeting its BOD (biochemical oxygen demand), TSS (total suspended solids), and ammonia limits. In order to address these problems as well as the toxicity issue, the facility and DWQ entered into a Special Order by Consent (SOC); this document became effective October 29, 2004 and requires compliance with all parameters by March 31, 2007. During this period DWQ will withhold issuance of NOVs and civil penalty assessments for the problem parameters; the facility must make good faith efforts to solve its wastewater compliance issues. Should the facility fail to correct its problems during the period of the Order, significant civil penalties will be assessed by DWQ. To address the issues, the plant is undergoing modifications to improve treatment. Due to the closing of heavy water using industries in the town, the wastewater treatment facility has effectively become oversized; the modifications will allow more efficient treatment of the smaller volume of wastewater.

Figure 2. NPDES facility whole effluent toxicity compliance in the Broad River basin, 1985-2005. The compliance values were calculated by determining whether facilities with WET limits were meeting their ultimate permit limits during the given time period, regardless of any SOCs in force.

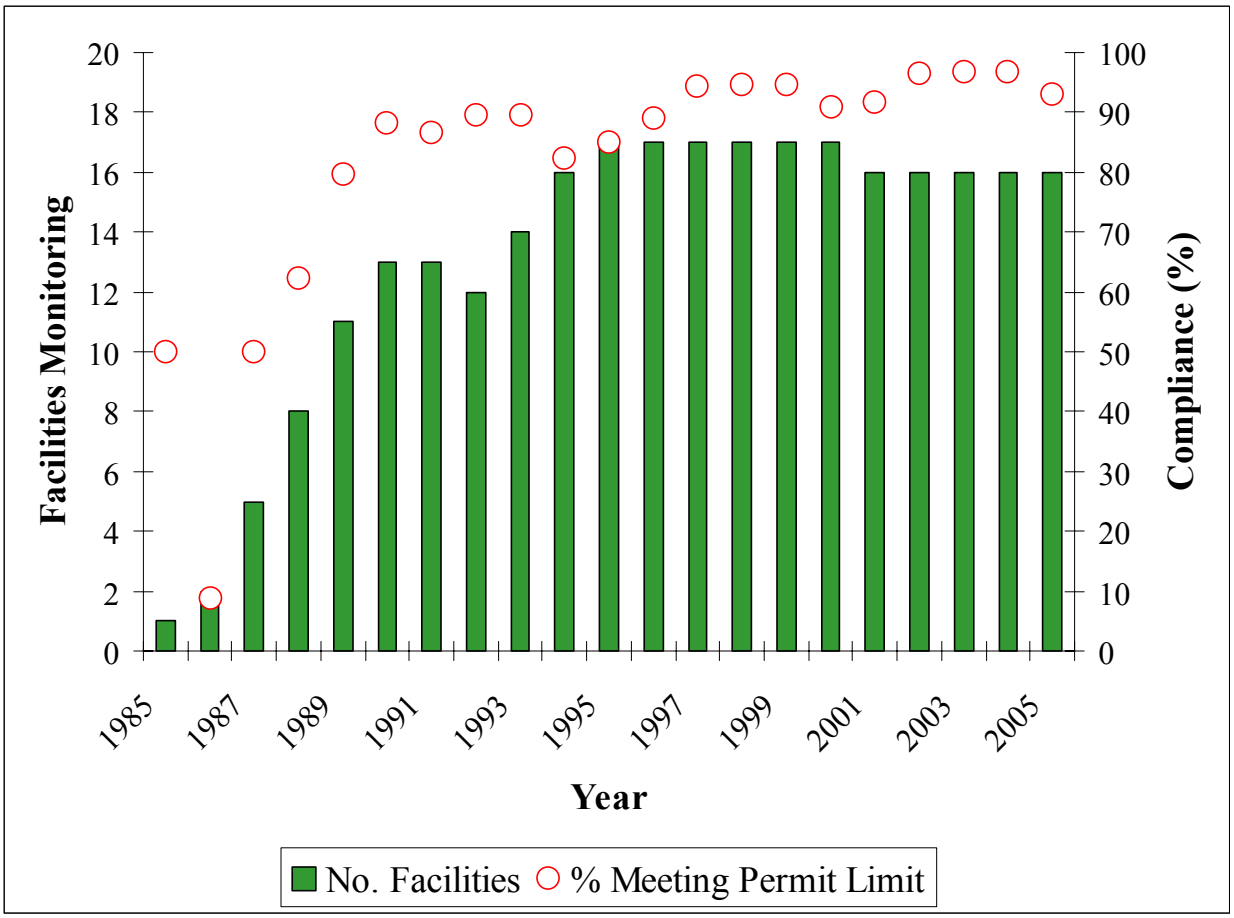


Table 2. Recent compliance record of facilities performing whole effluent toxicity testing in the Broad River basin

Subbasin/Facility	NPDES Permit No.	2001- 2004 Passes	2001- 2004 Fails	2005 Passes	2005 Fails
03-08-02					
Cliffside Plant WWTP	NC0004405/001	17	2	4	0
Columbus WWTP	NC0021369/001	16	0	4	0
Dan River Inc. Harris Plant WWTP	NC0083275/001	17	1	4	0
Duke Power - Cliffside	NC0005088/002	16	0	4	0
Forest City WWTP	NC0025984/001	19	4	5	1
Rutherfordton WWTP	NC0025909/001	15	18	3	3
Spindale WWTP	NC0020664/001	17	4	5	1
03-08-04					
E-flex, LLC WWTP	NC0004120/001	8	0	2	0
Jefferson Smurfit Corp.	NC0005061/001	18	2	5	1
PPG-Shelby	NC0004685/001	16	0	4	0
Shelby WWTP	NC0024538/001	16	0	4	0
03-08-05					
Chemetall Foote Corporation	NC0033570/001	4	2	1	0
CNA Holdings, Inc.	NC0004952/001	17	0	4	0
Grover Industries, Inc.- Cleveland	NC0083984/001	16	1	4	0
King's Mtn.-Pilot Cr. WWTP	NC0020737/001	19	3	4	2
03-04-06					
Grover Industries, Inc.-Polk	NC0004391/001	17	1	4	0
Tryon WWTP	NC0021601/001	19	0	4	0

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.