BASINWIDE ASSESSMENT REPORT

HIWASSEE RIVER BASIN

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

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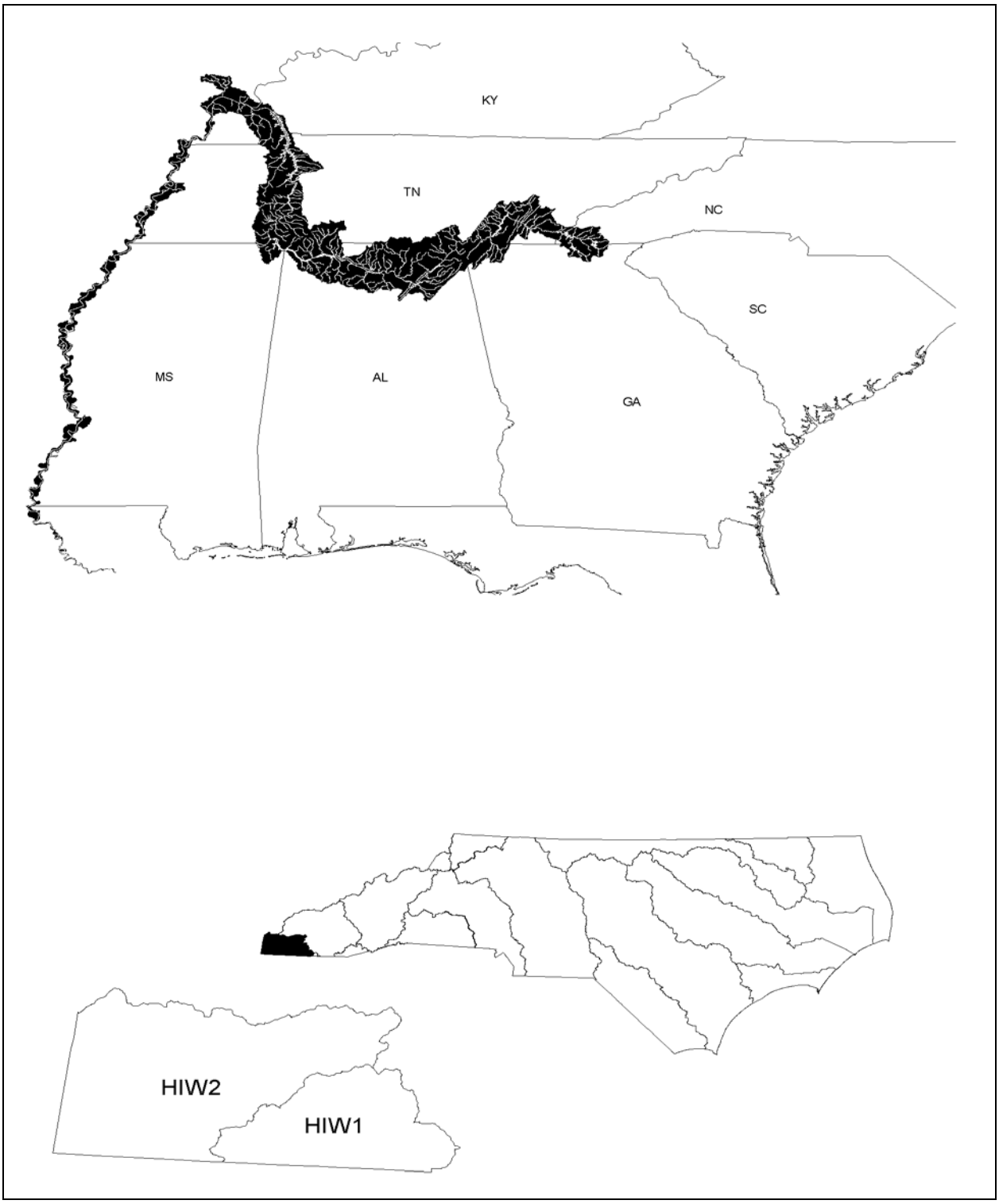


Figure 1. Geographic relationships of the Hiwassee River and its tributaries to the lower Tennessee River and lower Mississippi River drainages.

OVERVIEW

The Hiwassee River Basin is located in the remote southwestern corner of North Carolina (Figure 1). This mountainous basin covers approximately 640 mi^2 in Cherokee and Clay counties. The largest rivers are the Hiwassee River and the Valley River. Many of the streams in the basin are located within the US Forest Service's Nantahala National Forest.

Overall, water quality in this basin is high because most of the streams drain undisturbed, undeveloped, and protected mountain areas. Much of the water quality information for this basin comes from benthic macroinvertebrate data, but fish community data was collected for the first time in this basin in 2004. Basinwide sampling in 2004 included 18 benthos sites and 13 fish sites. These samples resulted in 15 Excellent and 3 Good bioclassifications for the benthos samples, and one Excellent, two Good, three Good-Fair, one Fair, one Poor and four Not Rated trout streams for the fish community samples. The much wider range of water quality based on IBI (fish community data) should be investigated further.

The Hiwassee River is completely regulated by the Tennessee Valley Authority (TVA) for the production of hydroelectric power. The river is impounded three times in North Carolina to form Chatuge Lake, Hiwassee Lake, and Apalachia Lake. Mission Dam on the Hiwassee River near the Clay/Cherokee County line below Chatuge Lake, is the only dam that does not form an impoundment (i.e., it operates as a run-of river hydroelectric project).

In general, this basinwide assessment report is structured such that each subbasin is physically described and an overview of the water quality is given at the beginning of each of the two subbasin section. General water quality conditions are then presented by waterbody for each benthos or fish community site in an upstream to downstream format. A map of each subbasin is included in each subbasin section. The Hiwassee River subbasins are described by six digit codes (040501 and 040502), but are referred to by the last two digits (e.g. Subbasin 01).

HIWASSEE RIVER SUBBASIN 01

Description

This subbasin contains the Level IV ecoregions of the High Mountains (rugged terrain with scattered elevations up to and exceeding 4,500 feet and characterized by very high precipitation rates), the Southern Crystalline Ridges and Mountains (elevations less than 4,500 feet but still containing areas of high precipitation) and The Broad Basins (characterized by much lower elevations, less relief, and less precipitation; Griffith *et al* 2002). The High Mountains ecoregions include northern portions of Clay County and contain the drainages of Big Tuni Creek and Fires Creek. Land use in this area is mostly forest and the terrain is rugged. The Southern Crystalline Ridges and Mountains ecoregions are located in the eastern portion of Clay County and include the Shooting Creek catchment. While elevations are still significant, the overall terrain is less steep than those seen in the High Mountains, and there is slightly more overall agricultural landuse. The Broad basins are located in the southern half of Clay County and include most of the Tusquitee and Brasstown Creek drainages. The lessened relief allows for more agricultural and residential landuse in these areas. The predominant land use in this subbasin is forest, with lesser amounts of agricultural and residential impacts (Table 1).

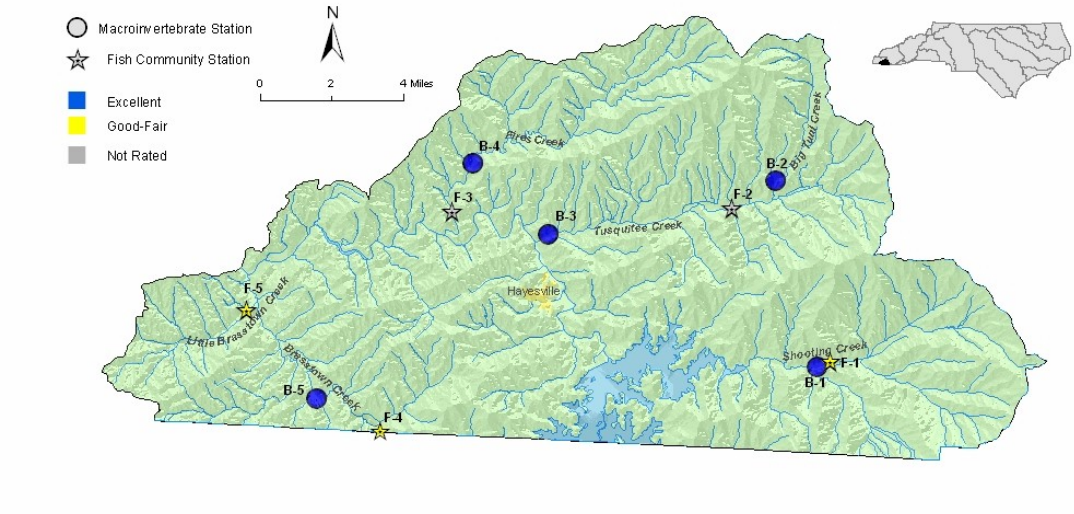


Figure 2. Sampling sites in Subbasin 01 in the Hiwassee River basin. Monitoring sites are listed in Table 1.

Table 1. Land use in Subbasin 01.

Land use	Percent
Water	14.8
Cultivated crop	6.9
Pasture	6.8
Urban	2.5
Forest	69

There is only one large NPDES discharger in this subbasin (Clay County WWTP, NC0026697) whose permitted discharge is 0.3 MGD. Since the last basinwide assessment in 1999, this facility has had an upgrade in treatment and is no longer required to perform toxicity testing. There is also a facility in Georgia (Town of Young Harris Water Pollution Control Plant, 0.24 MGD) that discharges to Brasstown Creek about six miles upstream of the North Carolina state line in Union county. Excluding this facility, there are no permitted NPDES facilities in this subbasin above any of the 2004 basinwide sites.

Overview of Water Quality

Shooting, Big Tuni, Fires, and Tusquitee Creeks are all supplementally classified as trout waters (Tr). Big Tuni Creek is also classified as High Quality Waters (HQW) and Fires Creek is classified as Outstanding Resource Waters (ORW). Brasstown and Little Brasstown Creeks are surface water supply waters with a classification of WS-IV. There are no ambient monitoring sites located in this subbasin.

Benthic macroinvertebrates have been collected from sites in subbasin 01 since 1985.
All streams sampled in 2004 for benthic macroinvertebrates in subbasin 01 were classified using mountain criteria. Based on benthic macroinvertebrate data, Fires, Tusquittee, and Big Tuni Creeks all received Excellent bioclassifications in both 1999 and 2004 (Table 2). Shooting Creek and Brasstown Creek improved from Good in 1999 to Excellent in 2004.

All of the fish community sites in this subbasin were sampled by DWQ for the first time in 2004 using mountain criteria. The 2004 basinwide assessment will therefore serve as a baseline for the 2009 basinwide monitoring cycle. Based on ratable fish community data, Shooting, Brasstown, and Little Brasstown Creeks all received Good-Fair bioclassifications in 2004 (Table 2). The North Carolina Wildlife Resources Commission manages Shooting and Tusquitee Creeks as Hatchery Supported Trout Waters (HSTW). Wild, not stocked, trout were collected from Shooting, Tusquitee, and Fires Creeks.

Table 2. Waterbodies monitored in Subbasin 01 in the Hiwassee River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Shooting Cr	Clay	SR 1370	Good	Excellent
B-2	Big Tuni Cr	Clay	SR 1311	Excellent	Excellent
B-3	Tusquitee Cr	Clay	SR 1300	Excellent	Excellent
B-4	Fires Cr	Clay	SR 1334	Excellent	Excellent
B-5	Brasstown Cr	Clay	SR 1104	Good	Excellent
F-1	Shooting Cr	Clay	SR 1340	---	Good-Fair
F-2	Tusquitee Cr	Clay	SR 1330	---	Not Rated
F-3	Fires Cr	Clay	SR 1300	---	Not Rated
F-4	Brasstown Cr	Clay	SR 1111	---	Good-Fair
F-5	L Brasstown Cr	Cherokee	SR 1565	---	Good-Fair

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

River and Stream Assessment

Shooting Creek, SR 1340

This site is located in the southeast corner of Clay County, about two miles upstream of the Shooting Creek backwaters of Chatuge Lake. The sample segment is nine meters wide and the drainage area is about 23 square miles. Substrates in this segment consist mostly of cobble, gravel, and sand. Instream habitats are good at this site and are composed of riffles, chutes, and snag pools. Riparian habitats are intact but narrow on both banks with some eroded areas. The total habitat score for this site was 75.

The 2004 fish community rating at this site was Good-Fair (NCIBI = 40) due to a mixed assemblage of cool and warm water species including two catfish species (yellow and brown bullhead), and 12 yellow perch that likely migrated upstream from Chatuge Lake. Twelve of the 16 species collected at this site are native, including two species of darters and three cyprinid species. There were also a relatively low percentage of omnivores+herbivores present. This portion of Shooting Creek is supplementally classified

as Trout Waters (Tr) by the Division and is annually stocked by the Wildlife Resources Commission with over 2,000 brook, rainbow, and brown trout from March to June. Fifteen wild rainbow trout including 12 young-of-year were collected at this site, indicating that water quality is sufficient to support trout reproduction.

Shooting Creek, SR 1370

Shooting Creek at this location is eight meters wide and has a drainage area of 22.5 square miles. Predominant land use in this catchment is forest with widely scattered areas of residences, row crops, and pasture. Substrate was comprised of a mostly unembedded mix of boulder (10%), rubble (40%), gravel (30%), and sand (20%). Riffles and pools were well developed. The primary habitat problems observed were areas of moderate bank erosion and portions of the riparian zone that had been cleared in association with a residence. Conductivity at the time of sampling was slightly high for a mountain stream at 30.4 μmhos/cm and the stream received a habitat score of 80.

This site has been sampled twice previously receiving bioclassifications of Good in 1994 (32 EPT) and Good in 1999 (30 EPT). For 2004, this site improved to Excellent with 39 EPT collected. Seven EPT taxa not previously collected at this site were present in 2004.

Big Tuni Creek, SR 1311

Big Tuni Creek is approximately five meters wide at this road crossing and has a drainage area of 5.3 square miles. The dominant land use in this catchment is undisturbed forest. Substrate was an unembedded mix of boulder (30%), rubble (40%), gravel (20%), and silt (10%). Riffles and pools were abundant as were nearly all major instream habitat parameters. The only deficiency was a small portion of the riparian zone that had been cleared for a gravel road. Conductivity in this forested catchment was very low (14.7 μmhos/cm) and the habitat scored high at 87.

Big Tuni Creek has always received an Excellent bioclassification (1989, 1994, 1999) and was again Excellent in 2004. Highly intolerant taxa that were either common or abundant included the mayflies *Rhithrogena fuscifrons*, *Drunella conestee*, *Serratella carolina*, and the caddisflies *Arctopsyche irrorata* and *Rhyacophila atrata*. Moreover, 11 stonefly taxa were collected at this site, which was the most from any site sampled in the Hiwassee basin in 2004.

Tusquitee Creek, SR 1330

This site is located in central Clay County about six miles upstream of the Tusquitee Creek confluence with the Hiwassee River. At this crossing, the instream, riparian, and watershed characteristics are of high quality (habitat score = 85), and qualified the site as a new fish community regional reference site (Appendix F-2). The site is nine meters wide and drains about 23 square miles of predominantly forested land. The specific conductance at this site (15 µmhos/cm) was the second lowest of any fish community site in this basin (Appendix F-6). Substrates in this high gradient stream are mostly cobble with some gravel and boulder. Instream habitats consist of riffles, runs, and chutes.

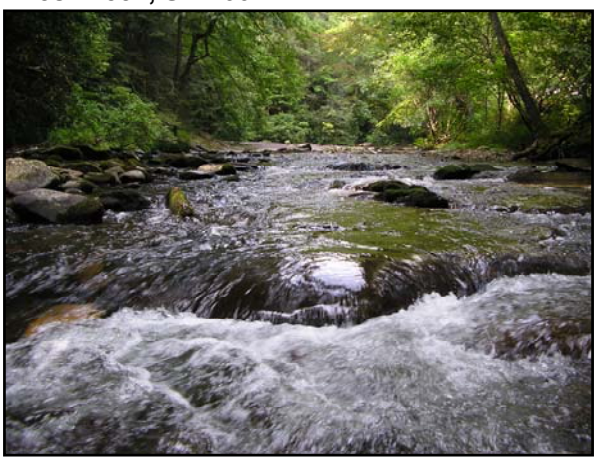
In 2004, the fish community at this site was not ratable with the NCIBI even though it qualified as a regional reference site. This stream appears to be a high quality trout stream with high quality habitat and low number of species including 67% cold-cool water species. Of the six species collected, mottled sculpin represented 94% of the total catch. This portion of Tusquitee Creek is annually stocked with over 5,000 brook, rainbow and brown trout from March to July. The presence of young-of-year rainbow and brown trout in this stream shows that trout are viable, and is indicative of high quality water in this watershed.

Tusquitee Creek, SR 1300

Tusquittee Creek is nine meters wide along this reach and has a 42.8 square mile drainage area. Land use in the catchment includes mostly forest, but significant areas of pasture, row crops, and scattered residences also occur. Substrate was generally unembedded and consisted of boulder (20%), rubble (30%), gravel (20%), sand (10%), and bedrock (20%). Riffles and pools were both well developed. Major habitat shortcomings at this location included moderate bank erosion and a broken riparian zone just downstream of the primary sampling site. Conductivity was surprisingly low for such a large catchment at 18 µmhos/cm. The lower habitat score of 72 reflected the bank erosion and riparian problems.

Tusquitee Creek has been sampled at this location on two previous occasions (1989 and 1999) both times receiving an Excellent bioclassification. In 2004, this site again received an Excellent bioclassification. While the BI at this site has steadily increased from 3.1 (1989), to 3.5 (1999) to 4.0 (2004), the EPTBI has remained essentially unchanged from 1999 (2.8) to 2004 (2.7). Moreover, the 2004 collection resulted in the highest diversity of EPT taxa since monitoring at this location started.

Fires Creek, SR 1334



This section of Fires Creek is located within the Nantahala National Forest and is approximately seven meters wide with a drainage area of 19.5 square miles. The entire catchment of Fires Creek consists of undisturbed forest. Substrate was completely unembedded and was an even mix of boulder (30%), rubble (40%), and gravel (30%). As would be expected for an undisturbed catchment, conductivity was very low (12 μmhos/cm) and few habitat problems were detected. Fires Creek received a habitat score of 88, the highest in the Hiwassee basin.

Fires Creek at this location (and one other nearby at Bristol Camp) has been sampled a total of 12 times since 1985 with only two of these samples resulting in anything lower than an Excellent bioclassification. Those two samples were taken immediately after severe flooding and the lower Good bioclassifications were the direct result of scour effects. For 2004, this site again received an Excellent bioclassification with 118 total taxa collected and 53 EPT taxa present. Highly intolerant EPT taxa collected included the mayflies *Nixe sp*., *Serratella carolina*, *Drunella longicornis*, and the caddisflies *Arctopsyche irrorata* and *Molana blenda*.

Fires Creek, SR 1300

This site is about one mile upstream of the Fires Creek confluence with the Hiwassee River in west-central Clay County. At this crossing, the instream, riparian, and watershed characteristics are of exceptionally high quality (habitat score = 96), and qualified the site as a new fish community regional reference site (Appendix F-2). The habitat score at this location was the highest of any fish community site in the basin in 2004. The Division also classifies this stream as Outstanding Resource Waters (ORW). The sample segment is 11 meters wide and has a drainage area of 23 square miles. The specific conductance in this reach (13 μmhos/cm) was the lowest of any fish community site in the basin (Appendix F-6). Substrates are mostly cobble with bedrock and boulder. The high quality instream habitat at this site is made up of fast runs, riffles and chute pools. The rhododendron and hemlock riparian corridors are also excellent quality, exemplified by clear water during sampling following rainfall the previous evening.

In 2004, the fish community was not rated with the NCIBI at this location, despite its qualification as a regional reference site and extreme high quality habitats. This is a high quality trout stream with cool and cold-water non-game species. A two-mile portion of Fires Creek just above the 2004 site is stocked annually with about 2,000 brook, rainbow, and brown trout from March to June. The entire Fires Creek watershed above this site is classified as Wild Trout Waters (WTW) by the Wildlife Resources Commission. Wild, young-of-year rainbow trout were collected from this reach, indicating high quality water, and habitats.

Brasstown Creek, SR 1111

This stream is located near the Georgia state line in the southwest corner of Clay County. This sample reach is nine meters wide and the drainage area is about 37 square miles. Substrates in this stream consist of cobble, gravel, boulder and sand. Habitat quality in this reach is good (total score = 74), and is dominated by shallow runs and riffles, with some rootwad pools and bedrock shelves. A narrow riparian zone on both banks is the primary reason for the lower habitat score.

In 2004, the fish community at this site was rated Good-Fair (NCIBI = 46). Although this site is not classified as trout waters (Tr), there seems to be a shift in species composition from a cool water trout stream to a stream with a mixture of cool and warm water species, including 22 bluegills, a green sunfish (exotic), and a largemouth bass. There were also no smallmouth bass, few cyprinid species, few intolerant species, and no trout species collected. The specific conductance at this site (40 µmhos/cm) suggests that nutrient inputs from upstream agricultural land use and the Young Harris municipal treatment plant in Georgia may be contributing to the species shift.

Brasstown Creek, SR 1104

This section of Brasstown Creek drains small portions of the Chattahoochee National Forest in Georgia but its catchment also contains areas of scattered residences, pasture, and row crops in North Carolina that lie outside of the national forest boundary. Brasstown Creek is 16 meters in width at this location and has a drainage area of 51 square miles. Substrate here was moderately embedded and had among the most bedrock (50%) of any site assessed in the Hiwassee basin. Remaining substrate was composed of boulder (10%), rubble (10%), gravel (20%), and sand (10%). Conductivity was 32 µmhos/cm and the habitat received a score of 69.

Brasstown Creek has been sampled for benthos at this location three previous times receiving a Fair bioclassification in 1994 (EPT sample) and a Good bioclassification in 1999 (Full-Scale sample). In 2004, this site showed additional improvement resulting in an Excellent bioclassification. Further, the 2004 collection resulted in an all-time high EPT diversity (53) for this site. Although the EPT increased from 44 in 1999 to 53 in 2004, the BI was stable between years (4.6 in 1999 and 4.8 in 2004), as was the EPTBI (3.8 in 1999 and 3.7 in 2004).

Little Brasstown Creek, SR 1565

This site is located less than one half mile above its confluence with Brasstown Creek in the southeast corner of Cherokee County. The sample segment is six meters wide and the drainage area is nine square miles. Substrates in this reach of Little Brasstown Creek include mostly sand, gravel, and boulder. Instream habitats at this site are poor due to nonpoint sedimentation of alluvial soils, and include mostly sandy runs, boulder runs, and a few gravel riffles. Riparian habitats are mostly shrubs, grasses, and exotic species such as multifloral rose and Oriental bittersweet. The total habitat score for this site was 45.

In the spring of 2001, this sample reach was partially restored as part of a large-scale stream restoration project targeting the sedimentation problems that extend along most of the creek's length

(http://www.hrwc.net/littlebrasstown.htm). Historically, 75% of Little Brasstown Creek was channelized and or moved. To date, the Hiwassee River Watershed Coalition has restored 55% of the stream's total length (C. Dobson, HRWC, per. com. 2/2/05). Although no instream restoration has yet been completed in this reach, efforts to restore the riparian zone at this site have included: 1) planting of trees along the tops of both banks, 2) installation of livestock exclusion structures, and 3) a 30 year riparian buffer protection agreement with the local landowner. Further efforts to re-establish the instream habitats and prevent further sedimentation are needed at this site.

Sediment filled pool (A), and bank erosion (B), Little Brasstown Creek at SR 1565, Cherokee County.

Even with severe sediment erosion problems in Little Brasstown Creek, the 2004 NCIBI rating for this site was Good-Fair based on it's diverse fish community. Despite the poor habitat quality and the low number of fish at this site (n = 195), the total number of species collected was 20, including nine cyprinids and two intolerant species. This is the second highest species count out of all 13 fish community sites sampled in the Hiwassee River basin. However, 6 of the 20 species collected were uncommon and represented by only one or two fish per species. The percentage of tolerant fish was also elevated at 24%. This site would have likely scored higher with the NCIBI given more suitable habitats that support greater species abundance. Therefore, this stream should be re-sampled after an adequate time allotment for habitat-specific fish recruitment following the scheduled instream restoration efforts.

Additional fish community data

Little Brasstown Creek

The Tennessee Valley Authority (TVA) also sampled the fish community of Little Brasstown Creek at SR 1565 in 1995, 1997 and 1999 as part of its routine monitoring efforts. The index of biotic integrity developed by the TVA staff to summarize these data and rate this stream is different than the NCIBI, therefore scores and ratings assigned are not equivalent. However, these data can be used to "screen" waterbodies in further need of monitoring efforts by DWQ or in need of local restoration efforts. The rating assignment for Little Brasstown Creek improved with each of these successive assessments for undescribed reasons (1995 = Poor-Fair, 1997 = Fair, and 1999 = Good). A rating of Good-Fair was assigned to Little Brasstown Creek in 2004 by DWQ.

HIWASSEE RIVER SUBBASIN 02

Description

This subbasin lies entirely within Cherokee County and contains the Level IV ecoregions of the Broad Basins (characterized by lower elevations, less relief, less precipitation, and less forested cover) and the Southern Meta-sedimentary Mountains (characterized by steeper relief, more precipitation, and more forested area; Griffith *et al* 2002). The Broad Basins ecoregion includes the southern and central portions of Cherokee County and the drainages of the Hiwassee River, Martin Creek, Nottely River, Persimmon Creek, Peachtree Creek, South Shoal Creek, and the Valley River. Land use in this area is generally forest but as relief is less, the amount of human disturbance is higher and areas of residential and agriculture can be found. The Southern Meta-sedimentary Mountains ecoregion is restricted to the western and northern portions of Cherokee County. These areas include the catchments of Junaluska, Hanging Dog, Owl, Beaverdam, Shuler, and Welch Mill Creeks. The Nantahala National Forest generally dominates land use in this ecoregion but some small areas of residential impact can be found in the Junaluska Creek watershed associated with the town of Andrews. The predominant land use in subbasin 02 is forest but small agricultural and residential areas associated with Andrews and Murphy are also present. (Table 1).

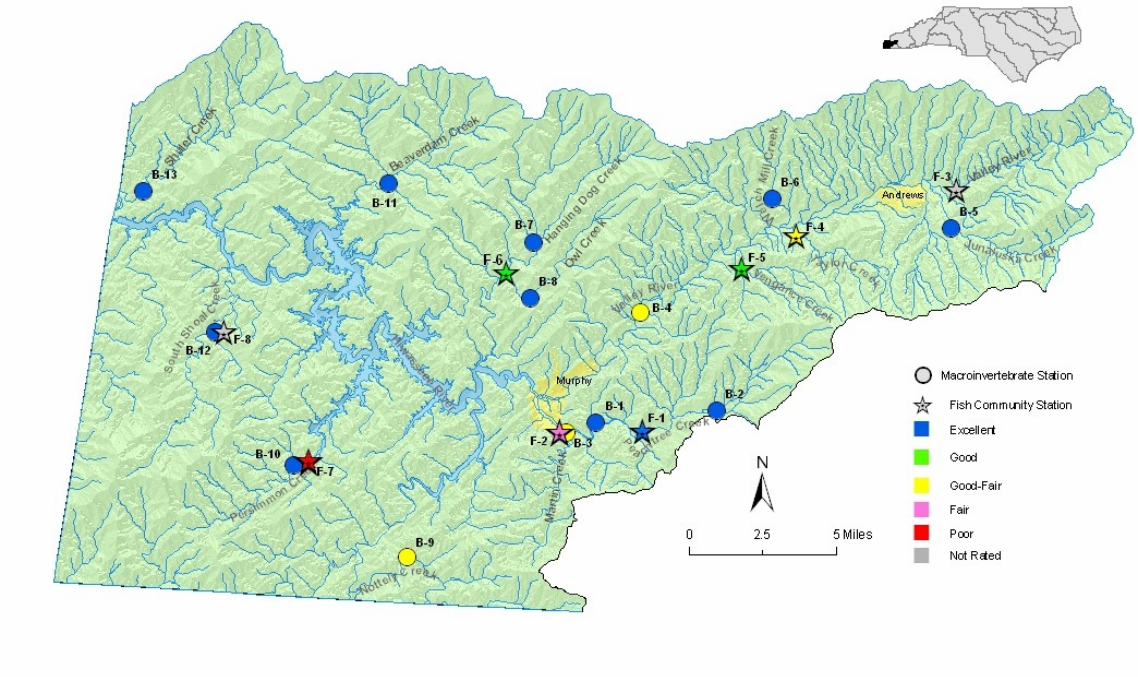


Figure 3. Sampling sites in Subbasin 02 in the Hiwassee River basin. Monitoring sites are listed in Table 2.

Table 3. Land use in Subbasin 02.

Land use	Percent
Water	6.4
Cultivated crop	4.4
Pasture	17.8
Urban	2
Forest	69.4

There are only two significant NPDES dischargers in this subbasin and both are required to perform whole effluent toxicity testing (NCDENR, 2000). The Andrews WWTP (NC0020800, 1.5 MGD) has had three failing tests since 2001 and discharges to the Valley River. The Murphy WWTP (NC0020940, 0.925 MGD) has had no failing tests since January of 2001 and discharges to the Hiwassee River. There is only one site in this subbasin located below an NPDES discharge -Valley River benthos site, located 11 river miles below the Andrews WWTP.

Overview of Water Quality

The Valley River, Junaluska, Welch Mill, Beaverdam, South Shoal, Taylor, and Vengeance Creeks are all supplementally classified as trout waters. The Hiwassee River is considered surface water supply waters with a classification of WS-V. The remaining waterbodies in this subbasin are water supply waters with C use designations.

There are only two ambient monitoring sites located in this subbasin. Ambient water chemistry values at the Hiwassee River (US 64) have been stable since 1999 with only three measurements (one turbidity and two copper measurements) in five years exceeding water quality standards or action levels. The remaining ambient site is on the Valley River (SR 1373). This location has also been stable with only seven measurements (six for turbidity and one for iron) exceeding water quality standards or action levels.

Benthic macroinvertebrates have been collected from sites in subbasin 02 since 1983. All streams sampled for benthic macroinvertebrates in subbasin 02 (Figure 1) were classified using mountain criteria. Based on benthic macroinvertebrate data, four of the 13 sites improved in bioclassification. Junaluska Creek, South Shoal Creek, and the Hiwassee River improved from Good to Excellent, while the Valley River improved from Good-Fair to Good. The remaining nine sites maintained Excellent bioclassifications (Table 2).

All of the fish community sites in this subbasin were classified by DWQ for the first time in 2004 using mountain criteria. Therefore, the 2004 basinwide assessment will serve as a baseline for the 2009 basinwide monitoring cycle. Fish community bioclassifications in 2004 varied from Poor (Persimmon Creek) to Excellent (Peachtree Creek). Four of the eight sites in this subbasin are supplementally classified as trout waters (Tr). The NC Wildlife Resources Commission manages the Valley River and Persimmon Creek as Hatchery Supported Trout Waters (HSTW). Wild, not stocked, trout were collected from the Valley River, Peachtree, Taylor, Vengeance, Hanging Dog, and South Shoal Creeks.

Table 4. Waterbodies monitored in Subbasin 02 in the Hiwassee River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Hiwassee R	Cherokee	US 64	Good	Excellent
B-2	Peachtree Cr	Cherokee	SR 1537	Excellent	Excellent
B-3	Martin Cr	Cherokee	SR 1558	-------	Good
B-4	Valley R	Cherokee	SR 1554	Good-Fair	Good
B-5	Junaluska Cr	Cherokee	SR 1505	Good	Excellent
B-6	Welch Mill Cr	Cherokee	SR 1381	Excellent*	Excellent
B-7	Hanging Dog Cr	Cherokee	SR 1331	Excellent	Excellent
B-8	Owl Cr	Cherokee	SR 1331	-------	Excellent
B-9	Nottely R	Cherokee	SR 1596	Good	Good
B-10	Persimmon Cr	Cherokee	SR 1127	Excellent	Excellent
B-11	Beaverdam Cr	Cherokee	SR 1326	Excellent	Excellent
B-12	South Shoal Cr	Cherokee	SR 1314	Good	Excellent
B-13	Shuler Cr	Cherokee	SR 1323	Excellent	Excellent
F-1	Peachtree Cr	Cherokee	US 64	---	Excellent
F-2	Martin Cr	Cherokee	SR 1558	---	Fair
F-3	Valley R	Cherokee	SR 1409	---	Not Rated
F-4	Taylor Cr	Cherokee	SR 1515	---	Good-Fair
F-5	Vengeance Cr	Cherokee	NC 141	---	Good
F-6	Hanging Dog Cr	Cherokee	SR 1342	---	Good
F-7	Persimmon Cr	Cherokee	SR 1127, 1st bridge	---	Poor
F-8	S Shoal Cr	Cherokee	SR 1314	---	Not Rated

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.
* This sample on Welch Mill Creek was collected in 2002.

River and Stream Assessment

Hiwassee River, US 64

The Hiwassee River along this segment is approximately 70 meters in width and has a drainage area of 210.2 square miles. Most of the land use in this catchment is forest with scattered areas of residences, row crops and pasture. In addition, runoff associated with adjacent US 64 is also present. This portion of the river is regulated and is below a hydroelectric power station located approximately five river miles upstream at Mission. Substrate was composed of an embedded mix of boulder (10%), rubble (10%), gravel (20%), sand (10%) and bedrock (50%). Riffles and pools were practically absent with most of the instream habitat comprised of long, deep runs. The primary habitat problems observed were lack of riffles and moderate bank erosion. Conductivity was low for such a large catchment (25 μmhos/cm) and the habitat score for this reach was also comparatively low for a large mountain river at 61.

This site has been sampled on seven previous occasions since 1983 receiving Good-Fair bioclassifications twice (1983 and 1986) and Good bioclassification five times (1984, 1985, 1987, 1990, and 1999). In 2004, this site improved receiving an Excellent bioclassification with 46 EPT taxa collected. This represented the highest EPT diversity ever recorded here. The two previous high EPT totals measured here occurred in 1990 and 1999 when 38 and 36 EPT taxa were collected respectively. New EPT taxa collected at this site included the stonefly *Suwallia*, and the caddisflies *Brachycentrus spinae*, *Goera calcarata*, *Molanna tryphena*, and *Phylocentropus*.

Peachtree Creek, SR 1537

Peachtree Creek is approximately five meters wide at this location and has a drainage area of 8.7 square miles. The dominant landuse in this catchment is forest but agriculture and scattered residences are also present. Substrate was a moderately embedded mix of boulder (10%), rubble (40%), gravel (20%), sand (10) and silt (20%). Riffles and pools were well developed but bank erosion was the worst observed in the entire basin and the riparian zone was not intact. Conductivity was 24 μmhos/cm and the habitat received a score of 67, which is quite low for a stream in this ecoregion.

Peachtree Creek has been sampled at this location in 1994 (37 EPT) and in 1999 (38 EPT) both yielding Excellent bioclassifications. In 2004, this site also received an Excellent bioclassification and EPT diversity increased dramatically to 49.

Peachtree Creek, US 64

This site is located just southeast of the Town of Murphy, about a half mile upstream from the Hiwassee River confluence. The sample segment is nine meters wide and the drainage area is about 18 square miles. Substrates at this site are gravel, sand, and cobble. Instream habitats include runs, chutes, riffles, and a few deadfall pools. The riparian corridor along both sides of the stream is quite poor with several areas of recent and severe bank erosion. Overall, habitat quality at this site is low (total score = 58).

Despite having the third worst habitat score among all 2004 fish community sites in the basin, this site rated the highest among all NCIBI ratings (Excellent, NCIBI = 58). The greatest number of species in the basin was collected at this site (n = 22), including wild rainbow trout. However, five species were represented by two or fewer individuals. This stream may be experiencing relatively new erosion and sedimentation problems from recent high flows, and the fish community has yet to fully respond. Flows in 2004 did increase to eight times the three-year mean in mid-April in Brasstown Creek at Brasstown. However, there is no way to know for sure if this event caused the recent scouring and "blowouts" seen in this reach of Peachtree Creek. Furthermore, the close proximity of Peachtree Creek to the Hiwassee River confluence (< ½ mile) may be acting as a source for fish recruitment.

Martin Creek, SR 1558

This road crossing is approximately 400 meters upstream from Martin Creek's confluence with the Hiwassee River in the southeast corner of Cherokee County. The sample segment is seven meters wide and the drainage area is nine square miles. Landuse in the Martin Creek catchment was the most developed seen in the Hiwassee basin and consisted largely of residential areas associated with the town of Murphy. This development was reflected by the second highest conductivity recorded in the basin during benthos sampling (49.3 μmhos/cm), and the highest conductivity recorded during fish community sampling (50 μmhos/cm). Substrate was a moderately embedded mix of flat boulders (20%), rubble (30%), gravel (20%), sand (10%), and silt (20%). Due to the low gradient near the confluence, riffles and pools (while present) were not very well developed. The primary habitat problem was the high percentages of sand and silt associated with one uniform depth. The habitat score was 73 during benthos sampling and 74 during fish community sampling.

This is the first benthic macroinvertebrate sample from Martin Creek and resulted in a Good bioclassification. However, this site had the lowest EPT diversity (30), the second highest EPTBI (3.14), and had the lowest stonefly diversity (n = 3) measured from all the Hiwassee basin samples. While this site is certainly not impaired, it is clearly showing adverse effects from the upstream development.

Fish community sampling revealed a mixed community of cool and warm water species, dominated by mottled sculpin. Despite qualifying as a regional reference site (Appendix F-2), the fish community was rated Fair (NCIBI = 38) because of the low number of fish collected. Six species were represented by only one individual. Although, this was the only site in the basin where the intolerant highland shiner was captured. The uniform depth and lack of habitat diversity may be contributing to the low numbers of fish in this reach of Martin Creek, but it is not totally clear what is impacting the fish community.

Valley River, SR 1409

This site is located in the northeast corner of Cherokee County, just upstream of the Towns of Andrews and Valleytown. The sample segment is seven meters wide and the drainage area is about 17 square miles. Substrates are cobble and boulder; instream habitats are mainly high gradient riffles and chutes. Riparian habitats are of good quality, except for a residential area on the right bank with a section of mowed lawn. The overall habitat score was 86.

In 2004, this site was not ratable with the NCIBI, but qualified as a regional reference site (Appendix F-2). Habitats are of high quality and the fish community is representative of a typical trout stream with 73% cool water species including 10 native species. The entire Valley River is classified as Hatchery Supported Trout Waters (HSTW) by the NC Wildlife Resources Commission and is stocked annually with 4,500 brook, rainbow, and brown trout from March to July. The collection of wild adult rainbow trout (n = 24) and several dozen young-of-year at this site is an indication of good habitats and high quality water.

Valley River, SR 1554

The Valley River at this location is approximately 18 meters wide with a drainage area of 103.4 square miles. Land use in the catchment includes extensive commercial and residential areas associated with Andrews, row crops found throughout the valley, and some scattered tracts of forest. This segment of the Valley River is also downstream of the Andrew's WWTP which has a permitted discharge of 1.5 MGD. These non point and point inputs are reflected by the highest conductivity value measure in the Hiwassee basin (52 μmhos/cm). Substrate was a slightly embedded mix of boulder (10%), rubble (30%), gravel (30%), sand (20%), and silt (10%). The primary habitat problems at this site included moderate bank erosion and the clearing of portions of the riparian zone to the river's edge. The habitat score (64) was somewhat low for a waterbody of this size in this region.

The Valley River has been sampled at this location on six previous occasions receiving a Good-Fair bioclassification five times (1984, 1986, 1988, 1994, and 1999) and Good in 1990. For 2004, this site improved from the 1994 and 1999 samples receiving a Good bioclassification with 36 EPT collected. The NCBI at this site has been very stable since 1994 (5.0), 1999 (5.1), and 2004 (5.0) while the EPTBI continues to drop receiving 4.3 in 1994, 4.2 in 1999, and (3.9) in 2004. Previously uncollected EPT taxa collected at this site included the mayfly *Stenonema mediopunctatum* and the caddisflies *Diplectrona modesta* and *Leucotrichia pictipes*. Additional monitoring at this long-term benthos site is recommended in order to determine if the bioclassification improvement this year indicates a trend or is due to natural variation.

Junaluska Creek, SR 1505

This section of Junaluska Creek drains some very small residential areas on the outskirts of Andrews but most of the catchment remains forested. Stream width was six meters and the drainage area is 7.7 square miles. Substrate was an unembedded mix of boulder (20%), rubble (40%), gravel (30%), and sand (10%). Instream habitat was plentiful, riffles and pools were abundant, and the only habitat deficiency observed was a narrow riparian zone on the left bank associated with SR 1505. The overall favorable habitat resulted in a habitat score of 81. However, conductivity was slightly higher than would be expected for a mostly forested catchment (32 μmhos/cm) and likely reflects the upstream residential areas.

Junaluska Creek has been sampled at this road crossing on three previous occasions. Two samples in 1994 resulted in Good-Fair bioclassifications (22 and 25 EPT taxa), while a sample collected in 1999 resulted in a Good bioclassification with 31 EPT collected. In 2004, this site improved to an Excellent bioclassification with 40 EPT taxa collected. Taxa not previously collected at this location include the mayfly *Serratella spiculosa*, and the caddisflies *Diplectrona modesta*, *Lype diversa*, *Nyctiophylax celta*, *Setodes*, and *Triaenodes ignitus*.

Welch Mill Creek, SR 1381

The catchment of Welch Mill Creek upstream of this road crossing is entirely within the Nantahala Game Lands and is completely forested. Stream width was five meters and the drainage area is 2.8 square miles. Substrate is an unembedded mixture of boulder (20%), rubble (20%), gravel (10%), sand (10%), and bedrock (40%). Riffles were moderately developed whereas pool habitat was among the best surveyed in the entire Hiwassee basin. No major habitat deficiencies were noted and the habitat received a score of 81. As would be expected from a forested catchment, conductivity was low at 13 μmhos/cm.

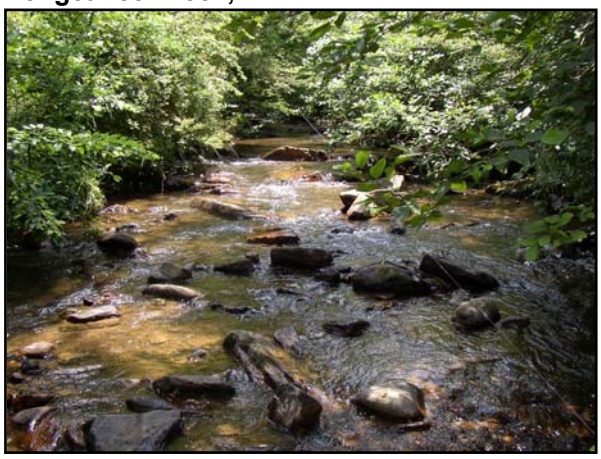
Welch Mill Creek was sampled at this location in 2002 as a TMDL study regional reference site. In 2002, Welch Mill Creek received an Excellent bioclassification with 43 EPT, an EPTBI of 1.8 and an EPT abundance of 207. In 2004, this site also received an Excellent bioclassification with 44 EPT taxa collected, an EPTBI of 1.9, and an EPT abundance of 207. The remarkable stability in the metrics at this site between years is indicative of an undisturbed forested catchment.

Taylor Creek, SR 1515

This site is located in the northeast corner of Cherokee County, about one-third of a mile above its confluence with the Valley River below the Town of Andrews. The sample reach is five meters wide and the drainage area is about six square miles. Substrates in the sample segment include cobble, gravel, sand, and bedrock. Instream habitats are composed of riffles, snag pools, and bedrock shelves covered with *Podostemum*. Cattle access along the banks have resulted in common breaks in the riparian zone, bank instability, and instream sedimentation. Both instream and riparian habitats could be improved if cattle were excluded from the stream. The total habitat score for this site was 68.

In 2004, this site was rated Good-Fair for its fish community (NCIBI = 44). Despite the classification as trout waters (Tr), this site is another example of a cool water stream that may be shifting to a mixed assemblage of cool and warm water species. Although the mottled sculpin is a cool water fish that represented almost 50% of the sample, warm water species made up 36% of the total catch. Nonetheless, wild rainbow trout were collected at this site, including three adults and several young-of-year fish indicating adequate habitat and water quality to support trout reproduction.

Vengeance Creek, NC 141



This site is located due south of the Town of Marble in east central Cherokee County, three quarters of a mile upstream of its confluence with the Valley River. The sample segment is five meters wide and the drainage area is about seven square miles. Substrates consist of cobble and boulder; instream habitats are comprised of high gradient runs, riffles, chutes, and a few plunge pools. The riparian zone is narrow but dense along both banks and provides good instream shading. Just upstream there are many residences with gardens and lawns along the banks that may be contributing nonpoint nutrients to the stream. The total habitat score for this site was 78.

In 2004, the fish community rating at this site was Good (NCIBI score = 56). This sample reach has high quality habitats and a noteworthy trophic structure. More than twice as many fish were collected at this site than any other site in the Hiwassee River basin, roughly half of which were mottled sculpin (n = 475). Seventeen of the species collected in this reach are native to this watershed including 10 species of cyprinids. Although not stocked, eight wild rainbow trout were also collected from this stream. The upstream residential area and the adjacent road may be contributing nonpoint nutrients that are influencing the benthic macroinvertebrate community and thus, the high number of fish at this site.

Hanging Dog Creek, SR 1331

Large portions of the Hanging Dog Creek catchment are contained within the Nantahala National Forest, although the immediate watershed near the sampling site had some sparse residences and pasture. Stream width was five meters and the drainage area was 17.6 square miles. Substrate was an unembedded mix of boulder (10%), rubble (40%), gravel (30%), and sand (20%). Riffles and pools were generally well developed and the major habitat problems at this site were the moderate levels of bank erosion and the broken riparian zone. The habitat score was 75 and conductivity was 19.6 μmhos/cm.

Hanging Dog Creek has been sampled here in 1994 (46 EPT) and in 1999 (40 EPT) both times yielding an Excellent bioclassification. In 2004, this site also received an Excellent bioclassification with 41 EPT taxa collected. The EPTBI at this location has remained remarkable stable between years as it was 2.4 in 1994, 2.6 in 1999, and 2.4 in 2004.

Hanging Dog Creek, off SR 1342

This site is located below the 2004 benthos site in central Cherokee County, just above its confluence with Owl Creek. The sample segment is nine meters wide and the drainage area is approximately 22 square miles. Substrates are mainly cobble and bedrock; instream habitats include mostly runs, chutes, riffles, and bedrock shelves. Habitat qualities for this site are moderate (total score = 71), with infrequent pools and a narrow riparian corridor that provides insufficient vegetative shading.

The NCIBI rating for the fish community at this site is Good (NCIBI = 56), bordering the rating of Excellent. The dominant species was the Tennessee shiner (n = 152), making up one quarter of the fish collected. The percentage of tolerant species collected was low and the number and diversity of darters was good. While habitat quality is high enough to support a diverse assemblage of fish in this stream, an increase in pool frequency and riparian cover would likely benefit the fish community at this site. Although not classified as trout waters (Tr), the presence of reproducing rainbow trout may warrant the reclassification of this stream to Tr.

Owl Creek, SR 1331

Owl Creek is one ridgeline south of Hanging Dog Creek and shares the same catchment characteristics, namely a mostly forested watershed with only small impacts from residences and pasture. This reach was six meters wide and has a drainage area of 7.4 square miles. Substrate was a moderately unembedded mix of boulder (10%), rubble (40%), gravel (30%), sand (10%), and silt (10%). Riffles were abundant and the lack of well-developed pools and the broken riparian zone were the primary habitat problems. Owl Creek received a habitat score of 72. Conductivity was slightly less (16.7 μmhos/cm) than neighboring Hanging Dog Creek.

Owl Creek has no previous benthological data and was sampled in order to increase monitoring coverage of unassessed tributaries. In 2004, Owl Creek received a bioclassification of Excellent with 44 EPT taxa collected and an EPTBI of 2.5.

Nottely River, SR 1596

This regulated reach of the Nottely River lies downstream of Nottely Lake. At normal base flow, the stream width is 25 meters and the drainage area is approximately 238 square miles. Land use in this catchment includes Lake Nottely, residences, agriculture, and some areas of forest. Substrate was the most embedded of any site assessed in the Hiwassee basin and consisted of boulder (10%), rubble (10%), gravel (40%), sand (30%) and silt (10%). Bank erosion, substrate embeddedness, and a lack of well-developed pools and riffles were the primary habitat deficiencies. These combined to produce the worst habitat score in the Hiwassee basin (55). Water released from Lake Nottely is hypolimnetic and is reflected by the lowest water temperature (11.6 C) measured in the basin. Conductivity was 27.3 μmhos/cm.

The Nottely River has been sampled here in 1994 (36 EPT) resulting in an Excellent bioclassification, and in 1999 (33 EPT) resulting in a lowered bioclassification of Good. In 2004, the Nottely River maintained a Good bioclassification although the EPT taxa decreased to an all-time low for this site at 32. This is the only site in the entire Hiwassee basin where the EPT taxa declined from 1999 levels.

Persimmon Creek, SR 1127 (upstream of bridge)

This site is located in the southwest corner of Cherokee County, almost one mile upstream of the backwaters to Lake Cherokee. The stream is six meters wide and the drainage area is about 12 square miles. Substrates in the sample segment are composed of sand, gravel, and a little bit of cobble. The poor instream habitats observed at this site are more typical of Piedmont streams and were composed mostly of sandy runs, and gravel riffles. Riparian habitats were also very poor, with severely eroded and sloughing banks on both sides of the stream, bamboo stands, and mowed lawns. The total habitat score for this site was 41, the lowest out of all fish community sites sampled in the basin.

The NCIBI rating for the fish community in this stream was Poor, with an extremely low score of 20. Species diversity was low, and there were very few fish collected at this site (n = 199). The only darter species present was the greenside darter (n = 3), and only three cyprinid species were present. No rockbass, smallmouth bass, nor rainbow trout were collected, nor were any other intolerant fish. The percentage of tolerant species was quite high for a mountain stream (30%). All of these problems can be attributed to poor habitats. The Cherokee County Soil and Water Conservation Service is planning a stream bank restoration project for this stream (M. Stiles, CCSWC, per. com. 1/6/05). This site should therefore be re-sampled in the next few years to evaluate the success of this restoration project; the 2004 sample serves as a pre-restoration assessment of its fish community. Although not classified as trout waters (Tr), Persimmon Creek is annually stocked by the NC Wildlife Resources Commission with about 1,500 brook, rainbow, and brown trout from March to July. No trout were collected at this site in 2004.

Persimmon Creek, SR 1127 (downstream of bridge)

This location of Persimmon Creek is five meters wide and has a drainage area of 12.1 square miles. The immediate catchment of Persimmon Creek is in a valley and landuse was primarily residential and pasture. Substrate was a moderately embedded mix of boulder (10%), rubble (40%), gravel (30%), sand (20%), and silt (10%). The primary habitat drawbacks here included moderate bank erosion, lack of pools, and no riparian zone upstream from the sample point. Persimmon Creek received a habitat score of 65. The conductivity was 26 μmhos/cm.

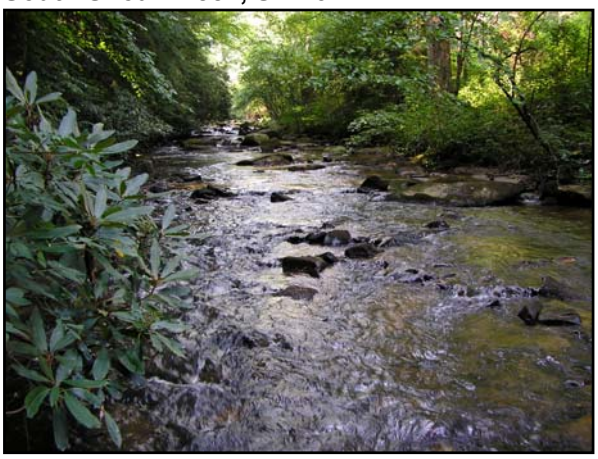
Persimmon Creek has been sampled at this road crossing on two previous occasions. In 1994, Persimmon Creek received an Excellent bioclassification (42 EPT taxa) and was again Excellent in 1999 (40 EPT taxa). In 2004, this site also received an Excellent bioclassification with 40 EPT taxa present.

Beaverdam Creek, SR 1326

The headwaters of Beaverdam Creek include portions of the Nantahala National Forest. The remainder of the catchment includes small quantities of residential, agricultural and forested areas. This particular reach of Beaverdam Creek was seven meters wide and had a drainage area of 21.5 square miles. This site also featured a large (1.5 meter) high waterfall, with numerous chutes and rapids associated with bedrock outcrops. Upstream of the waterfall, riffles were well developed, while downstream of this area plunge pools were abundant. Substrate was an unembedded mix of boulder (20%), rubble (20%), gravel (10%), sand (10%), silt (10%) and bedrock (30%). No major habitat problems were observed and the stream received a habitat score of 80. Conductivity was low at 16 μmhos/cm.

Beaverdam Creek has been sampled on two previous occasions (1994 and 1999) receiving Excellent bioclassifications each time with 39 EPT collected in 1994 and 38 in 1999. In 2004, Beaverdam Creek retained its Excellent bioclassification with a record high (50) EPT taxa collected. While the EPT increased dramatically in 2004, the EPTBI has been remarkably consistent between years scoring 2.4 (1994), 2.7 (1999), and 2.5 (2004) indicating that water quality is stable at this location.

South Shoal Creek, SR 1314

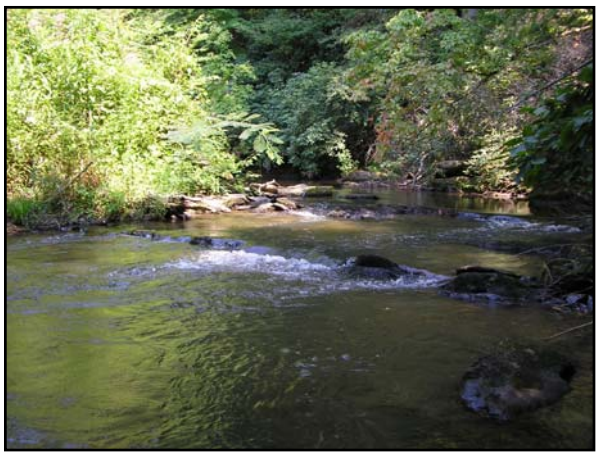


This site is located about three and a half miles upstream of the confluence with Apalachia Lake in west central Cherokee County. At this crossing, South Shoal Creek is about seven meters wide and has a drainage area of 13 square miles. Most of the catchment is forested with only scattered residences comprising the remainder of the land use. Substrates are an unembedded mix of boulder (30%), rubble (30%), gravel (20%) and sand (20%), and instream habitats are composed of high gradient chutes, riffles, and pools. Conductivity was 20 μmhos/cm during both benthos and fish community assessments. The stream received a habitat score of 79 during the benthos sample and a score of 90 during the fish community sample. The difference between these scores was largely in the assessment of instream habitats (difference of 6 points). Nonetheless, both assessments indicate high quality habitats.

South Shoal Creek has been sampled on two previous occasions (1994 and 1999) receiving a Good bioclassification each time with 30 and 33 EPT taxa collected respectively. In 2004, this site improved to Excellent with 38 EPT taxa recorded from this site. New EPT not previously collected included the mayfly *Baetisca carolina*, and the caddisflies *Apatania*, *Heteroplectron americanum*, *Neophylax mitchelli*, *Nyctiophylax celta*, *Rhyacophila acutiloba*, and *Setodes*.

South Shoal Creek is another high elevation trout stream that can't presently be rated, despite qualifying as a regional reference site (Appendix F-2). Only three fish species (rainbow trout, mottled sculpin, and creek chub) typical of high gradient trout streams were collected. Just downstream is a section that is classified as Wild Trout Waters (WTW) by the NC Wildlife Resources Commission. Indicative of high quality water that is sufficient for trout reproduction, nine wild adults, and several young-of-year rainbow trout were collected at this site.

Shuler Creek, SR 1323



The entire Shuler Creek catchment is undisturbed forest and lies within the Nantahala National Forest. The stream width at this location is five meters wide and has a drainage area of 17.7 square miles. Substrate was an unembedded mix of boulder (10%), rubble (20%), gravel (20%), sand (10%), and bedrock (30%). No significant habitat problems were noted (habitat score was 82) and the conductivity was low at 18.5 μmhos/cm.

Shuler Creek was sampled here once in 1994 when it received a Good bioclassification (35 EPT taxa collected) and once again in 1999 when it improved to an Excellent bioclassification (40 EPT taxa collected). In 2004, this site maintained the Excellent bioclassification with 54 EPT taxa collected. While the EPT increased dramatically for 2004, the EPTBI has been remarkably consistent between years scoring 2.4 (1994), 2.7 (1999), and 2.7 (2004) indicating that water quality is stable at this location.

Additional Fish Community Data

The Tennessee Valley Authority (TVA) in association with the Hiwassee River Watershed Coalition, Inc. (HRWC) has conducted a fish community monitoring program in the Valley River watershed in Cherokee County since 1993 (Table 3). Some of the watersheds sampled by DWQ in 2004 were at the same sites or very close to those sites monitored by TVA (e.g. Valley River, Taylor and Vengeance Creeks). The index of biotic integrity developed by the TVA staff to summarize these data and rate these streams is different than the NCIBI, therefore scores and ratings assigned to streams are not equivalent. However, these data can be used to "screen" waterbodies in further need of monitoring efforts by DWQ or in need of local restoration efforts. Within a nine year period, TVA has identified six streams in the Valley River watershed as degraded (rated Fair, Poor-Fair or Poor) and eight streams with moderate to high quality water (rated Good-Fair, Good, Good-Excellent and Excellent). These sites with variable water quality ratings are evenly distributed throughout the Valley River watershed. Complete data summaries and watershed impairments are described in HRWC (2004).

Table 5. Fish community assessments conducted by the Tennessee Valley Authority in Subbasin 02 in the Hiwassee River basin, 1993 – 2002.

Waterbody	Location	County	Date	Drainage Area	TVA IBI Score	TVA IBI rating
MAINSTEM SITES						
Valley River*	Downstream - railroad trestle	Cherokee	4/28/94	14	42	Fair
Valley River*	SR 1389	Cherokee	6/24/02	20	48	Good
Valley River	Upstream Main St., Andrews	Cherokee	5/10/94	52	44	Fair
			5/27/99	52	52	Good
			6/25/02	52	46	Good-Fair
Valley River	Below Landfill Marble	Cherokee	5/23/94	74.2	52	Good
			6/26/02	74.2	50	Good
Valley River	Near armory Murphy	Cherokee	7/1/93	109	46	Good-Fair
			8/15/99	109	58	Excellent
South Side Tributaries						
Worm Creek	Roper property	Cherokee	4/14/94	3	38	Not Rated
			6/24/02	3	38	Not Rated
Junaluska Creek	US 19 (Bus)	Cherokee	3/30/93	8.1	32	Not Rated
			6/17/02	8.1	34	Not Rated
Tatham Creek	US 19 (Bus)	Cherokee	3/30/93	8.2	38	Not Rated
			6/23/02	8.2	36	Not Rated
Taylor Creek*	SR 1515	Cherokee	3/30/93	5.8	52	Good
			6/23/02	5.8	48	Good
Vengeance Creek*	NC 141	Cherokee	3/29/93	7.4	56	Good-Excellent
			6/20/02	7.4	56	Good-Excellent
North Side Tributaries						
Pile Creek	SR 1389	Cherokee	4/25/94	2.6	24	Not Rated
			6/18/02	2.6	36	Not Rated
Britton Creek	Mile 0.3	Cherokee	3/31/93	1.7	46	Good-Fair
			6/18/02	1.7	48	Good
Beaver Creek	SR 1388	Cherokee	3/31/93	2.2	42	Fair
			6/20/02	2.2	36	Poor-Fair
Dan Holland Creek	Upstream SR 1386	Cherokee	4/14/94	1.8	30	Poor
			6/18/02	1.8	28	Poor
Morris Creek	Upstream US 74	Cherokee	4/27/94	3.5	50	Good
			6/25/02	3.5	46	Good-Fair
Thrash Creek	SR 1428	Cherokee	4/28/94	1	36	Poor-Fair
			6/19/02	1	38	Poor-Fair
Welch Mill Creek	SR 1428	Cherokee	4/25/94	3.8	52	Good
			6/21/02	3.8	52	Good
Hyatt Creek	SR 1428	Cherokee	5/2/94	7.1	38	Poor-Fair
			6/20/02	7.1	38	Poor-Fair
Colvard Creek	SR 1426	Cherokee	5/2/94	3.2	42	Fair
			6/21/02	3.2	36	Poor-Fair
Marble Creek	Upstream of US 74	Cherokee	4/7/93	2.6	28	Poor
			6/19/02	2.6	20	Poor

*TVA fish community sites at or close to the 2004 DWQ fish community sites.

Valley River mainstem
DWQ's 2004 Valley River site lies between TVA's two uppermost sites on the main stem of the Valley River (downstream of railroad trestle site and upstream of SR 1389). Although the 2004 DWQ fish community site captures about 3 additional square miles of stream than the uppermost TVA site, these sites are quite comparable, even with different rating methods and sample dates that occur 10 years apart. In addition to the 11 species collected by DWQ in 2004, one black redhorse and two redbreast sunfish were captured during the 1994 TVA sample. Species richness was similar in these two samples, including the same two most abundant species (mottled sculpin and central stoneroller), suggesting stability in this portion of the Valley River over the last decade.

Valley River Tributaries
Taylor Creek
The 2004 DWQ fish community site on Taylor Creek is at the same location as the site sampled in 1993 and 2002 by TVA. Similar results were obtained during these three assessments, despite the differing protocols. The TVA rating for Taylor Creek was Good in both assessments and the 2004 DWQ rating was Good-Fair. Although the greatest number of fish was collected by DWQ in 2004, species diversity was essentially the same in all three samples, indicating minimal land use development.

Vengeance Creek
TVA also sampled Vengeance Creek in 1993 and 2002 at the same site as the 2004 DWQ site. As in the mainstem Valley River sites and in Taylor Creek, the ratings assigned to the fish community in Vengeance Creek are comparable, regardless of the methods. Both of the TVA assessments reported ratings of Good-Excellent, and the 2004 DWQ assessment assigned a rating of Good to Vengeance Creek. Species composition differed slightly among the three samples with a total of 18 species captured in 2004 and 16 and 15 species caught during the respective TVA samples. There were also about five times more fish caught during the 2004 DWQ assessment, further evidence that nonpoint nutrients may be stimulating benthic macroinvertebrate production, thereby benefiting the fish population (i.e. mottled sculpin) in Vengeance Creek.

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GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL *a*	Chlorophyll *a*.
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, and soil type. Examples include Southern Outer Piedmont, Carolina Flatwoods, Sandhills, and Slate Belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters. Waters which are rated as 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.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).

NPDES	National Pollutant Discharge Elimination System.
NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters. 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.
SA Waters	Suitable for commercial shellfishing and all other tidal saltwaters uses.
SB Waters	Saltwaters protected for primary recreation which includes swimming on a frequent or organized basis and all Class SC waters.
SC Waters	Saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All saltwaters shall be classified to protect these uses at a minimum.
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. Benthic macroinvertebrate data, sampling methods, and criteria

Summary

Based on benthic macroinvertebrate data, water quality in the Hiwassee River basin is Excellent to Good. Since 1999, 34 benthic macroinvertebrate basinwide samples have been collected with one (3%) receiving a Good-Fair bioclassification, nine (26%) resulting in Good bioclassifications, and 24 (71%) receiving Excellent bioclassifications. Comparisons of benthos data from 1999 to 2004 between repeat sites show that one site (Valley River at SR 1555) improved from Good-Fair to Good, while five sites (Shooting Creek at SR 1370, Brasstown Creek SR 1104, Hiwassee River at US 64, Junaluska Creek at SR 1505, South Shoal Creek at SR 1314) improved from Good to Excellent. All remaining sites were Excellent in both 1999 and 2004 while the Nottely River maintained a Good bioclassification from 1999 to 2004. Overall, water quality in this basin has improved since 1999.

Several rare invertebrate taxa were collected in the Hiwassee River basin in 2004 including the mayflies *Serratella spiculosa* (Persimmon Creek, Beaverdam Creek, Big Tuni Creek, Junaluska Creek), *Rhithrogena fuscifrons* (Big Tuni Creek, Welch Mill Creek), *Nixe* (Fires Creek), the caddisflies *Molanna tryphena* (Hiwassee River), *Molanna blenda* (Fires Creek), *Micrasema rickeri* (Welch Mill Creek), *Agarodes* (Brasstown Creek) and the stoneflies *Beloneuria* (Welch Mill Creek) and *Agnetina* (Fires Creek). The collection of *Molanna tryphena* at the Hiwassee River represents a significant range extension for this species as it has only previously been collected in the coastal plain and sandhills ecoregions of North Carolina. Two particularly noteworthy benthos sites (Shuler Creek SR 1323, and Tusquittee Creek at SR 1300) set the highest total taxa and EPT taxa diversities ever recorded in the Hiwassee River basin.

Sampling methods and criteria

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Biological Assessment Unit's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (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 an EPT sampling procedure. [Note: "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution.] Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

Several data-analysis summaries (metrics) can be produced from standard qualitative and EPT samples to detect water quality problems (Table 1). These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

For standard qualitative (Full Scale) samples, EPT taxa richness (EPT S) is used with NCDWQ criteria to assign water quality scores. Higher EPT S values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI or BI).

Tolerance values for individual species and the final BI values have a range of 0 - 10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality scores assigned with the BI numbers are combined with EPT S scores to produce a final bioclassification, using criteria for mountain streams. EPT N (EPT N) and Total S calculations also are used to help examine between-site

differences in water quality. If the EPT S score and the BI differ by one, the EPT N value is used to determine the final site rating.

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

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

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

Small streams criteria

Benthic studies in unimpacted mountain ecoregion watersheds have shown naturally reduced EPT S in small streams (less than four meters wide), but similar studies have not been done in small streams that have disturbance in the watershed. For this reason, samples taken from sites with a width less than four meters in watersheds with some disturbance are currently being listed as Not Impaired for use support evaluations, if the bioclassification would be Good-Fair or better using standard EPT criteria. Because such ratings are minimum ratings (no stream size correction factor has yet been developed), small stream sites that would be at least Poor or Fair, are listed as Not Rated to reflect the possibility that such sites might have higher ratings if a size correction was used. This Not Impaired or Not Rated terminology is applied to data that will be used for use support (collected since September 1997) and has not been retrofitted to all of the older data from small streams.

Appendix B-1. Benthic macroinvertebrate basinwide monitoring data collected in the Hiwassee River basin, 1999-2004. Basin sites are in bold.

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPT BI	Bioclass
1									
Shooting Cr	SR 1340	Clay	1-5	8/04	-----	39	-----	2.6	Excellent
				8/99	-----	30	-----	2.5	Good
Big Tuni Cr	SR 1311	Clay	1-21-5	8/04	-----	48	-----	1.5	Excellent
				8/99	-----	45	-----	1.6	Excellent
Tusquitee Cr	SR 1300	Clay	1-21-(16.5)	8/04	119	51	4.0	2.7	Excellent
				8/99	84	39	3.4	2.7	Excellent
Fires Cr	SR 1334	Clay	1-27-(5.5)	8/04	118	53	3.7	2.6	Excellent
				8/99	77	44	2.9	2.4	Excellent
Brasstown Cr	SR 1104	Clay	1-42	8/04	108	53	4.8	3.7	Excellent
				8/99	77	44	4.6	3.8	Good
Webb Cr	SR 1428	Cherokee	1-42-1-1	8/99	58	37	3.2	2.8	Good
	Off SR 1384	Cherokee	1-42-1-1	6/02	63	45	2.4	2.0	Not Impaired
2									
Hiwassee R	US 64	Cherokee	1-(43.7)	8/04	100	46	4.4	3.5	Excellent
				8/99	73	36	4.4	3.5	Good
Peachtree Cr	SR 1537	Cherokee	1-44	8/04	-----	49	-----	2.5	Excellent
				8/99	-----	38	-----	2.9	Excellent
Martin Cr	SR 1558	Cherokee	1-49	8/04	-----	30	-----	3.1	Good
Valley R	SR 1554	Cherokee	1-52	8/04	101	36	5.0	3.9	Good
		Cherokee		8/99	80	33	5.0	4.1	Good-Fair
Valley R	Main Street, Andrews	Cherokee	1-52	6/02	94	52	4.6	3.6	Excellent
Valley R	Stewart Rd.	Cherokee	1-52	6/02	99	51	4.0	3.2	Excellent
Valley R	Off SR 1515	Cherokee	1-52	6/02	92	40	5.0	4.2	Good
Valley R	Off SR 1515	Cherokee	1-52	8/99	63	28	5.2	4.4	Good-Fair
Valley R	Main Street, Andrews	Cherokee	1-52	8/99	-----	24	-----	4.7	Good-Fair
Gipp Cr	SR 1409	Cherokee	1-52-23	6/02	76	44	2.7	2.2	Excellent
Worm Cr	SR 1393A	Cherokee	1-52-24	6/02	62	35	3.6	3.0	Not Impaired
	SR 1502	Cherokee	1-52-24	6/02	53	31	2.5	1.8	Not Impaired
Junaluska Cr	SR 1505	Cherokee	1-52-25	8/04	-----	41	-----	2.2	Excellent
				8/99	-----	31	-----	3.2	Good
Tatham Cr	US 19 Business	Cherokee	1-52-28	6/02	85	40	4.0	3.3	Excellent
Collet Cr	SR 1507	Cherokee	1-52-28-2	6/02	63	36	3.2	2.6	Not Impaired
Beaver Cr	SR 1388	Cherokee	1-52-30-(1)	6/02	49	29	2.8	2.4	Not Impaired
Taylor Cr	SR 1515	Cherokee	1-52-39	6/02	96	41	4.3	3.0	Not Impaired
Colvard Cr	SR 1426	Cherokee	1-52-39-1-1	6/02	60	41	2.8	2.0	Not Imapired
Colvard Cr	US 19/74	Cherokee	1-52-39-1-1	6/02	62	35	3.0	2.1	Not Impaired
Welch Mill Cr	SR 1381	Cherokee	1-52-40	8/04	-----	44	-----	1.9	Excellent
				6/02	-----	43	-----	1.8	Excellent
Welch Mill Cr	SR 1428	Cherokee	1-52-40	6/02	60	34	3.4	2.8	Not Impaired
Hyatt Cr	SR 1428	Cherokee	1-52-43	6/02	80	45	2.9	2.1	Excellent
Hyatt Cr	SR 1379	Cherokee	1-52-43	6/02	-----	49	-----	2.0	Excellent
Vengeance Cr	Off NC 141	Cherokee	1-52-45	6/02	92	50	4.1	3.3	Good
Hanging Dog Cr	SR 1331	Cherokee	1-57	8/04	-----	41	-----	2.4	Excellent
				8/99	-----	40	-----	2.5	Excellent
Owl Cr	SR 1331	Cherokee	1-57-6	8/04	-----	44	-----	2.5	Excellent
Nottely R	SR 1596	Cherokee	1-58	8/04	-----	32	-----	2.6	Good
				8/99	-----	33	-----	3.5	Good
Persimmon Cr	SR 1127	Cherokee	1-63	8/04	-----	40	-----	3.0	Excellent
				8/99	-----	40	-----	3.6	Excellent
Beaverdam Cr	SR 1326	Cherokee	1-72	8/04	-----	50	-----	2.5	Excellent
				8/99	-----	38	-----	2.7	Excellent
South Shoal Cr	SR 1314	Cherokee	1-77	8/04	-----	38	-----	2.3	Excellent
				8/99	-----	33	-----	3.5	Good
Shuler Cr	SR 1323	Cherokee	1-86	8/04	-----	54	-----	2.7	Excellent
				8/99	-----	40	-----	2.7	Excellent
Morris Cr	SR 1383	Cherokee	1-86-6	6/02	56	34	3.1	2.5	Not Impaired
Morris Cr	US 19/74	Cherokee	1-86-6	6/02	74	36	4.2	3.6	Not Impaired

Appendix F1. Fish community assessment

Summary

In 2004, 13 sites were sampled in the Hiwassee River basin in mid June. No previous fish community assessments have been performed by DWQ in any of these mountain streams. The most commonly collected species in 2004 was the mottled sculpin, which was collected at all 13 sites and comprised almost 50 percent of all individuals collected in this watershed. The second most abundant species was the central stoneroller, collected at 12 of 13 sites, making up roughly eight percent of all individuals collected in the basin.

Nine of the 13 stream sites were evaluated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendices F2 – F5). Four of the sites were not rated with the NCIBI because "Trout stream" specific criteria and metrics have not yet been developed for the mountain ecoregions of North Carolina. Furthermore, criteria should be considered "tentative" for the Hiwassee River basin because no previous fish community data exists for this basin. More reference site data is needed to verify that the present metrics being used are appropriate for the Hiwassee River basin.

The NCIBI ratings for the nine ratable streams ranged from Poor to Excellent with scores that varied from 20 to 58. Although Martin Creek qualified as a regional reference site based on its abiotic characteristics, its rating was Fair. This inconsistency warrants further monitoring efforts including a site further upstream from the mouth of the Hiwassee River with slightly higher gradient and more riffles. The sediment laden instream habitat and failing banks of Persimmon Creek are likely the cause of its unbalanced trophic structure. A habitat restoration project for Persimmon Creek is currently in the planning and engineering stages to repair the eroding banks and re-plant the riparian zone.

Habitat assessments

A method has been developed by the Biological Assessment Unit to evaluate the physical habitats of a stream (NCDENR 2001a). The habitat score, which ranges between 1 and 100, is based on the evaluation of channel modification, amount of instream habitat, bottom substrate type, pool variety, size and frequency of riffles, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but criteria have not been developed to assign impairment ratings. Habitat metric scores for all fish community sites in the Hiwassee River basin, which were evaluated in 2004, are listed in Table 1.

In 2004, habitat scores at the fish community sites ranged from 41 (Persimmon Creek, Cherokee County) to 96 (Fires Creek, Clay County) (Table 2). Ten streams had overall moderate to high quality habitats (score ≥ 65), whereas three had overall habitat scores of low to poor quality habitats (score < 65). Major differences between the two types were in the instream habitats, substrates, and riffles and bank stabilities (Table 3.) Differences in habitat scores were not as pronounced in the abundance of pools, extent of canopy cover or width of riparian zone. In general, low habitat scores in the basin were attributable to chronic nonpoint erosion, sedimentation, bank instability, and narrow riparian corridors.

Table 1. Habitat evaluations at 13 fish community sites in the Hiwassee River basin, 2004.

Subbasin	Stream	Location	County	Stream Width	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
040501															
	Shooting Cr	SR 1340	Clay	9	5	16	11	8	16	4	4	7	2	2	75
	Tusquittee Cr	SR 1330	Clay	9	5	18	14	4	16	6	6	10	3	3	85
	Fires Cr	SR 1300	Clay	11	5	18	15	9	16	7	7	9	5	5	96
	Brasstown Cr	SR 1111	Clay	8	5	16	11	6	15	5	5	7	2	2	74
	L Brasstown Cr	SR 1565	Cherokee	6	4	11	3	6	2	2	2	7	3	5	45
040502															
	Peachtree Cr	US 64	Cherokee	9	5	12	8	6	10	2	2	9	2	2	58
	Martin Cr	SR 1558	Cherokee	7	5	16	11	7	5	5	5	10	5	5	74
	Valley R	SR 1409	Cherokee	7	5	18	12	7	16	7	5	9	5	2	86
	Taylor Cr	SR 1515	Cherokee	5	5	14	11	7	15	3	3	8	1	1	68
	Vengeance Cr	NC 141	Cherokee	5	5	18	12	7	15	5	5	7	2	2	78
	Hanging Dog Cr	SR 1342	Cherokee	9	5	18	10	4	14	6	6	4	2	2	71
	Persimmon Cr	SR 1127	Cherokee	6	5	12	4	8	3	2	6	2	1	1	41
	S Shoal Cr	SR 1314	Cherokee	6	5	18	13	9	16	7	7	9	4	2	90
Maximum possible scores					**5**	**20**	**15**	**10**	**16**	**7**	**7**	**10**	**5**	**5**	**100**

Table 2. Rankings of 13 waterbodies in the Hiwassee River basin according to the total habitat scores, 2004.

Subbasin	Waterbody	Location	County	Score
Moderate to High Quality Habitats				
1	Fires Cr	SR 1300	Clay	96
2	S Shoal Cr	SR 1314	Cherokee	90
2	Valley R	SR 1409	Cherokee	86
1	Tusquittee Cr	SR 1330	Clay	85
2	Vengeance Cr	NC 141	Cherokee	78
1	Shooting Cr	SR 1340	Clay	75
1	Brasstown Cr	SR 1111	Clay	74
2	Martin Cr	SR 1558	Cherokee	74
2	Hanging Dog Cr	SR 1342	Cherokee	71
2	Taylor Cr	SR 1515	Cherokee	68
Low to Poor Quality Habitats				
2	Peachtree Cr	US 64	Cherokee	58
2	L Brasstown Cr	SR 1565	Cherokee	45
2	Persimmon Cr	SR 1127, 1st bridge	Cherokee	41

Table 3. Mean habitat scores for 13 fish community sites in the Hiwassee River basin, 2004.

Habitat characteristics	Low - Poor Quality Habitat	Moderate - High Quality Habitat	Max score
Instream Habitat	11.7	17	20
Substrate	5.0	12	15
Riffle	5.0	14.4	16
Bank stability (right and left)	5.3	10.8	14

Characteristics of moderate to high quality habitat Mountain streams are (Figure 1):

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

Figure 1. Instream habitats composed of boulder, cobble, gravel, sticks, leafpacks, snags, logs, root mats (A, B), and wide riparian zones with good tree canopy (A, B), South Shoal Creek, SR 1314, Cherokee County.

Characteristics of low to poor quality habitat are (Figure 2):

- substrates of primarily sand and silt with instream bar development;
- an absence of riffles; if present, they are usually caused by embedded, coarse woody debris;
- narrow and sparsely vegetated riparian zones offering little or no stream shading; and
- deeply entrenched channel with unstable, vertical, and sparsely vegetated banks.

Figure 2. Poor habitats with sandy substrates, few riffles, and few chutes (A), and unstable banks, and poorly vegetated riparian zones (B), Persimmon Creek, SR 1127, Cherokee County.

Habitat and NCIBI relationships

The two fish communities that rated Good had habitats of moderate to high quality (Table 4), while Peachtree Creek rated Excellent where habitats were of slightly lower quality (habitat score = 58). The fish communities that rated Good-Fair were found where habitats were of moderate to high quality, except for Little Brasstown Creek. The fish community that rated Fair (Martin Creek) was found where habitats

were of moderate to high quality, and the fish community that rated Poor (Persimmon Creek) had the lowest habitat score. The Not Rated trout streams were found where habitats were of the highest quality (habitat scores = 85 – 96). More than half of the ratable streams in the 2004 fish community assessment are rated Good-Fair or better, even though there were substantial habitat problems stemming from long-term nonpoint erosion, sedimentation, bank instability, and narrow riparian corridors.

Table 4. NCIBI ratings and habitat quality for 13 streams in Hiwassee River basin, 2004.[1]

NCIBI Rating	Waterbodies with Low to Poor Quality Habitat (Score < 65)	Waterbodies with Moderate to High Quality Habitat (Score ≥ 65)
Excellent	Peachtree Cr	
Good		Vengeance Cr, Hanging Dog Cr
Good-Fair	Little Brasstown Cr	Shooting Cr, Brasstown Cr, Taylor Cr
Fair		Martin Cr
Poor	Persimmon Cr	
Not Rated		Tusquitee Cr, Fires Cr, Valley R., South Shoal Cr

[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.

Appendix F-2. Fish community sampling methods and criteria.

In 2004, fish community assessments were performed at 13 sites in the basin. The drainage areas of the assessed watersheds ranged from 5.7 to 37.3 square miles. None of these sites had ever been sampled before by the Division. Four of these sites (Tusquitee, Fires, Martin, and South Shoal Creeks) were selected as possible candidates for regional reference sites.

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. In 2004, staff from the Wildlife Resources Commission and interns from North Carolina State University assisted the Biological Assessment Unit staff with fish collection. After collection, all readily identifiable fish were examined for diseases, sores, lesions, fin damage, and 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 lab for identification, examination and total length measurement. Detailed descriptions of the sampling methods can be found at: http://www.esb.enr.state.nc.us/BAU.html. Raw data for the fish community monitoring program can be found at: http://www.esb.enr.state.nc.us/NCIBI.htm.

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, may 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 North Carolina 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 indicates 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.

For the Hiwassee River basin, the assessment of biological integrity using the North Carolina Index of Biotic Integrity (NCIBI) is provided by the cumulative assessment of 10 parameters or metrics. 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 reference 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 10 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 (Tables 1 – 4). To qualify as a reference site, the site had to satisfy all seven criteria in the order listed in Table 1. 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 1. Reference site selection hierarchy. A watershed-based approach for mountain 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	Width of the riparian zone along both banks is ≥ 6m
Exception 1	If the site satisfied Criteria 1 - 6, except one of the two riparian widths was less than 6 m, 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 2. Revised scores and classes for evaluating the fish community of a wadeable stream using the North Carolina Index of Biotic Integrity in the French Broad, Hiwassee, Little Tennessee, New and Watauga River basins.

NCIBI Scores	Integrity Class
58 or 60	Excellent
48, 50, 52, 54, or 56	Good
40, 42, 44, or 46	Good-Fair
34, 36, or 38	Fair
≤ 32	Poor

Criteria and ratings applicable only to wadeable streams in the Hiwassee River basin are the same as those for the Little Tennessee, French Broad, New, and Watauga River Basins. Metrics and ratings should not be applied to non-wadeable streams and trout streams in each of these basins.

Table 3. Fish community sites selected as possible regional reference sites in the Hiwassee River basin.

Subbasin/Waterbody	Station	County	Date
Tusquitee Cr[1]	SR 1330	Clay	6/15/2004
Fires Cr[1]	SR 1300	Clay	6/15/2004
Martin Cr	SR 1558	Cherokee	6/17/2004
South Shoal Cr[1]	SR 1314	Cherokee	6/16/2004

[1]To be used for future trout stream ratings.

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).

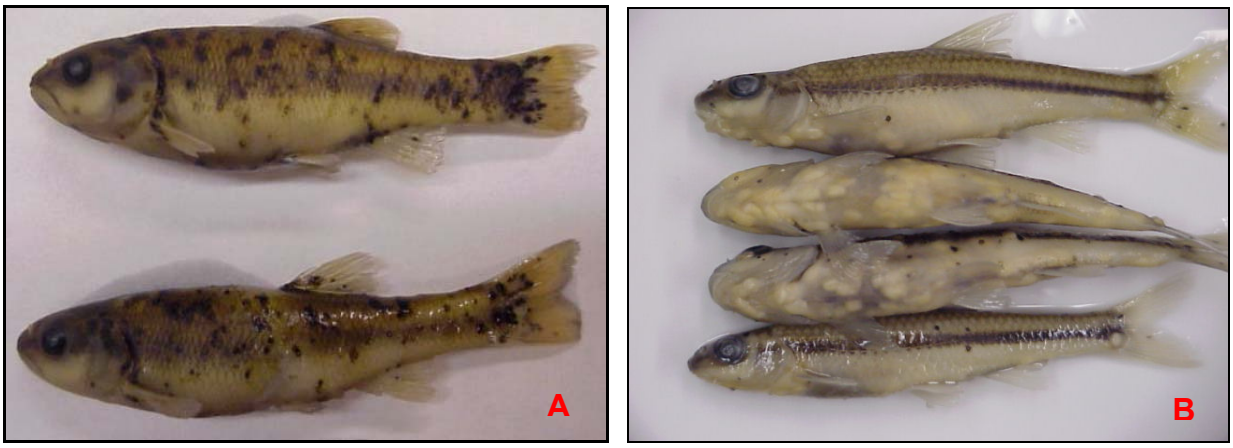


Figure 1. Heavy infestation of blackspot disease in creek chub (A) and yellow grub in bigeye chub (B).

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). These diseases are not considered in the NCIBI because they are widespread, affecting fish in all types of streams. Blackspot was noted in Shooting and Peachtree Creeks. Species affected included central stoneroller, river chub and mirror shiner.

Other diseases observed in 2004 included (Figure 2):

- "Popeye" or exophthalmos in two bluegill from Martin Creek. This disease can be caused by bacterial and viral infections as well as nematode infections;
- Scoliosis in one warpaint shiner from Vengeance Creek.

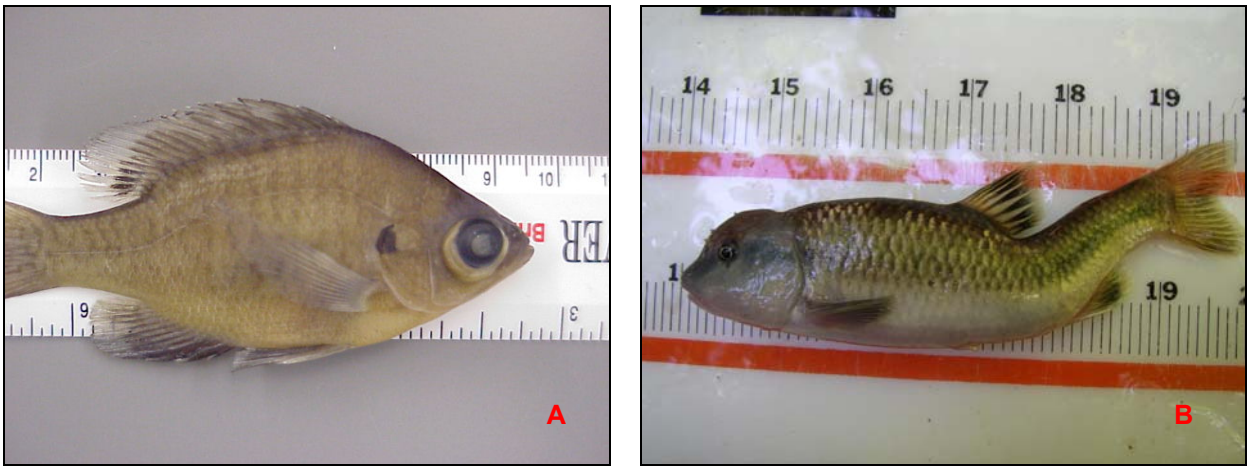


Figure 2. **Popeye caused by nematode infection in bluegill (A), and scoliosis in bluehead chub (B).**

Table 4. Scoring criteria for the NCIBI for wadeable streams in the Western and Northern Mountains of the French Broad (including the Pigeon River), Hiwassee, Little Tennessee, New, and Watauga River basins with watersheds ranging between 3.1 and 161 mi^2.

No.	Metric		Score
1	**No. of species**		
	≥ 16 species		5
	12-15 species		3
	< 12 species		1
2	**No. of fish**		
	320-1,000 fish		5
	205-319 fish		3
	< 205 fish		1
	> 1,000 fish		3
3	**No. of species of darters**		
	French Broad & Little Tennessee River Basins	New River, Pigeon River, Watauga[1], & Hiwassee River Basins	
	≥ 4 species	≥ 3 species	5
	2 or 3 species	1 or 2 species	3
	0 or 1 species	0 species	1
4	**No. of species of rock bass, smallmouth bass, and trout**		
	≥ 2 species		5
	1 species		3
	0 species		1
5	**No. of species of cyprinids**		
	All basins, except Pigeon River Basin	Pigeon River Basin	
	≥ 8 species	≥ 6 species	5
	6 or 7 species	4 or 5 species	3
	≤ 5 species	≤ 3	1
6	**No. of intolerant species**		
	All basins, except New River Basin	New River Basin	
	≥ 3 species	≥ 5 species	5
	2 species	3 or 4 species	3
	0 or 1 species	0, 1, or 2 species	1
7	**Percentage of tolerant individuals**		
	≤ 2%		5
	2-10%		3
	> 10%		1
8	**Percentage of omnivorous + herbivorous individuals**		
	10-36%		5
	37-50%		3
	> 50%		1
	< 10%		1
9	**Percentage of insectivorous individuals**		
	55-85%		5
	40-54%		3
	< 40%		1
	> 85%		1
12	**Percentage of species with multiple age groups**		
	≥ 65% of all species have multiple age groups		5
	45-64% all species have multiple age groups		3
	< 45% all species have multiple age groups		1

[1]Tentative for the Watauga River basin; also includes *Cottus bairdii* (mottled sculpin) and *Noturus insignis* (margined madtom). The Watauga River basin is the only basin in North Carolina where these three benthic, insectivorous groups (darters, mottled sculpin, and margined madtom) are sympatric. Recently (in 2001), *N. insignis* was found in the Toxaway River (Savannah River basin) in North Carolina.

Table 5. Tolerance ratings and adult trophic guild assignments for fish in the Hiwassee River basin. Species collected in 2004 are highlighted in blue.

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Petromyzontidae	**lampreys**		
Ichthyomyzon greeleyi	mountain brook lamprey	Intermediate	Non-feeding
Clupeidae	**herrings**		
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 (smoky dace)	Intermediate	Insectivore
Cyprinella galactura	whitetail shiner	Intermediate	Insectivore
C. spiloptera	spotfin shiner	Intermediate	Insectivore
Cyprinus carpio	common carp	Tolerant	Omnivore
Erimystax insignis	blotched chub	Intermediate	Omnivore
Hybopsis amblops	bigeye chub	Intermediate	Insectivore
Luxilus coccogenis	warpaint shiner	Intermediate	Insectivore
Nocomis micropogon	river chub	Intermediate	Omnivore
Notemigonus crysoleucas	golden shiner	Tolerant	Omnivore
Notropis leuciodus	Tennessee shiner	Intermediate	Insectivore
N. micropteryx	highland shiner	Intolerant	Insectivore
N. photogenis	silver shiner	Intolerant	Insectivore
N. spectrunculus	mirror shiner	Intermediate	Insectivore
N. telescopus	telescope shiner	Intolerant	Insectivore
Pimephales notatus	bluntnose minnow	Tolerant	Omnivore
Rhinichthys. cataractae	longnose dace	Intermediate	Insectivore
R. obtusus	western blacknose dace	Intermediate	Insectivore
Semotilus atromaculatus	creek chub	Tolerant	Insectivore
Catostomidae	**suckers**		
Carpiodes velifer complex	highfin carpsucker	Intermediate	Insectivore
Catostomus commersonii	white sucker	Tolerant	Omnivore
Hypentelium nigricans	northern hog sucker	Intermediate	Insectivore
Moxostoma anisurum	silver redhorse	Intermediate	Insectivore
M. carinatum	river redhorse	Intermediate	Insectivore
M. duquesnei	black redhorse	Intermediate	Insectivore
M. erythrurum	golden redhorse	Intermediate	Insectivore
M. sp. cf. *macrolepidotum*	sicklefin redhorse	Intermediate	Insectivore
M. sp. cf. *macrolepidotum*	Smallmouth Redhorse	Intermediate	Insectivore
Ictaluridae	**North American catfishes**		
Ameiurus natalis	yellow bullhead	Tolerant	Omnivore
A. nebulosus	brown bullhead	Tolerant	Omnivore
Ictalurus punctatus	channel catfish	Intermediate	Omnivore
Pylodictis olivaris	flathead catfish	Intermediate	Piscivore
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
Cottidae	**sculpins**		
Cottus bairdii	mottled sculpin	Intermediate	Insectivore
Moronidae	**temperate basses**		
Morone chrysops	white bass	Intermediate	Piscivore

Table 5 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Centrarchidae	**sunfishes**		
Ambloplites cavifrons	Roanoke bass	Intermediate	Piscivore
A. rupestris	rock bass	Intolerant	Piscivore
Lepomis auritus	redbreast sunfish	Tolerant	Insectivore
L. cyanellus	green sunfish	Tolerant	Insectivore
L. gulosus	warmouth	Intermediate	Insectivore
L. macochirus	bluegill	Intermediate	Insectivore
L. microlophus	redear sunfish	Intermediate	Insectivore
Micropterus dolomieu	smallmouth bass	Intolerant	Piscivore
M. punctulatus	spotted bass	Intermediate	Piscivore
M. salmoides	largemouth bass	Intermediate	Piscivore
Pomoxis annularis	white crappie	Intermediate	Piscivore
P. nigromaculatus	black crappie	Intermediate	Piscivore
Percidae	**perches**		
Etheostoma blennioides	greenside darter	Intermediate	Insectivore
E. rufilineatum	redline darter	Intermediate	Insectivore
E. zonale	banded darter	Intermediate	Insectivore
Perca flavescens	yellow perch	Intermediate	Piscivore
Percina aurantiaca	tangerine darter	Intolerant	Insectivore
Percina evides	gilt darter	Intolerant	Insectivore
P. squamata	olive darter	Intolerant	Insectivore
Sander canadensis	sauger	Intermediate	Piscivore
S. vitreus	walleye	Intermediate	Piscivore

Appendix F-3. Fish community data collected from the Hiwassee River basin, 2004.

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
040501						
Shooting Cr	SR 1340	Clay	1-5	06/14/04	40	Good-Fair
Tusquittee Cr	SR 1330	Clay	1-21-(0.5)	06/15/04	---	Not Rated
Fires Cr	SR 1300	Clay	1-27-(5.5)	06/15/04	---	Not Rated
Brasstown Cr	SR 1111	Clay	1-42	06/14/04	46	Good-Fair
Little Brasstown Cr	SR 1565	Cherokee	1-42-11	06/17/04	44	Good-Fair
040502						
Peachtree Cr	US 64	Cherokee	1-44	06/15/04	58	Excellent
Martin Cr	SR 1558	Cherokee	1-49	06/17/04	38	Fair
Valley R	SR 1409	Cherokee	1-52	06/18/04	---	Not Rated
Taylor Cr	SR 1515	Cherokee	1-52-39	06/18/04	44	Good-Fair
Vengeance Cr	NC 141 / SR 1520	Cherokee	1-52-45	06/17/04	56	Good
Hanging Dog Cr	off SR 1342	Cherokee	1-57	06/16/04	56	Good
Persimmon Cr	SR 1127	Cherokee	1-63	06/16/04	20	Poor
S Shoal Cr	SR 1314	Cherokee	1-77	06/16/04	---	Not Rated

Appendix F-4. Fish community metric values from 13 wadeable streams in the Hiwassee River basinwide monitoring program, 2004.[1]

Subbasin Waterbody	Location	County	d.a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. RST	No. Sp. Cyprinids	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% MA
040501														
Shooting Cr	SR 1340	Clay	22.5	06/14/04	16	430	2	1	3	2	1	7	85	56
Tusquittee Cr	SR 1330	Clay	22.8	06/15/04	6	432	0	1	3	1	0	0	97	67
Fires Cr	SR 1300	Clay	23	06/15/04	11	395	1	2	5	3	4	17	81	64
Brasstown Cr	SR 1111	Clay	37.3	06/14/04	18	497	4	1	7	2	0	12	87	61
Little Brasstown Cr	SR 1565	Cherokee	9.1	06/17/04	20	195	3	1	9	2	24	14	78	55
040502														
Peachtree Cr	US 64	Cherokee	18.4	06/15/04	22	535	4	2	8	3	2	11	85	64
Martin Cr	SR 1558	Cherokee	9	06/17/04	19	288	4	1	7	3	4	7	91	63
Valley R	SR 1409	Cherokee	16.8	06/18/04	11	558	2	2	4	2	2	10	88	82
Taylor Cr	SR 1515	Cherokee	5.7	06/18/04	15	469	3	2	7	2	14	11	87	67
Vengeance Cr	NC 141	Cherokee	7.2	06/17/04	18	1013	2	2	10	3	2	16	83	72
Hanging Dog Cr	off SR 1342	Cherokee	21.7	06/16/04	15	574	4	2	6	3	1	14	85	73
Persimmon Cr	SR 1127	Cherokee	12	06/16/04	11	199	1	0	3	0	30	6	86	73
S Shoal Cr	SR 1314	Cherokee	13	06/16/04	3	112	0	1	1	1	12	0	100	100

[1]Abbreviations are d.a. = drainage area, No. = number, Sp. = species, RST = rockbass, smallmouth bass, and trout, Intol. = intolerants, Omni. + Herb. = omnivores+herbivores, Insect. = insectivores, MA = species with multiple age groups.

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

Based on Menhinick (1991), TVA's data, NC DWQ's data, and data from other researchers, 64 species have been collected from the Hiwassee River basin in North Carolina (Table 5 in Appendix F-2). The known species assemblage includes one lamprey species, three species of herrings, 20 species of carps and minnows, nine species of suckers, four species of North American catfishes, one pike species, three species of trout, one sculpin species, one bass species, 12 species of sunfishes, and nine species of perches. At least 17 of the 64 species (about 27%) are exotics that were introduced either as sportfish, baitfish or for unknown reasons. All streams sampled in the 2004 basinwide assessment have at least one exotic species.

In 2004, 32 of the 64 known species were collected during the NC DWQ's fish community monitoring program. The most common species collected were the mottled sculpin (collected at all sites) and the central stoneroller (collected at all but one site). The most abundant fish species collected was the mottled sculpin, which represented about 50% of all the fish collected in 2004.

Five of the 64 species found in the Hiwassee River basin have been given special protection status by the United States Department of the interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337) (LeGrand, *et al*., 2004; Menhinick and Braswell, 1997) (Table 1). Additional information on these five species may be found in Jenkins and Burkhead (1993), Menhinick and Braswell (1997) and Rhode et al., (1998). In 2004, only one of the five species (smoky dace) was collected as part of the NC DWQ's fish community monitoring program. The smoky dace was collected from Taylor, and Vengeance Creeks.

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

Species	Common Name	State or Federal Status	State Rank[1]
Clinostomus funduloides ssp 1	smoky dace	Federal - Special concern	S2
Erimystax insignis	blotched chub	Federal - Special concern	S3
Moxostoma sp. cf. macrolepidotum	sicklefin redhorse	Federal - Special concern	S2
Percina squamata	olive darter	Federal - Special concern	S2
Sander canadensis	sauger	State - Reported (not documented)	S2

[1]S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; S3 = rare or uncommon in North Carolina (LeGrand *et al*. 2004).

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

- mountain brook lamprey – Shooting, Tusquitee, Fires, and Brasstown Creeks (Clay County), Valley River, Little Brasstown, Peachtree, Martin, Taylor, Vengeance, and Persimmon Creeks (Cherokee County).
- yellow bullhead – Shooting Creek (Clay County).
- brown bullhead -- Shooting Creek (Clay County).

Appendix F-6. Water quality at fish community sites in the Hiwassee River basin, 2004.

In 2004, water quality data were collected at every site during fish community assessments (Table 1). Conductivity (specific conductance) ranged from 13 to 50 µmhos/cm at Fires and Martin Creeks, respectively (Figure 1). Compared to most other sites, the slight elevation in conductivity in Martin and Little Brasstown Creeks reflected the upstream landuse practices.

All dissolved oxygen concentrations were greater than the water quality standard of 5 mg/L. Dissolved oxygen saturation ranged from 84% at Little Brasstown Creek shortly after sunrise to 97% at South Shoal Creek during the late afternoon hours. Nine of the 13 pH measurements could not be taken because of a malfunctioning pH meter. Of the four pH measurements taken at Shooting, Fires, Brasstown, and Peachtree Creeks, all met the water quality standard for non-swamp waters with a reading of 6 s.u.

Table 1. Water quality measurements at 13 fish community sites in the Hiwassee River basin, 2004.

Subbasin/ Waterbody	Location	COUNTY	Date	Temperature (°C)	Specific Conductance (µmhos/cm)	Dissolved Oxygen (mg/L)	Saturation (%)	pH (s.u.)
040501								
Shooting Cr	SR 1340	Clay	6/14/04	19.4	29	8.6	93.5	6
Tusquittee Cr	SR 1330	Clay	6/15/04	18	15	8.6	90.9	-
Fires Cr	SR 1300	Clay	6/15/04	18.9	13	8.9	95.8	6
Brasstown Cr	SR 1111	Clay	6/14/04	21.8	40	8.2	93.5	6
L Brasstown Cr	SR 1565	Cherokee	6/17/04	19.3	46	7.7	83.5	-
040502								
Peachtree Cr	US 64	Cherokee	6/15/04	21.1	39	7.9	88.8	6
Martin Cr	SR 1558	Cherokee	6/17/04	21	50	7.6	85.3	-
Valley R	SR 1409	Cherokee	6/18/04	19.7	32	8.1	88.6	-
Taylor Cr	SR 1515	Cherokee	6/18/04	19.1	25	8.4	90.8	-
Vengeance Cr	NC 141	Cherokee	6/17/04	21.5	27	8.3	94.0	-
Hanging Dog Cr	SR 1342	Cherokee	6/16/04	17.9	18	9.1	96.0	-
Persimmon Cr	SR 1127, 1st bridge	Cherokee	6/16/04	19.9	26	8.7	95.5	-
S Shoal Cr	SR 1314	Cherokee	6/16/04	19.7	20	8.9	97.3	-

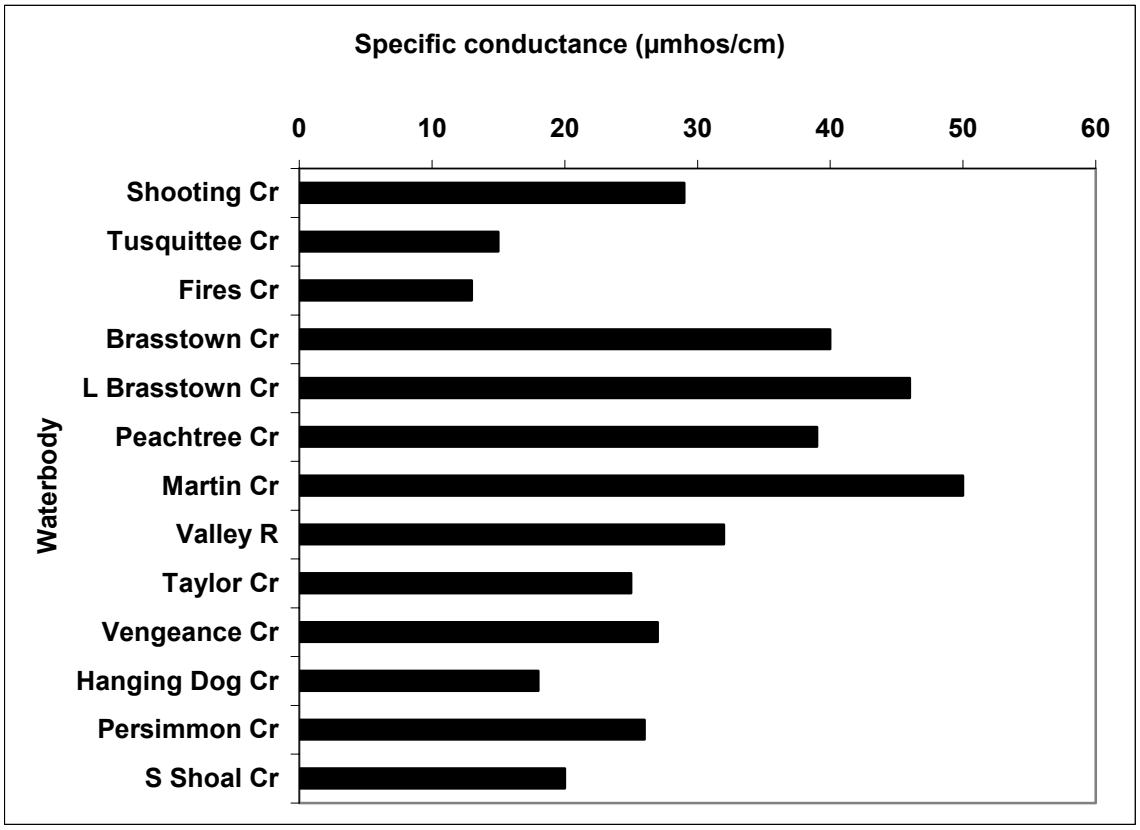


Figure 1. Specific conductance at 13 fish community sites in the Hiwassee River basin, 2004.

LAKE & RESERVOIR ASSESSMENTS – Hiwassee River Basin

Chatuge Lake – Clay County

Assessment Overview

Three lakes were sampled in the Hiwassee River Basin during 2004 –Chatuge, Hiwassee and Appalachia Lakes. These three water bodies are all oligotrophic with good water clarity.

Subbasin 040501

Chatuge Lake was monitored by DWQ in June, July, and August of 2004. This lake is located on the Hiwassee River near the North Carolina/Georgia border. Low nutrient and chlorophyll a concentrations were found in all months indicating low biological productivity. The NCTSI scores calculated for this lake confirmed the low biological productivity and oligotrophic status of this lake. Water clarity was good in all months as evidenced by the Secchi disk readings (range = 2.4-5.4 meters). This water clarity was good despite the frequent rainfall that occurred in the summer of 2004. Secchi disk readings were highest on the August sampling trip.

The Tennessee Valley Authority (TVA) performed fecal coliform bacteria monitoring at seven locations in Chatuge Lake in the summer of 2004 as a part of a monitoring program targeting heavily used recreational areas throughout the Tennessee Valley. All geometric mean fecal coliform values found by TVA were low and well under the North Carolina water quality standard of 200/100 ml for five consecutive samples taken within a 30 day period (Rebecca Hallman, 2004; NCDENR-Division of Water Quality, August 1, 2004). TVA has also historically monitored Chatuge Lake to evaluate the reservoir's ecological health under a range of weather and flow conditions. The lakes monitored by TVA are rated as good, fair, or poor. Chatuge rated poor in all years from 1999 through 2003, except in 2001, when it rated fair. Prior to 1998, Chatuge rated good in most years. The unusual weather conditions have been a major factor in the fluctuating health scores. For further information

on the TVA ecological health rating of Chatuge Lake, please go to http://www.tva.gov/environment/ecohealth/chatuge.htm.

For further background information on Chatuge Lake (including sampling data), please go to the table found later in this section and http://www.esb.enr.state.nc.us/.

Subbasin 040502

Two lakes were monitored in this subbasin by DWQ in June, July, and August of 2004. Hiwassee Lake is a large reservoir located on the Hiwassee River, just upstream of Appalachia Lake. This reservoir had low biological productivity in the summer of 2004 as indicated by the low nutrient and chlorophyll a concentrations found. Some floating debris was noticed on the lake during the June sampling trip because of recent rains. Water clarity was good in the summer of 2004 (Secchi depth range of 1.8-3.5 meters) despite the frequent rainfall that occurred. The oligotrophic NCTSI scores calculated for data collected during the summer of 2004 correlated well with the good water clarity and low nutrient and chlorophyll a concentrations and indicated low biological productivity. Hiwassee Lake has consistently rated as oligotrophic since historical sampling was first performed by DWQ in 1981.

The Tennessee Valley Authority has historically monitored Hiwassee Reservoir to evaluate the reservoir's ecological health under a range of weather and flow conditions. The lakes monitored by TVA are rated as good, fair, or poor. Hiwassee Reservoir has consistently rated fair every year. Low dissolved oxygen levels at the forebay and poor ratings for bottom life consistently lower the reservoir's overall ecological health score. For further information on the TVA ecological health rating of Hiwassee Lake, please go to http://www.tva.gov/environment/ecohealth/hiwassee.htm.

Appalachia Lake is located on the Hiwassee River immediately downstream of the Hiwassee Lake dam. Low nutrient and chlorophyll a concentrations found in 2004 indicated a low potential for algal productivity. Water clarity was also good (range = 1.9-3.2 meters) despite frequent rainfall during the summer of 2004. The rainfall-influenced conditions were most notable on the June sampling trip when a large amount of floating debris and lower Secchi readings were found. The calculated NCTSI scores were in agreement with the low nutrient levels and good water clarity and indicated oligotrophic conditions throughout the summer of 2004. Appalachia Lake has consistently rated as oligotrophic since first monitored by DWQ in 1981.

The Tennessee Valley Authority has historically monitored Appalachia Lake to evaluate the reservoir's ecological health under a range of weather and flow conditions. The lakes monitored by TVA are rated as good, fair, or poor. Appalachia Lake rated good in 2003 (the last sampling year that the ecological health rating has been calculated). The reservoir's score has fluctuated between fair and good since historical monitoring has been performed. For further information on the TVA ecological health rating of Appalachia Lake, please go to http://www.tva.gov/environment/ecohealth/apalachia2.htm.

For further background information on these lakes (including sampling data), please go to http://www.esb.enr.state.nc.us/.

LAKES ASSESSMENT – HIWASSEE RIVER BASIN

Subbasin		***040501***	***040502***	***040502***
Waterbody		***Chatuge Lake***	***Hiwassee Lake***	***Appalachia Lake***
Classification		B	B, C	B,C
Trophic Status (NC TSI)		Oligotrophic	Oligotrophic	Oligotrophic
Mean Depth (meters)		11	46.8	18
Volume ($10^6 m^3$)		305	118.8	8.0
Watershed Area (mi^2)		187	968	1006
Sampling Dates		10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04
Number of Samples (click here to see data)		n =9	n = 15	n =9
Water Quality Standards				
Chlorophyll *a*	>10% above standard (N>9) = Y; exceeding 40 ug/L but not 10% of time = C	NE	N	NE
Dissolved Oxygen	Below standard >10% of samples (N>9)	NE	N	NE
pH	Below or above standard >10% of samples (N>9)	NE	N	NE
Turbidity	>10% above standard (N>9)	NE	N	NE
Temperature	Minor and infrequent excursions of temperature standards due to anthropogenic activity. No impairment of species evident. (N>9)	NE	N	NE
Metals (excluding copper, iron & zinc)	>10% above standard (N>9)	NS	NS	NS
Other Data				
% Saturation DO	>10% above >120%	N	N	N
Algae	Documented blooms during 2 or more sampling events in 1 year with historic blooms	N	N	N
Fish	Kills related to eutrophication	N	N	N
Chemically/ Biologically Treated	For algal or macrophyte control - either chemicals or biologically by fish, etc.	N	N	N
Aesthetics complaints	Documented sheens, discoloration, etc. - written complaint and follow-up by a state	N	N	N
TSI	Increase of 2 trophic levels from one 5-yr period to next	N	N	N
Historic DWQ Data	Conclusions from other reports (link to other reports)	N	N	N
AGPT	Algal Growth Potential Test 5-9 mg/L = C; 10 mg/L or more = P	NS	NS	NS
Macrophytes	Limiting access to public ramps, docks, swimming areas; reducing access by fish and other aquatic life to habitat	N	N	N
Taste and Odor	Public complaints = P; Potential based on algal spp = C	N	N	N
Sediments	Clogging intakes – dredging program necessary = P Public/agency complaints – visual	N	N	N

Note: C = of notable Concern or productive P= Problematic or highly productive
E = parameter is Exceeded, but in less than 10 percent of the measurements
N = Not a concern NS = No sample taken for this parameter
NE = Not exceeded but insufficient samples to rate as N

References:

Hallman, Rebecca L. September 16, 2004. 2004 TVA Bacteriological Data in North Carolina. Electronic mail message.

NCDENR-Division of Water Quality. August 1, 2004. Adminstrative Code Section: 15A NCAC 2B.0200. Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands of N.C. Environmental Management Commission, Raleigh, N.C.

Assessment Methodology

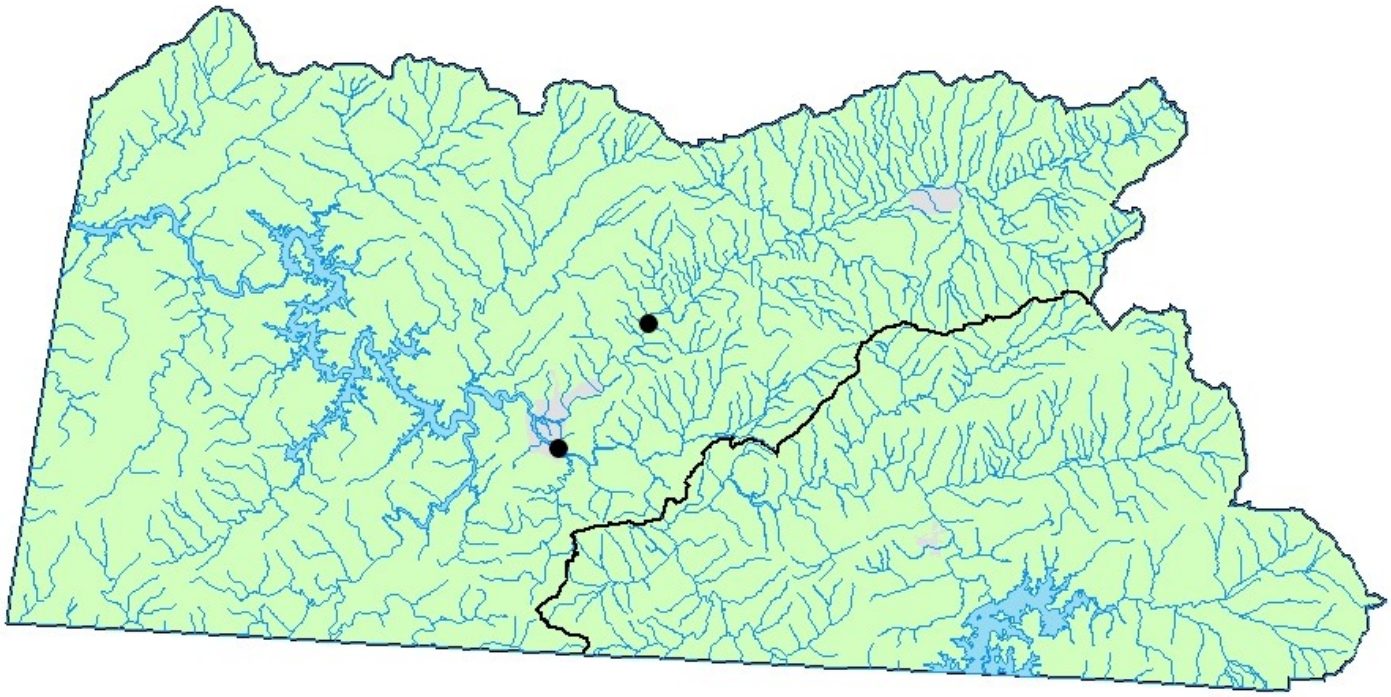
Like streams, lakes are classified for a variety of uses. Most of the lakes monitored as part of North Carolina's Ambient Lakes Monitoring Program are classified for recreation (B & SB) and water supply (WS-I through WS-V). The surface water quality numeric standard specifically associated with recreation is fecal coliform. For water supplies, there are 29 numeric standards based on consumption of water and fish. Narrative standards for B and WS classifications include aesthetics such as no odors and no untreated wastes. There are other numeric standards that also apply to lakes under protection of aquatic life and human health. These standards also apply to all other waters of the state and are listed under the Class C rules.

When possible, lake use support evaluations are made similar to free-flowing waters. Parameters with sufficient (10 or more observations), quality-assured, surface water quality data will be compared to surface water quality standards. However, for nutrient enrichment - one of the main causes of impacts to lakes and reservoirs, a more holistic or weight of evidence approach is necessary since nutrient impacts are not always reflected by the parameters sampled. For instance, some lakes have taste and odor problems associated with particular algal species, yet these lakes do not have chlorophyll a concentrations above 40 ug/L frequently enough to impair them based on the standard.

In addition to being moderated by biological factors, environmental factors such as climate, hydrology and morphology can impact whether nutrient loading results in lose of uses. Shorter retention times (less than 14 days) prevent excessive growth of algae even in the presence of elevated nutrients. Therefore, just measuring standard water quality parameters such as chlorophyll a and nutrients may not give an accurate picture of lake water quality. Where exceedances of surface water quality standards are not sufficient to impair a lake, the weight of evidence approach can take into consideration indicators and parameters not in the standards to allow a sounder determination of water quality.

The following sources of information are used in determining lake use support through the weight of evidence approach:

- Quantitative water quality parameters - dissolved oxygen, chlorophyll a, pH, etc.
- Algal bloom reports
- Fish kill reports
- Third party reports – citizens, water treatment plant operators, State agencies, etc.
    - Taste & odor
    - Sheens
    - Odd colors
    - Other aesthetic and safety considerations



Hiwassee River Basin
Ambient Monitoring System Report

September 1, 1999 through August 31, 2004

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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 evaluated 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 constructing lists 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, 1999 through August 31, 2004) chemical and physical measurements were obtained by DWQ from the two active stations (F2500000, Hiwassee River beside US 64 above Murphy, and F4000000, Valley River at US 74/19/129 at Tomotla) located in the basin.

In order to confidently 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 data on each station, reference the AMS Station Summary Sheets located in Appendix A.

All data were collected between September 1, 1999 and August 31, 2004. F4000000 had one SSE for Water Temperature. One 10 percent violation that was not an SSE occurred for turbidity.

The following table gives a summary of the problem areas located in the basin.

Table 1. Violations and Areas of Concern in the Hiwassee River Basin

Subbasin/ Station ID	Location	Class	Parameter/Evaluation Level	% Exceedance	% Confidence
2	***Hiawassee River (lower) and Valley River***				
F4000000	Valley River at US 74/19/129 at Tomotla	C Tr	Turbidity (>10)	12.2%	79%
			Water Temperature (>20)	20.4%	99%

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

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 action 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.

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 and an 's' indicates the parameter has a standard or action level.
[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.

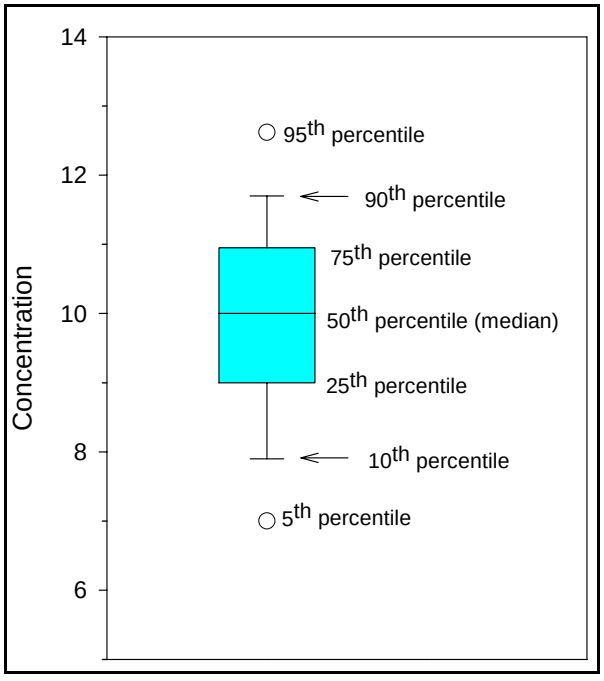


Figure 1. Explanation of box plots.

Table 3. Selected water quality 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[2]		250			
Chlorophyll *a* (corrected)	40[3]			15[3]		
Chromium, total	50					
Coliform, total (MFTCC/100 ml)[4]			50[3] (WS-I only)			
Coliform, fecal (MFFCC/100 ml)[5]		200[3]				
Copper, total	7[2]					
Dissolved oxygen (mg/L)	5.0[6,7]			6.0		[3, 7]
Hardness, total (mg/L)			100			
Iron	1,000[2]					
Lead	25[3]					
Manganese			200			
Mercury	0.012					
Nickel	88		25			
Nitrate nitrogen			10,000			
pH (units)	6.0 - 9.0[3, 7]					[3, 7]
Solids, total suspended (mg/L)					10 Trout, 20 other[8]	
Turbidity (NTU)	50, 25[3]			10[3]		
Zinc	50[2]					

[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. April 1, 2001).
[2]Action level.
[3]Refer to 2B.0211 for narrative description of limits.
[4]Membrane filter total coliform count per 100 ml of sample.
[5]Membrane filter fecal coliform count per 100 ml of sample.
[6]An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.
[7]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.
[8]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.

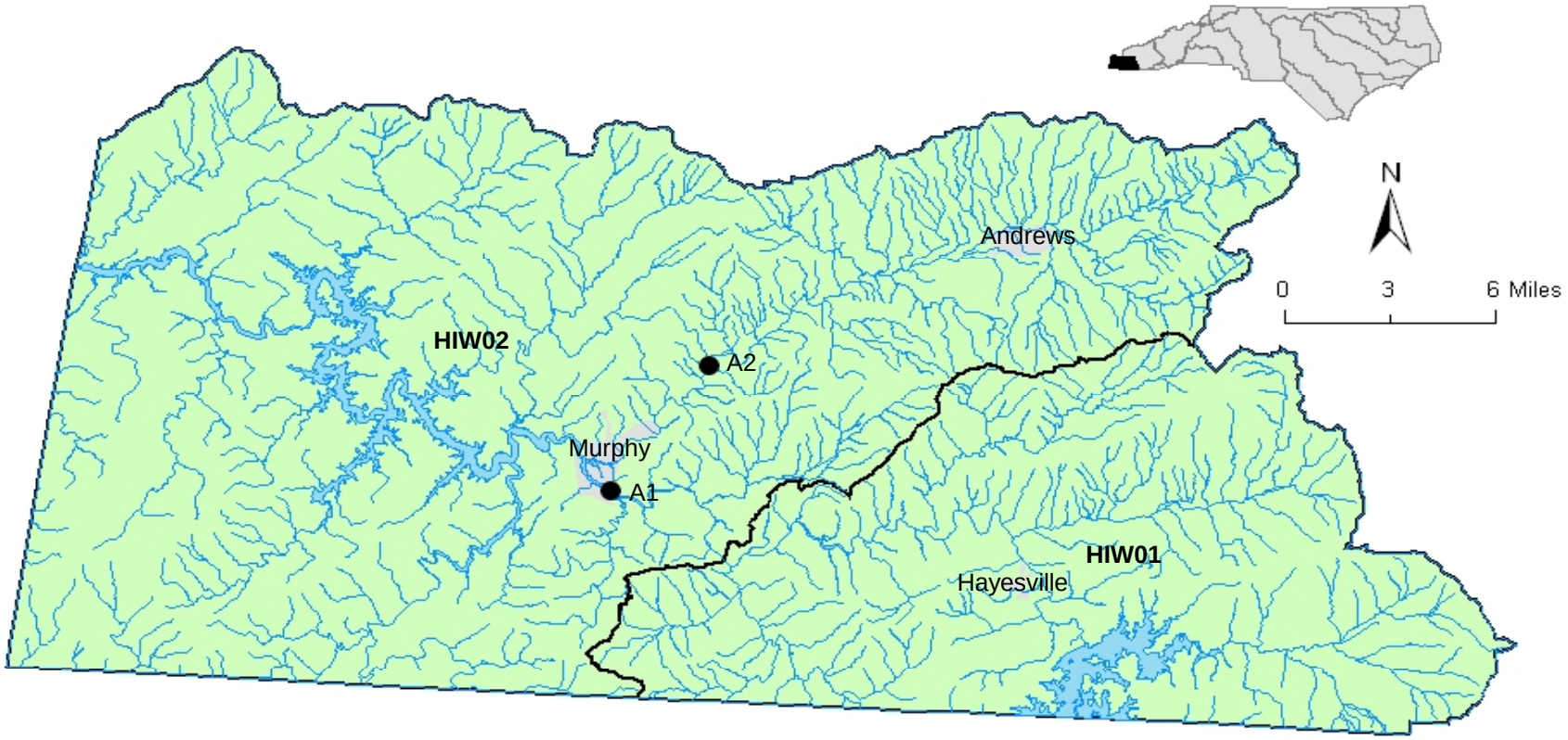


Figure 2. DWQ's Ambient Monitoring System within the Hiwassee River Basin.

Table 4. Monitoring stations in the Hiwassee River Basin, 1999 - 2004.

Subbasin/ Station ID	Location	Class	Lat.	Long.	County	Map ID
01	**Hiwassee River (upper)**					
	No Stations					
02	**Hiwassee River (lower) and Valley River**					
F2500000	Hiwassee River beside US 64 above Murphy	WS-V	35.0788	-84.0254	Cherokee	A1
F4000000	Valley River at US 74/19/129 at Tomotla	C Tr	35.1373	-83.9796	Cherokee	A2

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-detects) 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.

Analytical Considerations

Two 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).

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 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 action 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 most details on a station-by-station basis. They are included as an appendix to this report.

Use Support Assessment Considerations

1) The dissolved freshwater oxygen concentrations of 5.0 and 4.0 mg/L are presented as evaluation levels. Instantaneous concentrations of 4.0 mg/L or less 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" (15A NCAC 2B.0200).
2) Action levels (copper, iron, and zinc) are used primarily as evaluation guidelines because results include fractions that may have little effect on aquatic life. Where appropriate, follow-up toxicological work will need to be conducted before use support determination can be made for these parameters.

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.

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 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). According to a USGS study completed in 1992, North Carolina freshwater streams have a natural conductance range of 17-65 µmhos/cm (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 soils.

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 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.

Fecal Coliform 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 Hiwassee River Basin, the standard specified in Administrative Code 15A NCAC 02B.0211 (3)(e) (August 1, 2004) 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 strict 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.

Only fresh waters are present in the Hiwassee River basin. 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

Subbasin	Station	Class	Percentage Of Results That Exceeded The Evaluation Level Parameters With Less Than 10 Measurements Were Not Evaluated			
			Water Temperature	**Turbidity**	**Iron**	**Fecal Coliform**
1	Hiwassee River (Upper)					
No Stations						
2	Hiwassee River (Lower) and Valley River					
	F2500000	WS-V	0%	2%	9%	4%
	F4000000	C Tr	**<u>24%</u>**	**12%**	5%	19%

Notes:

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

<u>Underlined</u> entries indicate 95% confidence that site conditions truly exceed the evaluation level at least 10% of the time, with a minimum of 10 results required before determination.

WATER QUALITY PATTERNS IN THE HIWASSEE RIVER BASIN

Box and whisker plots, scatterplots, and maps were used to depict differences in a variety of water quality parameters. 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 than 10 data points for a given parameter were not included.

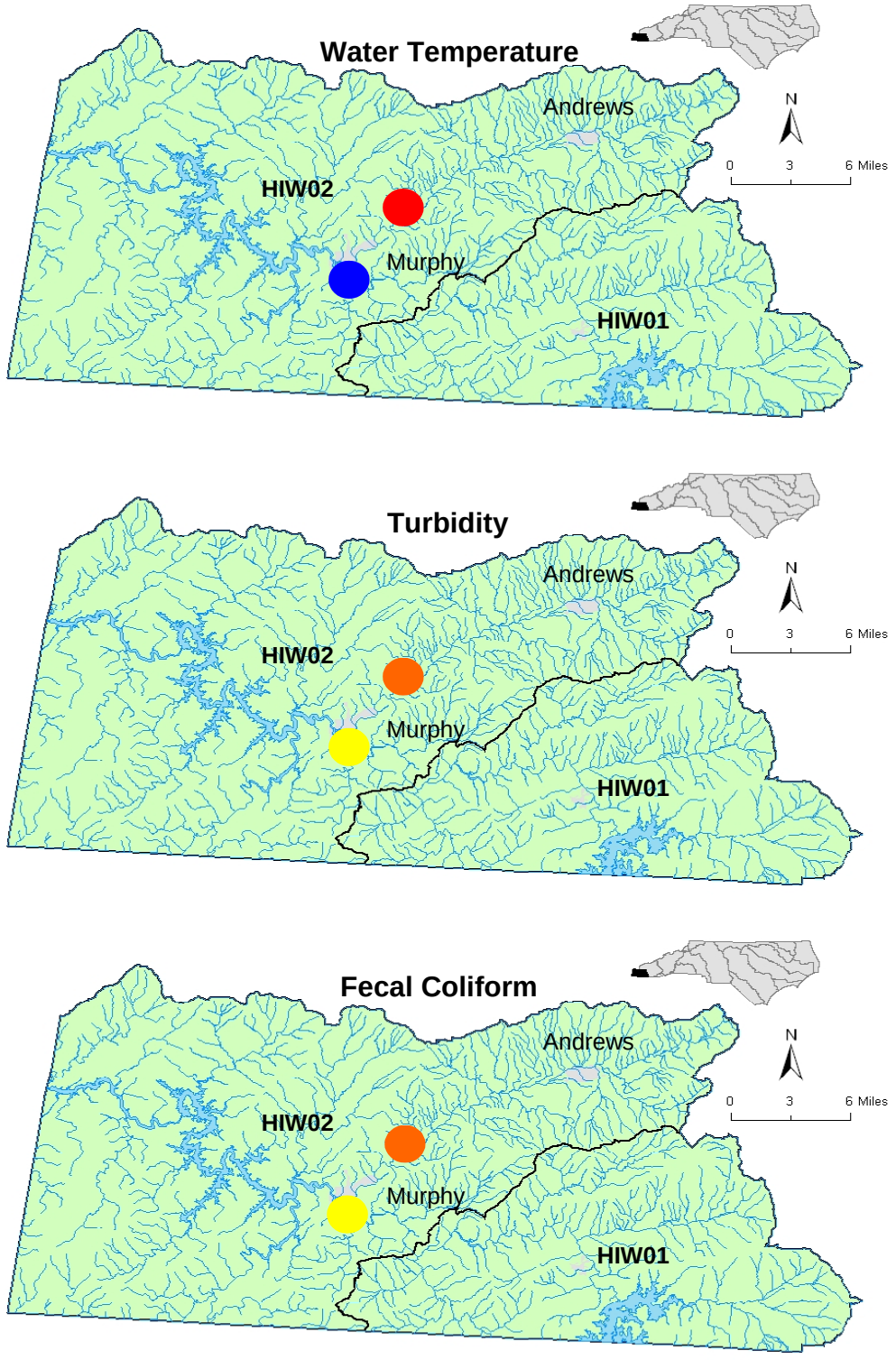
Regional Patterns

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.

One SSE was recorded in this basin, for water temperature. F4000000 is classified as trout waters, which are held to a very restrictive temperature standard of 20 degrees Celsius. The standard was violated 10 times out of 47 samples. Each of the violations was during the summer months. F4000000 also exceeded the turbidity standard six times, and the fecal coliform evaluation level (400 colonies per 100 ml) nine times, but these instances do not rise to the level of an SSE.

Trends over Time

No significant trends ($p < 0.05$) of interest were identified.



Note: Stations with no circle have no Evaluation Level or recorded less than 10 measurements for the given parameter.

Figure 3. Water Temperature, Turbidity, and Fecal Coliform in the Hiwassee River Basin

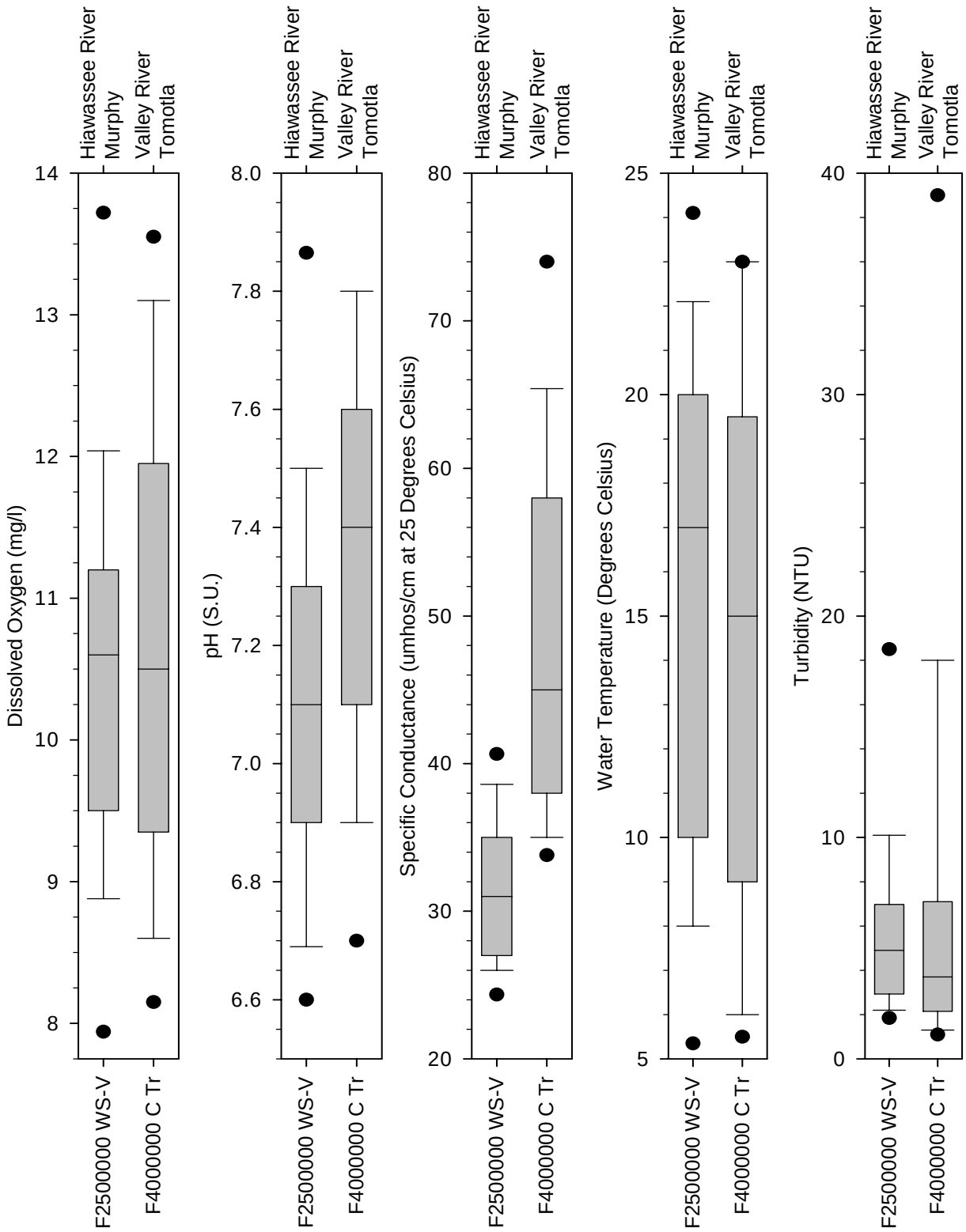


Figure 4. Box Plots for Dissolved Oxygen, pH, Specific Conductance, Water Temperature, and Turbidity in the Hiwassee River Basin

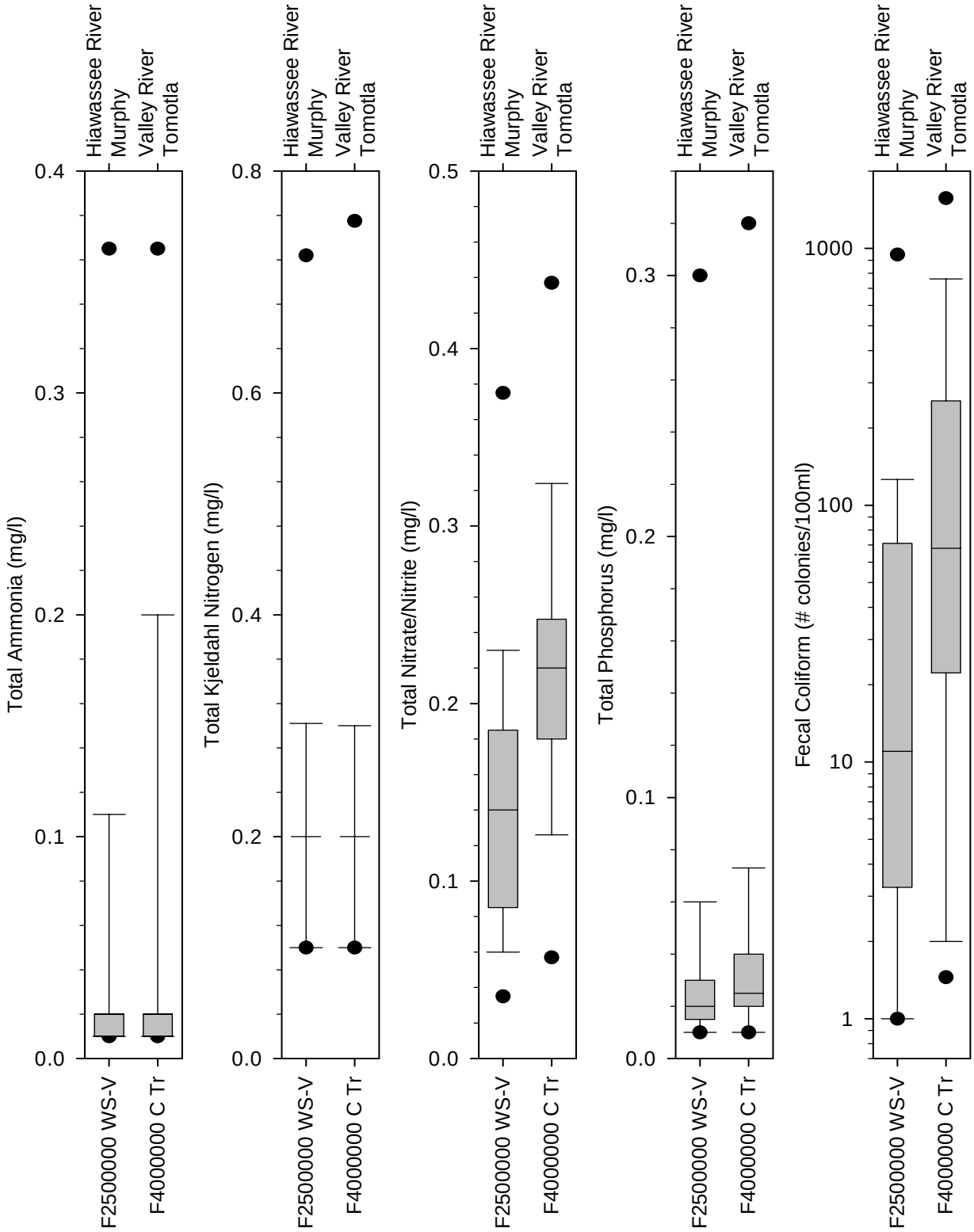


Figure 5. Box Plots for Total Ammonia, Total Kjeldahl Nitrogen, Total Nitrate/Nitrite, Total Phosphorus, and Fecal Coliform in the Hiwassee River Basin

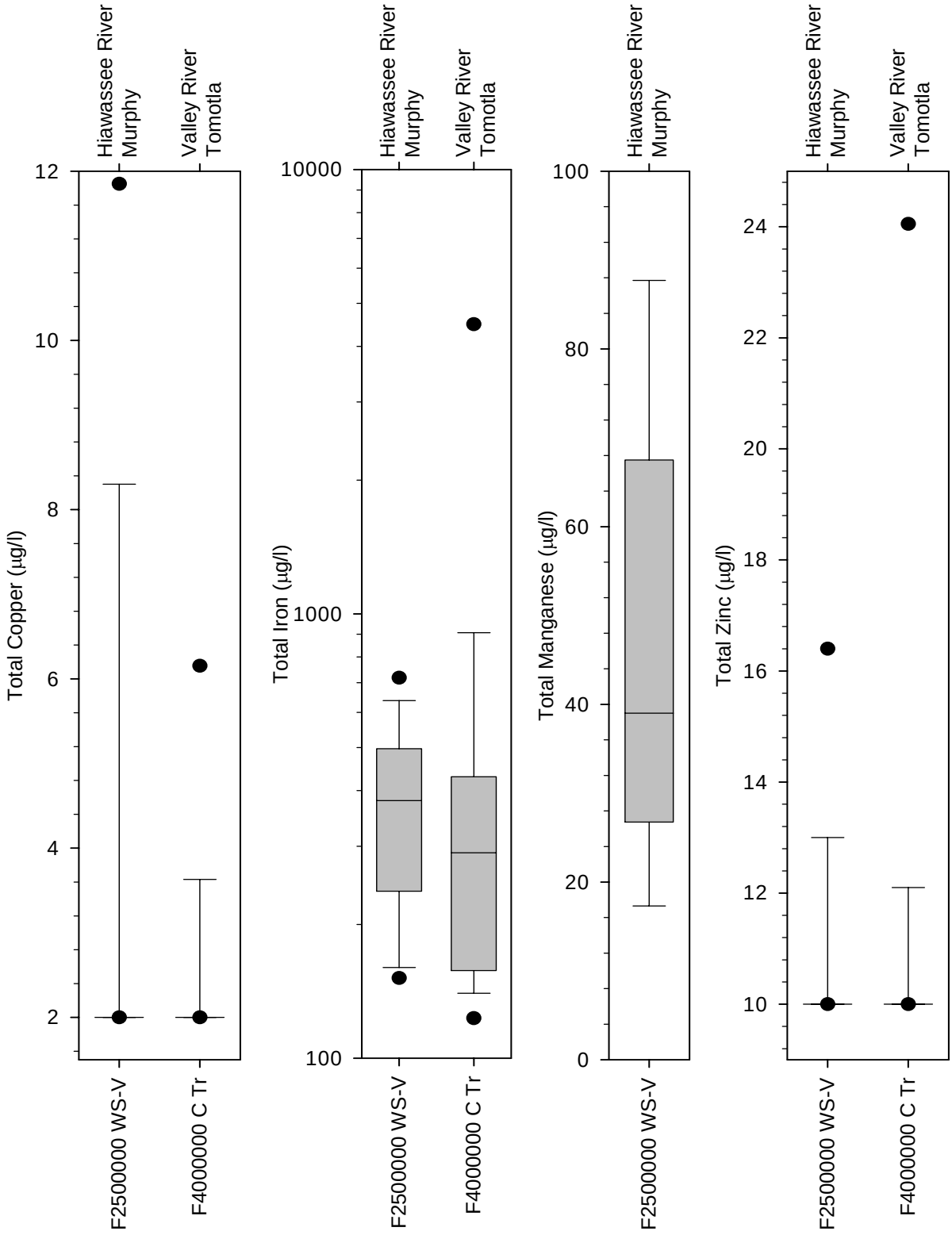


Figure 6. Box Plots for Total Copper, Total Iron, Total Manganese, and Total Zinc in the Hiwassee River Basin

Appendix A: AMS Station Summary Sheets

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: HIWASSEE RIV BESIDE US 64 ABOVE MURPHY
Station #: F2500000 **Subbasin:** HIW02
Latitude: 35.07878 **Longitude:** -84.02540 **Stream class:** WS-V
Agency: NCAMBNT **NC stream index:** 1-(43.7)

Time period: 10/28/1999 to 08/31/2004

	# result	# ND	Results not meeting EL	#	%	95%	Percentile Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	47	0	<4	0	0		7.9	8.9	9.5	10.6	11.2	12	14.7
	47	0	<5	0	0		7.9	8.9	9.5	10.6	11.2	12	14.7
pH (SU)	48	0	<6	0	0		6.4	6.7	6.9	7.1	7.3	7.5	8.5
	48	0	>9	0	0		6.4	6.7	6.9	7.1	7.3	7.5	8.5
Spec. conductance (umhos/cm at 25°C)	46	0	N/A				24	26	27	31	35	39	41
Water Temperature (°C)	48	0	>29	0	0		4	8	10	17	20	22.1	25
Other													
Chloride (mg/L)	6	1	>250	0	0		1	1	1	2	3	4	4
Hardness (mg/L as CaCO3)	10	0	>100	0	0		1	2	8	9	10	15	15
TSS (mg/L)	22	5	N/A				1	1	3	4	6	8	9
Turbidity (NTU)	48	0	>50	1	2.1		2	2	3	5	7	10	110
Nutrients (mg/L)													
NH3 as N	28	20	N/A				0.01	0.01	0.01	0.02	0.02	0.11	0.5
NO2 + NO3 as N	29	1	>10	0	0		0.03	0.06	0.09	0.14	0.19	0.23	0.5
TKN as N	27	14	N/A				0.1	0.1	0.2	0.2	0.2	0.3	1
Total Phosphorus	29	8	N/A				0.01	0.01	0.01	0.02	0.03	0.06	0.5
Metals (ug/L)													
Aluminum, total (Al)	22	0	N/A				51	57	90	125	252	448	490
Arsenic, total (As)	22	22	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	22	22	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	22	22	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	22	19	>7	2	9.1		2	2	2	2	2	8	12
Iron, total (Fe)	22	0	>1000	0	0		150	160	238	380	498	638	730
Lead, total (Pb)	22	22	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	12	0	>200	0	0		17	17	27	39	68	88	91
Mercury, total (Hg)	22	22	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	22	22	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	22	17	>50	0	0		10	10	10	10	10	13	17

Fecal Coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
48	16	2	4	

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
NCDENR, Division of Water
Basinwide Assessment

Location: VALLEY RIV AT US 74/19/129 AT TOMOTLA
Station #: F4000000 **Subbasin:** HIW02
Latitude: 35.13728 **Longitude:** -83.97960 **Stream class:** C Tr
Agency: NCAMBNT **NC stream index:** 1-52

Time period: 10/28/1999 to 08/31/2004

	# result	# ND	Results not meeting EL	#	%	95%	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	49	0	<6	0	0		8	8.6	9.3	10.5	11.9	13.1	14
pH (SU)	49	0	<6	0	0		6.4	6.9	7.1	7.4	7.6	7.8	8.1
	49	0	>9	0	0		6.4	6.9	7.1	7.4	7.6	7.8	8.1
Spec. conductance (umhos/cm at 25°C)	47	0	N/A				32	35	38	45	58	65	80
Water Temperature (°C)	49	0	>20	10	20.4	Yes	2	6	9	15	19.5	23	25
Other													
Chlorophyll A (ug/L)	1	0	>15	0	0		7	7	7	7	7	7	7
TSS (mg/L)	22	4	N/A				2	2	2	5	8	21	200
Turbidity (NTU)	49	0	>10	6	12.2	No	1	1	2	4	7	18	120
Nutrients (mg/L)													
NH3 as N	28	21	N/A				0.01	0.01	0.01	0.02	0.02	0.2	0.5
NO2 + NO3 as N	28	1	N/A				0.03	0.13	0.18	0.22	0.25	0.32	0.5
TKN as N	26	13	N/A				0.1	0.1	0.2	0.2	0.2	0.3	1
Total Phosphorus	28	4	N/A				0.01	0.01	0.02	0.02	0.04	0.07	0.5
Metals (ug/L)													
Aluminum, total (Al)	22	3	N/A				50	50	88	195	302	656	3800
Arsenic, total (As)	22	22	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	22	22	>0.4	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	22	22	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	22	19	>7	0	0		2	2	2	2	2	4	6
Iron, total (Fe)	22	0	>1000	1	4.5		120	140	158	290	430	907	5100
Lead, total (Pb)	22	22	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	22	22	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	22	22	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	22	19	>50	0	0		10	10	10	10	10	12	26

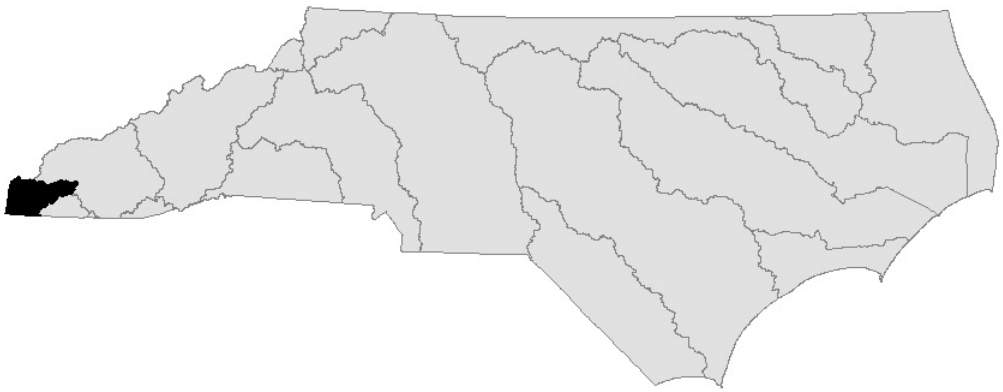
Fecal Coliform (#/100mL)

# results:	Geomean	# > 400:	% > 400:	95%:
48	66	9	19	

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

Hiwassee River Basin
Basinwide Assessment Report
Whole Effluent Toxicity Program

2000-2004



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 Hiwassee River Basin – 2000-2004

Two facility permits in the Hiwassee River basin currently require whole effluent toxicity (WET) monitoring (Figure 1 and Table 1). Both facility permits have a WET limit.

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

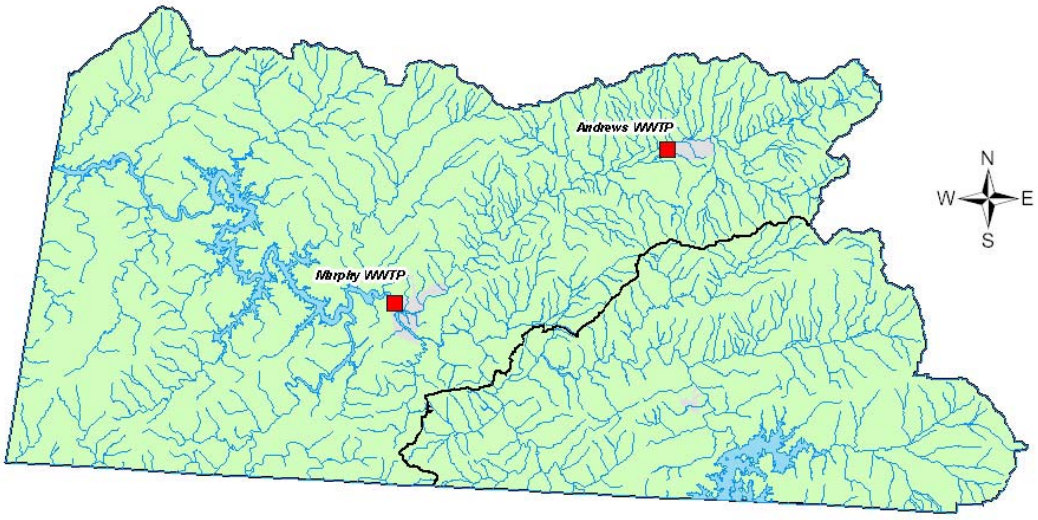


Table 1. Hiwassee River basin facilities required to conduct whole effluent toxicity testing

Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	7Q10 (cfs)
04-05-02						
Andrews WWTP	NC0020800/001	Valley R.	Cherokee	1.5	13.0	15.0
Murphy WWTP	NC0020940/001	Hiwassee R.	Cherokee	0.925	1.5	96.9

The relatively small number of facilities in this basin monitoring whole effluent toxicity increased slightly since 1987, the first year that monitoring was required. The compliance rate of those facilities has generally risen since the inception of the program. Since 1991 the compliance rate has stabilized in the range of 90-100% (Figure 1 and Table 2).

The Town of Andrews WWTP (Subbasin 02) has failed six WET tests from September 2000 through June 2003. In an inspection report DWQ personnel noted “marginal” operational conditions during this time, partially due to construction occurring at the facility. The facility has failed no compliance WET tests since July 2003.

Figure 2. NPDES facility whole effluent toxicity compliance in the Hiwassee River basin, 1990-2004. 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.

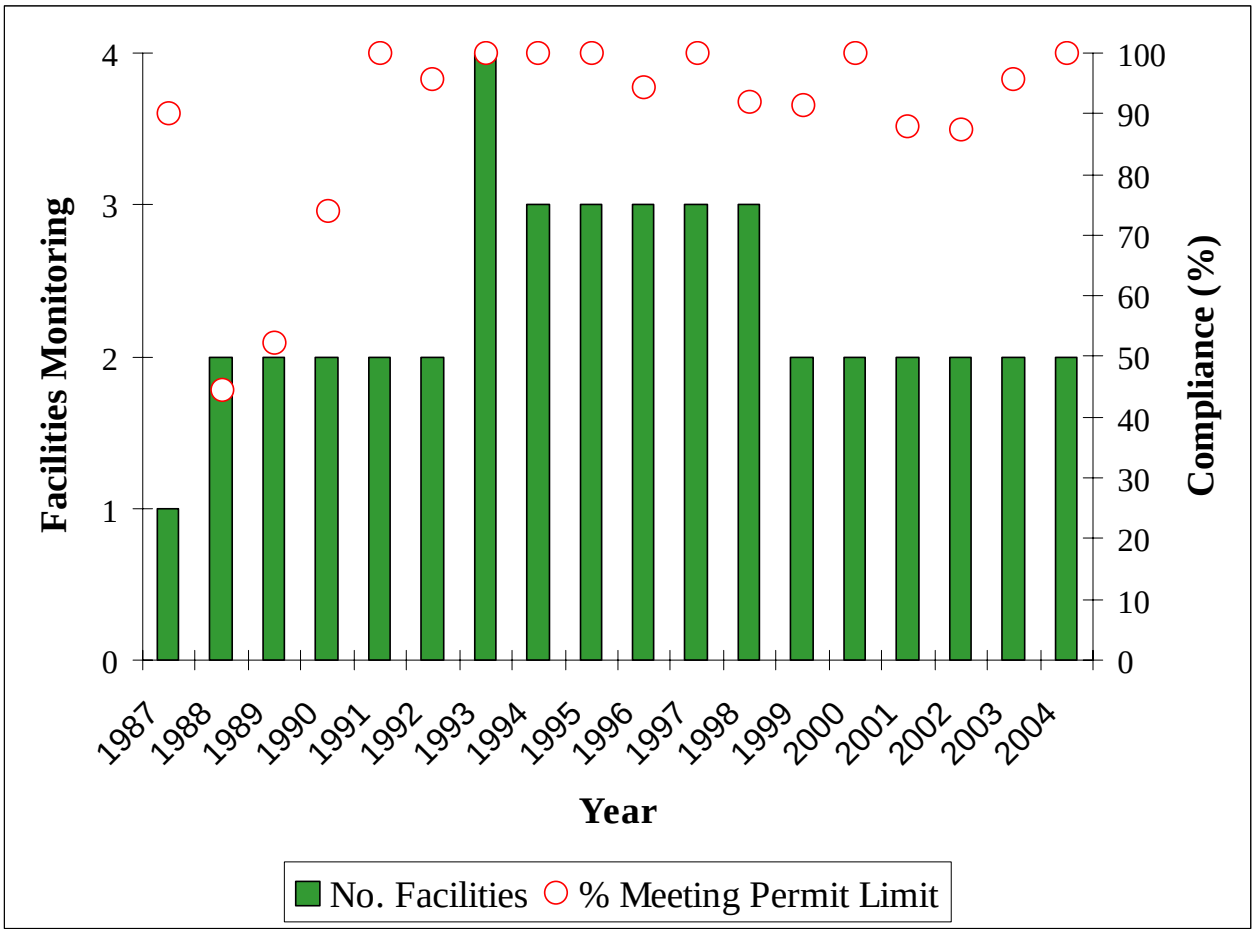


Table 2. Recent compliance record of facilities performing whole effluent toxicity testing in the Hiwassee River basin

Subbasin/Facility	NPDES Permit No.	2000- 2003 Passes	2000- 2003 Fails	2004 Passes	2004 Fails
04-05-02					
Andrews WWTP	NC0020800/001	20	6	4	0
Murphy WWTP	NC0020940/001	14	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.