# BASINWIDE ASSESSMENT REPORT

# HIWASSEE RIVER BASIN

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

January 2011

**This page was intentionally left blank**

## TABLE OF CONTENTS

Page

LIST OF APPENDICIES ..... 3

LIST OF TABLES ..... 4

LIST OF FIGURES ..... 4

INTRODUCTION TO PROGRAM METHODS ..... 5

BASIN DESCRIPTION ..... 6

HIWASSEE RIVER HUC 06020002 ..... 7

RIVER AND STREAM ASSESSMENT ..... 8

SPECIAL STUDIES ..... 9

GLOSSARY ..... 10

## LIST OF APPENDICIES

Appendix ..... Page

B-1 Summary of Benthic Macroinvertebrate Data, Sampling Methods, and Criteria ..... 12

F-1 Fish Community Sampling Methods and Criteria ..... 18

F-2 A Summary of Fish Community Assessment Data ..... 23

F-3 Fish Community Data Collected From the Hiwassee River Basin, 2004 and 2009 ..... 26

F-4 Fish Community Metric Values From 13 Wadeable Streams in the Hiwassee River Basinwide Monitoring Program, 2009 ..... 27

F-5 Fish Distributional Records for the Hiwassee River Basin ..... 28

F-6 Habitat Evaluations and Stream and Riparian Habitats at 13 Fish Community Monitoring Sites in the Hiwassee River Basin, 2009 ..... 30

F-7 Water Quality at 13 Fish Community Sites in the Hiwassee River Basin, 2009 ..... 33

S -1 Benthic Macroinvertebrate and Fish Community Site Summaries ..... Attachment

## LIST OF TABLES


Table Page

1. Waterbodies monitored in HUC 06020002 (2004 and 2009) ..... 8
2. Rare Invertebrate Taxa Collected ..... 13
3. Benthic Macroinvertebrate Data (1987-2009) ..... 15
4. Fish Reference Site Selection Hierarchy ..... 19
5. Regional Fish Community Reference Sites ..... 19
6. Fish Community Scoring Criteria ..... 20
7. Fish Community Tolerance Ratings and Trophic Guild Assignments ..... 21
8. Fish Community Scores and Bioclasses ..... 22
9. Fish Community Data (2004-2009) ..... 26
10. Fish Community Metric Values ..... 27
11. Nonindigenous Fish Species ..... 28
12. Narrowly Distributed Fish Species ..... 28
13. Fish Species Listed as Endangered, Rare, Threatened, or Special Concern ..... 29
14. Fish Community Rankings ..... 30
15. Fish Community Habitat Evaluations ..... 31
16. Water Quality Measurements ..... 33


## LIST OF FIGURES


Figure Page

1. Geographical relationships of the Hiwassee River basin in North Carolina . ..... 6
2. Sampling sites in HUC 06020002 ..... 7
3. Benthic Macroinvertebrate Bioclassification Trends (1994-2009) ..... 12
4. NCIBI Scores and Ratings ..... 24
5. NCIBI Scores and Ratings at Repeat Fish Community Sites ..... 25
6. Favorable Instream Habitat Photograpsh ..... 32
7. Unfavorable Instream Habitat Photographs ..... 32
8. Specific Conductance at Fish Community Sites ..... 34

## INTRODUCTION TO PROGRAM METHODS

The Division of Water Quality uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are re-assessed every five years. The Hiwassee River basin has been sampled by the Environmental Sciences Section (ESS) four times for basinwide monitoring: 1994, 1999, 2004, and 2009.

The ESS collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide-planning program. In some program areas there may be adequate data to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Hiwassee River basin include benthic macroinvertebrates and fish community for the period 2004 - 2009. Details of biological sampling methods (including habitat evaluation) and rating criteria can be found in the appendices of this report. Technical terms are defined in the Glossary.

The document is structured with physical, geographical, and biological data discussions presented by hydrologic units (HUCs). General water quality conditions are given in an upstream to downstream format. Lakes data, ambient chemistry data and aquatic toxicity data, with summaries, are presented in separate reports.

## BASIN DESCRIPTION

The Hiwassee River Basin is located in the remote southwestern corner of North Carolina within the Blue Ridge Province of the Great Smoky Mountains, and is part of the Mississippi River system (Figure 1). This mountainous basin covers approximately 640 square miles in Cherokee and Clay counties and includes many densely forested and biologically diverse areas with elevations that exceed 4,500 ft. The largest municipalities in the basin are Murphy and Andrews in Cherokee County. Many of the streams in the basin are located within the US Forest Service's Nantahala National Forest. Major tributaries include the Hiwassee River, Valley River, Nottely River and Brasstown Creek. The Hiwassee River is 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). Urban development pressures continue to threaten water quality in the basin, particularly through non-point runoff, as impervious surface coverage increases.

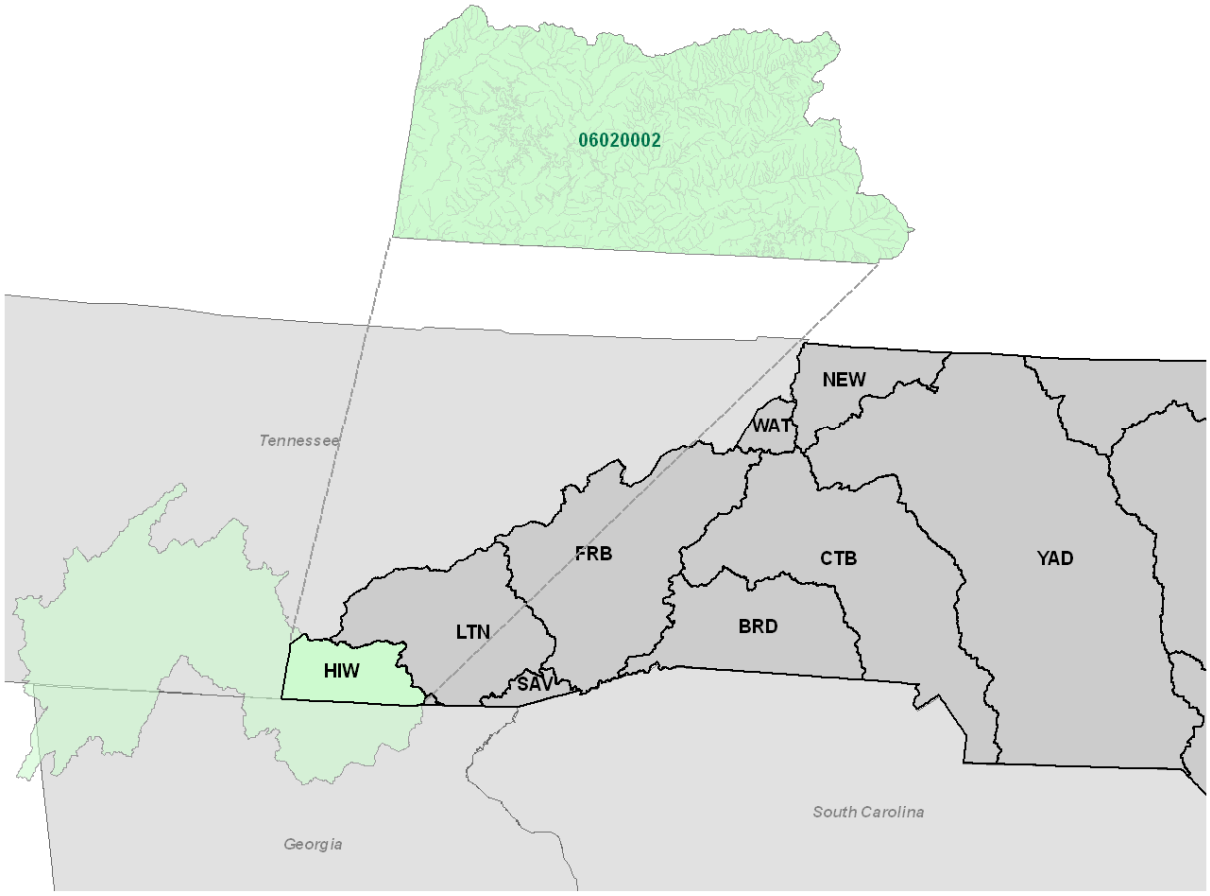



**Figure 1. Geographic Relationships of the Hiwassee River Basin.**

## HIWASSEE RIVER HUC 06020002 – HIWASSEE RIVER

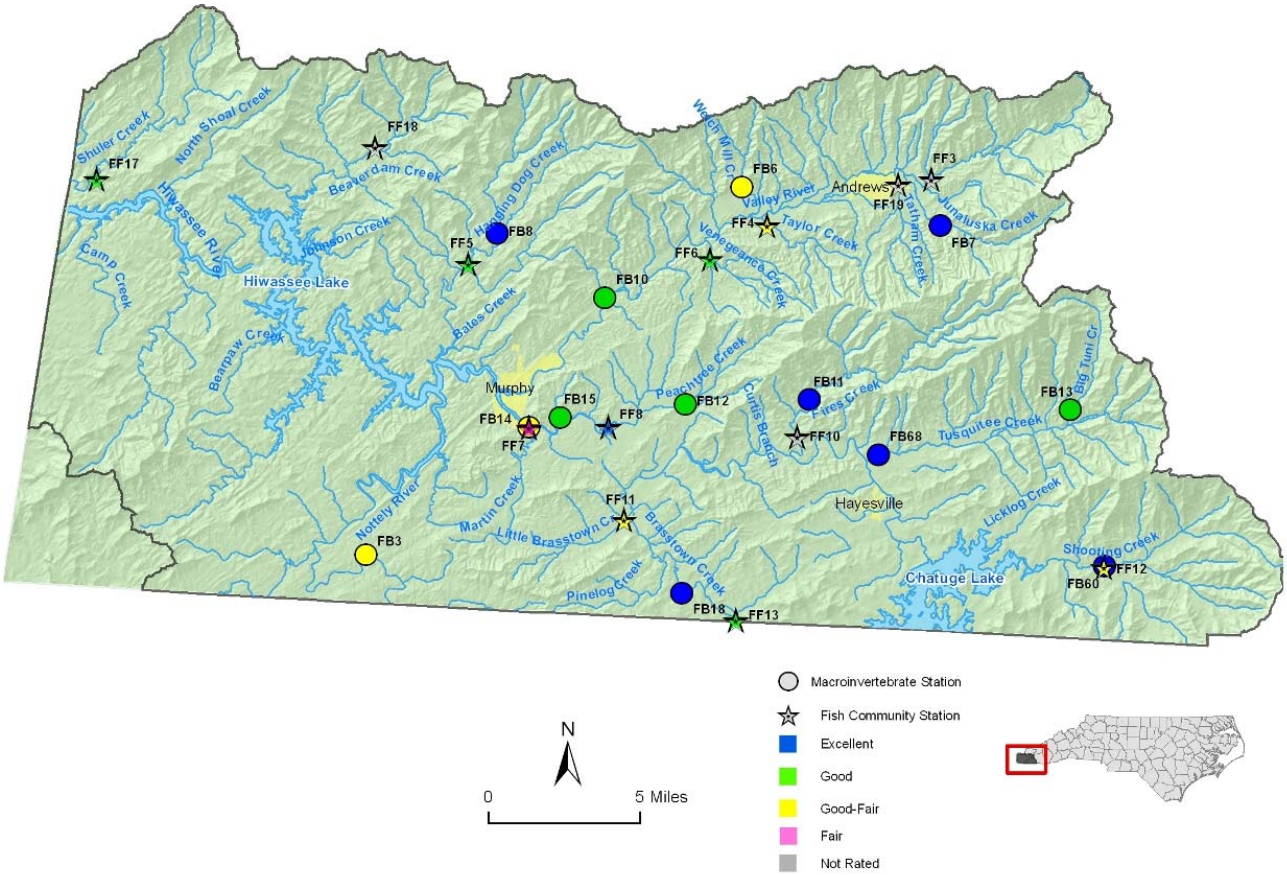



**Figure 2.** **Sampling Sites in the Hiwassee River Basin (HUC 06020002). Monitoring Sites are Listed in Table 1.**

**Table 1. Waterbodies Monitored in HUC 06020002 in the Hiwassee River Basin for Basinwide Assessment, 2004 and 2009.**

| Map #[1] | Waterbody | County | Location | 2004 | 2009 |
|---|---|---|---|---|---|
| B-1 | Shooting Cr | Clay | SR 1370 | Excellent | Excellent |
| B-2 | Big Tuni Cr | Clay | SR 1311 | Excellent | Good |
| 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 | Excellent | Good |
| B-6 | Hiwassee R | Cherokee | US 64 | Excellent | Good |
| B-7 | Peachtree Cr | Cherokee | SR 1537 | Excellent | Good |
| B-8 | Martin Cr | Cherokee | SR 1558 | Good | Good-Fair |
| B-9 | Valley R | Cherokee | SR 1554 | Good | Good |
| B-10 | Junaluska Cr | Cherokee | SR 1505 | Excellent | Excellent |
| B-11 | Welch Mill Cr | Cherokee | SR 1381 | Excellent | Good-Fair |
| B-12 | Hanging Dog Cr | Cherokee | SR 1331 | Excellent | Excellent |
| B-13 | Owl Cr | Cherokee | SR 1331 | Excellent | --- |
| B-14 | Nottely R | Cherokee | SR 1596 | Good | Good |
| B-15 | Persimmon Cr | Cherokee | SR 1127 | Excellent | --- |
| B-16 | Beaverdam Cr | Cherokee | SR 1326 | Excellent | --- |
| B-17 | South Shoal Cr | Cherokee | SR 1314 | Excellent | --- |
| B-18 | Shuler Cr | Cherokee | SR 1323 | Excellent | --- |
| | | | | | |
| F-1 | Shooting Cr | Clay | SR 1340 | Good-Fair | Good-Fair |
| F-2 | Tusquitee Cr | Clay | SR 1330 | Not Rated | Not Rated |
| F-3 | Fires Cr | Clay | SR 1300 | Not Rated | Not Rated |
| F-4 | Brasstown Cr | Clay | SR 1111 | Good-Fair | Good-Fair |
| F-5 | L Brasstown Cr | Cherokee | SR 1565 | Good-Fair | Good-Fair |
| F-6 | Peachtree Cr | Cherokee | US 64 | Excellent | Excellent |
| F-7 | Martin Cr | Cherokee | SR 1558 | Fair | Fair |
| F-8 | Valley R | Cherokee | SR 1409 | Not Rated | Not Rated |
| F-9 | Taylor Cr | Cherokee | SR 1515 | Good-Fair | Good-Fair |
| F-10 | Vengeance Cr | Cherokee | NC 141 | Good | Good |
| F-11 | Hanging Dog Cr | Cherokee | SR 1342 | Good | Good |
| F-12 | Persimmon Cr | Cherokee | SR 1127, 1st bridge | Poor | Poor |
| F-13 | S Shoal Cr | Cherokee | SR 1314 | Not Rated | Not Rated |

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

## River and Stream Assessment

Thirteen benthic macroinvertebrate sites and thirteen fish community sites were sampled in 2009. Five long-term benthic macroinvertebrate basinwide sites were not sampled due to insufficient time: Shuler Creek at SR 1323, South Shoal Creek at SR 1314, Persimmon Creek at SR 1128 and Beaverdam Creek at SR 1326 (Table 1).

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. 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.

Specific site summaries of the 26 benthic macroinvertebrate and fish community samples may be found in Appendix S-1 (attachment). Information for all the historic benthic macroinvertebrate samples collected within the Hiwassee River basin can be found in Table 3 and similar information for fish collections can be found in Table 9.

## Special Studies

### Hiwassee River Basin Ecosystem Enhancement Program's Peachtree and Martin Creek Projects, Cherokee County

In March 2006, twelve benthic community stream sites were sampled for this study. Seven were small-stream sites (i.e. drainage area less than 3.0 square miles). Six small-stream sites were assigned a classification of Not Impaired: Calhoun Branch at SR 1537, Cherokee County; Hampton Creek at SR 1558, Cherokee County; Messer Branch at SR 1533, Cherokee County; Pipes Branch at SR 1540, Cherokee County; Slow Creek at SR 1528, Cherokee County; Snead Branch at SR 1531, Cherokee County. The small-stream site near the mouth of McCombs Branch was assigned a classification of Not Rated. Of the large-stream sites, one classified as Excellent (Peachtree Cr at SR 1537, Cherokee County), two classified as Good (Martin Creek at SR 1576, Cherokee County; Peachtree Creek at US 64, Cherokee County), and two classified as Good-Fair (Martin Creek at SR 1558, Cherokee County; Slow Creek at SR 1531, Cherokee County). (BAU Memorandum B-20060731).

Four fish community sites (Peachtree Creek at SR 1537, Slow Creek at SR 1531, and Martin Creek at SR 1576 and at SR 1558) were also assessed. Less than optimal instream and riparian habitats characteristics were observed at each site, but especially so at Slow and Martin Creeks. Nonpoint source runoff was contributing to elevated specific conductivities at Slow and Martin Creeks. Even though the fish communities were rated Good- Fair at Slow Creek and at Martin Creek (SR 1558), the community at Slow Creek was clearly more impacted than that at Martin Creek. The community at upper Peachtree Creek, although Not Rated, seemed to be healthy and perhaps minimally affected by the narrow riparian buffers along its streambanks. The fish community in the upper Martin Creek watershed at SR 1576 was also Not Rated, but it was clearly more impacted by the altered landscapes than that at Peachtree Creek. (BAU Memorandum F-20060731).

## GLOSSARY

| | |
|---|---|
| $7Q_{10}$ | A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. $7Q_{10}$ flow (in cfs) is used to allocate the discharge of toxic substances to streams. |
| Bioclass or Bioclassification | Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value. |
| cfs | Cubic feet per second, generally the unit in which stream flow is measured. |
| CHL *a* | Chlorophyll *a*. |
| Class C Waters | Freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum. |
| Conductivity | In this report, synonymous with specific conductance and reported in the units of µmhos/cm at 25 $^{o}$C. Conductivity is a measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts. |
| Division | The North Carolina Division of Water Quality. |
| D.O. | Dissolved Oxygen. |
| Ecoregion | An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, vegetation, and soil type. Examples include Mountains, Piedmont, Coastal Plain, Sand Hills, and Carolina Slate Belt. |
| EPT | The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community. |
| EPT N | The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant. |
| EPT S | Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality. |
| HQW | High Quality Waters. Waters which are rated Excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and all Class SA waters. |
| Major Discharger | Greater than or equal to one million gallons per day discharge (≥ 1 MGD) |
| MGD | Million Gallons per Day, generally the unit in which effluent discharge flow is measured. |
| Minor Discharger | Less than one million gallons per day discharge (< 1 MGD). |
| NPDES | National Pollutant Discharge Elimination System. |

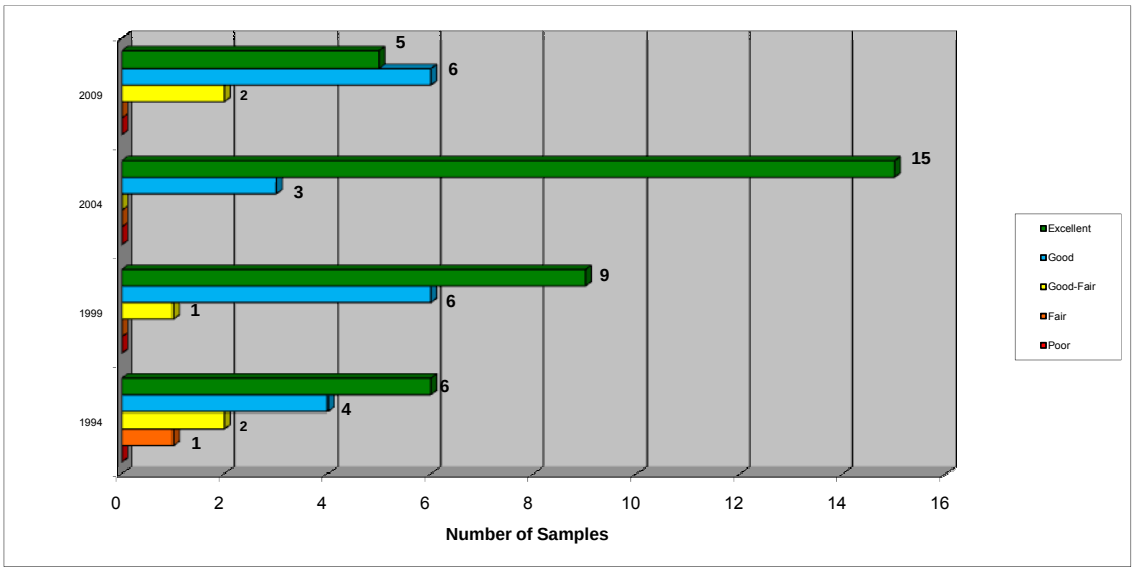
| | |
|---|---|
| NCBI (EPT BI) | North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI. |
| NCIBI | North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community. |
| NSW | Nutrient Sensitive Waters. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs. |
| 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. |
| SOC | A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits. |
| Total S (or S) | The number of different taxa present in a benthic macroinvertebrate sample. |
| UT | Unnamed tributary. |
| WWTP | Wastewater treatment plant |

**Appendix B-1. Summary of Benthic Macroinvertebrate Data, Methods and Criteria.**

### Overall Hiwassee River Basin: Benthic Macroinvertebrate Summary

For 2009, 13 long-term benthic macroinvertebrate samples were sampled in the Hiwassee River Basin. Graphical representations of bioclassification trends from 1994-2009 among the Hiwassee benthos sites can be seen in Figure 3. In summary, the 2009 benthic macroinvertebrate community bioclassifications have declined from 2004 and 1999 levels. However, this data must be interpreted with caution as five Excellent sites sampled from previous basinwide cycles were not sampled in 2009 (Table 1) due to time constraints. Nevertheless, even if these five consistently Excellent stations sites been sampled in 2009, there would still have been a decrease in Excellent ratings relative to 2004 levels as Big Tuni Creek, Brasstown Creek, Hiwassee River and Peachtree Creek declined from Excellent in 2004 to Good in 2009 while Welch Mill Creek declined from Excellent in 2004 to Good-Fair. Specific discussion of these sites can be found in Appendix S-1 (attachment).

**Figure 3. Hiwassee River Basin Bioclassification Trends: (1994-2009[1]).**



There were numerous rare invertebrate taxa collected in the Hiwassee River Basin in 2009. These organisms are listed below in Table 2.

**Table 2. Rare Taxa Collected in the Hiwassee River Basin: 2009. (Rare Taxa are Defined as Those Taxa Which Occur Less Than or Equal to 0.5% of Approximately 6,500 NCDWQ Benthic Collections).**

| CC Num | Sample Type | Date | Waterbody | Location | County | Subbasin | Huc_8Digit | Scientific Name |
|---|---|---|---|---|---|---|---|---|
| 10724 | Full Scale | 8/27/09 | HIWASSEE R | US 64 | CHEROKEE | 2 | 06020002 | ISWAEON DAVIDI |
| 10718 | Full Scale | 8/26/09 | VALLEY R | SR 1554 | CHEROKEE | 2 | 06020002 | ORTHOCLADIUS CARLATUS |
| 10718 | Full Scale | 8/26/09 | VALLEY R | SR 1554 | CHEROKEE | 2 | 06020002 | ISWAEON DAVIDI |
| 10718 | Full Scale | 8/26/09 | VALLEY R | SR 1554 | CHEROKEE | 2 | 06020002 | PARATRICHOCLADIUS SPP |
| 10693 | Full Scale | 8/26/09 | BRASSTOWN CR | SR 1104 | CLAY | 1 | 06020002 | TANYTARSUS SP G |
| 10715 | Full Scale | 8/25/09 | FIRES CR | SR 1344 | CLAY | 1 | 06020002 | AGNETINA FLAVESCENS |
| 10715 | Full Scale | 8/25/09 | FIRES CR | SR 1344 | CLAY | 1 | 06020002 | AESHNA SPP |

## BENTHIC MACROINVERTEBRATE SAMPLING METHODS

### Standard Qualitative (Full Scale) Method

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using three sampling procedures. The Biological Assessment Unit's standard qualitative (Full Scale) sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDWQ 2006b). 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).

### EPT Method

Benthic macroinvertebrates can also be collected using the EPT sampling procedure. Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections (NCDWQ 2006b). Only EPT taxa are collected and identified and only EPT criteria are used to assign a bioclassification.

### Habitat Evaluation

An assessment form has been developed by the Biological Assessment Unit to better evaluate the physical habitat of a stream. The habitat score, which ranges between 1 and 100, is based on the evaluation of channel modification, amount of instream habitat, and type of bottom substrate, pool variety, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed to assign impairment ratings.

### Data Analysis

Bioclassification criteria for standard qualitative and EPT samples in the mountain ecoregion are provided in NCDWQ 2006b. Tolerance values for individual species and biotic index values have a range of 0 - 10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality scores (5 = Excellent, 4 = Good, 3 = Good-Fair, 2 = Fair and 1 = Poor) assigned with the biotic index numbers are averaged with EPT taxa richness scores to produce a final bioclassification. Criteria bioclassifications for the EPT sample method is based on the total number of these taxa present in the sample and bioclassification thresholds for this method can be found in NCDWQ 2006b. In addition to the biotic index and the EPT taxa richness metrics, the
EPT abundance and total taxa richness calculations also are used to help examine between-site differences in water quality.

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

**Table 3. Benthic Macroinvertebrate Data Collected from the Hiwassee River Basin, 1987-2009. Basinwide Sites are in Bold Font.**

| HUC/Waterbody | Location | County | Index No | Date | ST | EPT | BI | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **06020002** | | | | | | | | | |
| Allbone Br | SR 1300 | Clay | FB16 | 5/19/87 | 79 | 37 | 2.75 | 1.74 | Excellent |
| | | | | 4/8/87 | 77 | 38 | 3.07 | 2.16 | Excellent |
| Beaver Cr | SR 1388-1389 | Cherokee | FB19 | 6/24/02 | 49 | 29 | 2.51 | 2.08 | Not Impaired |
| Beaverdam Cr | SR 1326 | Cherokee | FB4 | 8/19/04 | --- | 50 | --- | 2.16 | Excellent |
| | | | | 8/9/99 | --- | 38 | --- | 2.45 | Excellent |
| | | | | 8/30/94 | --- | 39 | --- | 2.39 | Excellent |
| Big Tuni Cr | FS RD 440 | Clay | FB17 | 3/31/89 | --- | 46 | --- | 1.55 | Excellent |
| | | | | 6/6/88 | --- | 41 | --- | 1.40 | Excellent |
| | | | | 4/21/88 | --- | 39 | --- | 1.39 | Excellent |
| | | | | 5/19/87 | 90 | 46 | 1.88 | 1.30 | Excellent |
| | | | | 4/8/87 | 77 | 38 | 1.92 | 1.41 | Excellent |
| **Big Tuni Cr** | SR 1311 | Clay | FB13 | 7/6/09 | --- | 35 | --- | 1.54 | Good |
| | | | | 8/16/04 | --- | 48 | --- | 1.44 | Excellent |
| | | | | 8/11/99 | --- | 45 | --- | 1.50 | Excellent |
| | | | | 7/13/94 | 62 | 37 | 2.15 | 1.72 | Excellent |
| | | | | 3/31/89 | 83 | 45 | 2.75 | 2.21 | Excellent |
| **Brasstown Cr** | SR 1104 | Clay | FB18 | 8/26/09 | 84 | 40 | 4.84 | 4.17 | Good |
| | | | | 8/14/04 | 109 | 53 | 4.58 | 3.35 | Excellent |
| | | | | 8/11/99 | 77 | 44 | 4.26 | 3.46 | Good |
| | | | | 7/28/94 | --- | 18 | --- | 4.52 | Fair |
| Britton Cr | Nr SR 1399 | Cherokee | FB22 | 12/9/91 | --- | 35 | --- | 1.82 | Excellent |
| Calhoun Br | SR 1537 | Cherokee | FB23 | 3/20/06 | 79 | 23 | 4.19 | 2.89 | Not Impaired |
| Coldspring Br | FS RD | Clay | FB30 | 6/7/88 | --- | 39 | --- | 1.98 | Excellent |
| | | | | 4/19/88 | --- | 37 | --- | 1.46 | Excellent |
| Collet Cr | SR 1507 | Cherokee | FB31 | 6/25/02 | 63 | 36 | 2.73 | 2.29 | Not Impaired |
| Colvard Cr | SR 1426 | Cherokee | FB36 | 6/27/02 | 60 | 41 | 2.38 | 1.69 | Not Impaired |
| Colvard Cr | US 19-74 | Cherokee | FB37 | 6/27/02 | 62 | 35 | 2.58 | 1.86 | Not Impaired |
| Falls Br | US 64 | Cherokee | FB39 | 1/31/06 | --- | 21 | --- | 2.93 | Not Rated |
| Faye Puett Cove Cr | SR 1535 | Cherokee | FB40 | 2/1/06 | --- | 28 | --- | 2.98 | Good |
| Fires Cr | Bristol Camp | Clay | FB42 | 7/13/94 | 80 | 43 | 2.60 | 1.65 | Excellent |
| | | | | 6/7/88 | 102 | 47 | 3.06 | 1.85 | Excellent |
| | | | | 4/18/88 | 103 | 54 | 2.72 | 1.84 | Excellent |
| | | | | 5/19/87 | 95 | 52 | 2.76 | 1.94 | Excellent |
| Fires Cr | FS RD C | Clay | FB43 | 6/7/88 | --- | 35 | --- | 1.22 | Excellent |
| | | | | 4/19/88 | --- | 39 | --- | 1.24 | Excellent |
| Fires Cr | SR 1300 | Clay | FB41 | 5/19/87 | --- | 41 | --- | 2.10 | Excellent |
| | | | | 4/9/87 | --- | 43 | --- | 2.43 | Excellent |
| **Fires Cr** | SR 1344 | Clay | FB11 | 8/25/09 | 71 | 43 | 2.74 | 2.45 | Excellent |
| | | | | 8/17/04 | 118 | 53 | 3.37 | 2.25 | Excellent |
| | | | | 8/11/99 | 77 | 44 | 2.70 | 2.16 | Excellent |
| | | | | 8/29/94 | 81 | 36 | 3.44 | 2.28 | Good |
| | | | | 7/13/94 | --- | 34 | --- | 1.87 | Good |
| | | | | 8/11/88 | 107 | 54 | 3.38 | 2.48 | Excellent |
| | | | | 4/19/88 | --- | 48 | --- | 1.59 | Excellent |
| | | | | 5/19/87 | 113 | 58 | 2.82 | 2.07 | Excellent |
| | | | | 4/6/87 | 101 | 54 | 2.57 | 2.03 | Excellent |
| | | | | 8/7/85 | 111 | 50 | 3.84 | 2.29 | Excellent |
| Gipp Cr | SR 1409 | Cherokee | FB20 | 6/25/02 | 76 | 44 | 2.46 | 1.91 | Excellent |
| Graham Br | SR 1531 | Cherokee | FB44 | 1/31/06 | --- | 26 | --- | 2.61 | Excellent |
| Greasy Cr | SR 1318 | Clay | FB45 | 3/30/89 | --- | 38 | --- | 2.46 | Good |
| Hampton Cr | SR 1558 | Cherokee | FB46 | 3/22/06 | 49 | 19 | 4.15 | 3.02 | Not Impaired |
| **Hanging Dog Cr** | SR 1331 | Cherokee | FB8 | 8/26/09 | --- | 40 | --- | 2.50 | Excellent |
| | | | | 8/17/04 | --- | 41 | --- | 2.28 | Excellent |
| | | | | 8/10/99 | --- | 40 | --- | 2.18 | Excellent |
| | | | | 7/12/94 | --- | 46 | --- | 2.53 | Excellent |
| **Hiwassee R** | US 64 | Cherokee | FB15 | 8/27/09 | 82 | 37 | 4.47 | 3.63 | Good |
| | | | | 8/18/04 | 100 | 46 | 4.26 | 3.30 | Excellent |
| | | | | 8/10/99 | 73 | 36 | 4.25 | 3.33 | Good |

**Table 3. Benthic Macroinvertebrate Data Collected from the Hiwassee River Basin, 1987-2009. (Continued).**

| HUC/Waterbody | Location | County | Index No | Date | ST | EPT | BI | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **06020002** | | | | | | | | | |
| | | | | | 79 | 38 | 4.37 | 3.28 | Good |
| | | | | | 78 | 35 | 4.68 | 3.30 | Good |
| | | | | | 65 | 32 | 4.95 | 3.81 | Good-Fair |
| | | | | | 56 | 25 | 4.29 | 3.53 | Good |
| | | | | | 67 | 29 | 4.47 | 3.27 | Good |
| | | | | | 62 | 23 | 4.66 | 3.50 | Good-Fair |
| Hyatt Cr | SR 1379 | Cherokee | FB27 | 6/28/02 | --- | 49 | --- | 1.81 | Excellent |
| Hyatt Cr | SR 1428 | Cherokee | FB34 | 6/26/02 | 80 | 45 | 2.51 | 1.77 | Excellent |
| Johnson Mill Cr | SR 1307 | Clay | FB47 | 3/30/89 | --- | 42 | --- | 1.78 | Excellent |
| **Junaluska Cr** | SR 1505 | Cherokee | FB7 | 8/26/09 | --- | 37 | --- | 2.51 | Excellent |
| | | | | 8/17/04 | --- | 40 | --- | 2.00 | Excellent |
| | | | | 8/12/99 | --- | 31 | --- | 2.56 | Good |
| | | | | 8/31/94 | --- | 22 | --- | 2.50 | Good-Fair |
| | | | | 7/11/94 | --- | 25 | --- | 2.12 | Good-Fair |
| L Fires Cr | Nr Mouth | Clay | FB48 | 12/10/91 | --- | 34 | --- | 1.83 | Excellent |
| | | | | 6/6/88 | --- | 38 | --- | 1.63 | Excellent |
| | | | | 4/19/88 | --- | 37 | --- | 1.58 | Excellent |
| Lamb Br | SR 1535 | Cherokee | FB49 | 1/31/06 | --- | 20 | --- | 2.75 | Not Rated |
| Leatherwood Br | FS RD | Clay | FB50 | 6/7/88 | --- | 30 | --- | 2.26 | Excellent |
| | | | | 4/19/88 | --- | 34 | --- | 1.90 | Excellent |
| | | | | 5/19/87 | 60 | 30 | 2.65 | 1.78 | Excellent |
| | | | | 4/7/87 | 58 | 34 | 1.99 | 1.55 | Excellent |
| **Martin Cr** | SR 1558 | Cherokee | FB14 | 8/26/09 | --- | 25 | --- | 3.30 | Good-Fair |
| | | | | 3/22/06 | 119 | 38 | 4.74 | 3.09 | Good-Fair |
| | | | | 8/18/04 | --- | 30 | --- | 2.97 | Good |
| Martin Cr | SR 1573 | Cherokee | FB52 | 1/31/06 | --- | 22 | --- | 2.78 | Not Rated |
| Martin Cr | SR 1576 | Cherokee | FB51 | 3/22/06 | 127 | 40 | 4.59 | 3.28 | Good |
| Mccombs Br | Nr Mouth | Cherokee | FB53 | 3/21/06 | 59 | 12 | 5.26 | 4.06 | Not Rated |
| Messer Br | SR 1533 | Cherokee | FB54 | 3/21/06 | 61 | 25 | 4.22 | 3.48 | Not Impaired |
| Mission Br | SR 1537 | Cherokee | FB55 | 2/1/06 | --- | 14 | --- | 2.20 | Not Rated |
| Morris Cr | SR 1383 | Cherokee | FB25 | 6/26/02 | 56 | 34 | 2.58 | 2.04 | Not Impaired |
| Morris Cr | US 19-74 | Cherokee | FB29 | 6/26/02 | 74 | 36 | 3.78 | 3.17 | Not Impaired |
| **Nottely R** | SR 1596 | Cherokee | FB3 | 8/27/09 | --- | 26 | --- | 2.64 | Good-Fair |
| | | | | 8/19/04 | --- | 32 | --- | 2.50 | Good |
| | | | | 8/12/99 | --- | 33 | --- | 3.13 | Good |
| | | | | 7/12/94 | --- | 36 | --- | 2.93 | Excellent |
| Owl Cr | SR 1331 | Cherokee | FB9 | 8/18/04 | --- | 44 | --- | 2.21 | Excellent |
| **Peachtree Cr** | SR 1537 | Cherokee | FB12 | 8/25/09 | --- | 35 | --- | 2.56 | Good |
| | | | | 3/20/06 | 103 | 54 | 3.19 | 2.37 | Excellent |
| | | | | 2/1/06 | --- | 42 | --- | 2.52 | Excellent |
| | | | | 8/17/04 | --- | 49 | --- | 2.52 | Excellent |
| | | | | 8/10/99 | --- | 38 | --- | 2.50 | Excellent |
| | | | | 7/12/94 | --- | 37 | --- | 2.46 | Excellent |
| Peachtree Cr | SR 1539 | Cherokee | FB57 | 2/1/06 | --- | 37 | --- | 2.06 | Excellent |
| Peachtree Cr | SR 1655 | Cherokee | FB58 | 2/1/06 | --- | 31 | --- | 2.17 | Good |
| Peachtree Cr | US 64 | Cherokee | FB56 | 3/21/06 | 77 | 36 | 4.03 | 3.21 | Good |
| Persimmon Cr | SR 1127 | Cherokee | FB2 | 3/23/06 | --- | 39 | --- | 2.67 | Good |
| | | | | 8/19/04 | --- | 40 | --- | 2.79 | Excellent |
| | | | | 8/10/99 | --- | 40 | --- | 3.11 | Excellent |
| | | | | 7/12/94 | --- | 42 | --- | 2.91 | Excellent |
| Pipes Br | SR 1540 | Cherokee | FB59 | 3/20/06 | 69 | 42 | 2.53 | 2.01 | Not Impaired |
| | | | | 2/1/06 | --- | 20 | --- | 2.24 | Good |
| S Shoal Cr | SR 1314 | Cherokee | FB1 | 8/19/04 | --- | 38 | --- | 2.24 | Excellent |
| | | | | 8/9/99 | --- | 33 | --- | 2.25 | Good |
| | | | | 8/30/94 | --- | 30 | --- | 2.34 | Good |
| Shooting Cr | SR 1168 | Clay | FB61 | 8/29/94 | 59 | 28 | 3.04 | 2.65 | Good |
| **Shooting Cr** | SR 1340 | Clay | FB60 | 8/20/09 | --- | 37 | --- | 1.88 | Excellent |
| | | | | 7/6/09 | --- | 37 | --- | 1.72 | Excellent |
| | | | | 8/16/04 | --- | 39 | --- | 2.17 | Excellent |
| | | | | 8/11/99 | --- | 30 | --- | 1.90 | Good |

**Table 3. Benthic Macroinvertebrate Data Collected from the Hiwassee River Basin, 1987-2009. (Continued).**

| HUC/Waterbody | Location | County | Index No | Date | ST | EPT | BI | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **06020002** | | | | | | | | | |
| | | | | 7/13/94 | --- | 32 | --- | 2.27 | Good |
| Shooting Cr | SR 1349 | Clay | FB62 | 8/29/94 | 68 | 37 | 2.67 | 2.00 | Good |
| Shuler Cr | SR 1323 | Cherokee | FB5 | 8/19/04 | --- | 54 | --- | 2.35 | Excellent |
| | | | | 8/9/99 | --- | 40 | --- | 2.40 | Excellent |
| | | | | 8/30/94 | --- | 35 | --- | 2.44 | Good |
| Slow Cr | SR 1528 | Cherokee | FB64 | 3/21/06 | 66 | 36 | 2.92 | 2.55 | Not Impaired |
| Slow Cr | SR 1531 | Cherokee | FB63 | 3/21/06 | 112 | 32 | 5.23 | 3.74 | Good-Fair |
| Snead Br | SR 1531 | Cherokee | FB65 | 3/21/06 | 65 | 29 | 3.08 | 2.12 | Not Impaired |
| | | | | 1/31/06 | --- | 30 | --- | 2.77 | Excellent |
| Sudderth Br | SR 1537 | Cherokee | FB66 | 2/1/06 | --- | 5 | --- | 3.87 | Not Rated |
| Sweetwater Cr | SR 1302 | Clay | FB81 | 8/25/09 | --- | 31 | --- | 3.41 | Good |
| Tatham Cr | US 19 BUS | Cherokee | FB24 | 6/25/02 | 85 | 40 | 3.60 | 2.86 | Good |
| Taylor Cr | SR 1515 | Cherokee | FB33 | 6/27/02 | 96 | 41 | 4.03 | 2.64 | Not Impaired |
| **Tusquitee Cr** | SR 1300 | Clay | FB68 | 8/25/09 | 105 | 45 | 3.43 | 2.24 | Excellent |
| | | | | 8/16/04 | 119 | 51 | 3.74 | 2.45 | Excellent |
| | | | | 8/11/99 | 84 | 39 | 3.16 | 2.43 | Excellent |
| | | | | 3/30/89 | 90 | 47 | 2.85 | 2.32 | Excellent |
| Tusquitee Cr | SR 1307 Ab Hurricane Cr | Clay | FB80 | 3/30/89 | --- | 49 | --- | 2.61 | Excellent |
| Tusquitee Cr | SR 1307 Be Perry Cr | Clay | FB69 | 3/31/89 | --- | 35 | --- | 2.21 | Good |
| Tusquitee Cr | SR 1330 | Clay | FB67 | 7/28/94 | 68 | 33 | 3.68 | 2.81 | Good |
| | | | | 3/30/89 | --- | 45 | --- | 2.35 | Excellent |
| | | | | 5/19/87 | 101 | 51 | 3.06 | 2.35 | Excellent |
| | | | | 4/8/87 | 95 | 53 | 3.07 | 2.40 | Excellent |
| UT Hiwassee R | Nr Brierwood Dr | Cherokee | FB70 | 2/1/06 | 6 | 0 | 6.84 | | Not Rated |
| UT Martins Cr | SR 1576 | Cherokee | FB71 | 1/31/06 | --- | 18 | --- | 3.40 | Not Rated |
| Valley R | Be Andrews | Cherokee | FB75 | 8/8/85 | 75 | 30 | 5.59 | 3.58 | Good-Fair |
| Valley R | Main St | Cherokee | FB28 | 8/23/99 | --- | 24 | --- | 3.76 | Good-Fair |
| | | | | 8/30/94 | 40 | 6 | 6.12 | 3.31 | Poor |
| Valley R | Nr US 74 | Cherokee | FB76 | 8/8/85 | 76 | 33 | 5.24 | 3.77 | Good-Fair |
| Valley R | Off SR 1315 | Cherokee | FB32 | 6/27/02 | 92 | 40 | 4.73 | 3.85 | Good |
| | | | | 8/23/99 | 63 | 28 | 4.89 | 4.02 | Good-Fair |
| Valley R | Off US 19 | Cherokee | FB77 | 8/30/94 | 57 | 13 | 5.55 | 3.90 | Fair |
| Valley R | SR 1389 | Cherokee | FB72 | 6/25/02 | 96 | 49 | 3.61 | 2.56 | Excellent |
| | | | | 8/31/94 | --- | 15 | --- | 3.27 | Fair |
| **Valley R** | SR 1554 | Cherokee | FB10 | 8/26/09 | 78 | 38 | 4.28 | 3.65 | Good |
| | | | | 8/17/04 | 100 | 36 | 4.79 | 3.76 | Good |
| | | | | 8/10/99 | 80 | 33 | 4.90 | 3.82 | Good-Fair |
| | | | | 7/11/94 | 77 | 29 | 4.90 | 4.02 | Good-Fair |
| | | | | 8/8/90 | 86 | 33 | 4.56 | 3.56 | Good |
| | | | | 8/10/88 | 91 | 33 | 4.97 | 4.13 | Good-Fair |
| | | | | 7/22/86 | 71 | 28 | 5.48 | 3.75 | Good-Fair |
| | | | | 8/21/84 | 70 | 26 | 4.94 | 3.83 | Good-Fair |
| Valley R | US 19 BUS | Cherokee | FB73 | 6/26/02 | 94 | 52 | 4.25 | 3.15 | Excellent |
| Valley R | US 74 | Cherokee | FB74 | 8/31/94 | --- | 23 | --- | 2.92 | Good-Fair |
| Vengeance Cr | NR NC 141 | Cherokee | FB35 | 6/27/02 | 92 | 50 | 3.58 | 2.81 | Good |
| Webb Cr | SR 1428 | Cherokee | FB78 | 8/12/99 | 58 | 37 | 2.62 | 2.36 | Good |
| Webb Cr | Webb Creek Rd | Cherokee | FB21 | 6/25/02 | 63 | 45 | 2.07 | 1.82 | Not Impaired |
| **Welch Mill Cr** | SR 1381 | Cherokee | FB6 | 8/26/09 | --- | 27 | --- | 1.51 | Good-Fair |
| | | | | 8/30/04 | --- | 44 | --- | 1.76 | Excellent |
| | | | | 6/26/02 | --- | 43 | --- | 1.60 | Excellent |
| Welch Mill Cr | SR 1428 | Cherokee | FB79 | 6/26/02 | 60 | 34 | 3.09 | 2.44 | Not Impaired |
| Worm Cr | SR 1393A | Cherokee | FB38 | 6/24/02 | 62 | 35 | 3.06 | 2.49 | Not Impaired |
| Worm Cr | SR 1502 | Cherokee | FB26 | 6/24/02 | 53 | 31 | 2.24 | 1.59 | Not Impaired |

## Appendix F-1. Fish Community Sampling Methods and Criteria.

### Sampling Methods

At each sample site, a 600 ft. section of stream was selected and measured. Fish within the delineated stretch of stream were then collected using two backpack electrofishing units and usually, two persons netting the stunned fish. A seine was also used where there were substantial riffles. After collection, all readily identifiable fish were examined for 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 laboratory for identification, examination, and total length measurement. These fish have been deposited as voucher specimens with the North Carolina State Museum of Natural Sciences in Raleigh. All young-of-year were excluded from the analyses.

### NCIBI Analysis

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

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

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 streams of the region. Each metric is designed to contribute unique information to the overall assessment. The scores for all metrics are then summed to obtain the overall NCIBI score. Finally, the score (an even number between 12 and 60) is then used to determine the ecological integrity class of the stream from which the sample was collected. Refer to Tables 6-8 for more information.

The NCIBI has been revised (NCDWQ 2006a). 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. In 2001, the bioclassifications and criteria were recalibrated against regional reference site data (Biological Assessment Unit Memorandum F-20010922). To qualify as a reference site, the site had to satisfy all seven criteria in the order listed in Table 4. 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 and for the Hiwassee Basin are listed in (Table 5).

**Table 4. Reference Site Selection Hierarchy -- A Watershed-Based Approach for Streams.**

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

**Table 5. Regional Fish Community Reference Sites in the Hiwassee River Basin.**

| Waterbody | Station | County | Level IV Ecoregion |
|---|---|---|---|
| Tusquitee Cr | SR 1330 | Clay | Broad Basins |
| Fires Cr | SR 1300 | Clay | Broad Basins |
| Martin Cr | SR 1558 | Cherokee | Broad Basins |
| S Shoal Cr | SR 1314 | Cherokee | Broad Basins |

Metrics, criteria, and ratings are applicable only to wadeable streams in the Hiwassee River basin and are the same as those for the French Broad, Little Tennessee, New, and Watauga River basins. The NCIBI should not be applied to non-wadeable streams nor to small, wadeable Southern Appalachian type trout streams. General characteristics of rout streams include high gradient, certain aspects of the stream and riparian zones (e.g., *Rhododendron*, *Leucothoe*, and *Tsuga*-lined), presence of boulder and rock outcrop plunge pools, overall faunal characteristics (naturally low diversity), low specific conductance (often < 25 µS/cm), temperature (often < 20˚C), clarity (gin-clear), elevation, and stream order ($1^{st}$ – $3^{rd}$).

**Table 6. Scoring Criteria for the NCIBI for Wadeable Streams in the Western and Northern Mountains of the French Broad, 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 & 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 |

**Table 7. Tolerance Ratings and Adult Trophic Guild Assignments for Fish in the Hiwassee River Basin. Species Collected in 2009 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* sp. cf. *funduloides* | 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* | Highfin Carpsucker | Intermediate | Insectivore |
| *Catostomus commersonii* | White Sucker | Tolerant | Omnivore |
| *Hypentelium nigricans* | Northern Hogsucker | Intermediate | Insectivore |
| *Moxostoma anisurum* | Silver Redhorse | Intermediate | Insectivore |
| *M. breviceps* | Smallmouth 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 |
| **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 |
| **Poeciliidae** | **Livebearers** | | |
| *Gambusia affinis* | Western Mosquitofish | Tolerant | Insectivore |
| **Cottidae** | **Sculpins** | | |
| *Cottus bairdii* | Mottled Sculpin | Intermediate | Insectivore |
| **Moronidae** | **Temperate Basses** | | |
| *Morone chrysops* | White Bass | Intermediate | Piscivore |
| **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 |

**Table 7. Tolerance Ratings and Adult Trophic Guild Assignments for Fish in the Hiwassee River Basin. Species Collected in 2009 are Highlighted in Blue.**

| | | | |
|---|---|---|---|
| *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 |

**Table 8. Scores and Classes for Evaluating the Fish Community of a Wadeable Streams Using the North Carolina Index of Biotic Integrity in the French Broad, Hiwassee, Little Tennessee, New, and Watauga River Basins.**

| NCIBI Scores | NCIBI Classes |
|---|---|
| 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 |

**Appendix F-2. A Summary of Fish Community Assessment Data.**

Monitoring efforts for 2009 can be summarized as:

- Thirteen sites were assessed as part of the 2009 basinwide monitoring cycle.
- All of the sites, except for Tatham, Beaverdam, and Shuler creeks, had been assessed during the previous basinwide cycle in 2004.
- None of the streams sampled were on the 303 (d) impaired waters list (NCENR 2007).
- The most commonly collected species were the Central Stoneroller, Creek Chub, Northern Hogsucker, and Mottled Sculpin which were collected at all 13 sites. The most abundant species was the Mottled Sculpin which constituted almost one-half of all the fish collected.
- Nine of the 13 streams were evaluated and rated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendices F-1, and F-3 – F-5). The NCIBI scores and ratings ranged from 38 to 58 and from Fair to Excellent (Figures 4-5).
- Streams not evaluated with the NCIBI included the Valley River and Fires, Tatham, and Beaverdam creeks. These streams are trout-type streams that have limited diversity and for which metrics and criteria have yet to be developed.
- Eight of the sites had been sampled and rated during the previous basinwide monitoring cycle (Figure 5). Of these, only Brasstown Creek had an actual improvement in its rating (from Good-Fair to Good). Although no fish communities declined between 2004 and 2009, the communities in Vengeance and Hanging Dog creeks bear additional assessments during the next monitoring cycle in 2014 because of drastically altered riparian zones (at Hanging Dog Creek) and a loss of several uncommon species and possible localized impacts in the lower Vengeance Creek watershed.
- Streams classified as Trout waters (Tr) from which no trout were collected included Beaverdam and Taylor creeks.
- The instream and riparian habitat scores for the 13 sites ranged from 55 at Little Brasstown Creek to 97 at Fires Creek (Appendix F-6). Lower scoring sites generally had narrow riparian zones, often with breaks, and would benefit from bank stabilization and stream restoration techniques.
- All dissolved oxygen concentrations met the state water quality standard of 5 mg/L (Appendix F-7). Five pH measurements were less than 6.0 s.u., but the water quality meter and measurements may be affected by the low specific conductance of the water. Elevated specific conductance measurements were associated primarily with nonpoint source runoff.

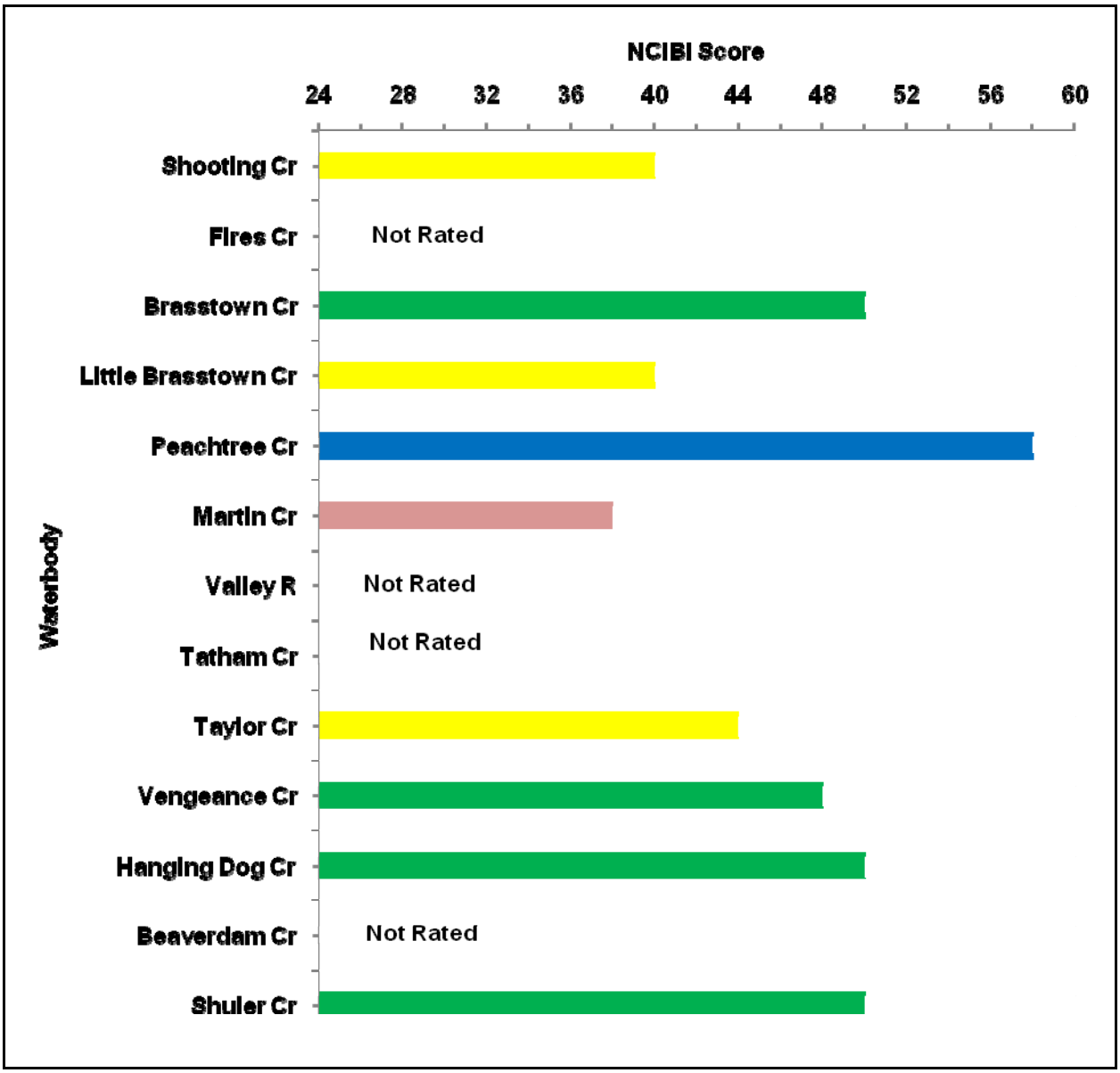



**Figure 4.** **NCIBI Scores and Ratings of 13 Fish Community Basinwide Sites in the Hiwassee River Basin, 2009. Blue = Excellent, Green = Good, Yellow = Good-Fair, and Rose = Fair.**

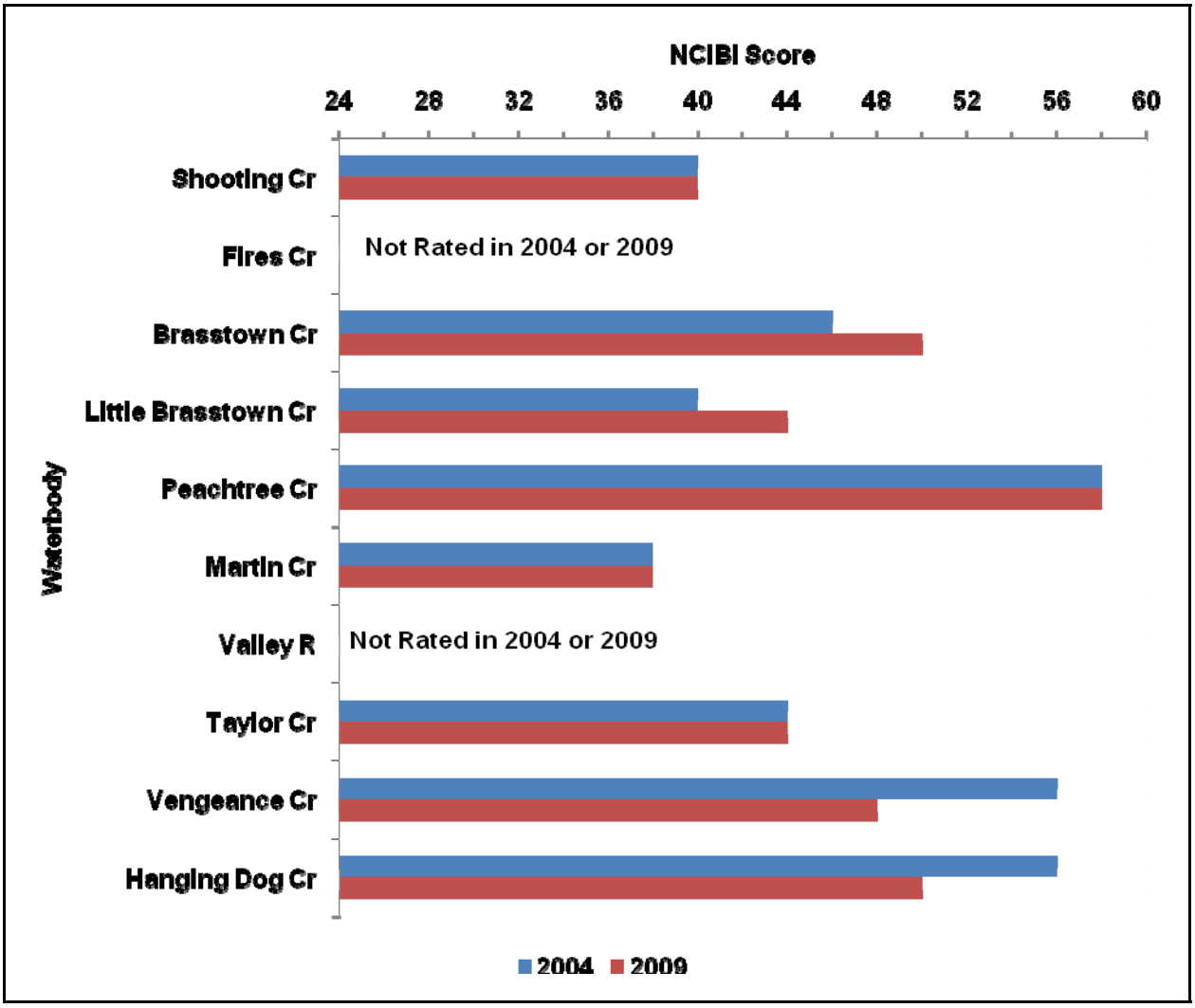



**Figure 5.** **NCIBI Scores and Ratings of 10 Repeat Fish Community Sites in the Hiwassee River Basin, 2004 and 2009.**

**Appendix F-3. Fish Community Data Collected from the Hiwassee River Basin, 2004 – 2009. Basinwide Sites are in Bold Font.**

**Table 9.**

| HUC/Waterbody | Station | County | Site ID | Date | NCIBI Score | NCIBI Rating |
|---|---|---|---|---|---|---|
| **Beaverdam Cr** | **off SR 1331** | **Cherokee** | FF18 | 06/24/09 | --- | Not Rated |
| **Brasstown Cr** | **SR 1111** | **Clay** | FF13 | 06/14/04 | 46 | Good-Fair |
| | | | | 06/22/09 | 50 | Good |
| **Fires Cr** | **SR 1300** | **Clay** | FF10 | 06/15/04 | --- | Not Rated |
| | | | | 06/23/09 | --- | Not Rated |
| **Hanging Dog Cr** | **off SR 1342** | **Cherokee** | FF5 | 06/16/04 | 56 | Good |
| | | | | 06/24/09 | 50 | Good |
| **Little Brasstown Cr** | **SR 1565** | **Cherokee** | FF11 | 06/17/04 | 44 | Good-Fair |
| | | | | 06/23/09 | 40 | Good-Fair |
| Martin Cr | SR 1576 | Cherokee | FF14 | 03/23/06 | --- | Not Rated |
| **Martin Cr** | **SR 1558** | **Cherokee** | FF7 | 06/17/04 | 38 | Fair |
| | | | | 03/23/06 | 46 | Good-Fair |
| | | | | 06/23/09 | 38 | Fair |
| Peachtree Cr | SR 1537A | Cherokee | FF15 | 03/22/06 | --- | Not Rated |
| **Peachtree Cr** | **US 64** | **Cherokee** | FF8 | 06/15/04 | 58 | Excellent |
| | | | | 06/23/09 | 58 | Excellent |
| **Persimmon Cr** | **SR 1127** | **Cherokee** | FF2 | 06/16/04 | 20 | Poor |
| | | | | 03/23/06 | 26 | Poor |
| **Shooting Cr** | **SR 1340** | **Clay** | FF12 | 06/14/04 | 40 | Good-Fair |
| | | | | 06/22/09 | 40 | Good-Fair |
| **Shuler Cr** | **SR 1323** | **Cherokee** | FF17 | 06/24/09 | 50 | Good |
| Slow Cr | SR 1531 | Cherokee | FF16 | 03/22/06 | 40 | Good-Fair |
| **South Shoal Cr** | **SR 1314** | **Cherokee** | FF1 | 06/16/04 | --- | Not Rated |
| **Tatham Cr** | **US Bus 19** | **Cherokee** | FF19 | 06/25/09 | --- | Not Rated |
| **Taylor Cr** | **SR 1515** | **Cherokee** | FF4 | 06/18/04 | 44 | Good-Fair |
| | | | | 06/25/09 | 44 | Good-Fair |
| **Tusquitee Cr** | **SR 1330** | **Clay** | FF9 | 06/15/04 | --- | Not Rated |
| **Valley R** | **SR 1409** | **Cherokee** | FF3 | 06/18/04 | --- | Not Rated |
| | | | | 06/25/09 | --- | Not Rated |
| **Vengeance Cr** | **NC 141/SR** | **Cherokee** | FF6 | 06/17/04 | 56 | Good |
| | | | | 06/25/09 | 48 | Good |

**Appendix F-4. Fish Community Metric Values from 13 Wadeable Streams in Hiwassee River Basinwide Monitoring Program, 2009.[1]**

**Table 10**

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shooting Cr | SR 1340 | Clay | 22.5 | 06/22/09 | 11 | 689 | 1 | 1 | 4 | 1 | 0 | 21 | 77 | 82 |
| Fires Cr | SR 1300 | Clay | 23.0 | 06/23/09 | 11 | 485 | 1 | 2 | 5 | 3 | 0 | 9 | 89 | 73 |
| Brasstown Cr | SR 1111 | Clay | 37.3 | 06/22/09 | 17 | 601 | 4 | 1 | 6 | 2 | 3 | 14 | 85 | 76 |
| Little Brasstown Cr | SR 1565 | Cherokee | 9.1 | 06/23/09 | 19 | 138 | 2 | 1 | 8 | 1 | 31 | 18 | 78 | 68 |
| Peachtree Cr | old US 64 | Cherokee | 18.4 | 06/23/09 | 24 | 982 | 4 | 1 | 10 | 3 | 2 | 14 | 84 | 79 |
| Martin Cr | SR 1558 | Cherokee | 9.0 | 06/23/09 | 22 | 449 | 3 | 0 | 9 | 1 | 1 | 8 | 90 | 55 |
| Valley R | SR 1409 | Cherokee | 16.8 | 06/25/09 | 13 | 652 | 1 | 2 | 6 | 2 | 6 | 7 | 91 | 69 |
| Tatham Cr | US Bus 19 | Cherokee | 8.24 | 06/25/09 | 8 | 1072 | 0 | 1 | 4 | 1 | 8 | 9 | 91 | 75 |
| Taylor Cr | SR 1515 | Cherokee | 5.7 | 06/25/09 | 15 | 646 | 2 | 1 | 8 | 1 | 15 | 14 | 85 | 73 |
| Vengeance Cr | NC 141/SR | Cherokee | 7.2 | 06/25/09 | 14 | 639 | 2 | 2 | 7 | 2 | 3 | 21 | 77 | 86 |
| Hanging Dog Cr | off SR 1342 | Cherokee | 21.7 | 06/24/09 | 15 | 521 | 4 | 2 | 6 | 3 | 1 | 11 | 88 | 73 |
| Beaverdam Cr | off SR 1331 | Cherokee | 12.4 | 06/24/09 | 11 | 399 | 2 | 0 | 7 | 0 | 12 | 7 | 93 | 91 |
| Shuler Cr | SR 1323 | Cherokee | 17.6 | 06/24/09 | 17 | 453 | 3 | 3 | 6 | 3 | 4 | 11 | 86 | 65 |

[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, and MA = species with multiple age groups.

**Appendix F-5. Fish Distributional Records for the Hiwassee River Basin.**

Based upon Menhinick (1991) and data from DWQ, North Carolina State Museum of Natural Sciences, TVA, and from other researchers, 65 species have been collected from the Hiwassee River basin in North Carolina (Table 7 in Appendix F-1). The known species assemblage includes 20 species of cyprinids, 9 species of suckers, 12 species of sunfish and bass, and 6 species of darters. There were no new county distributional records recorded in 2009. Fourteen of the 65 species (22 percent of the total basin fauna) are nonindigenous (exotic) and were introduced either as sportfish, forage fish, baitfish, or for reasons unknown (Table 7). In 2009, 4 of the 33 species collected were nonindigenous species and every stream, except for Taylor, Hanging Dog, and Beaverdam creeks, had at least one nonindigenous species present.

**Table 11. Nonindigenous Species in the Hiwassee River Basin. Species Collected in 2009 are Highlighted in Blue.**

| Family/Species | Common Name | Family/Species | Common Name |
|---|---|---|---|
| **Clupeidae** | **Herrings** | **Moronidae** | **Temperate Basses** |
| *Alosa aestivalis* | Blueback Herring | *Morone chrysops* | White Bass |
| *Dorosoma petenense* | Threadfin Shad | **Centrarchidae** | **Sunfishes** |
| **Cyprinidae** | **Carps and Minnows** | *Ambloplites cavifrons* | Roanoke Bass |
| *Carassius auratus* | Goldfish | *Lepomis auritus* | Redbreast Sunfish |
| *Cyprinus carpio* | Common Carp | *L. cyanellus* | Green Sunfish |
| *Notemigonus crysoleucas* | Golden Shiner | *L. microlophus* | Redear Sunfish |
| **Ictaluridae** | **North American Catfishes** | **Percidae** | **Perches** |
| *Ameiurus natalis* | Yellow Bullhead | *Perca flavescens* | Yellow Perch |
| **Salmonidae** | **Trouts and Salmons** | | |
| *Oncorhynchus mykiss* | Rainbow Trout | | |
| *Salmo trutta* | Brown Trout | | |

In 2009, 33 of the 65 species were collected during NC DWQ's fish community monitoring program (Table 7 in Appendix F-1). The most commonly collected species were the Central Stoneroller, Creek Chub, Northern Hogsucker, and Mottled Sculpin which were collected at all 13 sites. The most abundant species was the Mottled Sculpin which constituted 46 percent of all the fish collected. It was also the most abundant species at 8 of the 13 sites. Except for the Highland Shiner which was extremely abundant in Martin Creek and the Smoky Dace, uncommon species were represented by only 1-6 fish per species. Although not considered "rare" species, these species are not commonly encountered in the size of streams that are assessed as part of the wadeable stream fish community assessment program.

**Table 12. Narrowly Distributed and Uncommonly Collected Species Encountered by the Wadeable Stream Fish Community Assessment Program in the Hiwassee River Basin, 2009.**

| Species | No. of Sites Collected | No. Specimens Collected |
|---|---|---|
| Smoky Dace | 2 | 26 |
| Highland Shiner | 1 | 233 |
| Silver Shiner | 1 | 1 |
| Telescope Shiner | 1 | 2 |
| White Sucker | 1 | 1 |
| Golden Redhorse | 2 | 4 |
| Brook Trout | 1 | 1 |
| Smallmouth Bass | 1 | 1 |
| Spotted Bass | 1 | 1 |
| Largemouth Bass | 2 | 6 |
| Yellow Perch | 2 | 6 |

Special protection status has been given to 3 of the 65 species by the U. S. Department of the Interior, the NC Wildlife Resources Commission, or the NC Natural Heritage Program under the NC State Endangered Species Act (G.S. 113-331 to 113-337) (LeGrand *et al*. 2008; Menhinick and Braswell 1997)

(Table 13). In 2009, the Smoky Dace was collected as part of the fish community monitoring program from Taylor and Vengeance creeks.

**Table 13. 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* sp cf. *funduloides* | Smoky Dace | State - Special Concern | S3 |
| *Moxostoma* sp. cf. *macrolepidotum* | Sicklefin Redhorse | State – Threatened | S1 |
| *Percina squamata* | Olive Darter | State - Special Concern | S2 |

[1]S1 = critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina; S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; S3 = rare or uncommon in North Carolina (LeGrand *et al*. 2008).

**Appendix F-6. Habitat Evaluations and Stream and Riparian Habitats at 13 Fish Community Monitoring Sites in the Hiwassee River Basin, 2009.**

**Habitat Assessments**

A method and scoring system has been developed to evaluate the physical habitats of a stream (NCDWQ 2006a). The narrative descriptions of eight habitat characteristics, including channel modification, amount of instream habitat, type of bottom substrate, pool variety, riffle frequency, bank stability, light penetration, and riparian zone width, are converted into numerical scores. The total habitat score ranges between 1 and 100. Higher numbers suggest better habitat quality, but criteria have not been developed to assign ratings. Scores greater than 65 generally represent moderate to high quality habitat site, whereas scores less than 65 generally represent low to poor quality habitat sites (DWQ unpublished data).

In 2009 fish community sampling was conducted at 13 sites (Tables 1 and 14). Habitat scores ranged from 55 at Little Brasstown Creek to 97 at Fires Creek. Lower scoring sites generally had narrow riparian zones which were sparsely vegetated with mature trees providing less than optimal shading to the streams (Table 14). Several of the sites would benefit from bank stabilization and stream restoration techniques. The lower ranking sites also scored low during the 2004 assessment period.

**Table 14. Rankings of 13 Waterbodies in the Hiwassee River Basin According to the Total Habitat Scores, 2009.**

| Waterbody | Location | County | Level IV Ecoregion | Score |
|---|---|---|---|---|
| Fires Cr | SR 1300 | Clay | Broad Basins | 97 |
| Valley R | SR 1409 | Cherokee | Southern Metasedimentary Mountains | 93 |
| Shuler Cr | SR 1323 | Cherokee | Southern Metasedimentary Mountains | 88 |
| Tatham Cr | US 19 bus. | Cherokee | Broad Basins | 86 |
| Shooting Cr | SR 1340 | Clay | Broad Basins | 84 |
| Brasstown Cr | SR 1111 | Clay | Broad Basins | 84 |
| Vengeance Cr | NC 141/SR 1520 | Cherokee | Broad Basins | 83 |
| Hanging Dog Cr | off SR 1342 | Cherokee | Southern Metasedimentary Mountains | 79 |
| Beaverdam Cr | off SR 1331 | Cherokee | Southern Metasedimentary Mountains | 76 |
| Peachtree Cr | Old US 64 | Cherokee | Broad Basins | 74 |
| Martin Cr | SR 1558 | Cherokee | Broad Basins | 72 |
| Taylor Cr | SR 1515 | Cherokee | Broad Basins | 67 |
| Little Brasstown Cr | SR 1565 | Cherokee | Broad Basins | 55 |

**Table 15. Habitat Evaluations of 13 Basinwide Fish Community Sites in the Hiwassee River Basin, 2009. Red Bold Denotes Less than Optimal Habitat Conditions.**

| Waterbody | Location | County | Channel | Instream Habitat | Substrate | Pools | Riffles | Erosion | Bank Vegetation | Shade | Riparian Zone-L | Riparian Zone-R | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shooting Cr | SR 1340 | Clay | 5 | 18 | 12 | 6 | 16 | 7 | 6 | 7 | 4 | 3 | 84 |
| Fires Cr | SR 1300 | Clay | 5 | 20 | 15 | 8 | 16 | 7 | 7 | 10 | 4 | 5 | 97 |
| Brasstown Cr | SR 1111 | Clay | 5 | 18 | 12 | 8 | 12 | 6 | 7 | 10 | 3 | 3 | 84 |
| Little Brasstown Cr | SR 1565 | Cherokee | 4 | 14 | **5** | 6 | **3** | 4 | 4 | 8 | 3 | 4 | 55 |
| Peachtree Cr | Old US 64 | Cherokee | 5 | 16 | 10 | 10 | 10 | 6 | 5 | 7 | 3 | **2** | 74 |
| Martin Cr | SR 1558 | Cherokee | 5 | 18 | 8 | **4** | **5** | 5 | 7 | 10 | 5 | 5 | 72 |
| Valley R | SR 1409 | Cherokee | 5 | 20 | 12 | 10 | 16 | 7 | 6 | 10 | 5 | **2** | 93 |
| Tatham Cr | US 19 bus. | Cherokee | 5 | 20 | 14 | 4 | 16 | 7 | 6 | 7 | **2** | 5 | 86 |
| Taylor Cr | SR 1515 | Cherokee | 5 | 16 | 10 | 6 | 12 | **3** | 6 | 7 | **1** | **1** | 67 |
| Vengeance Cr | NC 141/SR 1520 | Cherokee | 5 | 18 | 12 | 6 | 16 | 6 | 5 | 9 | 3 | 3 | 83 |
| Hanging Dog Cr | off SR 1342 | Cherokee | 5 | 18 | 12 | 6 | 16 | 5 | 5 | 7 | 3 | **2** | 79 |
| Beaverdam Cr | off SR 1331 | Cherokee | 5 | 18 | 10 | 10 | 14 | 6 | 5 | 5 | 2 | **1** | 76 |
| Shuler Cr | SR 1323 | Cherokee | 5 | 18 | 10 | 10 | 14 | 6 | 6 | 9 | 5 | 5 | 88 |
| **Maximum possible scores** | | | **5** | **20** | **15** | **10** | **16** | **7** | **7** | **10** | **5** | **5** | **100** |

Characteristics of moderate to high quality habitat streams are (Figure 6):

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

**Figure 6. Favorable Instream Habitats. Fires Creek at SR 1300, Clay County (left) and Valley River at SR 1409, Cherokee County (right).**

Characteristics of lower quality habitat streams are (Figure 7):

- a substrate of primarily sand 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 with breaks; and
- deeply entrenched channel with unstable, vertical, and sparsely vegetated banks.

**Figure 7. Unfavorable Instream Habitats. Little Brasstown Creek at SR 1565, Cherokee County (left) and Taylor Creek at SR 1515, Cherokee County (right).**

**Appendix F-7. Water Quality at 13 Fish Community Sites in the Hiwassee River Basin, 2009.**

Temperature, specific conductance, dissolved oxygen, and pH were collected at every site during fish community assessments in 2009 (Table 16). All measured dissolved oxygen concentrations met the water quality standard of 5 mg/L. Five pH measurements were less than 6.0 s.u. Specific conductance ranged from 13 µS/cm at Fires Creek to 53 µS/cm at Martin Creek (Figure 8). Elevated readings were associated primarily with nonpoint source runoff.

**Table 16. Water Quality Measurements at 13 Fish Community Sites in the Hiwassee River Basin, 2009. Red Bold Denotes Less than the Water Quality Standard.[1]**

| HUC/ Waterbody | Location | County | Date | Temperature (˚C) | Specific conductance (µS/cm) | Dissolved oxygen (mg/L) | pH (s.u.) |
|---|---|---|---|---|---|---|---|
| Shooting Cr | SR 1340 | Clay | 06/22/09 | 21.6 | 30 | 7.8 | 6.2 |
| Fires Cr | SR 1300 | Clay | 06/23/09 | 18.8 | 13 | 8.4 | **5.7** |
| Brasstown Cr | SR 1111 | Clay | 06/22/09 | 22.6 | 42 | 7.6 | 6.1 |
| Little Brasstown Cr | SR 1565 | Cherokee | 06/23/09 | 18.9 | 47 | 8.1 | **5.9** |
| Peachtree Cr | old US 64 | Cherokee | 06/23/09 | 20.4 | 44 | 8.8 | 6.3 |
| Martin Cr | SR 1558 | Cherokee | 06/23/09 | 24.3 | 53 | 7.8 | 6.3 |
| Valley R | SR 1409 | Cherokee | 06/25/09 | 20.3 | 34 | 9.0 | 6.4 |
| Tatham Cr | US Bus 19 | Cherokee | 06/25/09 | 20.9 | 42 | 9.0 | 6.7 |
| Taylor Cr | SR 1515 | Cherokee | 06/25/09 | 17.7 | 27 | 9.1 | **5.8** |
| Vengeance Cr | NC 141/SR 1520 | Cherokee | 06/25/09 | 17.5 | 29 | 9.6 | 6.0 |
| Hanging Dog Cr | off SR 1342 | Cherokee | 06/24/09 | 21.5 | 17 | 8.9 | 6.1 |
| Beaverdam Cr | off SR 1331 | Cherokee | 06/24/09 | 19.0 | 17 | 9.0 | **5.9** |
| Shuler Cr | SR 1323 | Cherokee | 06/24/09 | 18.8 | 20 | 8.8 | **5.6** |

[1]Note: pH measurements made with the Fisher-Accumet® AP 61 portable pH meter may be affected by low specific conductance of the water; pH measurement should be interpreted with caution.]

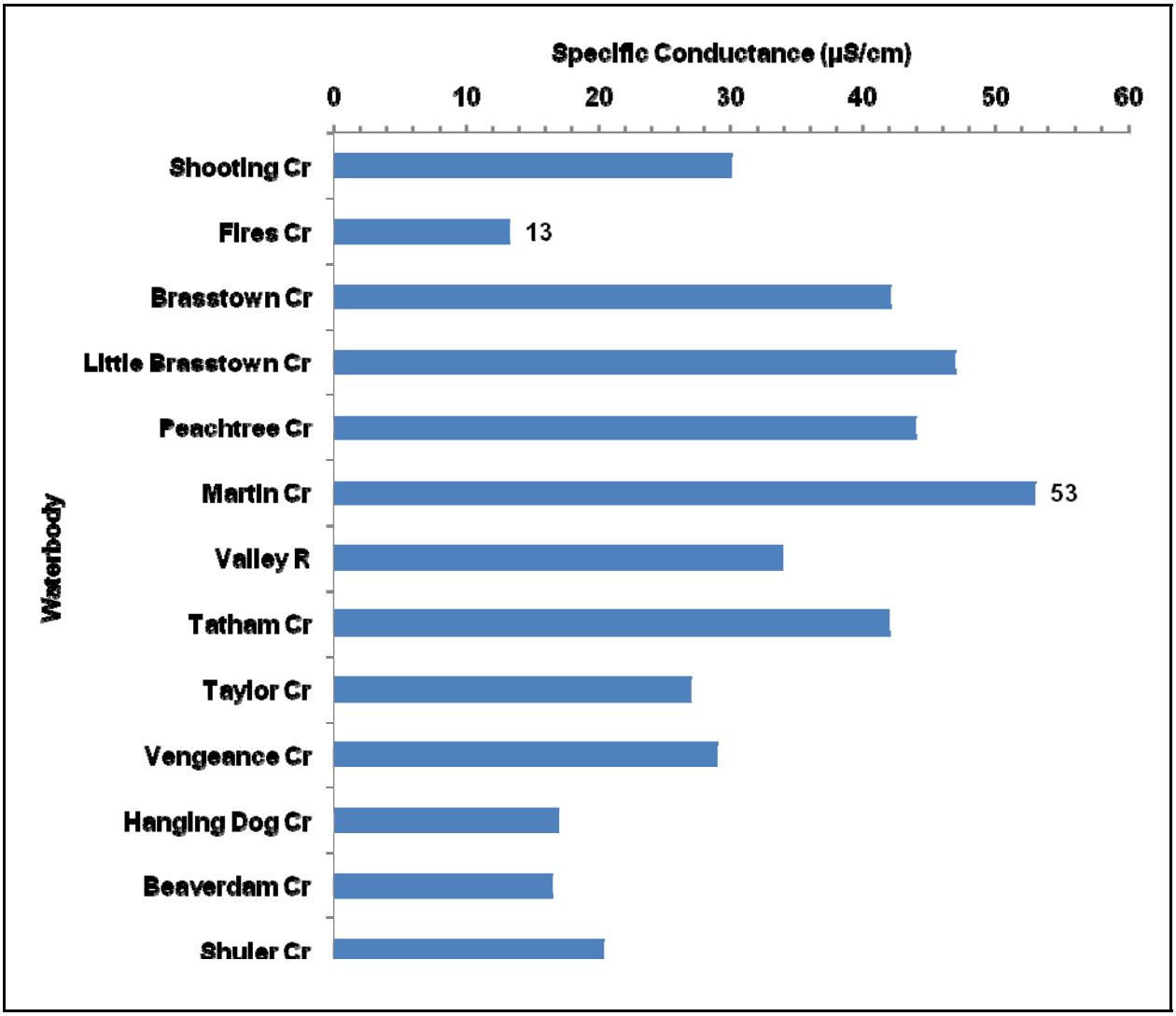



**Figure 8.** **Specific Conductance at 13 Fish Community Sites in the Hiwassee River Basin, 2009.**

**References Cited**

Fels, J. 1997. North Carolina watersheds map. North Carolina State University Cooperative Extension Service. Raleigh, NC.

Griffith, G., Omernik, J. and J. Comstock. 2002. Ecoregions of North Carolina. United States Environmental Protection Agency. Research and Development. NHEERL. Western Ecology Division. Corvallis, OR.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries. 6: 21 - 27.

_____, Fausch, K. D., Angermeier, P. L., Yant, P. R., and I. J. Schlosser. 1986. Assessing biological integrity in running water: a method and its rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5.

LeGrand, H. E., Hall, S. P., McRae, S. E., and J. T. Finnegan. 2006. Natural Heritage Program list of the rare animal species of North Carolina. North Carolina Natural Heritage Program, Office of Conservation and Community Affairs, North Carolina Department of Environment and Natural Resources. Raleigh, NC.

Menhinick, E. F. 1991. The freshwater fishes of North Carolina. North Carolina Wildlife Resources Commission. Raleigh, NC.

_____ and A. L. Braswell (eds). 1997. Endangered, threatened, and rare fauna of North Carolina. Part IV. A reevaluation of the freshwater fishes. Occas. Papers N.C. State Mus. Nat. Sci. and N.C. Biol. Surv. No. 11. Raleigh, NC.

NCDWQ. 2006a. Standard operating procedure. Biological monitoring. Stream fish community assessment program. Biological Assessment Unit. North Carolina Department of Environment and Natural Resources. Division of Water Quality. Environmental Sciences Section. Raleigh, NC.

NCDWQ. 2006b. Standard Operating Procedures for Benthic Macroinvertebrates. NC Dept. of Environment and Natural Resources, Division of Water Quality. Environmental Sciences Section. Raleigh, NC.

_____. 2007. North Carolina. Water quality assessment and impaired waters list (2006 integrated 305(b) and 303(d) report). Final. Approved May 17, 2007. North Carolina Department of Environment and Natural Resources. Division of Water Quality. Planning Section. Raleigh, NC.