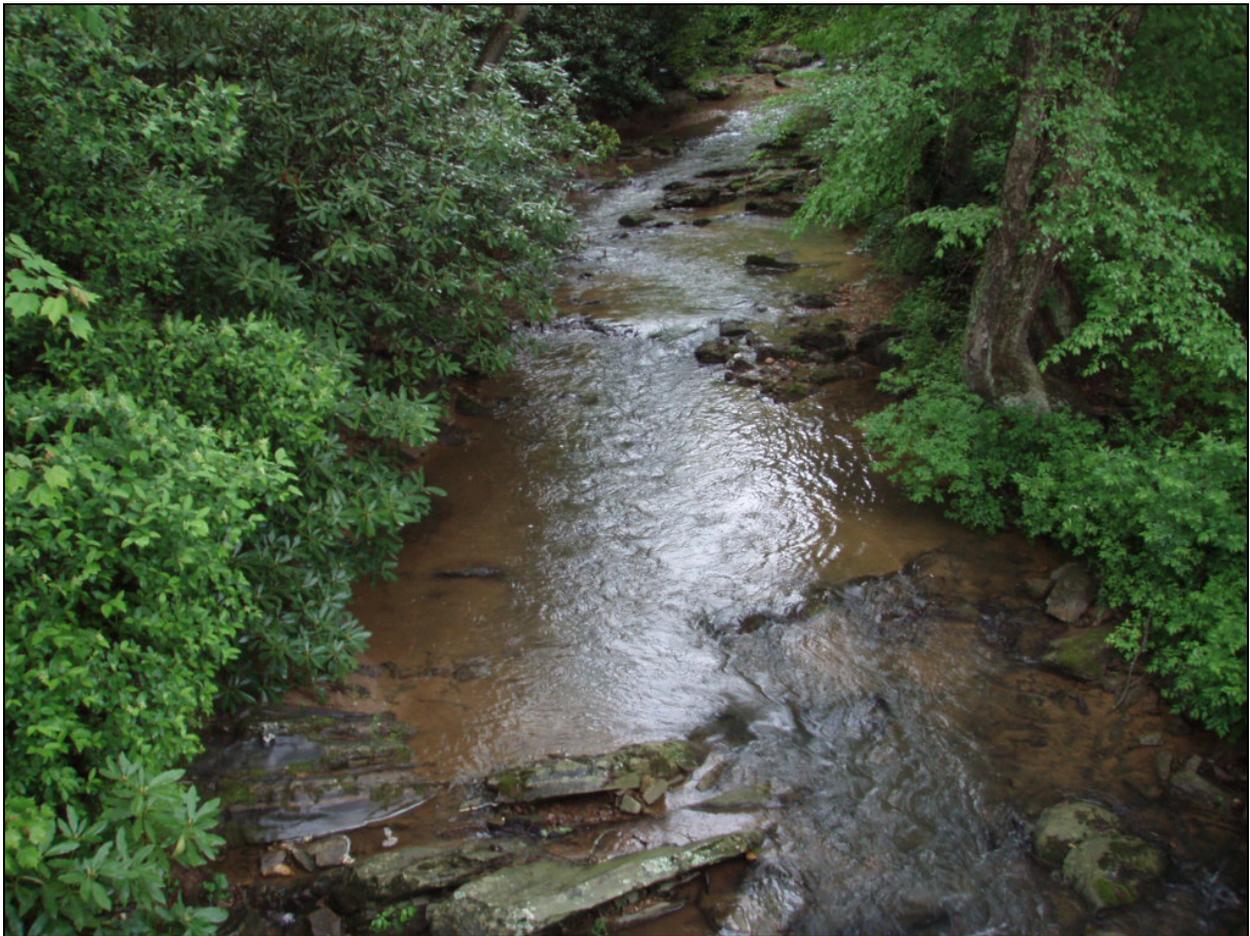


BASINWIDE ASSESSMENT REPORT ROANOKE RIVER BASIN



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

December 2010



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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 reassessed every five years. The Roanoke 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 from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data. 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 Roanoke River basin include benthic macroinvertebrates and fish community. 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.

This document is structured with physical, geographical, and biological data discussions presented in 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.

ROANOKE RIVER BASIN DESCRIPTION

The Roanoke River basin extends from its source in the Blue Ridge Mountains of Virginia to the Albemarle Sound in North Carolina, encompassing mountainous, piedmont, and coastal topography as it flows generally east- southeastward. As the sixth largest river basin in the state, the Roanoke River carries more water and has the widest floodplain of any in the state. The basin's five eight-digit hydrologic units (Figure 1) constitute 3,503 square miles of drainage area and approximately 2,389 miles of streams and rivers in North Carolina. Major tributaries to the Roanoke River include the Dan, Mayo River, Smith, and Cashie rivers. Fifteen counties and 42 municipalities are also included in the basin. The Level IV ecoregions associated with this basin include the Sauratown Mountains of the Blue Ridge ecoregion; the Triassic Basins, Southern Outer Piedmont, Northern Inner Piedmont, Carolina Slate Belt, and Northern Outer Piedmont ecoregions of the Piedmont; the Rolling Coastal Plain and Southeastern Floodplains and Low Terraces ecoregions of the Southeastern Plains; and the Mid-Atlantic Flatwoods and Mid-Atlantic Floodplains and Low Terraces ecoregions of the Middle Atlantic Coastal Plain.

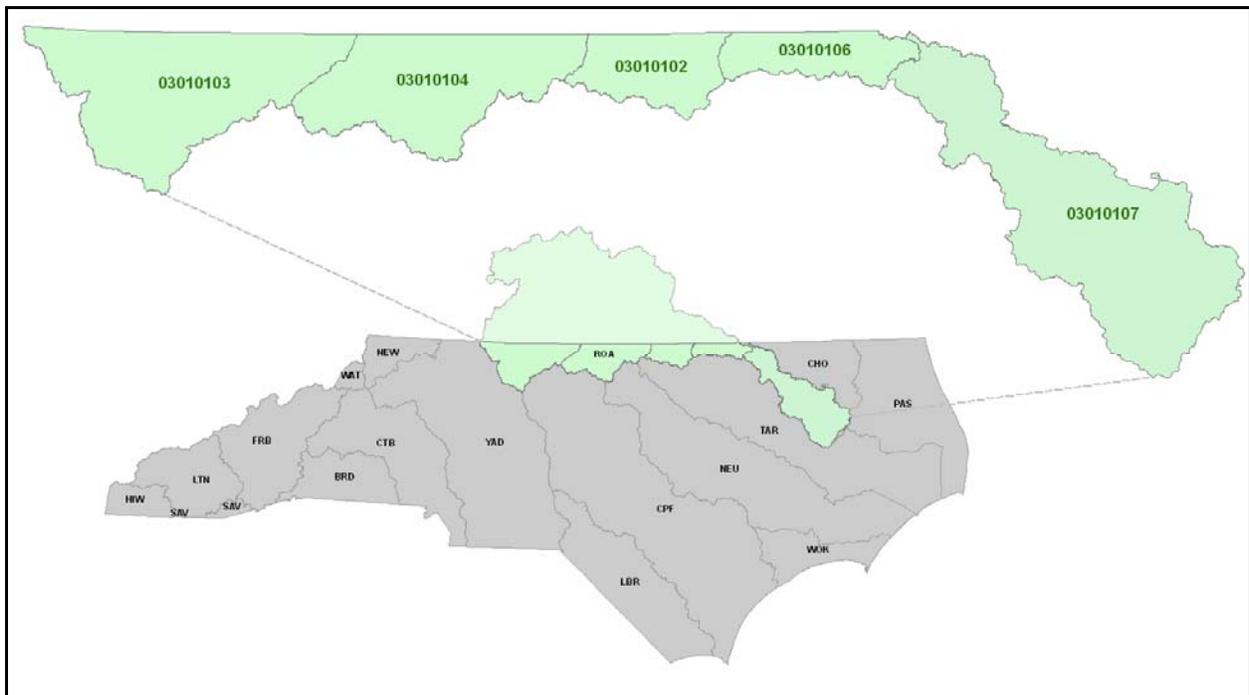


Figure 1. Geographical relationships and the 8 digit hydrologic units of the Roanoke River Basin.

Though the spread of urban and suburban development has occurred in the basin as elsewhere in the state, according to 2001 NLCD (Homer et al 2004¹), the greatest portion of land cover in the basin has remained forest and, to a lesser extent, agriculture-based. The fastest urban growth in the basin is occurring in Stokes, Forsyth, Person, and Granville Counties (NCDENR 2006²). Also characteristic of activities throughout the state, nonpoint source runoff and numerous small point source dischargers associated with development and agriculture have great potential to degrade water quality in the basin.

¹Homer, C., C. Huang, L. Yang, B. Wylie and M. Coan. 2004. Development of a 2001 national land-cover database for the United States. *Photogrammetric Engineering and Remote Sensing*. 70: 829-840.

ROA RIVER HUC 03010103—DAN RIVER HEADWATERS

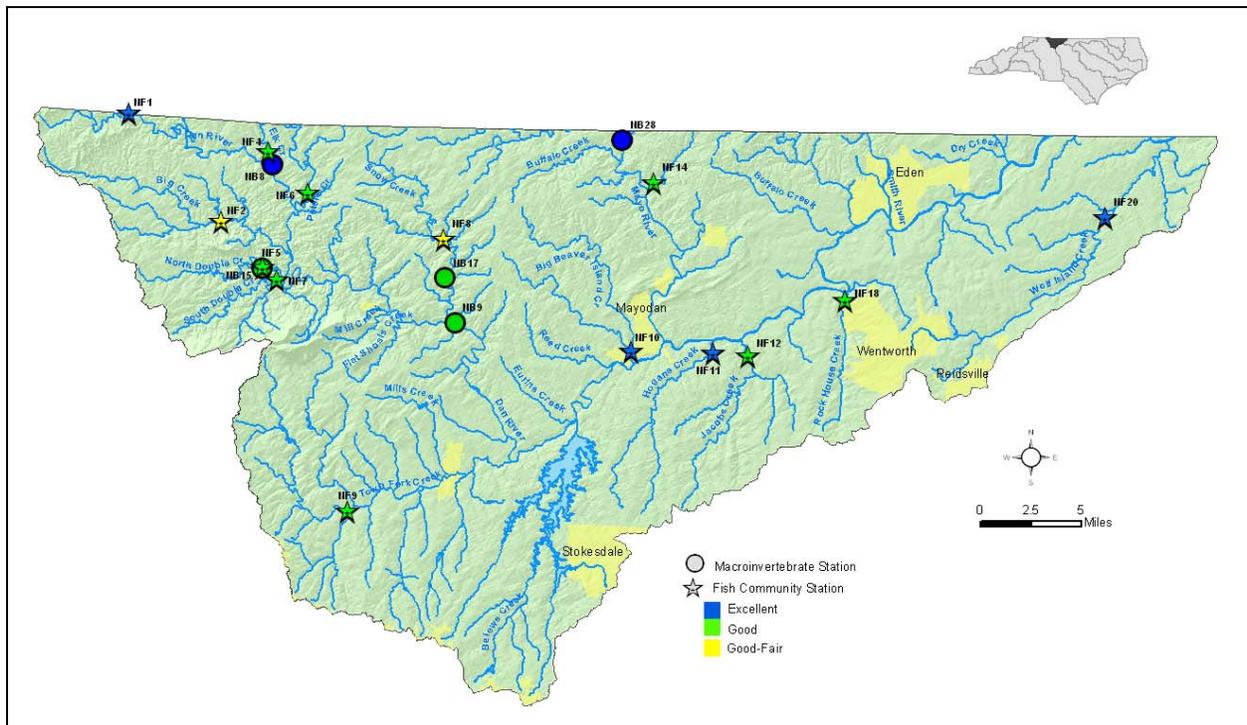


Figure 2. Sampling sites in HUC 03010103 in the Roanoke River basin. Monitoring sites are listed in Table 1.

River and Stream Assessment

Five benthic macroinvertebrate sites and 14 fish community sites were evaluated in 2009 representing 18 distinct localities (Table 1; Figure 2). Some non-point nutrient enrichment may have been responsible for the slight decline in the fish community ratings at Big Creek and Snow Creek between 2004 and 2009. Other than that, biological communities in the Dan River Headwaters are indicative of Good or Excellent water quality. If requested Archies Creek, the Dan River at NC 704, Hogans Creek, and upper Wolf Island Creek qualify as Outstanding Resource Waters or High Quality Waters.

Specific site summaries of the benthic macroinvertebrate and fish community samples (Table 1) may be found in the Templates Section.

Table 1. Waterbodies monitored in HUC 03010103 in the Roanoke River basin for basinwide assessment, 2004 and 2009.

Site ID ¹	Waterbody	County	Location	2004	2009
NB8	Dan R	Stokes	NC 704	Excellent	Excellent
NB9	Dan R	Stokes	SR 1695	Good	Good
NB15	N Double Cr	Stokes	SR 1504	Good	Good
NB17	Snow Cr	Stokes	SR 1673	Good	Good
NB28	Mayo R	Rockingham	SR 1358	Good	Excellent
NF1	Archies Cr	Stokes	SR 1415	Excellent	Excellent
NF4	Elk Cr	Stokes	SR 1433	Good-Fair	Good
NF6	Peters Cr	Stokes	SR 1497	Excellent	Good
NF2	Big Cr	Stokes	SR 1471	Good	Good-Fair
NF5	N Double Cr	Stokes	SR 1504	Good-Fair	Good
NF7	S Double Cr	Stokes	SR 1483	Good	Good
NF8	Snow Cr	Stokes	SR 1652	Good	Good-Fair
NF9	Town Fork Cr	Stokes	SR 1955	Good	Good
NF10	Big Beaver Island Cr	Rockingham	US 311	Good	Excellent
NF14	Pawpaw Cr	Rockingham	SR 1360	Good-Fair	Good
NF11	Hogans Cr	Rockingham	NC 704	Good	Excellent
NF12	Jacobs Cr	Rockingham	NC 704	Good	Good
NF18	Rockhouse Cr	Rockingham	SR 2127	Good	Good
NF19	Wolf Island Cr	Rockingham	SR 1767	Good	Excellent

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

Special Studies

Random Ambient Monitoring

The fish community in Crooked Creek, off SR 1626, Stokes County, a tributary to the South Mayo River, was sampled in 2007 as part of the 2007-2008 Random Ambient Monitoring Program. The community was rated Good-Fair with several key species lacking along with an absence of intolerant species.

ROA RIVER HUC 03010104—DAN RIVER

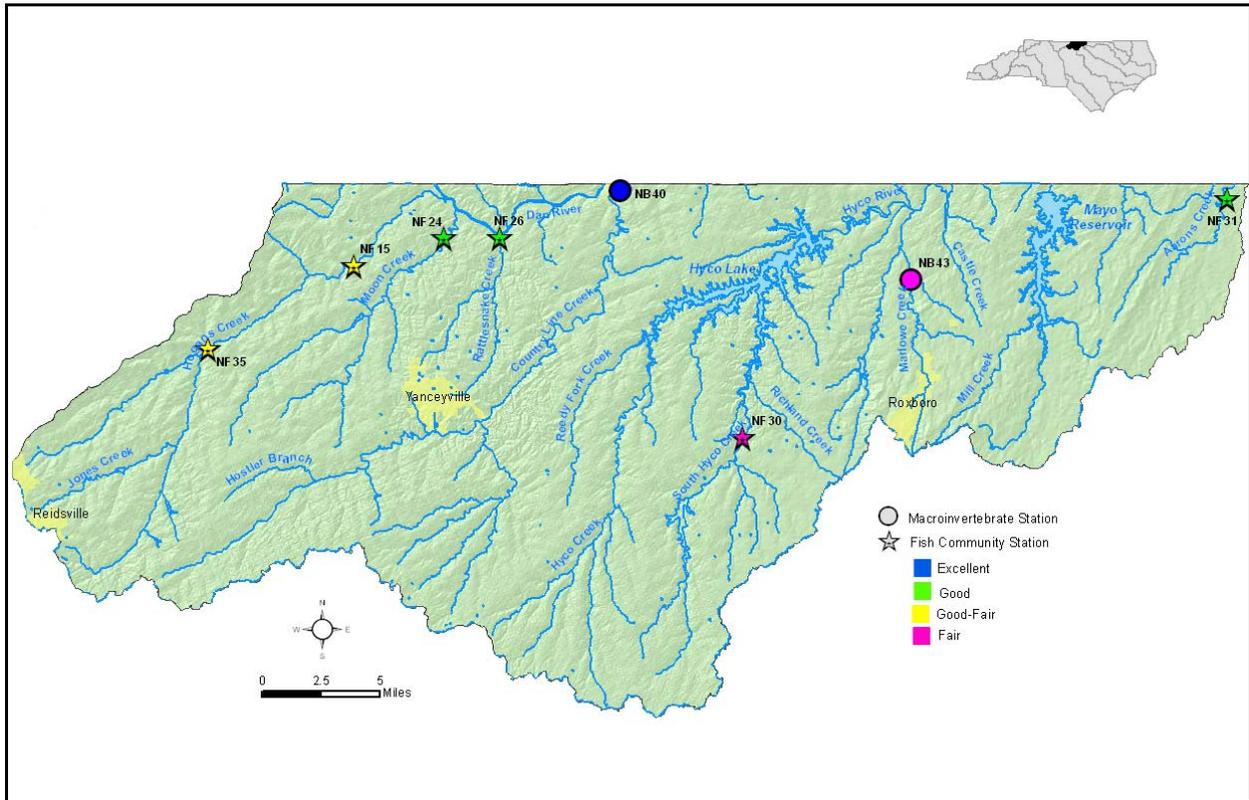


Figure 3. Sampling sites in HUC 03010104 in the Roanoke River basin. Monitoring sites are listed in Table 2.

River and Stream Assessment

Two benthic macroinvertebrate sites and six fish community sites were evaluated in 2009 representing eight distinct localities (Table 2; Figure 3). Most streams in the western and central portion of this HUC have very sandy substrates and show evidence of nonpoint source sediment runoff, yet most of the biological communities rate at least Good-Fair or Good. There were three exceptions; one being the benthic community in Country Line creek which rated Excellent. The other two major exceptions were Marlowe Creek and South Hyco Creek. The benthic macroinvertebrate community in Marlowe Creek, whose watershed includes the Town of Roxboro and which receives the treated effluent from its wastewater treatment plant, declined from Good-Fair to Fair between 2004 and 2009. In 3 of the 4 monitoring cycles over the past 15 years, the benthic macroinvertebrate community has rated Fair or Poor. The fish community in South Hyco Creek, a tributary to Hyco Reservoir, at the US 158 bridge is affected by limited recolonization avenues following prolonged droughts due to its location bracketed by Roxboro Lake and Hyco Reservoir. The community seemed to have yet recovered from the 2007-2008 droughts.

Specific site summaries of the benthic macroinvertebrate and fish community samples (Table 2) may be found in the Templates Section.

Table 2. Waterbodies monitored in HUC 03010104 in the Roanoke River basin for basinwide assessment, 2004 and 2009.

Site ID ¹	Waterbody	County	Location	2004	2009
NB40	Country Line Cr	Caswell	NC 57	Good	Excellent
NB43	Marlowe Cr	Person	SR 1322	Good-Fair	Fair
NF35	Hogans Cr	Caswell	SR 1301	---	Good-Fair
NF15	Hogans Cr	Caswell	SR 1330	Good	Good-Fair
NF24	Moon Cr	Caswell	SR 1511	Good	Good
NF26	Rattlesnake Cr	Caswell	SR 1523	Good	Good
NF30	S Hyco Cr	Person	US 158	Good	Fair
NF31	Aarons Cr	Granville	SR 1400	Good	Good

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

ROA RIVER HUC 03010102—JOHN H. KERR RESERVOIR

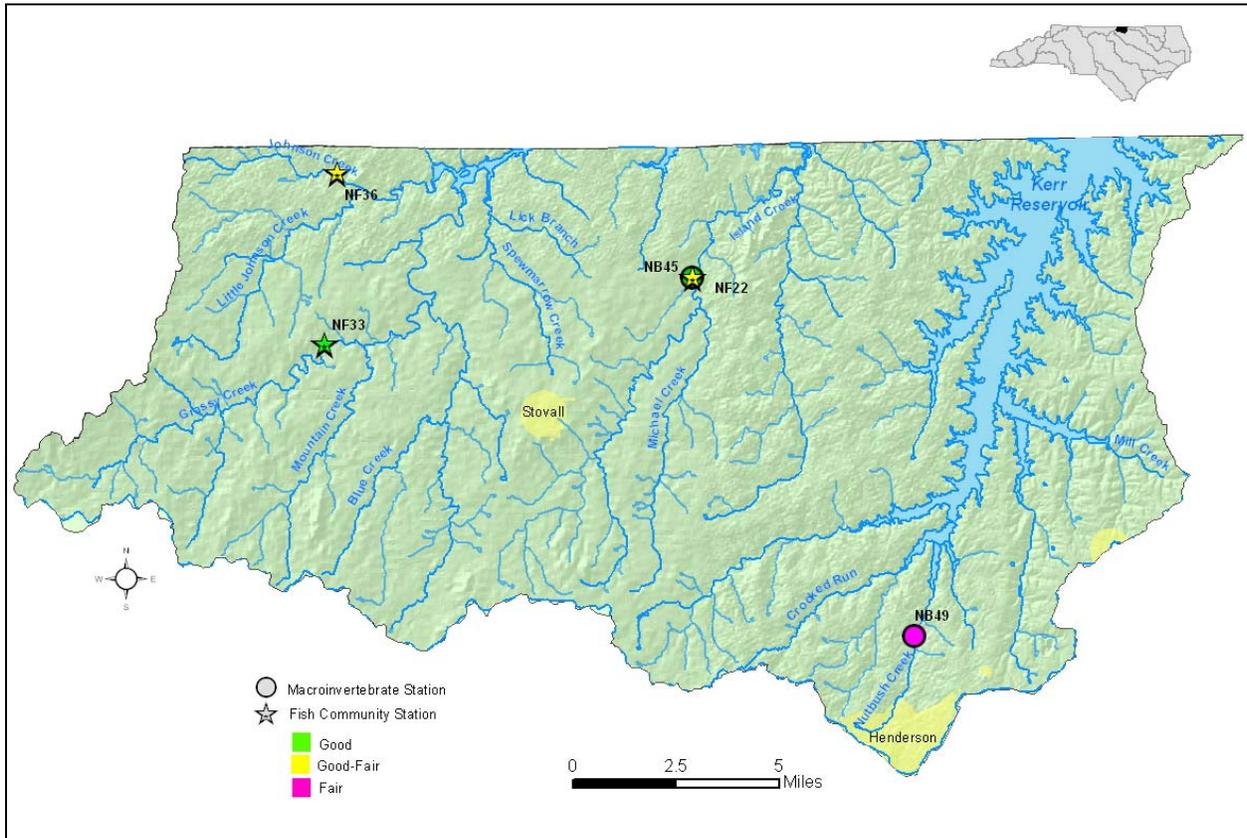


Figure 4. Sampling sites in HUC 03010102 in the Roanoke River basin. Monitoring sites are listed in Table 3.

River and Stream Assessment

Two benthic macroinvertebrate sites and three fish community sites were evaluated in 2009 representing four distinct localities (Table 3; Figure 4). Nutbush Creek, which receives the treated effluent from the City of Henderson’s wastewater treatment plant, continued to rate Fair; a rating which it has consistently received since 1994. Specific conductance at this site was also the greatest of any site in the basin in 2009. Island Creek was rated Good using the benthic macroinvertebrate data and Good-Fair using the fish community data, it had rated Excellent in 1999. It should be re-evaluated in 2010 or during a more normal flow year to determine why the fish community rating declined. Although the fish community in Grassy Creek, a regional reference site, was rated Good, the rating was based upon a very small sample size, the fewest of any site in the basin in 2009, and the site should be re-evaluated in 2014 or during a more normal flow year to determine if reference site status is still warranted. Johnson Creek, also a regional reference site, rated Good-Fair again in 2009, the same rating it received in 2004. Like other small streams in this area, Johnson Creek may quit flowing during extended low flow periods.

Specific site summaries of the benthic macroinvertebrate and fish community samples (Table 3) may be found in the Templates Section.

Table 3. Waterbodies monitored in HUC 03010102 in the Roanoke River basin for basinwide assessment, 2004 and 2009.

Site ID ¹	Waterbody	County	Location	2004	2009
NB45	Island Cr	Granville	SR 1445	Good-Fair	Good
NB49	Nutbush Cr	Vance	SR 1317	Fair	Fair
NF33	Grassy Cr	Granville	SR 1300	Good (1999)	Good
NF36	Johnson Cr	Granville	SR 1440	Good-Fair	Good-Fair
NF22	Island Cr	Granville	SR 1445	Excellent (1999)	Good-Fair

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

ROA RIVER HUC 03010106—LAKE GASTON

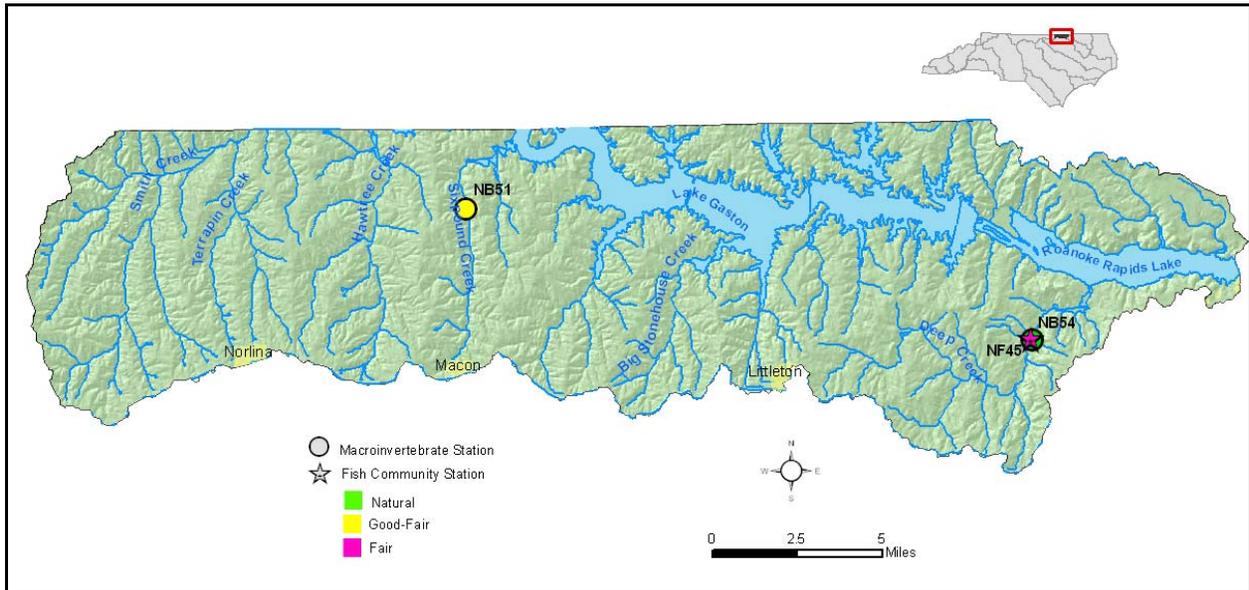


Figure 5. Sampling sites in HUC 03010106 in the Roanoke River basin. Monitoring sites are listed in Table 4.

River and Stream Assessment

Two benthic macroinvertebrate sites and one fish community sites were evaluated in 2009 representing two distinct localities (Table 4; Figure 5). The benthic community in Sixpound Creek has been rated Good-Fair during the past three basinwide monitoring cycles. The community may be influenced by chronic low flow conditions in this small watershed which drains to Lake Gaston. It has not been sampled for fish community assessments since 1994 due to low flow conditions. Deep Creek, a tributary to Roanoke Rapids Lake, is sampled for benthic macroinvertebrates during the winter as a coastal swamp stream and during the spring for fish community assessments as a Northern Outer Piedmont stream. In 2009 it was rated as Natural and as Fair (Table 4). A loss of 10 species, a greater than expected abundance of tolerant fish, and a loss of age classes warrants resampling this site in 2010 to determine if the Fair is justified. With no municipalities in its watershed, the fish community may be influenced by its proximity to the lake, nonpoint source runoff, or the lingering effects from the 2007-2008 drought.

Smith Creek at US 1 in Warren County was not sampled for fish community assessments because, when visited on May 27, 2009, the stream was bankfull, turbid, and there was water in the floodplain from thunderstorms during the past week. A return visit to the site was not possible.

Specific site summaries of the benthic macroinvertebrate and fish community samples (Table 4) may be found in the Templates Section.

Table 4. Waterbodies monitored in HUC 03010106 in the Roanoke River basin for basinwide assessment, 2004 and 2009.

Site ID ¹	Waterbody	County	Location	2004	2009
NB51	Sixpound Cr	Warren	SR 1306	Good-Fair	Good-Fair
NB54	Deep Cr	Halifax	US 158	Natural	Natural
NF45	Deep Cr	Halifax	US 158	Good	Fair

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

ROA RIVER HUC 03010107—ROANOKE RIVER

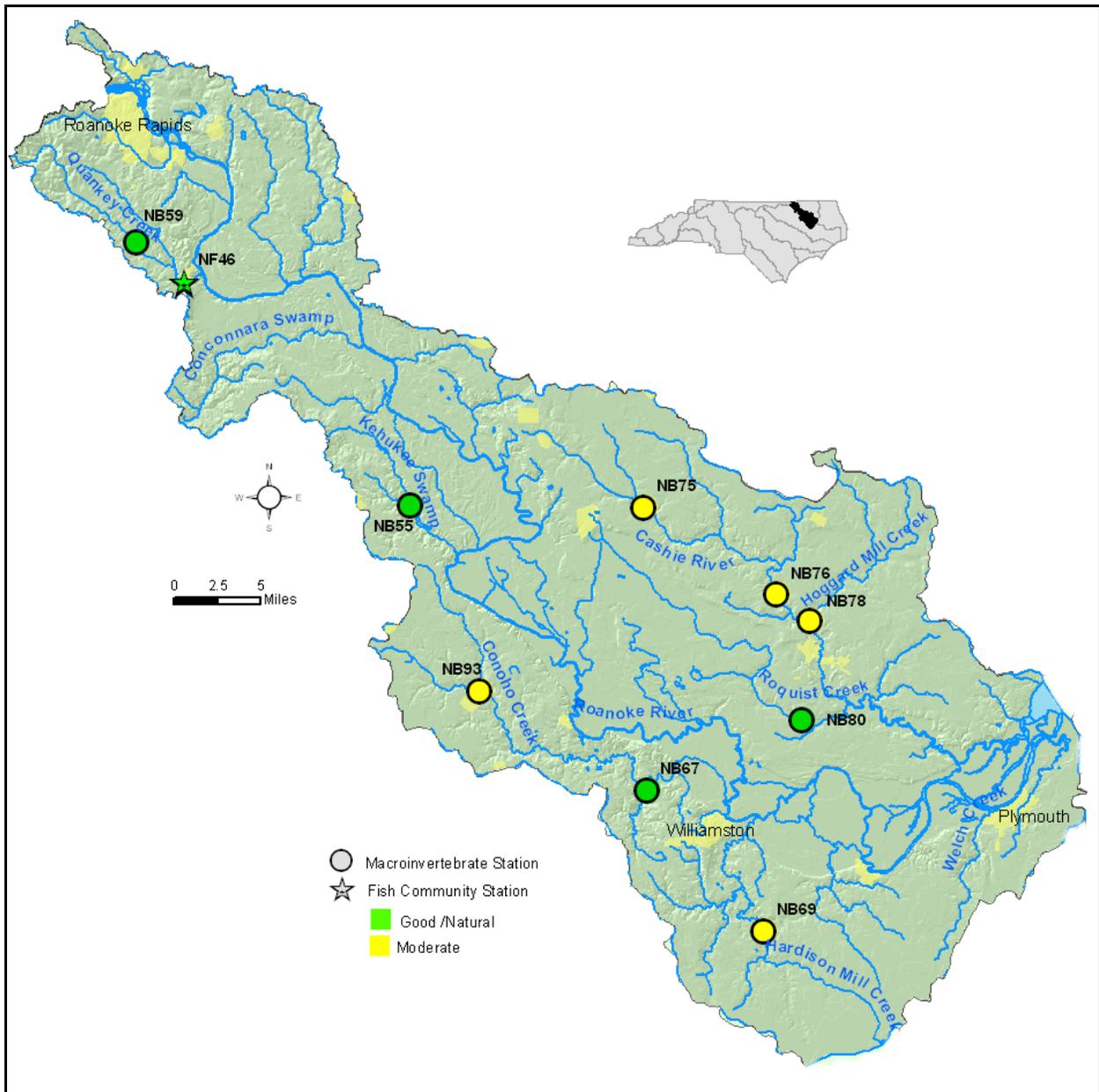


Figure 6. Sampling sites in HUC 03010107 in the Roanoke River basin. Monitoring sites are listed in Table 5.

River and Stream Assessment

The Roanoke River Basin HUC 03010107 includes streams, rivers, and swamps that are classified using the Biological Assessment Unit's (BAU) Swamp sampling criteria. All swamps with associated tributaries and wetlands flow into the Roanoke River and ultimately Albemarle Sound in the eastern part of the state. Overall, water quality in these tributaries to the Roanoke River remains good with benthic bioclassification ratings of Natural or Moderate (Table 5). The Roanoke River is 303(d) listed for 120 miles, from highway crossing at NC 48 to the 18-mile marker at Jamesville, for atmospheric deposition of mercury. The main stem of the river was not sampled for benthos in 2009. Main water quality concerns within this HUC have been attributed to point source runoff including inputs from various permitted waste water treatment plants (WWTP). Residential, recreational, forestry, and agricultural activities within this HUC should be monitored due to the potential for water quality degradation through nonpoint runoff and multiple point source dischargers.

One site in the basin improved in 2009 from 2004 ratings based on the benthic sampling regime. Kehukee Swamp at SR 1804 improved from a Moderate rating in 2004 to Natural in 2009. This improvement may have been the result of decreases in nonpoint pollution runoff resulting from the drought conditions observed from 2007 to 2008. Total taxa richness (66) and EPT richness (12) was the highest ever recorded from this sampling location.

Seven swamp sampling locations retained the same bioclassifications in 2009 as in 2004 (Table 5) including sites in the Cashie River, Conoho, Hardison Mill, Hoggard Mill, and Quankey Creeks, and Roquist Swamp. The Conoho Creek sites continue to reflect good water quality with relatively stable macroinvertebrate communities. In fact, Conoho Creek at NC 11-42 was near the threshold for receiving a Natural rating.

The 2009 benthic data at the Hardison Mill and Hoggard Mill Creek sites suggests some declines in water quality potentially due to lingering drought effects, more acidic conditions, and/or increases in anthropogenic activities upstream leading to elevated conductivity observed in 2009. Quankey Creek and Roquist Swamp both exhibited good water quality with Natural bioclassifications. Both sites have been rated Natural since 1999 using Region B swamp criteria. Quankey Creek at NC 903 continues to exhibit improving physical conditions based on macroinvertebrate fauna. The presence of several intolerant taxa collected in 2009 that were not collected in past samples from Roquist Swamp could suggest less nonpoint pollution inputs during recent (2007-2008) drought conditions.

Quankey Creek was placed on the 303(d) list in 1998 from the confluence of Little Quankey Creek to the Roanoke River for impaired biological integrity. Quankey Creek is now evaluated for benthos using BAU Swamp criteria and continues to exhibit a Natural bioclassification. Quankey Creek at NC 903—above the 303(d) listed segment—received a Natural rating in 1999, 2004, and 2009. Additionally, its tributary Little Quankey Creek received a Moderate rating in 2004 using Swamp criteria. Due to results using updated benthic biological metrics, it is suggested that the 1991 Fair rating using Coastal Plain criteria on Quankey Creek at NC 561 was inappropriate. The 303(d) listing of the segment of Quankey Creek between the confluence of Little Quankey Creek and the Roanoke River due to biological impairment should be removed from the present list.

Decreases in water quality were observed at the downstream segment of the Cashie River (Table 5 and Figure 6) from Natural in 2004 to Moderate in 2009. Total taxa richness remained similar at this site in 2009 compared to 2004, however, EPT richness decreased from seven in 2004 to only 3 in 2009. Habitat quality at the site has remained similar since 1999; however, data suggest more acidic conditions and higher conductivity could be correlated with this loss of EPT taxa. The latter may suggest inputs from the small upstream discharger (Lewiston-Woodville WWTP) or another unknown source.

Tributaries to the Roanoke River in this subbasin are swampy and may experience periods of very little or no flow. Therefore, due to low flow or no flow conditions, Conoconnara Swamp at NC 561 was not sampled for benthic macroinvertebrates in 2009 using Region B swamp criteria (Table 5).

Locations visited in June 2009 but not sampled for fish community assessments because either the stream was too deep to sample, the stream was out of its banks, or because the water body was a braided swamp included: Chockoyotte Creek at US 158, Halifax County, Occoneechee Creek at SR 1126, Northampton County, and Looking Glass Run at NC 561, Halifax County (very low water).

Specific site summaries of the benthic macroinvertebrate and fish community samples (Table 5) may be found in the Templates Section.

Table 5. Waterbodies monitored in HUC 03010107 in the Roanoke River basin for basinwide assessment, 2004 and 2009.

Site ID ¹	Waterbody	County	Location	2004	2009
NB59	Quankey Cr	Halifax	NC 903	Natural	Natural
NB55	Kehukee Swp	Halifax	SR 1804	Moderate	Natural
NB93	Conoho Cr	Martin	NC 11-42	Moderate	Moderate
NB67	Conoho Cr	Martin	SR 1147	Natural	Natural
NB69	Hardison Mill Cr	Bertie	SR 1058	Moderate	Moderate
NB 75	Cashie R	Bertie	SR 1219	Moderate	Moderate
NB76	Cashie R	Bertie	SR 1257	Natural	Moderate
NB78	Hoggard Mill Cr	Bertie	SR 1301	Moderate	Moderate
NB80	Roquist Swp	Bertie	US 17	Natural	Natural
NF46	Quankey Cr	Halifax	US 301/NC 903/NC 125	---	Good

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

GLOSSARY

Assessment Unit	A stream or a segment of a stream. Assessment Unit designations are used to uniquely identify streams or stream segments for the purpose of classifying waters for protection by use (such as for drinking water supply or trout waters).
BI or NCBI	North Carolina Biotic Index. This is one of two metrics used extensively to evaluate the results of benthic sampling, and is the weighted sum of tolerance values for taxa found in the sample relative to their abundance.
Bioclassification	A classification assigned to a stream site following biological sampling of either fish or macroinvertebrates. Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each sample. For invertebrates the bioclassification is based on the number of taxa present in the intolerant groups (EPT) and the North Carolina Biotic Index (BI or NCBI) value. For fish the classification is based on abundance, condition of specimens, species richness, composition, pollution-tolerance, trophic composition, and reproductive function.
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, and Trichoptera. As a whole, these are the most intolerant insects present in the benthic community. EPT also refers to taxa richness within the three insect orders, a metric used extensively to derive bioclassifications. Higher EPT taxa richness values are associated with better water quality.
EPT BI	North Carolina Biotic Index for the EPT portion of the benthic community. This is the weighted sum of the tolerance values of taxa in the insect orders Ephemeroptera, Plecoptera, and Trichoptera found in the sample, relative to their abundance.
HQW	High Quality Waters. Such waters are rated Excellent based on biological and physical/chemical characteristics through Division monitoring or special studies and have been approved for such designation by the state Environmental Management Commission; also, primary nursery areas designated by the Marine Fisheries Commission and all Class SA waters.
MGD	Million gallons per day. This is generally the unit in which effluent discharge flow is measured.
NPDES	National Pollutant Discharge Elimination System.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
ORW	Outstanding Resource Waters. These are unique and special waters of exceptional state or national recreational or ecological significance that require special protection to maintain existing uses and have been approved for such designation by the Environmental Management Commission.

GLOSSARY (continued)

Specific Conductance	The measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts. Reported in the units of $\mu\text{mhos/cm}$ at 25 °C.
ST	Total invertebrate richness. The total number of different taxa present in a Full Scale benthic macroinvertebrate sample.
UT	Unnamed tributary.
WTP	Water treatment plant.
WWTP	Wastewater treatment plant

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

Roanoke River Basin Summary:

Considering the two most recent basin cycles (2004-2009) the largest change seen in non-swamp streams was in the number of Excellent bioclassifications (Figure 7). Specifically, two sites (Mayo River at SR 1358 in Rockingham County and Country Line Creek at NC 57 in Caswell County) improved from Good in 2004 to Excellent in 2009. In a larger historical context, there were no Excellent bioclassifications in 1994 or 1999 in this basin. Moreover, since 1994 and 1999 the number of Poor and Fair bioclassifications have steadily decreased reaching lows in 2004 and 2009. In terms of swamp streams, there was no overall difference in the number of Moderate and Natural bioclassifications between 2004 and 2009 although there was a small reduction in the number of Natural bioclassifications from 1999 to 2004 and 2009 (Figure 8). The six Not Rated swamps sites from 1999 and the one from 1994 were largely the result of having provisional swamp biocriteria in place at that time. Since 2000, formalized swamp biocriteria have been in place and bioclassifications have been assigned since that time.

Figure 7. Bioclassification Trends in the Roanoke River Basin: 1994-2009. Stream and River Samples.

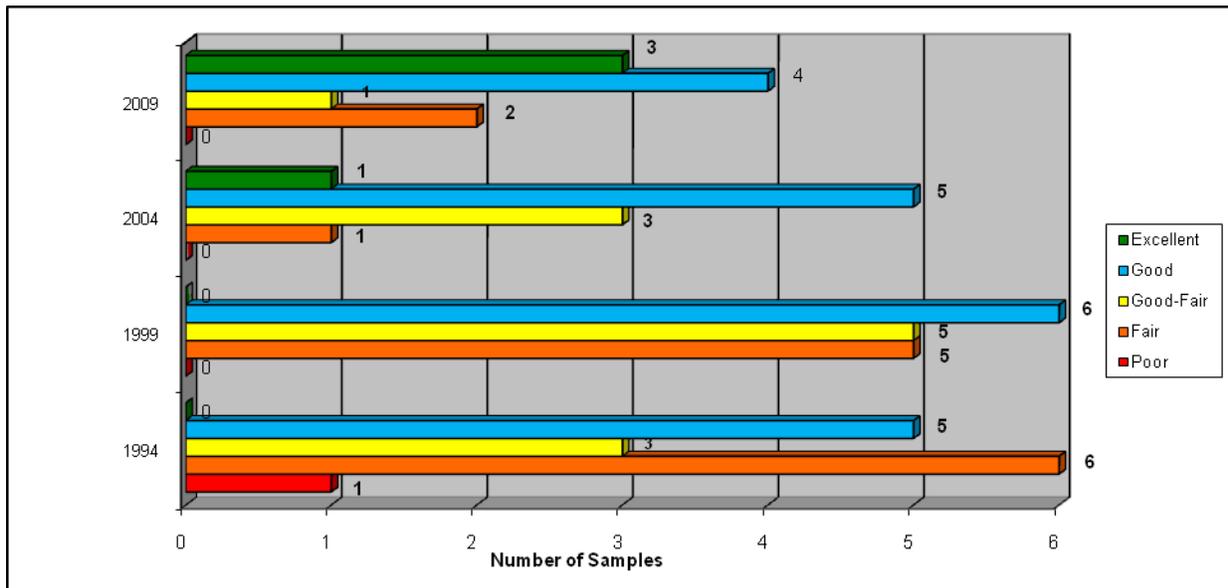
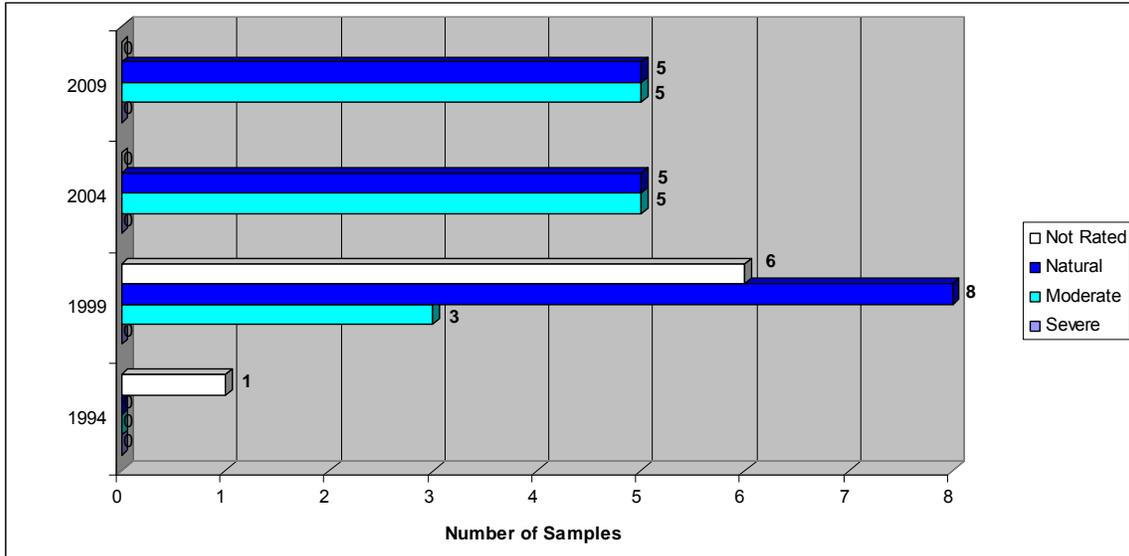


Figure 8. Bioclassification Trends in the Roanoke River Basin: 1994-2009. Swamp Samples.



Numerous rare invertebrate taxa were collected in the Roanoke River basin in 2009. These data are presented below in Table 6.

Table 6. Rare Taxa Collected in the Roanoke River Basin (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	Date	Waterbody	Location	County	Subbasin	Huc_8Digit	Scientific Name
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	DROMOGOMPHUS SPINOSUS
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	STYLURUS SPP
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	PROBEZZIA SPP
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	OPTIOSERVUS TRIVITTATUS
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	CLADOTANYTARSUS SP H
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	STENELMIS MIRABILIS
10774	9/10/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	CERACLEA MENTIEA
10811	8/13/09	ISLAND CR	SR 1445	GRANVILLE	6	03010102	PARACLOEODES FLEEKI
10812	8/13/09	SIXPOUND CR	SR 1306	WARREN	7	03010106	ORTHOCLADIUS CARLATUS
10811	8/13/09	ISLAND CR	SR 1445	GRANVILLE	6	03010102	ACERPENNA MACDUNNOUGHI
10809	8/12/09	MARLOWE CR	SR 1322	PERSON	5	03010104	CLADOTANYTARSUS SP B
10808	8/12/09	COUNTRY LINE CR	NC 57	CASWELL	4	03010104	CERACLEA MENTIEA
10810	8/12/09	NUTBUSH CR	SR 1317	VANCE	6	03010102	PARACLOEODES FLEEKI
10809	8/12/09	MARLOWE CR	SR 1322	PERSON	5	03010104	CLADOTANYTARSUS SP H
10809	8/12/09	MARLOWE CR	SR 1322	PERSON	5	03010104	ORTHOCLADIUS CARLATUS
10810	8/12/09	NUTBUSH CR	SR 1317	VANCE	6	03010102	CLADOTANYTARSUS SP B
10807	8/11/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	OPTIOSERVUS TRIVITTATUS
10807	8/11/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	CERACLEA MENTIEA
10807	8/11/09	MAYO R	SR 1358	ROCKINGHAM	2	03010103	TRICORYTHODES ROBACKI
10749	8/11/09	DAN R	SR 1695	STOKES	1	03010103	FORCIPOMYIA SPP
10749	8/11/09	DAN R	SR 1695	STOKES	1	03010103	CLADOTANYTARSUS SP H
10749	8/11/09	DAN R	SR 1695	STOKES	1	03010103	TRICORYTHODES ROBACKI
10749	8/11/09	DAN R	SR 1695	STOKES	1	03010103	CERACLEA MENTIEA
10749	8/11/09	DAN R	SR 1695	STOKES	1	03010103	OPTIOSERVUS TRIVITTATUS
10747	8/10/09	DAN R	NC 704	STOKES	1	03010103	NECTOPSYCHE N SP
10747	8/10/09	DAN R	NC 704	STOKES	1	03010103	OPTIOSERVUS TRIVITTATUS
10747	8/10/09	DAN R	NC 704	STOKES	1	03010103	NANOCLADIUS BRANCHICOLUS
10603	2/9/09	CASHIE R	SR 1257	BERTIE	10	03010107	SPIROSPERMA CAROLINENSIS
10603	2/9/09	CASHIE R	SR 1257	BERTIE	10	03010107	POLYPEDILUM TRIGONUS
10603	2/9/09	CASHIE R	SR 1257	BERTIE	10	03010107	CNEPHIA ORNITHOPHILIA
10603	2/9/09	CASHIE R	SR 1257	BERTIE	10	03010107	PELTODYTES MUTICUS
10603	2/9/09	CASHIE R	SR 1257	BERTIE	10	03010107	TVETENIA SP NC
10605	2/6/09	ROQUIST SWP	US 17	BERTIE	10	03010107	TROPISTERNUS COLLARIS
10605	2/6/09	ROQUIST SWP	US 17	BERTIE	10	03010107	ORTHOCLADIUS RUBICUNDUS
10605	2/6/09	ROQUIST SWP	US 17	BERTIE	10	03010107	PARACHIRONOMUS TENUICAUDATUS COMPLEX
10604	2/5/09	HOGGARD MILL CR	SR 1301	BERTIE	10	03010107	EPIPHRAGMA SPP
10604	2/5/09	HOGGARD MILL CR	SR 1301	BERTIE	10	03010107	CNEPHIA ORNITHOPHILIA
10602	2/5/09	CASHIE R	SR 1219	BERTIE	10	03010107	TVETENIA SP NC
10602	2/5/09	CASHIE R	SR 1219	BERTIE	10	03010107	PELTODYTES MUTICUS
10604	2/5/09	HOGGARD MILL CR	SR 1301	BERTIE	10	03010107	SYNURELLA SPP
10602	2/5/09	CASHIE R	SR 1219	BERTIE	10	03010107	POLYPEDILUM TRIGONUS
10604	2/5/09	HOGGARD MILL CR	SR 1301	BERTIE	10	03010107	CAECIDOTEA LATICAUDATUS
10601	2/4/09	HARDISON MILL CR	SR 1528	MARTIN	9	03010107	CHAETOCCLADIUS SPP
10600	2/4/09	CONOHO CR	SR 1417	MARTIN	9	03010107	TVETENIA SP NC
10600	2/4/09	CONOHO CR	SR 1417	MARTIN	9	03010107	CNEPHIA ORNITHOPHILIA
10601	2/4/09	HARDISON MILL CR	SR 1528	MARTIN	9	03010107	OMISUS SPP
10600	2/4/09	CONOHO CR	SR 1417	MARTIN	9	03010107	CHLOROTABANUS CREPUSCULARIS
10600	2/4/09	CONOHO CR	SR 1417	MARTIN	9	03010107	TANYTARSUS SP M
10601	2/4/09	HARDISON MILL CR	SR 1528	MARTIN	9	03010107	RHANTUS SPP
10527	2/3/09	DEEP CR	US 158	HALIFAX	8	03010106	TANYTARSUS SP M
10599	2/3/09	CONOHO CR	NC 11-42	MARTIN	9	03010107	TVETENIA SP NC
10599	2/3/09	CONOHO CR	NC 11-42	MARTIN	9	03010107	POLYPEDILUM TRIGONUS
10528	2/3/09	QUANKEY CR	NC 903	HALIFAX	8	03010107	PERICHAETINE OLIGOCHAETE
10528	2/3/09	QUANKEY CR	NC 903	HALIFAX	8	03010107	CERACLEA NR EXCISA
10599	2/3/09	CONOHO CR	NC 11-42	MARTIN	9	03010107	CNEPHIA ORNITHOPHILIA
10598	2/3/09	KEHUKEE SWP	SR 1804	HALIFAX	8	03010107	PLANORBELLA TRIVOLVIS
10598	2/3/09	KEHUKEE SWP	SR 1804	HALIFAX	8	03010107	PISIDIUM COMPRESSUM
10599	2/3/09	CONOHO CR	NC 11-42	MARTIN	9	03010107	MATUS OVATUS
10599	2/3/09	CONOHO CR	NC 11-42	MARTIN	9	03010107	CYPHON SPP
10528	2/3/09	QUANKEY CR	NC 903	HALIFAX	8	03010107	EPIPHRAGMA SPP
10598	2/3/09	KEHUKEE SWP	SR 1804	HALIFAX	8	03010107	CNEPHIA ORNITHOPHILIA
10528	2/3/09	QUANKEY CR	NC 903	HALIFAX	8	03010107	EPIAESCHNA HEROS

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 2006)³. 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 (\geq 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 2006)³. 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 samples in the mountain ecoregion are provided in NCDWQ 2006³ and 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 2006³.

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.

³ NC DWQ. 2006. Standard Operating Procedures for Benthic Macroinvertebrates. North Carolina Department of Environment and Natural Resources, Division of Water Quality, Biological Assessment Unit. July 2006. Unpublished.
<http://www.esb.enr.state.nc.us/BAUwww/benthossop.pdf>

Table 7. Benthic community data collected from the Roanoke River basin, 1983 – 2009. Basinwide sites are in bold font.

HUC/Waterbody	Location	County	Site ID	Date	ST	EPT	BI	EPT BI	BioClass
03010103/Dan River Headwaters									
Birch Fk	SR 1912	Rockingham	NB114	5/17/07	65	20	5.77	5.44	Not Impaired
Brushy Cr	SR 2321	Rockingham	NB115	5/17/07	79	26	5.55	3.98	Not Impaired
Brushy Fk	SR 1998	Stokes	NB82	5/18/04	87	37	5.10	4.06	Good
Cascade Cr	ab Hanging Rock St Pk Lk	Stokes	NB3	6/26/95	69	31	3.35	1.77	Excellent
				3/10/93	---	34	---	1.62	Excellent
				8/13/91	---	26	---	1.58	Good
				3/6/91	---	35	---	1.69	Excellent
				9/27/90	---	21	---	1.85	Good
Cascade Cr	SR 1001	Stokes	NB2	3/6/91	---	26	---	2.93	Good
				9/26/90	---	26	---	3.54	Good
Cascade Cr	SR 2012	Stokes	NB4	5/19/05	37	18	2.81	1.19	Not Impaired
				6/26/95	54	26	2.93	1.94	Good
				9/27/90	---	23	---	2.98	Good-Fair
Dan R	NC 704	Stokes	NB8	8/10/09	106	52	4.16	3.38	Excellent
				7/7/04	91	45	3.89	3.42	Excellent
				8/23/99	85	41	4.17	3.26	Good
				8/23/94	57	28	3.85	3.51	Good
				7/12/90	94	48	4.46	3.65	Excellent
				7/26/88	89	38	4.04	2.93	Good
				7/10/86	84	37	3.97	3.12	Good
				8/8/84	86	36	4.61	3.49	Good
Dan R	SR 1695	Stokes	NB9	8/11/09	100	42	4.62	3.82	Good
				7/7/04	87	43	4.89	4.07	Good
				8/23/99	72	37	4.56	3.93	Good
				8/23/94	45	20	4.74	3.83	Good-Fair
Dan R	SR 1761	Rockingham	NB20	8/14/91	55	26	5.06	4.27	Excellent
				7/23/87	68	26	5.14	4.16	Good
				7/9/86	61	20	5.88	4.65	Good-Fair
				9/13/84	56	17	5.68	4.33	Good-Fair
				8/11/83	65	22	5.54	4.71	Good
Dan R	SR 2150	Rockingham	NB23	8/8/89	64	26	5.50	4.66	Good
				7/22/87	94	33	5.65	4.58	Good
Hickory Cr	SR 1354	Rockingham	NB26	4/18/06	72	39	3.49	2.89	Not Impaired
				5/31/05	69	37	3.55	3.19	Not Impaired
Indian Cr	NR SR 2015	Stokes	NB29	3/10/93	---	30	---	1.48	Excellent
				3/6/91	---	25	---	1.38	Good
Indian Cr	nr Visitor Center	Stokes	NB31	3/10/93	---	34	---	1.54	Excellent
				3/6/91	---	27	---	1.23	Excellent
				9/26/90	---	26	---	2.54	Excellent
Indian Cr	SR 1001	Stokes	NB33	5/19/05	64	37	2.39	1.79	Not Impaired
				9/26/90	---	22	---	2.33	Good
Indian Cr	SR 1487	Stokes	NB30	9/26/90	---	27	---	2.75	Good
L Crooked Cr	SR 1622	Stokes	NB120	5/19/08	75	40	4.23	3.59	Good
Lynn Br	SR 1696	Stokes	NB41	5/20/05	73	39	3.75	3.25	Not Impaired
Mayo R	NC 135	Rockingham	NB44	8/8/89	---	28	---	4.32	Good
Mayo R	NC 770	Rockingham	NB50	3/30/89	---	37	---	3.48	Good-Fair

Table 7 (continued).

HUC/Waterbody	Location	County	Site ID	Date	ST	EPT	BI	EPT BI	BioClass
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Mayo R	SR 1358	Rockingham	NB28	8/11/09	92	48	4.03	3.37	Excellent
				7/8/04	78	33	4.74	4.13	Good
				8/23/99	70	32	4.27	3.45	Good
				8/22/94	64	38	3.58	3.20	Good
				8/8/89	79	42	4.79	4.00	Good
				3/30/89	96	54	3.77	2.92	Good
				7/22/87	87	40	4.68	4.04	Good
				7/10/86	102	37	4.97	3.76	Good
				8/24/99	52	21	5.22	4.24	Good-Fair
				9/7/94	73	35	4.85	4.47	Good
N Double Cr	SR 1504	Stokes	NB15	3/30/89	---	44	---	3.32	Good-Fair
				8/10/09	---	31	---	4.27	Good
				6/28/04	---	31	---	3.42	Good
				8/23/99	---	25	---	3.95	Good-Fair
Neatman Cr	SR 1961	Stokes	NB56	8/23/94	---	17	---	5.05	Fair
				9/7/95	---	29	---	4.46	Good
Raccoon Cr	Steele Rd	Stokes	NB63	5/31/05	73	41	3.67	3.04	Impaired
Rock House Cr	SR 2127	Rockingham	NB36	4/12/01	81	23	5.00	3.80	Good-Fair
Smith R	NC 14	Rockingham	NB74	9/13/99	51	18	5.24	3.70	Fair
				8/21/94	58	18	5.67	4.44	Fair
				7/9/90	81	31	5.52	4.03	Good-Fair
				7/25/88	69	24	6.00	5.04	Fair
				7/9/86	57	18	6.13	4.67	Fair
Snow Cr	SR 1673	Stokes	NB17	8/10/09	---	29	---	4.48	Good
				7/7/04	---	31	---	4.33	Good
				9/13/00	---	29	---	4.08	Good
				8/23/99	---	18	---	4.29	Fair
				8/23/94	---	22	---	4.04	Good-Fair
Town Fork Cr	SR 1917	Stokes	NB19	5/25/04	80	35	5.30	4.84	Good
				8/23/94	---	15	---	4.71	Good-Fair
				2/17/88	---	24	---	4.22	Good-Fair
				9/7/95	---	26	---	4.89	Good-Fair
Town Fork Cr	SR 1955	Stokes	NB79	9/7/95	---	26	---	4.89	Good-Fair
Town Fork Cr	SR 1961	Stokes	NB21	5/25/04	67	26	5.10	4.69	Good-Fair
				9/7/95	89	26	5.18	4.78	Good-Fair
Town Fork Cr	SR 1970	Stokes	NB81	9/7/95	---	7	---	5.94	Poor
Town Fork Cr	SR 1998	Stokes	NB83	5/18/04	85	34	4.85	3.85	Good
Town Fork Cr	US 311	Stokes	NB77	2/17/88	---	19	---	4.44	Good-Fair
Ut Cascade Cr	nr Family Cabins	Stokes	NB11	6/26/95	37	15	4.34	2.06	Good-Fair
Ut Dan R	nr Farmers Rd.	Stokes	NB12	2/9/87	---	15	---	4.40	Fair
Ut Dan R	US 311	Stokes	NB13	2/9/87	---	21	---	4.00	Good-Fair
									Not
Ut Mill Cr	SR 2018	Stokes	NB97	5/19/05	72	46	3.00	2.80	Impaired
Wolf Island Cr	NC 700	Caswell	NB100	7/25/88	82	24	5.86	4.85	Good-Fair
				7/30/85	68	25	5.38	4.59	Good
				8/11/83	76	24	5.49	4.43	Good
									Not
Wood Benton Br	SR 1707	Stokes	NB101	5/20/05	74	40	3.52	2.88	Impaired
03010104/Dan River									
Country Line Cr	NC 57	Caswell	NB40	8/12/09	---	28	---	4.31	Excellent
				7/1/04	---	24	---	4.82	Good
				8/24/94	---	14	---	4.55	Good-Fair
				7/10/90	73	26	5.52	4.53	Good
				7/23/87	78	26	5.80	5.15	Good
				8/11/83	72	19	5.84	4.34	Good-Fair
Country Line Cr	SR 1129	Caswell	NB84	7/1/04	---	24	---	4.89	Good
Crooked Fk	SR 1558	Person	NB112	4/19/06	34	14	4.76	3.28	Impaired
Dan R	NC 57	Caswell	NB22	8/24/99	66	32	5.43	4.53	Good
Hyco Cr	US 158	Caswell	NB27	8/22/94	---	10	---	6.37	Not Rated
				7/10/90	65	20	5.92	5.28	Good-Fair
				7/23/87	74	23	5.87	5.24	Good-Fair
				7/9/86	78	21	5.91	5.08	Good-Fair

Table 7 (continued).

HUC/Waterbody	Location	County	Site ID	Date	ST	EPT	BI	EPT BI	BioClass	
Jones Cr	SR 2571	Rockingham	NB35	12/1/87	83	27	5.62	4.50	Good	
Jones Cr	SR 2632	Rockingham	NB34	1/8/92	---	29	---	4.56	Excellent	
Marlowe Cr	NC 49	Person	NB119	4/19/06	26	5	6.95	5.62	Not Rated	
Marlowe Cr	SR 1322	Person	NB43	8/12/09	59	10	6.25	6.01	Fair	
				6/30/04	56	13	6.43	5.93	Good-Fair	
				8/25/99	53	9	6.35	5.74	Fair	
				8/24/94	33	5	6.91	6.49	Poor	
Marlowe Cr	SR 1351	Person	NB85	6/30/04	66	14	6.67	5.87	Fair	
									Not	
Negro Cr	SR 1769	Caswell	NB116	4/19/06	54	20	4.67	4.18	Impaired	
Tanyard Br	US 501	Person	NB118	4/19/06	15	3	7.78	6.89	Not Rated	
Ut Hogans Cr	SR 1503	Caswell	NB95	6/25/98	48	12	5.86	5.59	Not Rated	
				11/20/96	41	7	6.42	3.93	Not Rated	
03010102/John H. Kerr Reservoir-Roanoke River										
Anderson Swamp Cr	I-85		Vance	NB1	2/15/90	49	13	6.98	5.71	Not Rated
Grassy Cr	SR 1436		Granville	NB86	6/30/04	---	13	---	5.05	Not Rated
Island Cr	SR 1445		Granville	NB45	8/13/09	---	21	---	5.05	Good
					6/29/04	---	17	---	5.48	Good-Fair
					8/24/94	---	17	---	5.12	Good-Fair
L Island Cr	SR 1342		Vance	NB38	5/26/88	---	21	---	4.90	Good-Fair
Mountain Cr	SR 1300		Granville	NB87	7/2/04	---	13	---	5.40	Not Rated
Nutbush Cr	NC 39		Vance	NB48	4/20/06	48	6	7.21	7.09	Not Rated
					6/29/04	70	12	7.34	6.94	Not Rated
					11/10/94	58	12	6.89	6.12	Fair
					10/28/94	54	12	6.96	5.76	Fair
					5/26/88	44	6	7.41	6.75	Fair
Nutbush Cr	nr Parham Rd.		Vance	NB57	11/10/94	48	7	7.30	6.25	Fair
Nutbush Cr	SR 1317		Vance	NB49	8/12/09	57	12	6.54	6.03	Fair
					6/29/04	64	9	7.00	6.70	Fair
					8/25/99	41	8	6.73	6.75	Fair
					10/28/94	50	8	6.74	6.31	Fair
					8/24/94	44	8	6.84	6.89	Fair
					5/26/88	35	3	8.13	6.47	Poor
Quaqua Cr	SR 1928	Rockingham	NB117	5/17/07	53	17	5.49	5.25	Not Rated	
Rattlesnake Cr	SR 1437	Granville	NB64	6/3/05	57	16	5.43	4.50	Not Impaired	
Ut Anderson Swp Cr	US 1-158	Vance	NB10	2/15/90	18	2	7.56	7.76	Not Rated	
03010106/Lake Gaston-Roanoke River										
Deep Cr	US 158		Halifax	NB54	2/3/09	67	21	6.11	5.06	Natural
					2/23/04	63	23	5.54	4.42	Natural
					7/15/99	58	11	6.41	5.18	Not Rated
					8/23/94	64	13	6.37	5.70	Not Rated
Hubquarter Cr	SR 1337		Warren	NB113	4/21/06	80	27	4.96	4.21	Not Impaired
Jordan Cr	SR 1306		Warren	NB37	4/21/06	57	22	4.85	3.76	Not Impaired
					6/9/05	61	15	5.21	4.84	Not Impaired
L Stonehouse Cr	SR 1358		Warren	NB39	4/21/06	61	22	5.02	3.86	Not Impaired
Newmans Cr	SR 1218		Warren	NB88	4/27/04	76	15	6.30	5.32	Fair
Sixpound Cr	SR 1306		Warren	NB51	8/13/09	58	13	5.75	4.69	Good-Fair
					6/29/04	62	15	6.43	5.44	Good-Fair
					7/16/99	54	14	5.50	5.03	Good-Fair
					8/22/94	12	12	5.51	5.51	Fair
Smith Cr	SR 1208		Warren	NB90	4/26/04	87	22	6.06	4.97	Good-Fair
Smith Cr	SR 1217		Warren	NB89	4/26/04	68	18	6.29	5.09	Fair
Smith Cr	US 1		Warren	NB52	4/26/04	50	10	6.43	5.13	Fair
					7/16/99	59	12	6.56	5.52	Fair
					8/22/94	53	6	6.97	6.15	Fair
					7/12/89	59	12	6.81	5.08	Fair
					7/8/86	56	10	6.23	5.14	Fair
					8/15/84	56	12	6.50	5.36	Fair

Table 7 (continued).

HUC/Waterbody	Location	County	Site ID	Date	ST	EPT	BI	EPT BI	BioClass
03010107/Roanoke River									
Cashie R	NC 11 Above Bridge	Bertie	NB103	6/26/84	37	0	8.66	8.66	Not Rated
Cashie R	NC 11 Below Bridge	Bertie	NB6	6/26/84	41	0	8.40	8.4	Not Rated
Cashie R	SR 1219	Bertie	NB75	2/5/09	26	2	8.15	7.10	Moderate
				2/23/04	29	3	7.49	7.03	Moderate
				2/11/99	41	6	7.51	7.24	Natural
				6/26/84	41	2	8.20	7.00	Not Rated
				7/14/83	34	2	8.55	7.00	Not Rated
Cashie R	SR 1257	Bertie	NB76	2/9/09	34	3	7.40	6.59	Moderate
				2/24/04	35	7	6.59	4.90	Natural
				2/15/99	34	7	6.80	6.09	Natural
Cashie R	SR 1500	Bertie	NB5	9/13/94	56	9	8.11	6.73	Not Rated
Chockoyotte Cr	Country Club Rd	Halifax	NB91	2/23/04	52	11	6.78	5.40	Moderate
Conaby Cr	SR 1114	Washington	NB16	4/12/94	68	5	7.00	5.89	Not Rated
Conaby Cr	SR 1325	Washington	NB7	4/12/94	41	0	7.44	---	Not Rated
Conoconnara Swp	NC 561	Halifax	NB53	2/24/04	30	3	7.28	7.26	Moderate
				2/16/99	31	5	6.45	6.81	Natural
				7/5/84	39	3	7.60	6.24	Not Rated
Conoho Cr	NC 11-42	Martin	NB93	2/3/09	29	3	7.20	6.78	Moderate
				2/25/04	31	4	7.70	7.10	Moderate
Conoho Cr	NC 125-903	Martin	NB18	2/15/99	29	3	7.29	7.58	Moderate
Conoho Cr	NC 125-903	Martin	NB18	8/22/94	23	0	7.79	---	Poor
Conoho Cr	SR 1417	Martin	NB67	2/4/09	32	6	6.43	5.23	Natural
				2/24/04	38	6	6.80	5.40	Natural
				2/24/99	39	5	6.27	4.80	Natural
Deep Run Swp	NC 171	Martin	NB24	2/12/99	21	1	7.62	7.80	Severe
Hardison Mill Cr	NC 171	Martin	NB25	2/15/99	24	2	7.71	7.67	Moderate
Hardison Mill Cr	SR 1528	Martin	NB69	2/4/09	15	1	7.61	6.40	Moderate
				2/24/04	36	2	7.54	5.20	Moderate
				2/12/99	27	3	7.32	7.67	Moderate
Hoggard Mill Cr	SR 1301	Bertie	NB78	2/5/2009	24	3	7.40	7.57	Moderate
				2/15/99	46	7	6.81	6.38	Natural
Indian Cr	SR 1108	Bertie	NB32	3/11/97	30	1	7.42	7.80	Moderate
Kehukee Swp	SR 1804	Halifax	NB55	2/3/2009	66	12	6.79	6.06	Natural
				2/24/04	46	7	7.08	5.89	Moderate
				9/2/99	6	6	6.18	6.18	Not Rated
				2/11/99	59	8	7.13	6.64	Moderate
L Quankey Cr	NC 903	Halifax	NB92	2/23/04	46	17	5.70	4.49	Moderate
Occonechee Cr	SR 1126	Northampton	NB58	2/16/99	22	4	6.48	6.88	Natural
Quankey Cr	NC 561	Halifax	NB60	9/2/99	9	9	5.51	5.51	Fair
Quankey Cr	NC 903	Halifax	NB59	2/3/2009	51	15	5.80	4.77	Natural
				2/23/04	52	17	5.81	4.05	Natural
				2/16/99	40	9	6.66	5.93	Natural
Quankey Cr	nr Ferrell Ln	Halifax	NB62	12/3/92	51	7	6.55	5.68	Fair
Quankey Cr	US 301 Bus	Halifax	NB61	12/3/92	57	9	6.42	5.27	Fair
Roanoke R	NC 45	Bertie	NB66	7/14/99	59	9	7.55	6.54	Not Rated
				9/13/94	52	9	7.69	6.31	Not Rated
				6/22/92	60	8	7.66	5.84	Not Rated
				7/10/90	50	10	7.75	6.24	Not Rated
				7/12/88	60	7	8.45	6.62	Not Rated
				7/8/86	50	8	7.78	6.77	Not Rated
				7/15/85	37	4	8.44	6.52	Not Rated
				7/16/84	42	6	7.70	6.19	Not Rated
				7/18/83	38	6	8.15	5.44	Not Rated
Roanoke R	nr NC 125-903	Martin	NB72	3/31/99	61	23	5.82	4.81	Good-Fair
				9/12/94	51	19	5.22	4.41	Good
Roanoke R	S King St	Halifax	NB65	3/30/99	76	28	5.33	4.50	Good
Roanoke R	US 17	Martin	NB68	7/15/99	47	20	5.99	4.87	Good-Fair
				3/31/99	73	23	6.32	5.07	Good-Fair
				9/13/94	53	17	5.71	4.82	Good-Fair

Table 7 (continued).

HUC/Waterbody	Location	County	Site ID	Date	ST	EPT	BI	EPT BI	BioClass
Roanoke R	US 258	Halifax	NB70	7/15/99	41	19	5.22	4.76	NA
				3/30/99	67	30	5.38	4.72	Good
				9/12/94	45	16	4.91	4.30	Good
				7/9/87	46	12	5.99	5.05	Fair
				7/25/85	49	16	5.92	4.88	Good-Fair
Roanoke R	US 301-158	Halifax	NB71	9/12/94	45	16	5.27	4.64	Good-Fair
Roquist Swp	US 17	Bertie	NB80	2/6/09	30	3	6.73	2.28	Natural
				2/24/04	38	4	7.14	6.46	Natural
				2/11/99	31	4	6.99	5.50	Natural
Wading Place Cr	NC 308	Bertie	NB98	3/8/99	35	3	7.31	7.45	Moderate
Welch Cr	SR 1552	Martin	NB99	2/12/99	32	3	7.23	6.92	Moderate

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

Sampling Methods

Fish community assessments were performed adhering to all methods in the existing standard operating procedures (NCDENR 2006). At each site, a 600 ft. section of stream was selected and measured. The fish in the delineated reach were then collected using two backpack electrofishing units and two persons netting the stunned fish. After collection, all readily identifiable fish were examined for sores, lesions, fin damage, or skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Those fish that were not readily identifiable were preserved and returned to the laboratory for identification, examination, and total length measurement. These fish have been deposited as voucher specimens with the North Carolina State Museum of Natural Sciences in Raleigh.

NCIBI (North Carolina Index of Biotic Integrity) Analysis, Evaluation, and Scoring Criteria

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.

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

The NCIBI has been revised (NCDENR 2006). 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 8. Reference sites represented the least impacted streams and the overall biological condition of the fish communities that could be attained (Table 9). It has been difficult to identify reference sites within the Coastal Plain that satisfy all of the criteria listed in Table 8. Therefore, revisions to these criteria may be necessary.

Criteria and ratings are applicable only to wadeable streams in the Piedmont region of the Roanoke River basin. The metrics are the same as those for the Neuse, Cape Fear, and Tar River basins. The definition of the Piedmont for these basins is based on a map of North Carolina watersheds by Fels (1997) and Griffith *et al.* (2002). Metrics and ratings should not be applied to non-wadeable streams and streams in the Coastal Plain region in each of these basins, nor in the Sand Hills region. These streams are currently not rated.

Table 8. 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	$\geq 70\%$ 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	Piedmont streams -- width of the riparian zone along both banks is ≥ 12 m Coastal Plain streams -- width of the riparian zone along both banks is ≥ 18 m
Exception 1	If the site satisfied Criteria 1 - 6, except one of the two riparian widths was less than one unit optimal, then the site still qualified as a reference site
Exception 2	If the site satisfied Criteria 1 - 3 and 5 - 7, but the percentage of the watershed in forest or natural vegetations was $\geq 60\%$ (rather than $\geq 70\%$), then the site still qualified as a reference site. [Note: in the New River Basin this last exception is $\geq 50\%$.]

Table 9. Regional reference sites in the Roanoke River basin.

HUC/Waterbody	Station	County	Level IV Ecoregion
03010103 Dan River Headwaters			
N Double Creek	SR 1504	Stokes	Northern Inner Piedmont
Peters Creek	SR 1497	Stokes	Northern Inner Piedmont
Hogans Creek	NC 704	Rockingham	Triassic Basins
Aarons Creek	SR 1400	Granville	Carolina Slate Belt
Grassy Creek	SR 1300	Granville	Carolina Slate Belt
Johnson Creek	SR 1440	Granville	Carolina Slate Belt

Table 10. Scoring criteria for the NCIBI for wadeable streams in the Outer Piedmont of the Neuse, Cape Fear, Roanoke, and Tar River basins ranging between 3.1 and 328 mi².

No.	Metric	Score
1	No. of species	
	≥ 16 species	5
	10-15 species	3
	< 10 species	1
2	No. of fish	
	≥ 225 fish	5
	150-224 fish	3
	< 150 fish	1
3	No. of species of darters	
	<u>Cape Fear</u>	<u>Neuse, Roanoke, and Tar</u>
	≥ 2 species	≥ 3 species
	1 species	1 or 2 species
	0 species	0 species
4	No. of species of sunfish	
	≥ 4 species	5
	3 species	3
	0, 1, or 2 species	1
5	No. of species of suckers	
	<u>Cape Fear</u>	<u>Neuse, Roanoke, and Tar</u>
	≥ 2 species	≥ 3 species
	1 species	1 or 2 species
	0 species	0 species
6	No. of intolerant species	
	<u>Cape Fear</u>	<u>Neuse, Roanoke, and Tar</u>
	≥ 1 species	≥ 3 species
	no middle score	1 or 2 species
	0 species	0 species
7	Percentage of tolerant individuals	
	≤ 35%	5
	36-50%	3
	> 50%	1
8	Percentage of omnivorous and herbivorous individuals	
	10-35%	5
	36-50%	3
	> 50%	1
	< 10%	1
9	Percentage of insectivorous individuals	
	65-90%	5
	45-64%	3
	< 45%	1
	> 90%	1
10	Percentage of piscivorous individuals	
	≥ 1.4-15%	5
	0.4-1.3%	3
	< 0.4%	1
	> 15%	1
11	Percentage of diseased fish (DELT = diseased, fin erosion, lesions, and tumors)	
	≤ 1.75%	5
	1.76-2.75%	3
	> 2.75%	1
12	Percentage of species with multiple age groups	
	≥ 50% of all species have multiple age groups	5
	35-49% all species have multiple age groups	3
	< 35% all species have multiple age groups	1

Table 11. Tolerance ratings and trophic guild assignments for fish in the Roanoke River basin. Species collected in 2009 are highlighted in blue. Common and scientific names follow Nelson, *et al.* (2004), except for *Scartomyzon* and *Chrosomus*.

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Petromyzontidae	Lampreys		
<i>Petromyzon marinus</i>	Sea Lamprey	Intermediate	Parasitic
Acipenseridae	Sturgeons		
<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	Intermediate	Insectivore
Lepisosteidae	Gars		
<i>Lepisosteus osseus</i>	Longnose Gar	Tolerant	Piscivore
Amiidae	Bowfins		
<i>Amia calva</i>	Bowfin	Tolerant	Piscivore
Anguillidae	Freshwater Eels		
<i>Anguilla rostrata</i>	American Eel	Intermediate	Piscivore
Clupeidae	Herrings		
<i>Alosa aestivalis</i>	Blueback Herring	Intermediate	Insectivore
<i>A. mediocris</i>	Hickory Shad	Intermediate	Insectivore
<i>A. pseudoharengus</i>	Alewife	Intermediate	Insectivore
<i>A. sapidissima</i>	American Shad	Intermediate	Insectivore
<i>Dorosoma cepedianum</i>	Gizzard Shad	Intermediate	Omnivore
<i>D. petenense</i>	Threadfin Shad	Intermediate	Omnivore
Cyprinidae	Carps and Minnows		
<i>Campostoma anomalum</i>	Central Stoneroller	Intermediate	Herbivore
<i>Carassius auratus</i>	Goldfish	Tolerant	Omnivore
<i>Chrosomus oreas</i>	Mountain Redbelly Dace	Intermediate	Herbivore
<i>Clinostomus funduloides</i>	Rosyside Dace	Intermediate	Insectivore
<i>Ctenopharyngodon idella</i>	Grass Carp	Tolerant	Herbivore
<i>Cyprinella analostana</i>	Satinfin Shiner	Tolerant	Insectivore
<i>C. lutrensis</i>	Red Shiner	Tolerant	Insectivore
<i>Cyprinus carpio</i>	Common Carp	Tolerant	Omnivore
<i>Exoglossum maxillingua</i>	Cutlip Minnow	Intolerant	Insectivore
<i>Hybognathus regius</i>	Eastern Silvery Minnow	Intermediate	Herbivore
<i>Luxilus albeolus</i>	White Shiner	Intermediate	Insectivore
<i>L. cerasinus</i>	Crescent Shiner	Intermediate	Insectivore
<i>Lythrurus ardens</i>	Rosefin Shiner	Intermediate	Insectivore
<i>Nocomis leptcephalus</i>	Bluehead Chub	Intermediate	Omnivore
<i>N. raneyi</i>	Bull Chub	Intermediate	Omnivore
<i>Notemigonus crysoleucas</i>	Golden Shiner	Tolerant	Omnivore
<i>Notropis alborus</i>	Whitemouth Shiner	Intermediate	Insectivore
<i>N. altipinnis</i>	Highfin Shiner	Intermediate	Insectivore
<i>N. amoenus</i>	Comely Shiner	Intermediate	Insectivore
<i>N. chalybaeus</i>	Ironcolor Shiner	Intolerant	Insectivore
<i>N. chiliticus</i>	Redlip Shiner	Intermediate	Insectivore
<i>N. hudsonius</i>	Spottail Shiner	Intermediate	Omnivore
<i>N. procne</i>	Swallowtail Shiner	Intermediate	Insectivore
<i>Pimephales promelas</i>	Fathead Minnow	Tolerant	Omnivore
<i>Rhinichthys obtusus</i>	Western Blacknose Dace	Intermediate	Insectivore
<i>Semotilus atromaculatus</i>	Creek Chub	Tolerant	Insectivore
Catostomidae	Suckers		
<i>Carpiodes cyprinus</i>	Quillback	Intermediate	Omnivore
<i>Catostomus commersonii</i>	White Sucker	Tolerant	Omnivore
<i>Erimyzon oblongus</i>	Creek Chubsucker	Intermediate	Omnivore
<i>Hypentelium nigricans</i>	Northern Hogsucker	Intermediate	Insectivore
<i>H. roanokense</i>	Roanoke Hogsucker	Intermediate	Insectivore
<i>Moxostoma collapsum</i>	Notchlip Redhorse	Intermediate	Insectivore
<i>M. erythrurum</i>	Golden Redhorse	Intermediate	Insectivore
<i>M. macrolepidotum</i>	Shorthead Redhorse	Intermediate	Insectivore
<i>M. pappilosum</i>	V-Lip Redhorse	Intermediate	Insectivore
<i>Scartomyzon ariommus</i>	Bigeye Jumprock	Intolerant	Insectivore

S. cervinus	Blacktip Jumprock	Intermediate	Insectivore
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Table 11 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
<i>Thoburnia hamiltoni</i>	Rustyside Sucker	Intolerant	Insectivore
Ictaluridae	Catfishes		
<i>Ameiurus brunneus</i>	Snail Bullhead	Intermediate	Insectivore
A. catus	White Catfish	Tolerant	Omnivore
<i>A. melas</i>	Black Bullhead	Tolerant	Insectivore
A. natalis	Yellow Bullhead	Tolerant	Omnivore
A. nebulosus	Brown Bullhead	Tolerant	Omnivore
A. platycephalus	Flat Bullhead	Tolerant	Insectivore
<i>Ictalurus furcatus</i>	Blue Catfish	Intermediate	Piscivore
<i>I. punctatus</i>	Channel Catfish	Intermediate	Omnivore
<i>Noturus gilberti</i>	Orangefin Madtom	Intolerant	Insectivore
<i>N. gyrinus</i>	Tadpole Madtom	Intermediate	Insectivore
N. insignis	Margined Madtom	Intermediate	Insectivore
<i>Pylodictis olivaris</i>	Flathead Catfish	Intermediate	Piscivore
Esocidae	Pikes		
Esox americanus	Redfin Pickerel	Intermediate	Piscivore
E. niger	Chain Pickerel	Intermediate	Piscivore
Umbridae	Mudminnows		
<i>Umbra pygmaea</i>	Eastern Mudminnow	Intermediate	Insectivore
Salmonidae	Trouts And Salmon		
<i>Oncorhynchus mykiss</i>	Rainbow Trout	Intolerant	Insectivore
Salmo trutta	Brown Trout	Intermediate	Piscivore
<i>Salvelinus fontinalis</i>	Brook Trout	Intolerant	Insectivore
Aphredoderidae	Pirate Perches		
Aphredoderus sayanus	Pirate Perch	Intermediate	Insectivore
Amblyopsidae	Cavefishes		
<i>Chologaster cornuta</i>	Swampfish	Intermediate	Insectivore
Atherinopsidae	New World Silversides		
<i>Menidia beryllina</i>	Inland Silverside	Intermediate	Insectivore
Fundulidae	Topminnows		
<i>Fundulus diaphanus</i>	Banded Killifish	Intermediate	Insectivore
<i>F. lineolatus</i>	Lined Topminnow	Intermediate	Insectivore
F. rathbuni	Speckled Killifish	Intermediate	Insectivore
<i>F. sp cf. diaphanus</i>	"Lake Phelps Killifish"	Intolerant	Insectivore
Poeciliidae	Livebearers		
Gambusia holbrooki	Eastern Mosquitofish	Tolerant	Insectivore
Cottidae	Sculpins		
<i>Cottus caeruleomentum</i>	Blue Ridge Sculpin	Intermediate	Insectivore
Moronidae	Temperate Basses		
<i>Morone americana</i>	White Perch	Intermediate	Piscivore
<i>M. chrysops</i>	White Bass	Intermediate	Piscivore
<i>M. saxatilis</i>	Striped Bass	Intermediate	Piscivore
Centrarchidae	Sunfishes and Black Basses		
<i>Acantharchus pomotis</i>	Mud Sunfish	Intermediate	Insectivore
<i>Ambloplites cavifrons</i>	Roanoke Bass	Intermediate	Piscivore
<i>A. rupestris</i>	Rock Bass	Intolerant	Piscivore
Centrarchus macropterus	Flier	Intermediate	Insectivore
<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	Intermediate	Insectivore
E. gloriosus	Bluespotted Sunfish	Intermediate	Insectivore
<i>E. obesus</i>	Banded Sunfish	Intermediate	Insectivore
Lepomis auritus	Redbreast Sunfish	Intermediate	Insectivore
L. cyanellus	Green Sunfish	Tolerant	Insectivore
L. gibbosus	Pumpkinseed	Intermediate	Insectivore

<i>L. gulosus</i>	Warmouth	Intermediate	Insectivore
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Table 11 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
<i>L. macochirus</i>	Bluegill	Intermediate	Insectivore
<i>L. microlophus</i>	Redear Sunfish	Intermediate	Insectivore
<i>Lepomis</i> sp.	Hybrid Sunfish	Tolerant	Insectivore
<i>Micropterus dolomieu</i>	Smallmouth Bass	Intolerant	Piscivore
<i>M. salmoides</i>	Largemouth Bass	Intermediate	Piscivore
<i>Pomoxis annularis</i>	White Crappie	Intermediate	Piscivore
<i>P. nigromaculatus</i>	Black Crappie	Intermediate	Piscivore
Percidae	Darters and Perches		
<i>Etheostoma collis</i>	Carolina Darter	Intermediate	Insectivore
<i>E. flabellare</i>	Fantail Darter	Intermediate	Insectivore
<i>E. fusiforme</i>	Swamp Darter	Intermediate	Insectivore
<i>E. nigrum</i>	Johnny Darter	Intermediate	Insectivore
<i>E. olmstedii</i>	Tessellated Darter	Intermediate	Insectivore
<i>E. podostemone</i>	Riverweed Darter	Intolerant	Insectivore
<i>E. serrifer</i>	Sawcheek Darter	Intolerant	Insectivore
<i>E. vitreum</i>	Glassy Darter	Intermediate	Insectivore
<i>Perca flavescens</i>	Yellow Perch	Intermediate	Piscivore
<i>Percina nevisense</i>	Chainback Darter	Intolerant	Insectivore
<i>Percina rex</i>	Roanoke Logperch	Intolerant	Insectivore
<i>P. roanoka</i>	Roanoke Darter	Intolerant	Insectivore
<i>Sander vitreus</i>	Walleye	Intermediate	Piscivore
Sciaenidae	Drums and Croakers		
<i>Aplodinotus grunniens</i>	Freshwater Drum	Intermediate	Insectivore
Elassomatidae	Pygmy Sunfishes		
<i>Elassoma zonatum</i>	Banded Pygmy Sunfish	Intermediate	Insectivore

Table 12. Scores and classes for evaluating the fish community of a wadeable stream using the North Carolina Index of Biotic Integrity in the Outer Piedmont (Cape Fear, Neuse, Roanoke, and Tar River basins).

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

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. Heavy, acute infections can be fatal, especially to small fish. However, 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 9).

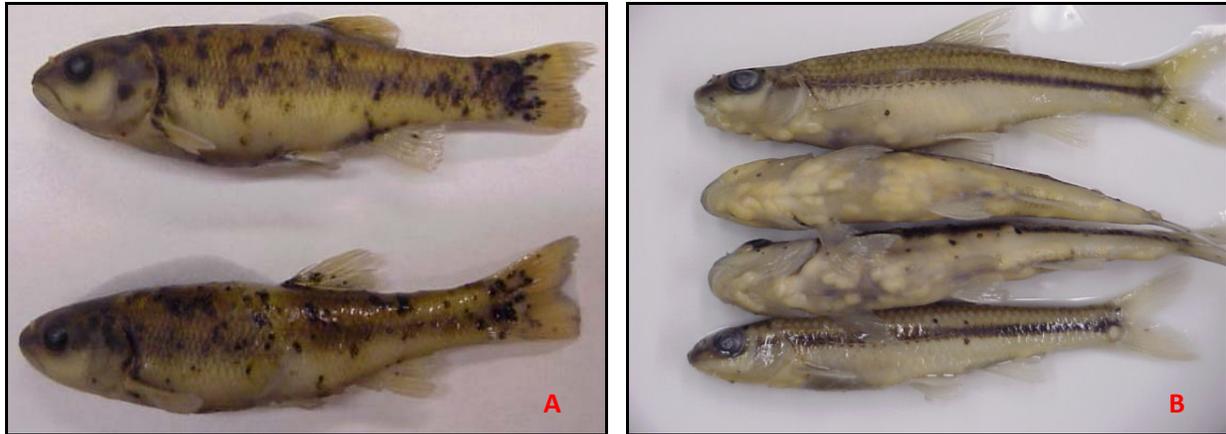


Figure 9. Heavy infestation of blackspot disease in Creek Chub (A) and yellow grub in Bigeye Chub (B).

Although some researchers incorporate the incidence of black spot and yellow grub into indices of biotic integrity (e.g., Steedman 1991), others, because of a lack of a consistent, inverse relationship to environmental quality, do not (e.g., Sanders *et al.* 1999). The diseases are not considered in the NCIBI because it is widespread, affecting fish in all types of streams. This disease was noted throughout the basin in many species such as Redlip Shiner, Crescent Shiner, Satinfin Shiner, White Shiner, Roanoke Hogsucker, and Fantail Darter, and Johnny darter.

Other diseases observed in 2009 included:

- skeletal deformities, including scoliosis and deformed mandibles,
- fungal infections and abdominal masses, and
- occasional incidences of “popeye” or exophthalmos in Pumpkinseed and Bluegill caused by bacterial, viral, and nematode infections (Figure 10).



Figure 10. Popeye caused by nematode infection in Bluegill, Hardee Creek (Pitt County, Tar River basin).

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

Monitoring efforts for 2009 can be summarized as:

- Twenty-five samples were collected as part of the basinwide monitoring cycle or as special studies.
- All of the sites, except two, had been sampled during the previous basinwide cycle in 2004 or as special study sites in the late 1990s.
- One of the two new sites, Hogans Creek at SR 1301 in Rockingham County, was sampled as part of the 2009-2010 state-wide probabilistic Random Ambient Monitoring program. The other new sampling site was on Quankey Creek at US 301/NC 903/NC 125 in Halifax County; it had been sampled in 1994 upstream at the SR 1619 crossing. The downstream site was a more wadeable location with flowing water than the upstream site which was more swamp-like.
- In 2009, 36 sites were planned to be sampled; of these 25 were actually sampled. The 11 remaining sites that were scheduled to be sampled plus others that were visited but could not be sampled were either:
 - too small to sample or were not flowing – Looking Glass Run (Halifax County);
 - braided swamp-like conditions – Occoneechee Creek (Northampton County);
 - too deep or had excessive turbidity – Smith Creek (Warren County) and Chockoyotte Creek (Halifax County); or
 - were not sampled due to time constraints – Wading Place Creek, Sutton Creek, and Indian Swamp Creek (Bertie County) and Deep Run Swamp, Lanier Swamp, and Copper Swamp (Martin County).
- No streams sampled were on the 303 (d) impaired waters list (NCDENR 2007).
- One site, Crooked Creek was sampled in 2007 as part of the 2007-2008 state-wide probabilistic Random Ambient Monitoring program.
- The most widely distributed species collected at 21-25 of the 25 sites and listed in order of most sites collected at, were the Bluehead Chub, Redbreast Sunfish, Bluegill, Fantail Darter, Crescent Shiner, Johnny Darter, and Rosefin Shiner. The Bluehead Chub and the Crescent Shiner were the most abundant species, representing 32 percent of all the fish collected.
- All streams were evaluated and rated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendices F-1). The NCIBI scores ranged from 38 to 54 and the NCIBI ratings ranged from Fair to Excellent; two-thirds of the sites rated Good or Excellent (Figures 11 and 12).
- Twenty-one sites had been sampled during the previous basinwide monitoring cycle (Figure 13). Of these 21 sites, 9 sites had no appreciable change in their NCIBI rating; 5 sites had ratings that increased; and 7 sites had scores or ratings that decreased between 2004 and 2009 (Figure 11).
- The improvements in scores and ratings were generally attributable to increases in the overall species diversity and a more balanced trophic structure at the various sites. There were no lingering impacts from the 2007-2008 droughts on the communities whose ratings either improved or did not change.
- The declines in the ratings were generally attributable to decreases in overall species diversity, loss of intolerant species, nonpoint source nutrient runoff contributing to an increase in the dominance of the omnivorous Bluehead Chub, and lingering impacts from the 2007-2008 drought.
- Two sites may qualify as new Outstanding Resource Waters or High Quality Waters if so requested:
 - Archies Creek at SR 1415 in Stokes County, and
 - Hogans Creek at NC 704 in Rockingham County.
- Repeat/verification sampling should be conducted at three sites in 2010 or 2011 to determine why the NCIBI ratings declined at:
 - South Hyco Creek at US 158 in Person County,
 - Island Creek at SR 1445 in Granville County, and
 - Deep Creek at US 158 in Halifax County.
- The instream and riparian habitat scores for the 25 sites ranged from 55 at Jacobs Creek to 95 at Hogans Creek at NC 704 in Rockingham County (Appendix F-6). Eighty percent of the streams

had overall moderate to high quality habitats (score ≥ 65); whereas the remaining 20 percent of the streams had overall low to poor quality habitats (score < 65).

- All dissolved oxygen concentrations met the state water quality standard of 5 mg/L (Appendix F-7). Three pH measurements were less than 6.0 s.u. and were found at sites not classified as Swamp Waters. Elevated specific conductance measurements were associated with nonpoint source runoff.

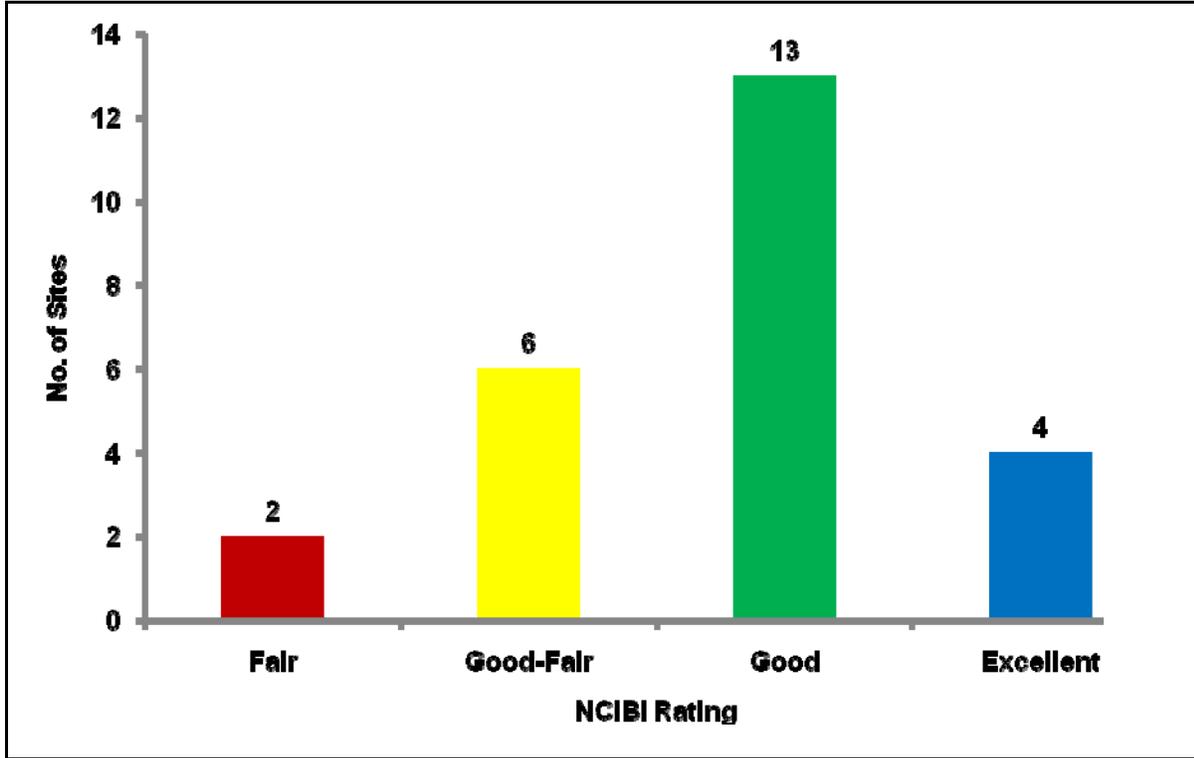


Figure 11. Distribution of the ratings of 25 fish community basinwide sites in the Roanoke River basin, 2009.

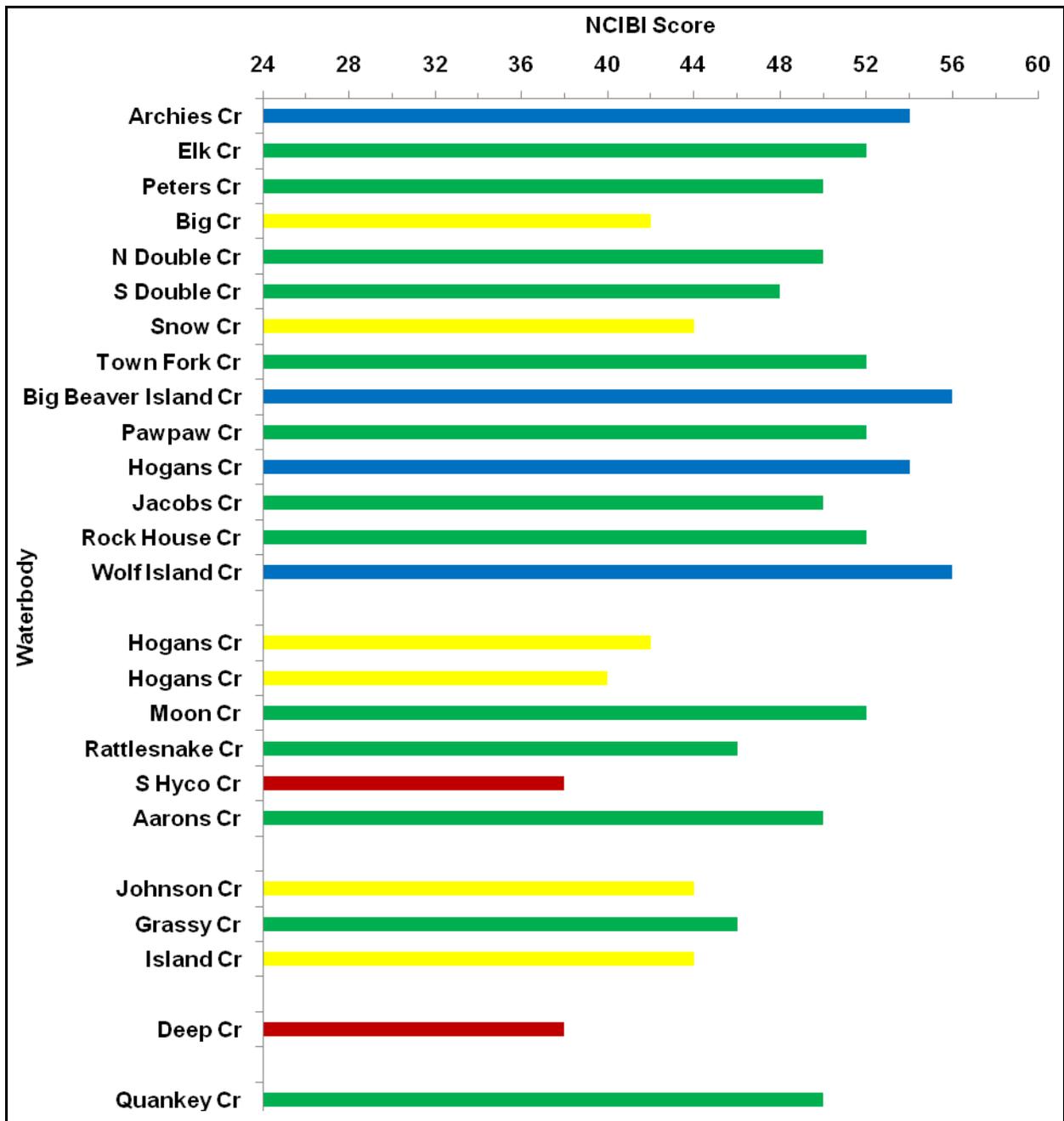


Figure 12. NCIBI scores and ratings of 25 fish community basinwide sites in the Roanoke River basin, 2009. Blue = Excellent, Green = Good, Yellow = Good-Fair, and Red = Fair sites.

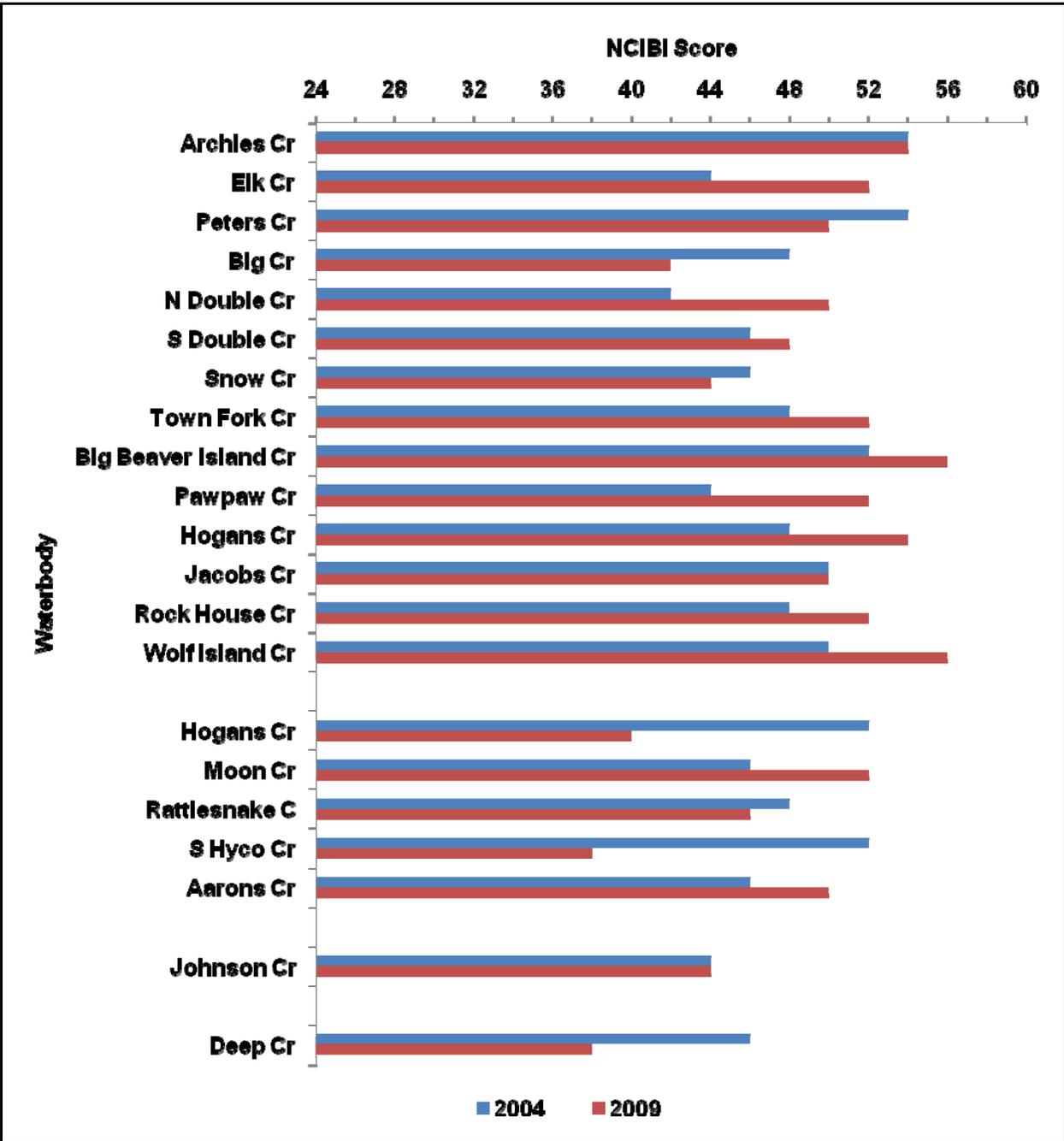


Figure 13. NCIBI scores and ratings of 21 repeat fish community sites in the Roanoke River basin, 2004 and 2009.

Table 13. Fish community data collected from the Roanoke River basin, 1994 – 2009. Basinwide sites are in bold font.

HUC/Waterbody	Station	County	Site ID	Date	NCIBI Score	NCIBI Rating
03020103 Dan River Headwaters						
Archies Cr	SR 1415	Stokes	NF1	05/11/09	54	Excellent
				04/19/04	54	Excellent
Big Beaver Island Cr	US 311	Rockingham	NF10	05/14/09	56	Excellent
					52	Good
Big Cr	SR 1471	Stokes	NF2	05/13/09	42	Good-Fair
				04/20/04	48	Good
Crooked Cr	off SR 1626	Stokes	NF42	03/29/07	42	Good-Fair
Dan R	SR 1416	Stokes	NF3	04/19/04	52	Good
Elk Cr	SR 1433	Stokes	NF4	05/11/09	52	Good
				04/20/04	44	Good-Fair
Hogans Cr	NC 704	Rockingham	NF11	05/14/09	54	Excellent
				04/22/04	48	Good
Jacobs Cr	NC 704	Rockingham	NF12	05/20/09	50	Good
				04/22/04	50	Good
Matrimony Cr	NC 770	Rockingham	NF17	04/23/04	52	Good
N Double Cr	SR 1504	Stokes	NF5	05/12/09	50	Good
				04/20/04	42	Good-Fair
Pawpaw Cr	SR 1360	Rockingham	NF14	05/14/09	52	Good
				04/22/04	44	Good-Fair
				08/03/90	48	Good
Peters Cr	SR 1497	Stokes	NF6	05/12/09	50	Good
				04/21/04	54	Excellent
Rock House Cr	SR 2127	Rockingham	NF18	05/20/09	52	Good
				04/23/04	48	Good
S Double Cr	SR 1483	Stokes	NF7	05/12/09	48	Good
				04/20/04	46	Good
Snow Cr	SR 1652	Stokes	NF8	05/13/09	44	Good-Fair
				04/21/04	46	Good
Town Fork Cr	SR 1955	Stokes	NF9	05/13/09	52	Good
				04/21/04	48	Good
Wolf Island Cr	SR 1767	Rockingham	NF20	05/20/09	56	Excellent
				04/23/04	50	Good
Wolf Island Cr	NC 700	Caswell	NF19	10/05/94	54	Excellent
03010104 Dan River						
Aarons Cr	SR 1400	Granville	NF31	05/26/09	50	Good
				04/28/04	46	Good
Cane Cr	SR 1527	Caswell	NF21	05/25/04	46	Good
				10/05/94	46	Good
Country Line Cr	NC 57	Caswell	NF23	09/07/94	48	Good
Hogans Cr	SR 1301	Caswell	NF35	07/06/09	42	Good-Fair
Hogans Cr	SR 1330	Caswell	NF15	07/06/09	40	Good-Fair
				05/25/04	52	Good
Jones Cr	SR 2571	Rockingham	NF16	06/08/04	48	Good
Marlowe Cr	SR 1322	Person	NF27	04/28/04	42	Good-Fair
				09/07/94	40	Good-Fair
Moon Cr	SR 1511	Caswell	NF24	05/21/09	52	Good
				04/30/04	46	Good
				09/07/94	44	Good-Fair
N Hyco Cr	US 158	Caswell	NF29	04/30/04	---	Not Rated
Rattlesnake Cr	SR 1523	Caswell	NF26	05/21/09	46	Good
				05/25/04	48	Good

Table 13 (continued).

HUC/Waterbody	Station	County	Site ID	Date	NCIBI Score	NCIBI Rating
S Hyco Cr	US 158	Person	NF30	05/21/09	38	Fair
				04/30/04	52	Good
03010102 J. H. Kerr Res.-Roanoke River						
Grassy Cr	SR 1300	Granville	NF33	05/26/09	46	Good
				06/09/99	46	Good
Grassy Cr	SR 1436	Granville	NF32	06/02/94	50	Good
Island Cr	SR 1445	Granville	NF22	05/27/09	44	Good-Fair
				06/09/99	54	Excellent
				06/02/94	50	Good
Johnson Cr	SR 1440	Granville	NF36	05/26/09	44	Good-Fair
				04/28/04	44	Good-Fair
Little Island Cr	SR 1348	Vance	NF37	04/29/04	---	Not Rated
Nutbush Cr	SR 1317	Vance	NF38	04/29/04	38	Fair
				10/04/94	44	Good-Fair
03010106 Lake Gaston-Roanoke River						
Deep Cr	US 158	Halifax	NF45	05/27/09	38	Fair
				05/26/04	46	Good
				09/21/94	50	Good
Sixpound Cr	SR 1306	Warren	NF40	05/12/94	42	Good-Fair
Smith Cr	US 1	Warren	NF41	04/29/04	38	Fair
				05/12/94	42	Good-Fair
03010107 Roanoke River						
Cashie R	SR 1257	Bertie	NF49	10/26/94	---	Not Rated
Chockoyotte Cr	US 158	Halifax	NF43	05/26/04	---	Not Rated
Conoconnara Swp	NC 561	Halifax	NF44	09/21/94	---	Not Rated
Kehukee Swp	SR 1804	Halifax	NF47	10/27/94	---	Not Rated
Quankey Cr	SR 1619	Halifax	NF25	09/21/94	38	Fair
Quankey Cr	US 301/NC 903/NC 125	Halifax	NF46	06/18/09	50	Good

Appendix F-4. Fish community metric values from 25 wadeable streams in the Roanoke River basinwide monitoring program, 2009.

HUC/Waterbody	Location	County	d. a. (mi ²)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. Sunfish	No. Sp. Suckers	No. Intol. Sp.	% Tol.	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
03020103 Dan River Headwaters																
Archies Cr	SR 1415	Stokes	9.3	05/11/09	22	666	5	1	3	4	3	28	71	0.5	0.0	73
Elk Cr	SR 1433	Stokes	8.5	05/11/09	18	588	5	1	3	3	5	43	56	1.7	0.0	89
Peters Cr	SR 1497	Stokes	28.6	05/12/09	27	725	5	2	6	2	22	30	70	0.0	0.1	70
Big Cr	SR 1471	Stokes	32.7	05/13/09	19	888	2	2	4	0	8	49	51	0.0	0.0	74
N Double Cr	SR 1504	Stokes	12.4	05/12/09	20	811	4	2	3	1	5	35	65	0.0	0.0	75
S Double Cr	SR 1483	Stokes	16.4	05/12/09	21	357	4	2	5	1	30	29	71	0.0	0.0	48
Snow Cr	SR 1652	Stokes	22.7	05/13/09	19	746	2	2	4	1	13	42	58	0.0	0.1	79
Town Fork Cr	SR 1955	Stokes	28.0	05/13/09	21	673	3	3	4	1	15	25	75	0.0	0.0	57
Big Beaver Island Cr	US 311	Rockingham	23.8	05/14/09	26	866	4	3	5	2	7	28	68	3.4	0.5	65
Pawpaw Cr	SR 1360	Rockingham	8.1	05/14/09	21	979	3	5	3	0	7	34	66	0.0	0.2	81
Hogans Cr	NC 704	Rockingham	23.0	05/14/09	24	660	5	4	5	2	6	17	83	0.2	0.2	63
Jacobs Cr	NC 704	Rockingham	36.2	05/20/09	22	459	5	2	5	2	14	23	77	0.0	0.4	59
Rock House Cr	SR 2127	Rockingham	23.0	05/20/09	24	1142	5	3	4	2	16	25	74	0.2	0.0	79
Wolf Island Cr	SR 1767	Rockingham	43.2	05/20/09	28	719	5	4	6	2	8	27	73	0.8	0.4	50
03010104 Dan River																
Hogans Cr	SR 1301	Caswell	65.4	07/06/09	15	265	2	2	1	0	31	19	81	0.0	0.4	67
Hogans Cr	SR 1330	Caswell	92.6	07/06/09	18	336	4	2	0	1	15	7	92	0.6	0.3	50
Moon Cr	SR 1511	Caswell	47.2	05/21/09	20	627	4	4	1	1	15	25	75	0.0	0.0	65
Rattlesnake Cr	SR 1523	Caswell	23.7	05/21/09	21	929	3	3	2	1	53	22	78	0.0	0.0	76
S Hyco Cr	US 158	Person	56.5	05/21/09	15	556	2	4	0	0	32	3	97	0.4	0.2	73
Aarons Cr	SR 1400	Granville	27.6	05/26/09	16	397	3	5	2	0	18	13	87	0.0	0.0	50
03010102 J. H. Kerr Res.-Roanoke River																
Johnson Cr	SR 1440	Granville	7.6	05/26/09	13	232	3	3	1	0	15	20	79	0.9	1.3	31
Grassy Cr	SR 1300	Granville	20.9	05/26/09	16	81	2	5	2	0	27	22	74	3.7	0.0	44
Island Cr	SR 1445	Granville	33.1	05/27/09	20	208	3	6	2	0	20	3	94	2.4	0.5	50
03010106 Lake Gaston-Roanoke River																
Deep Cr	US 158	Halifax	23.5	05/27/09	18	289	2	5	1	0	39	43	57	0.4	0.4	28
03010107 Roanoke River																
Quankey Cr	US 301/NC 903/NC 125	Halifax	33.6	06/18/09	24	571	2	5	1	1	29	44	46	10.3	0.0	54

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

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

Based upon Menhinick (1991) and data from the DWQ, North Carolina State Museum of Natural Sciences, and from other researchers, 111 species of freshwater fish are known from the Roanoke River basin in North Carolina. The known species assemblage now includes 26 species of cyprinids, 12 species of suckers, 12 species of catfish, 17 species of sunfish and bass, and 13 species of darters. There are nine species endemic to the basin in North Carolina: Cutlip Minnow, Crescent Shiner, Rosefin Shiner, Roanoke Hogsucker, Rustyside Sucker, Bigeye Jumprock, Orangefin madtom, Riverweed Darter, and Roanoke Logperch. Only a few new county distributional records were recorded in 2009 from DWQ's fish community monitoring efforts (Table 14). The Roanoke Logperch is a Federally Endangered Species which was found in Big Beaver Island Creek.

Table 14. New distributional records for the Roanoke River basin.

Family/Species	Common Name	County
Cyprinidae	Carps and Minnows	
<i>Luxilus albeolus</i>	White Shiner	Halifax
Percidae	Perches	
<i>Etheostoma podostemone</i>	Riverweed Darter	Caswell
<i>Etheostoma vitreum</i>	Glassy Darter	Caswell
<i>Percina rex</i>	Roanoke Logperch	Rockingham

Twenty-five of the 111 species (23 percent of the total basin fauna) are nonindigenous (exotic) and were introduced either as sportfish, forage fish, baitfish, or for reasons unknown (Table 15). In 2009, 6 of the 63 species collected were nonindigenous species and every stream had at least one nonindigenous species present.

Table 15. Nonindigenous species in the Roanoke River basin. Species collected in 2009 are highlighted in blue.

Family/Species	Common Name	Family/Species	Common Name
Clupeidae	Herrings	Moronidae	Temperate Bases
<i>Alosa pseudoharengus</i>	Alewife	<i>Morone americana</i>	White Perch
<i>Dorosoma petenense</i>	Threadfin Shad	<i>Morone chrysops</i>	White Bass
Cyprinidae	Carps and Minnows	Centrarchidae	Sunfishes and Black Bases
<i>Carassius auratus</i>	Goldfish	<i>Ambloplites rupestris</i>	Rock Bass
<i>Ctenopharyngodon idella</i>	Grass Carp	<i>Lepomis cyanellus</i>	Green Sunfish
<i>Cyprinella lutrensis</i>	Red Shiner	<i>L. macrochirus</i>	Bluegill
<i>Cyprinus carpio</i>	Common Carp	<i>L. microlophus</i>	Redear Sunfish
<i>Pimephales promelas</i>	Fathead Minnow	<i>Micropterus dolomieu</i>	Smallmouth Bass
Ictaluridae	Catfishes	<i>Pomoxis annularis</i>	White Crappie
<i>Ameiurus brunneus</i>	Snail Bullhead	Percidae	Perches
<i>A. melas</i>	Black Bullhead	<i>Sander vitreus</i>	Walleye
<i>Ictalurus furcatus</i>	Blue Catfish	Sciaenidae	Drums and Croakers
<i>I. punctatus</i>	Channel Catfish	<i>Aplodinotus grunniens</i>	Freshwater Drum
<i>Pylodictis olivaris</i>	Flathead Catfish		
Salmonidae	Trouds and Salmons		
<i>Oncorhynchus mykiss</i>	Rainbow Trout		
<i>Salmo trutta</i>	Brown Trout		
<i>Salvelinus fontinalis</i>	Brook Trout		

Special protection status has been given to 13 of the 112 species by the U.S. Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-331 to 113-337) (LeGrand *et al.* 2008; Menhinick and Braswell 1997) (Table 16). Additional information on these eight species may be found in Jenkins and Burkhead (1993), Menhinick and Braswell (1997), and Rohde, *et al.* (1998, 2001, and 2003). In 2009, 5 of the 13 species were collected as part of DWQ's fish community monitoring program (Table 17). The Bigeye Jumprock, Rustyside Sucker, and the Orangefin Madtom were not collected in 2009 during the assessments of streams in Stokes County. Their continued conservation status is warranted.

Table 16. Species of fish listed as endangered, threatened, of special concern, or significantly rare in the Roanoke Fear River basin.

Species	Common Name	State or Federal Status	State Rank ¹
<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	State - Special Concern	S3
<i>Exoglossum maxillingua</i>	Cutlip Minnow	State – Special Concern	S1
<i>Carpiodes cyprinus</i>	Quillback	State – Significantly Rare	S1
<i>Hypentelium roanokense</i>	Roanoke Hogsucker	State – Significantly Rare	S3
<i>Scartomyzon ariommus</i>	Bigeye Jumprock	State - Threatened	S2
<i>Thoburnia hamiltoni</i>	Rustyside Sucker	State - Endangered	S1
<i>Noturus gilberti</i>	Orangefin Madtom	State - Endangered	S1
<i>Cottus caeruleomentum</i>	Blue Ridge Sculpin	State – Special Concern	S1
<i>Ambloplites cavifrons</i>	Roanoke Bass	State-Significantly Rare	S2
<i>Enneacanthus obesus</i>	Banded Sunfish	State-Significantly Rare	S3
<i>Etheostoma collis</i> population 2 ²	Carolina Darter	State - Special Concern	S2
<i>Etheostoma podostemone</i>	Riverweed Darter	State - Special Concern	S3
<i>Percina rex</i>	Roanoke Logperch	Federal – Endangered	S1

¹S1 = 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 due to rarity or some factor(s) making it very vulnerable to extirpation from the state; and S3 = rare or uncommon in North Carolina (LeGrand *et al.* 2008).

²Eastern Piedmont population in the Roanoke, Tar, Neuse, and Cape Fear drainages (LeGrand *et al.* 2008).

Table 17. Number of specimens of species of fish listed as endangered, threatened, of special concern, or significantly rare that were collected in the Roanoke River basin in North Carolina, 2009.

Waterbody	Species				
	<i>Exoglossum maxillingua</i>	<i>Hypentelium roanokense</i>	<i>Etheostoma collis</i> population 2	<i>Etheostoma podostemone</i>	<i>Percina rex</i>
Archies Creek	1	14	---	8	---
Elk Creek	---	7	---	3	---
Peters Creee	---	11	---	1	---
Big Creek	---	10	---	---	---
N Double Creek	---	7	---	---	---
S Double Creek	---	4	---	---	---
Snow Creek	---	14	---	---	---
Town Fork Creek	---	15	---	---	---
Big Beaver Island Creek	---	14	---	---	1
Pawpaw Creek	---	44	---	---	---
Hogans Creek (NC 704)	---	8	---	10	---
Jacobs Creek	---	15	---	---	---
Rock House Creek	---	32	---	---	---
Wolf Island Creek	---	13	---	---	---
Hogans Creek (SR 1330)	---	---	---	1	---
Aarons Creek	---	---	1	---	---
Johnson Creek	---	---	3	---	---
Grassy Creek	---	---	1	---	---
Island Creek	---	---	11	---	---

In 2009, 63 of the 112 species known from the basin in North Carolina were collected. Species not collected included those with preferences for larger rivers or reservoirs (e.g. sturgeon, herrings, some species of catfish, temperate basses), coastal species (silversides, topminnows, and Banded Pygmy Sunfish), and rare or uncommonly collected species (e.g., Sea Lamprey, Bigeye Jumprock, Rustyside Sucker, Orangefin Madtom, and Banded Sunfish). The most widely distributed species collected at 21-25 of the 25 sites and listed in order of most sites collected at were the Bluehead Chub, Redbreast Sunfish, Bluegill, Fantail Darter, Crescent Shiner, Johnny Darter, and Rosefin Shiner. Twenty species were collected only at 1 or 2 sites (Table 18). The Bluehead Chub and the Crescent Shiner were the most abundant species; representing 32 percent of all the fish collected. By contrast, some of the more rare species were represented by only 1 or 2 fish per species (Table 18).

Table 18. Narrowly distributed and uncommonly collected species encountered by the wadeable stream fish community assessment program in the Roanoke River basin, 2009.

Species	No. of Sites Collected	No. Specimens Collected
Longnose Gar	1	2
American Eel	1	56
Redfin Shiner	1	18
Cutlip Minnow	1	1
Bull Chub	1	1
Highfin Shiner	2	28
Comely Shiner	2	5
Notchlip Redhorse	2	7
White Catfish	1	3
Yellow Bullhead	2	2
Brown Bullhead	1	4
Chain Pickerel	2	4
Brown Trout	1	1
Flier	2	3
Bluespotted Sunfish	2	5
Smallmouth Bass	2	12
Black Crappie	2	3
Tessellated Darter	2	22
Yellow Perch	1	1
Roanoke Logperch	1	1

Appendix F-6. Habitat evaluations and stream and riparian habitats at 25 fish community monitoring sites in the Roanoke River basin, 2009.

Habitat Assessments

A method and scoring system has been developed to evaluate the physical habitats of a stream (NCDENR 2006). The narrative descriptions of eight habitat characteristics, including channel modification, amount of instream habitat, type of bottom substrate, pool variety, riffle frequency (not evaluated in Sand Hills and Coastal Plain streams), 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 25 sites (Table 19). Habitat scores ranged from 55 at Jacobs Creek to 95 at Hogans Creek (NC 704, Rockingham County). Major differences between the high to moderate and the low to poor quality habitat types were in the substrates, riffles, and bank stabilities (Table 20). Differences were not as pronounced in the degree of channel modification, instream habitats, abundance of pools, extent of canopy cover, or width of riparian zones. Extremely low scores were attributable to poor landuse practices, chronic erosion of the easily eroded soils, and nonpoint source sedimentation within the respective watersheds.

Table 19. Rankings of 25 waterbodies using Mountain/Piedmont criteria in the Roanoke River basin according to the total habitat scores, 2009.

HUC	Waterbody	Location	County	Level IV Ecoregion	Score
High to Moderate Quality Habitats					
03010103	Hogans Cr	NC 704	Rockingham	Triassic Basins	95
03010103	Archies Cr	SR 1416	Stokes	Northern Inner Piedmont	93
03010107	Quankey Cr	US 301/NC 903/NC 125	Halifax	Rolling Coastal Plain	92
03010104	Aarons Cr	SR 1400	Granville	Carolina Slate Belt	88
03010103	Peters Cr	SR 1497	Stokes	Northern Inner Piedmont	83
03010103	Town Fork Cr	SR 1955	Stokes	Northern Inner Piedmont	79
03010102	Johnson Cr	SR 1440	Granville	Carolina Slate Belt	78
03010103	Elk Cr	SR 1433	Stokes	Northern Inner Piedmont	75
03010102	Island Cr	SR 1445	Granville	Carolina Slate Belt	75
03010103	Pawpaw Cr	SR 1360	Rockingham	Northern Inner Piedmont	75
03010103	Big Cr	SR 1471	Stokes	Northern Inner Piedmont	73
03010106	Deep Cr	US 158	Warren	Northern Outer Piedmont	73
03010103	N Double Cr	SR 1504	Stokes	Northern Inner Piedmont	73
03010103	Snow Cr	SR 1652	Stokes	Northern Inner Piedmont	72
03010104	Hogans Cr	SR 1330	Caswell	Northern Inner Piedmont	69
03010103	Rock House Cr	SR 2127	Rockingham	Triassic Basins	68
03010103	Big Beaver Island Cr	US 311	Rockingham	Triassic Basins	67
03010104	Hogans Cr	SR 1301	Caswell	Northern Inner Piedmont	66
03010104	Rattlesnake Cr	SR 1523	Caswell	Northern Inner Piedmont	65
03010103	S Double Cr	SR 1483	Stokes	Northern Inner Piedmont	65
Low to Poor Quality Habitats					
03010102	Grassy Cr	SR 1300	Granville	Carolina Slate Belt	64
03010103	Wolf Island Cr	SR 1767	Rockingham	Northern Inner Piedmont	63
03010104	Moon Cr	SR 1511	Caswell	Northern Inner Piedmont	59
03010104	S Hyco Cr	US 158	Person	Southern Outer Piedmont	58
03010103	Jacobs Cr	US 704	Rockingham	Northern Inner Piedmont	55

Table 20. Mean habitat scores for 25 fish community sites in the Roanoke River basin, 2009.

Habitat characteristics	Low-Poor Quality Habitat	Moderate to High Quality Habitat	Maximum Score
Substrate	3.4	7.4	15
Riffles	4.0	9.7	16
Bank stability (right and left)	9.2	11.9	14

Table 21. Habitat evaluations using Mountain/Piedmont criteria at 25 basinwide fish community sites in the Roanoke River basin, 2009. Red bold denotes less than optimal habitat conditions.

HUC	Waterbody	Location	County	Channel	Instream Habitat	Substrate	Pools	Riffles	Erosion	Bank Vegetation	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
03010103 Dan River Headwaters														
	Archies Cr	SR 1416	Stokes	5	19	12	10	16	7	7	9	5	3	93
	Elk Cr	SR 1433	Stokes	5	17	12	9	16	6	3	4	1	2	75
	Peters Cr	SR 1497	Stokes	5	16	12	10	11	4	7	10	3	5	83
	Big Cr	SR 1471	Stokes	5	16	5	10	7	4	7	9	5	5	73
	N Double Cr	SR 1504	Stokes	5	14	4	8	12	6	7	9	3	5	73
	S Double Cr	SR 1483	Stokes	5	14	3	10	5	6	6	9	3	4	65
	Snow Cr	SR 1652	Stokes	5	16	4	6	10	4	7	10	5	5	72
	Town Fork Cr	SR 1955	Stokes	5	18	8	7	15	6	7	7	3	3	79
	Big Beaver Island Cr	US 311	Rockingham	5	14	6	8	10	1	7	9	3	4	67
	Pawpaw Cr	SR 1360	Rockingham	5	17	10	4	15	5	6	7	3	3	75
	Hogans Cr	NC 704	Rockingham	5	19	12	10	16	6	7	10	5	5	95
	Jacobs Cr	US 704	Rockingham	5	17	4	4	3	2	4	8	3	5	55
	Rock House Cr	SR 2127	Rockingham	5	14	4	6	7	6	7	9	5	5	68
	Wolf Island Cr	SR 1767	Rockingham	5	16	3	10	7	1	6	5	5	5	63
03010104 Dan River														
	Hogans Cr	SR 1301	Caswell	5	13	3	9	3	6	7	10	5	5	66
	Hogans Cr	SR 1330	Caswell	5	16	3	9	4	5	7	10	5	5	69
	Moon Cr	SR 1511	Caswell	5	14	3	6	5	5	6	9	3	3	59
	Rattlesnake Cr	SR 1523	Caswell	5	14	4	6	7	3	6	10	5	5	65
	S Hyco Cr	US 158	Person	5	13	3	6	5	2	7	7	5	5	58
	Aarons Cr	SR 1400	Granville	5	18	12	8	12	6	7	10	5	5	88
03010102 J. H. Kerr Reservoir-Roanoke River														
	Johnson Cr	SR 1440	Granville	5	18	8	10	5	5	7	10	5	5	78
	Grassy Cr	SR 1300	Granville	5	12	4	10	0	6	7	10	5	5	64
	Island Cr	SR 1445	Granville	5	18	10	10	3	6	7	8	3	5	75
03010106 Lake Gaston-Roanoke River														
	Deep Cr	US 158	Warren	5	16	4	10	5	6	7	10	5	5	73
03010107 Roanoke River														
	Quankey Cr	US 301/NC 903/NC 125	Halifax	5	19	12	10	15	7	7	7	5	5	92
Maximum possible scores				5	20	15	10	16	7	7	10	5	5	100

Characteristics of moderate to high quality habitat Piedmont streams include:

- instream habitats composed of rocks, sticks, leafpacks, snags and logs, and undercut banks and root mats;
- a substrate of cobble and gravel with low embeddedness;
- frequent pools and riffles of varying depths and widths; and
- stable banks with a good tree canopy and a medium to wide riparian zone with no or rare breaks in riparian coverage (Figure 14).



Figure 14. Instream habitats composed of rocks, sticks, leafpacks, snags and logs, and root mats; stable banks with a good tree canopy; and a wide riparian zone, Archies Creek at SR 1415, Stokes County (left) and Hogans Creek at NC 704, Rockingham County (right).

Characteristics of low to poor quality habitat Piedmont streams include:

- highly embedded substrates of primarily sand;
- an absence of riffles; if present, they are usually caused by embedded, coarse woody debris in the current, and
- entrenched channel with unstable, vertical, and sparsely vegetated banks (Figure 15).



Figure 15. Sandy and gravelly substrates with woody debris riffles, and vertical and eroding banks, South Hyco Creek at US 158, Person County (left) and Moon Creek at SR 1511, Caswell County (right).

Appendix F-7. Water quality at 25 fish community sites in the Roanoke River basin, 2009.

Temperature, specific conductance, dissolved oxygen, and pH were collected at every site during fish community assessments in 2009 (Table 22). All dissolved oxygen concentrations met the water quality standard of 5 mg/L. Three pH measurements were less than 6.0 s.u. Specific conductance ranged from 48 $\mu\text{S}/\text{cm}$ at Elk Creek to 127 $\mu\text{S}/\text{cm}$ at Johnson Creek (Figure 16). Elevated readings were associated with nonpoint source runoff in agricultural areas.

Table 22. Water quality measurements at 25 fish community sites in the Roanoke River basin, 2009 Red bold denotes less than the water quality standard.

HUC/ Waterbody	Location	County	Date	Temperature (°C)	Specific conductance ($\mu\text{S}/\text{cm}$)	Dissolved oxygen (mg/L)	pH (s.u.)
03010103 Dan River Headwaters							
Archies Cr	SR 1415	Stokes	05/11/09	15.3	49	9.2	6.0
Elk Cr	SR 1433	Stokes	05/11/09	15.3	48	9.2	6.3
Peters Cr	SR 1497	Stokes	05/12/09	12.5	57	11.2	5.4
Big Cr	SR 1471	Stokes	05/13/09	13.7	52	13.0	6.0
N Double Cr	SR 1504	Stokes	05/12/09	15.0	52	10.2	6.1
S Double Cr	SR 1483	Stokes	05/12/09	12.9	47	10.5	5.9
Snow Cr	SR 1652	Stokes	05/13/09	13.9	66	12.2	6.2
Town Fork Cr	SR 1955	Stokes	05/13/09	16.7	95	12.4	6.9
Big Beaver Island Cr	US 311	Rockingham	05/14/09	17.5	64	8.8	6.3
Pawpaw Cr	SR 1360	Rockingham	05/14/09	14.4	57	9.2	6.1
Hogans Cr	NC 704	Rockingham	05/14/09	16.0	62	9.1	6.3
Jacobs Cr	NC 704	Rockingham	05/20/09	11.6	76	9.5	6.1
Rock House Cr	SR 2127	Rockingham	05/20/09	13.1	84	9.6	6.7
Wolf Island Cr	SR 1767	Rockingham	05/20/09	16.5	103	8.8	6.5
03010103 Dan River							
Hogans Cr	SR 1301	Caswell	07/06/09	20.0	122	7.1	6.7
Hogans Cr	SR 1330	Caswell	07/06/09	20.8	118	7.3	6.7
Moon Cr	SR 1511	Caswell	05/21/09	15.0	97	8.4	6.5
Rattlesnake Cr	SR 1523	Caswell	05/21/09	15.1	120	8.8	6.6
S Hyco Cr	US 158	Person	05/21/09	18.7	110	7.3	6.7
Aarons Cr	SR 1400	Granville	05/26/09	21.1	76	7.2	6.0
03010102 J. H. Kerr Reservoir-Roanoke River							
Johnson Cr	SR 1440	Granville	05/26/09	19.7	127	5.6	6.3
Grassy Cr	SR 1300	Granville	05/26/09	20.4	104	4.3	6.4
Island Cr	SR 1445	Granville	05/27/09	20.6	102	5.5	6.4
03010106 Lake Gaston-Roanoke River							
Deep Cr	US 158	Halifax	05/27/09	20.4	89	6.3	6.6
03010107 Roanoke River							
Quankey Cr	US 301/NC 903/NC 125	Halifax	06/18/09	22.0	120	5.4	5.6

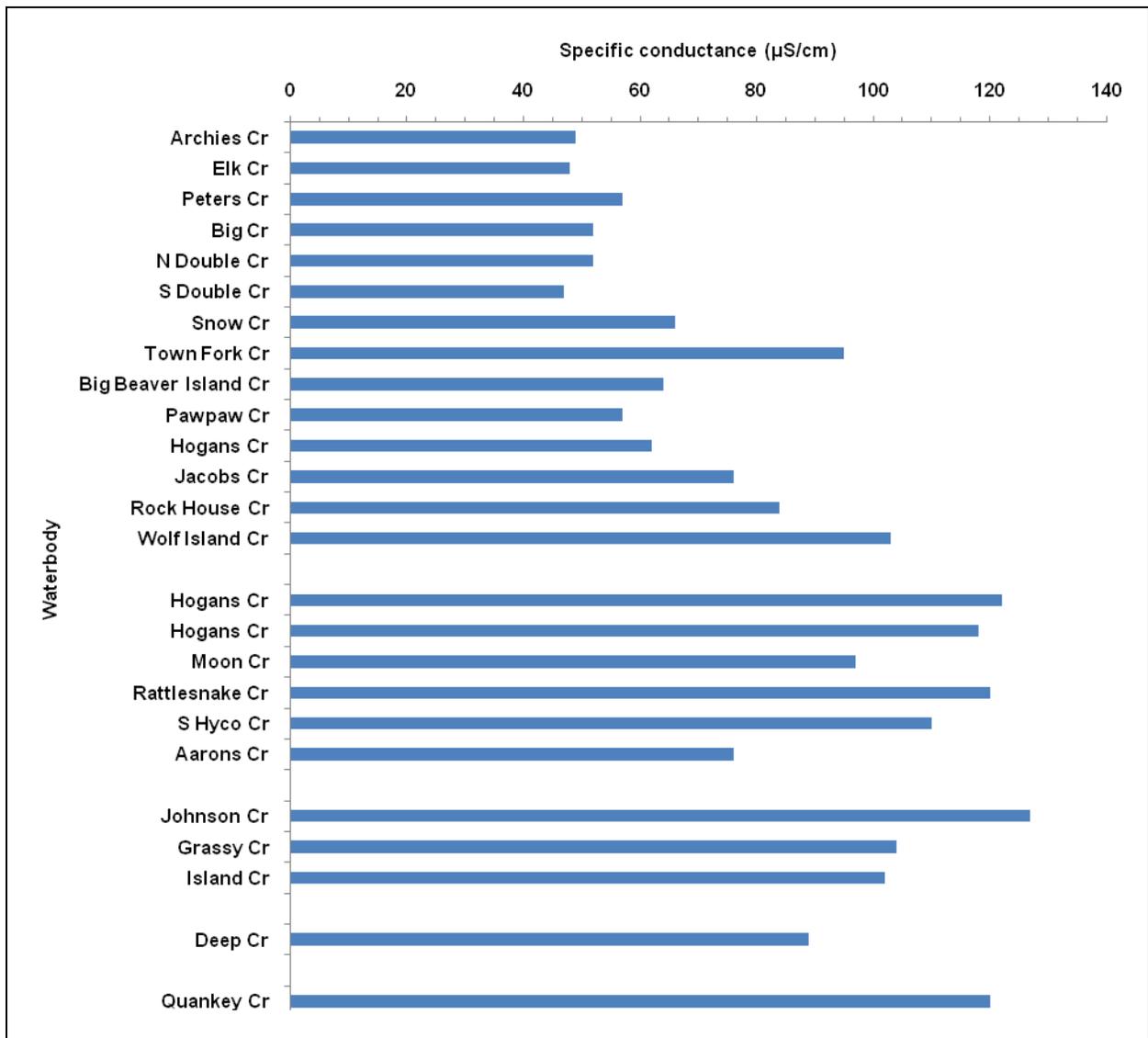


Figure 16. Specific conductance at 25 fish community sites in the Roanoke River basin, 2009.

Appendix F-8. Fish community references.

- 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. III. *Nat. Hist. Surv. Spec. Publ.* 5.
- Jenkins, R. E. and N. M. Burkhead. 1993. *Freshwater fishes of Virginia*. American Fisheries Society. Bethesda, MD.
- 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.
- NCDENR. 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.
- _____. 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.
- Nelson, J. S., Crossman, E. J., Espinosa-Pérez, H., Findley, L. T., Gilbert, C. R., Lea, R. N., and J. D. Williams. 2004. *Common and scientific names of fishes from the United States, Canada, and Mexico*. American Fisheries Society, Special Publication 29, Bethesda, MD.
- Noga, E. J. 1996. *Fish disease. Diagnosis and treatment*. Mosby-Year Book, Inc. St. Louis, MO.
- Rohde, F. C. 1993. *Distribution and status of five fishes in the Dan River*. Report to the North Carolina Wildlife Resources Commission. Raleigh, NC
- _____, Moser, M. L., and R. G. Arndt. 1998. Distribution and status of selected fishes in North Carolina, with a new state record. *Brimleyana*. 25:43-68.
- Rohde, F. C., Arndt, R. G., and S. M. Smith. 2001. Longitudinal succession of fishes in the Dan River in Virginia and North Carolina (BlueRidge/Piedmont provinces). *Southeastern Fishes Council Proceedings*. 42:1-13.

- Rohde, F. C., Arndt, R. G., Coughlan, D. J., and S. M. Smith. 2003. An annotated list of the fishes known from the Dan River in Virginia and North Carolina (Blue Ridge/Piedmont provinces). Southeastern Fishes Council Proceedings. 45:1-10.
- Sanders, R. E., Miltner, R. J., Yoder, C. O., and E. T. Rankin. 1999. The use of external deformities, erosion, lesions, and tumors (DELT anomalies) in fish assemblages for characterizing aquatic resources: a case study of seven Ohio streams. pp. 25-246. *In* Simon, T. P. (ed.). Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press. Boca Raton, FL.
- Steedman, R. J. 1991. Occurrence and environmental correlates of blackspot disease in stream fishes near Toronto, Ontario. Trans. American Fisheries Soc. 120: 494 - 499.