BASINWIDE ASSESSMENT REPORT
ROANOKE RIVER BASIN

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

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ROANOKE RIVER BASIN

OVERVIEW

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, and the Roanoke River basin was sampled by the Environmental Sciences Section in 1994 and 1999, prior to this assessment in 2004.

The Environmental Sciences Section collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Roanoke River basin include benthic macroinvertebrates and fish community monitoring for the period 2000-2004. Details of biological sampling methods and rating criteria can be found in the appendices to this report. Technical terms are defined in the Glossary. Studies conducted prior to 2000 were previously summarized in NCDENR (2000).

The document is structured with physical, geographical, and biological data discussions presented by subbasin. General water quality conditions are given in an upstream to downstream format. Lakes data, ambient chemistry data and aquatic toxicity data, with summaries, are presented in separate chapters following the subbasins.

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. The ten subbasins (Figure 1) constitute 3,503 square miles of drainage area and approximately 2,389 miles of streams and rivers in North Carolina. Fifteen counties and 42 municipalities are also included in the basin.

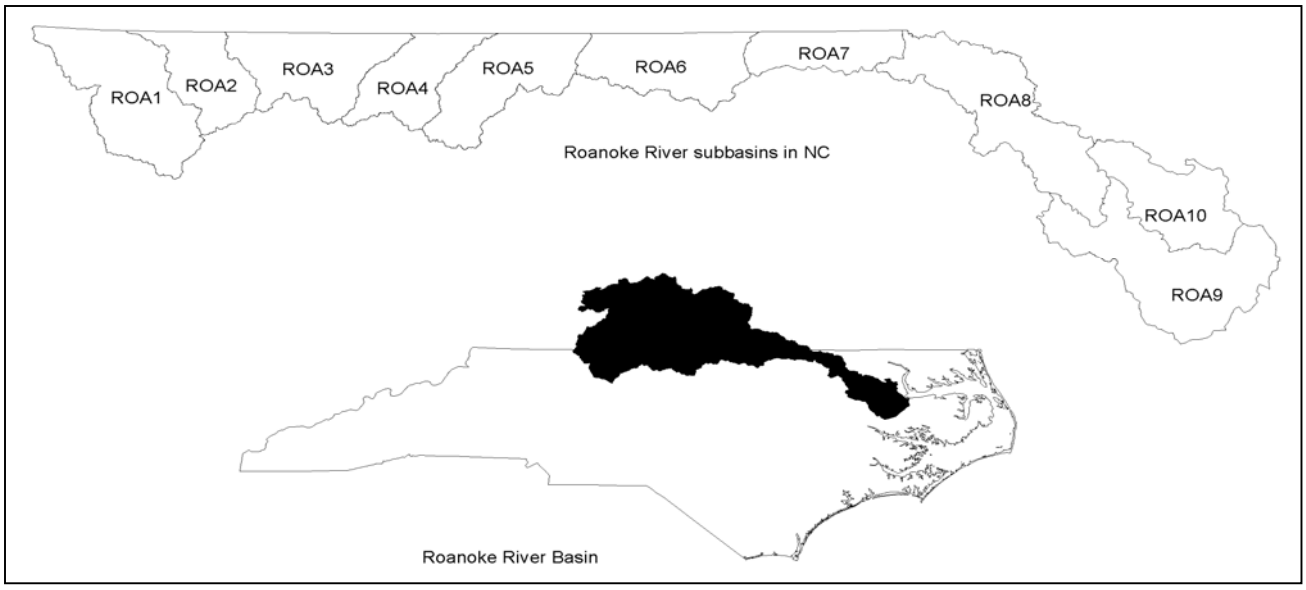


Figure 1. Geographic relationships of the Roanoke River basin and its subbasins.

The ecoregions associated with this river 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. Though the spread of urban and suburban development has occurred in the Roanoke River basin as elsewhere in the state, according to CGIA coverage (1993 – 1995), the greatest portion of land cover in the basin has remained forest and, to a lesser extent, agriculture-based (NCDENR 2001a). Also characteristic of activities throughout the state, nonpoint source runoff and numerous small point source dischargers associated with development and agricultural activities have great potential to affect water quality in the basin.

Based on benthic macroinvertebrate data, water quality in the Roanoke River basin is Good near the headwaters (subbasins 01-04), while in the lower reaches (subbasins 05-10) overall water quality is generally Good-Fair. Benthic macroinvertebrate basinwide samples resulted in the following bioclassifications: Excellent-1, Good-9, Good-Fair-6, Fair-3, Natural-11, and Moderate-6. Comparisons of benthos data from 1999 to 2004 between repeat sites reveal that Dan River at NC 704 improved from Good to Excellent, North Double Creek and Country Line Creek improved from Good-Fair to Good, Marlowes Creek improved from Fair to Good-Fair, while two swamp sites (Hoggard Mill and Conoconnara Swamp) declined from Natural to Moderate. All remaining sites maintained the same bioclassification from 1999 to 2004. Overall, water quality in this basin has improved slightly since 1999, based on benthos data.

In 2004, fish community assessments were performed at 30 sites in the basin, 29 in the Piedmont and 1 in the Coastal Plain. The drainage areas of the assessed watersheds ranged from 6.5 to 92.6 square miles. Twenty-three of the 29 Piedmont sites had never been sampled. The Piedmont NCIBI ratings ranged from Poor to Excellent with the scores ranging from 22 to 54. The two streams rated Excellent were Archies and Peters Creeks. Based upon the fish community ratings, degraded streams (bioclassifications of Fair or Poor) included North Hyco, Little Island, Nutbush, and Smith Creeks. Fish community sampling resulted in the following bioclassifications: Excellent-2, Good-18, Good-Fair-5, Fair-2, and Poor-2.

ROANOKE RIVER SUBBASIN 01

Description

This subbasin is located primarily in the Northern Inner Piedmont Level IV ecoregion. The region around Hanging Rock State Park is considered part of the Sauratown Mountain ecoregion and the lower watershed of Town Fork Creek lies within the Triassic Basins ecoregion (Griffith *et al*. 2002). This subbasin contains the uppermost reaches of the Dan River in North Carolina (Figure 2), although the headwater reaches (more than 70 square miles) of the river are in Virginia. Major tributaries within the North Carolina section in this subbasin include Double, Snow, and Town Fork Creeks.

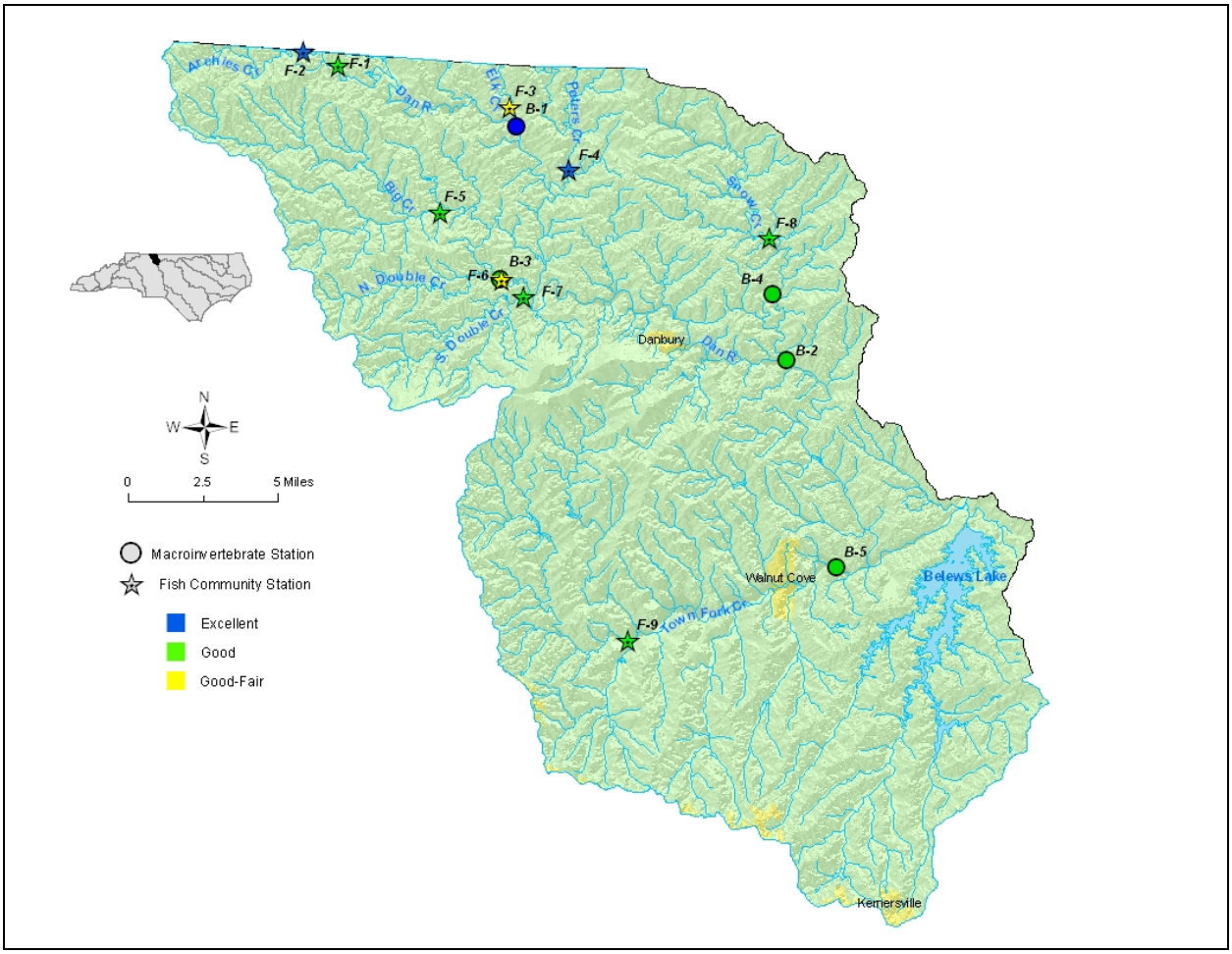


Figure 2. Sampling sites in Subbasin 01 in the Roanoke River basin. Monitoring sites are listed in Table ---.

More than 70 percent of the subbasin is forested (Table 1); less than three percent of the subbasin is in cultivated crops, the lowest percentage of this type land use in any of the subbasins. The percentage of the subbasin utilized for pasture was the greatest of any of the subbasins. There are no large metropolitan areas in the subbasin, although the suburbs of northeastern Winston-Salem are encroaching into the southwest corner of the subbasin. The largest publicly owned property in the subbasin is the 6,921 acre Hanging Rock State Park.

Table 1. Land use in Subbasin 01. Based upon CGIA coverage 1993 - 1995 (total area = 453 square miles (NCDENR 2001a).

Land use	Percent
Water	1.9
Cultivated crop	2.9
Pasture	21.8
Urban	0.6
Forest	72.8

There are 30 NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The largest discharger is the Town of Walnut Cove's WWTP which discharges 0.5 MGD to Town Creek. Duke Power Company's Belews Creek Steam Station discharges cooling water to Belews Lake and ash pond basin effluent to the Dan River. Five dischargers are required to monitor their effluent's toxicity: Kobe Copper Products, Inc., two Stokes County high schools, Rayco Utilities, and Duke Power's Belews Creek Steam Station.

Overview of Water Quality

The Dan River upstream of the confluence with Big Creek has the supplemental classification of Trout Stream. Cascade Creek and Indian Creek are Outstanding Resources Waters. Water Supply and B or C use designations make up the remainder of the subbasin water use classifications. One stream in subbasin 01 is 303(d) listed. Town Fork Creek is classified as impaired based on a 1995 benthos sample at SR 1970 which rated Poor. Hydromodification, agriculture and minor non-municipal dischargers were listed as potential sources of impairment.

One NC Ambient Monitoring Station is located in subbasin 01- at the Dan River at NC 704 near Francisco. Since 1999, water quality standards or action levels at this station have been exceeded for pH three times, turbidity 12 times, total copper once, total iron twice, and fecal coliform six times.

Benthic macroinvertebrates have been collected from sites in subbasin 01 since 1984. 2004 sampling included five basin sites (Table 2, in part). Improvements in the benthic community were noted at two sites. The Dan River at NC 704 improved from Good to Excellent, and North Double Creek improved from Good-Fair to Good. Ratings did not change since the last sampling for the Dan River at SR 1695, Snow Creek and Town Fork Creek. They each received Good ratings.

Based upon the Excellent fish community ratings and high quality instream and riparian habitats, reclassification of Archies and Peters Creek stream to High Quality Waters should be pursued, if petitioned.

All of the fish community sites were sampled for the first time in 2004. At the fish community sites on the Dan River and Archies, Elk, Peters, and Big Creeks, the waterbodies are supplementally classified as trout waters (Tr). There are no NPDES facilities within the watersheds in either North Carolina or Virginia at the fish community sites on the Dan River or Archies, Elk, Peters, Big, North Double, South Double, and Snow Creeks (Basinwide Information Management System query December 2004; VA DEQ pers. com. October 2004).

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

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Dan R	Stokes	NC 704	Good	Excellent
B-2	Dan R	Stokes	SR 1695	Good	Good
B-3	N Double Cr	Stokes	SR 1504	Good-Fair	Good
B-4	Snow Cr	Stokes	SR 1673	Good	Good
B-5	Town Fork Cr	Stokes	SR 1917	---[2]	Good
F-1	Dan R	Stokes	SR 1416	---	Good
F-2	Archies Cr	Stokes	SR 1415	---	Excellent
F-3	Elk Cr	Stokes	SR 1433	---	Good-Fair
F-4	Peters Cr	Stokes	SR 1497	---	Excellent
F-5	Big Cr	Stokes	SR 1471	---	Good
F-6	N Double Cr	Stokes	SR 1504	---	Good-Fair
F-7	S Double Cr	Stokes	SR 1483	---	Good
F-8	Snow Cr	Stokes	SR 1652	---	Good
F-9	Town Fork Cr	Stokes	SR 1955	---	Good

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites. [2]This site was not sampled in 1999, but received a Good-Fair rating for the previous basinwide survey in 1994.

River and Stream Assessment

Dan River, SR 1416

This fish community site on the Dan River is in the extreme northwest corner of Stokes County at the first bridge crossing in the state. Approximately 70 square miles of its watershed are upstream in Patrick County, VA. This site is near the beginning of the 30 mile long Dan River Aquatic Habitat, a North Carolina Natural Heritage Program site of national significance (Bridle, *et al*. 1998). The river is known for its high level of fish species diversity and the presence of several endemic species that are endangered, threatened, or significantly rare (Appendix F-5). The unique fauna has been surveyed extensively by Fritz Rohde (Division of Marine Fisheries) (Rohde, 1993 and Rohde, *et al* 1998; 2001; and 2003). Rohde (1993) advocated that based upon the diversity of its fauna, its biological integrity, and its beauty, that "*. . . this river should be afforded protection by the state through the Outstanding Resource Water program or an equivalent one which would protect this valuable watershed."*

The fish community was rated Good (NCIBI = 52) in 2004. Five species of darters and four endemic species (the most endemic species of any site in the basin, including 55 Blue Ridge sculpins and 65 cutlip minnows) were collected. This was the only site in the basin where the Blue Ridge sculpin was collected and this was also the only site in the basin where no tolerant species were collected. However, this was also the only site in the basin where no species of sunfish were collected; piscivores were also absent.

Rohde, *et al*. (2001) also reported no species of sunfish being collected at this site. This portion of the Dan River is managed as Hatchery Supported Trout Waters (HSTW) by the NC Wildlife Resources Commission and is annually stocked with 6,800 trout (brook, rainbow, and brown) from March – July. No wild trout were present, but four stocked trout (three brown and one rainbow trout) were collected during the 2004 monitoring efforts. Except for the two species of trout, no other exotic fish species were collected. Management of this reach as HSTW may prevent the colonization of this reach by native sunfish and the Roanoke bass. In addition to any impacts the stocking of trout may have on the native sunfishes, this reach is primarily fast runs and riffles with some side roots and snags; there are no true pools. The lack of pools may also contribute to the lack of sunfish.

Dan River, NC 704

This site was located at the Dan River boat access at NC 704. The river was roughly 20 meters wide at the site, with a drainage area of 169 square miles. The habitat score was 83, largely due to forested riparian zones, mixed rocky substrate, and stable, well-vegetated banks (providing an abundance of root habitat). The current was swift, the water was slightly turbid, and aufwuchs and *Podostemum* were abundant. Physical chemistry values were similar to those recorded in 1999. Conductivity was moderately low at 48 µmhos/cm (versus 45 µmhos/cm in 1999) and pH rose to 7.0 from 6.5 in 1999.

Using mountain benthos criteria, the site rated Excellent in 2004, an improvement from the Good rating it received in 1999. Total taxa richness increased from 85 in 1999 to 91 in 2004. EPT taxa richness rose from 41 to 45 with the overall addition of two mayfly taxa (including intolerant *Epeorus rubidus* and *Paraleptophlebia*) and three stonefly taxa (including intolerant *Pteronarcys dorsata* and *Sweltsa*). The BI decreased from 4.20 in 1999 to 3.89 in 2004.

Archies Creek, SR 1415

This stream is a tributary to the Dan River and drains primarily southern Patrick County, VA and a very small portion of the extreme northwest corner of Stokes and northeastern Surry counties. The specific conductance (37 µmhos/cm) was the lowest of any fish community site in the basin in 2004. The site would have qualified as a fish community regional reference site except the watershed land use did not appear to be as greatly forested (~ 50 percent) as required to meet the criteria (≥ 70 percent). The instream and riparian habitats were of high quality (habitat score = 85) (Appendix F-1).

The fish community was rated Excellent (NCIBI = 54) in 2004. Five species of darters and three endemic species including 11 cutlip minnows were collected.

Elk Creek, SR 1433

This high gradient stream is a tributary to the Dan River and drains primarily southern Patrick County, VA and a very small portion of northwestern Stokes County.

The fish community was rated Good-Fair (NCIBI = 44) in 2004, despite the occurrence of wild brown trout, five species of darters, and three endemic species including one cutlip minnow. This site and its fish community suffer from altered riparian habitats (narrow zones that offer minimal shading; riparian zones that have been periodically burned and riparian zones with numerous breaks that contribute nonpoint source nutrients and sediment to the stream) (Appendix F-1). The bluehead

chub, an indicator of excessive nutrients and abundant periphyton, constituted 44 percent of the fauna at this site.

Peters Creek, SR 1497

Raleigh Regional Office requested that Peters Creek be sampled in order to evaluate impacts from spray fields downstream of the confluence with Little Creek. Fish were sampled at SR 1497, but the suggested benthos sites were not accessible.

The watershed of Peters Creek includes a portion of the southern part of Patrick County, VA and north central Stokes County. It is a tributary to the Dan River and its watershed is adjacent to that of Elk Creek. At this crossing, the instream, riparian, and watershed characteristics are of exceptionally high quality (habitat score = 83; Appendix F-1) and qualified the site as a new fish community regional reference site.

In 2004, the fish community was rated Excellent (NCIBI = 54). Twenty-four species (the second greatest number of species collected from any site in the basin), six species of darters (the most number of species collected from any site in the basin) and three endemic species including two bigeye jumprocks were collected. This was the only site in the basin where the state Threatened bigeye jumprock was collected and was the only site in the basin where five intolerant species were collected.

Dan River, SR 1695

Forest surrounded this large river site. Stream width was greater than 25 meters at SR 1695, and the 335 square mile drainage area included mainly forest and agricultural land. The habitat scored 58, reflecting lack of woody habitat, an open canopy, and a nearly homogeneous bedrock substrate with few riffles. Riparian areas were extensive and banks were relatively stable and well vegetated. The water at the time of sampling was 28 º C and slightly turbid. Podostemum was present, and aufwuchs was abundant.

This site retained the Good rating it received in 1999 for the 2004 survey. Increases were evident in 2004 over results in 1999 in the total number of taxa (87 in 2004 versus 72 in 1999), EPT taxa (43 versus 37), number of mayflies (21 versus 17), and stoneflies (6 versus 4). However, values for EPT BI (4.7 versus 3.96) and BI (4.8 versus 4.5) were marginally elevated. An increase in the number of dipterans in 2004 (21 versus 12 in 1999) might account for this change. Intolerant taxa present in 2004 (though few in number) that were not collected in 1999 included the stoneflies *Neoperla* and *Tallaperla* and the caddisflies *Psychomyia flavida*, *Pycnopsyche* and *Setodes*.

Big Creek, SR 1471

Draining eastern Surry and northwestern Stokes counties, Big Creek is a tributary to the Dan River. The monitoring site is below Blue Ridge Fish Hatchery's Big Creek, Berry, and Locust Grove Farms where a suspected outbreak of Spring Viremia of Carp Virus (SVCV, a disease potentially fatal to native cyprinids) may have occurred in 2002 – 2003. Water used at the three facilities is withdrawn from Big Creek and discharged to Big Creek during rain events or pond draining. The fish farm closest to DWQ's 2004 monitoring site is the Berry Farm, which was located approximately 2.5 miles upstream.

In 2002 and 2003, the NC Wildlife Resources Commission sampled three sites on Big Creek and three sites on North Double Creek (the control stream) to determine any impacts on the fish community from the release of potentially virus-contaminated waters from the facilities. The three sites on Big Creek were approximately 1.5 miles upstream (near SR 1467) from the 2004 DWQ site. Pooling the data from the three sites on Big Creek, 12 species were collected including six species of cyprinids and the most abundant species in terms of density and biomass was the bluehead chub. The study concluded that no impacts to the fish community in Big Creek were documented and all fish tested as part of the study were negative for SVCV (Hodges 2004).

The fish community in 2004 was rated Good (NCIBI = 48). Seventeen species including six species of cyprinids (constituting 237 fish or 57 percent of the total fauna) and two endemic species were collected. The most abundant species was the bluehead chub. Thus, the data collected during the past three years by NCWRC and DWQ seemed to indicate that the possible escape and introduction of SVCV into Big Creek did not affect the native fish populations, especially the cyprinids.

North Double Creek, SR 1504

North Double Creek is a tributary to the Dan River whose watershed includes west-central Stokes County. This site was situated in an area typical of the upper Roanoke River basin: adjacent to crops, forest, and rural residence areas. The drainage area was approximately 12 square miles and the stream was eight meters wide. Habitat scored well overall (79 for benthos habitat, 70 for fish), and the instream, riparian, and watershed characteristics were of moderate quality (habitat score = 70; Appendix F-1), which qualified the site as a new fish community regional reference site. However few riffles, a relative abundance of sand, and moderate bank erosion kept the habitat from scoring higher. Flow was normal and the water was slightly turbid at the time of sampling. DO was 9.2 mg/l (up from 8.7 in 1999) and conductivity was 49 µmhos/cm (an improvement over 82 in 1999).

The benthic community at this site received a Good bioclassification in 2004, an improvement from the Good-Fair rating it received in 1999. The EPT BI decreased to 3.42 from 3.95 in 1999, and EPT taxa richness rose in 2004 to 31 from the prior collection of 25. An overall increase of four mayfly taxa (including intolerant *Ephemera* and *Paraleptophlebia*) and three caddisfly taxa (including intolerant *Glossosoma*, *Neophylax oligius*, and *Pycnopsyche lepida*) contributed to the improved bioclassification.

As previously discussed, in 2002 and 2003, the NC Wildlife Resources Commission sampled three sites on Big Creek and three sites on North Double Creek (the control stream) to determine the impacts on the fish community from the release of potentially virus contaminated waters from the facilities. The lowermost of the three NCWRC's sites on North Double Creek was approximately three miles upstream (near SR 1477) from the 2004 DWQ site. Pooling the data from the three sites on North Double Creek, 16 species were collected and the most abundant species in terms of density and biomass was the bluehead chub (Hodges 2004).

The fish community was rated only Good-Fair (NCIBI = 42) in 2004. This site was one of only two sites in the upper river basin in Stokes and Rockingham counties where no intolerant species were collected (the other site being Pawpaw Creek in Subbasin 02). However, the intolerant chainback darter was collected upstream in 2002 - 2003 by the NCWRC (Hodges 2004). Nonpoint nutrients from upstream sources may have contributed to the abundance of the bluehead chub; 43 percent of all the fish collected were this species. This site and others within the creek's watershed should be resampled to determine what is preventing the community from being rated Good or Excellent.

South Double Creek, SR 1483

The watershed of South Double Creek is adjacent to that of North Double Creek and borders the Sauratown Mountains ecoregion. It is also a tributary to the Dan River in west-central Stokes County.

In 2004 the fish community was rated Good (NCIBI = 46). Five species of darters and one endemic species were collected. Although rated Good, the fish community seemed to be slightly impacted by nonpoint erosion (habitat score = 46; including a sand bottom and a general lack of riffles). The number of intolerant species was lower than expected and the percentage of tolerant fish was also slightly elevated at 38 percent due to the abundance of redbreast sunfish, satinfin shiner, and white sucker.

Snow Creek, SR 1652

The watershed of Snow Creek is adjacent to that of Peters Creek. It is also a tributary to the Dan River in northeastern/north central Stokes County.

Similar to South Double Creek, the fish community in 2004 at Snow Creek was rated Good (NCIBI = 46). Although rated Good, the fish community seemed to be slightly impacted by nonpoint erosion (habitat score = 55; including primarily a sand bottom and unstable banks). The numbers of species of darters and suckers and intolerant species were lower than expected. Snow Creek was the only stream in the upper basin (from Caswell County westward) where the widely distributed Johnny darter was not collected.

Snow Creek, SR 1673

This 11 meter wide stream lay adjacent to roughly equal parts forest, residences, active crops, and fallow fields. Banks were well vegetated but steep and exhibited erosion in spots. Instream habitat included rocks (although all substrate types were present), undercut banks, and root mats. The reach was mainly a riffle-run series, with moderately embedded and infrequent riffles. Habitat scored 73 overall, with normal flow, and moderately turbid waters.

Improvement expected due to upstream mitigation since the last sampling saw fruition, as this site improved to Good in 2004 from the Good-Fair it was assessed in 1999. EPT BI decreased only marginally from 4.37 in 1999 to 4.33, but EPT richness increased significantly from 18 to 31 in 2004. Differences between the two communities included the addition of eight mayfly taxa (increase in number from nine to 17, including intolerant *Epeorus rubidus* and *Paraleptophlebia*) and five caddisfly taxa (11 taxa versus six in 1999) in the 2004 collection.

Town Fork Creek, SR 1955

Town Fork Creek is a tributary to the Dan River in south-central Stokes County; its watershed also includes northern Forsyth County, north and east of the Winston-Salem metropolitan area. There are two small NPDES facilities within the creek's watershed. One facility (NC0057720), located approximately 7.5 miles above the site, discharges 0.04 MGD to UT Timmons Creek. It had four permit violations in 2003 and 2004 for fecal coliform bacteria and total suspended solids. The other facility (NC0028746), located approximately 13 miles upstream and above the reservoir on Town Fork Creek, discharges 0.05 MGD to UT Brushy Fork Creek. It had one permit violation in 2003 for fecal coliform bacteria (Basinwide Information Management System queries December 2004).

In 1995 the NC Wildlife Resources Commission evaluated the fish community at five sites along Town Creek in response to a Natural Resources Conservation Service proposed flood control and water supply dam that was to have been built on the creek (USFWS and NCWRC 1995). One of their sampling sites (Site D) was the same site that DWQ sampled in 2004. Following 1995 DWQ sampling methods, all sites were rated Good. The study also documented a range (watershed) extension for the bigeye jumprock, a state Threatened species. The dam was not built but the project has not been abandoned (Fred Tarver, NCDENR's Division of Water Resources, pers. com.).

In 2004 the fish community was rated Good (NCIBI = 48). Five species of suckers (the second greatest number of species collected from any site in the basin in 2004) and one endemic species were collected. The fish community seemed to be slightly impacted by nonpoint erosion (habitat score = 53; including a gravel and sand bottom, unstable banks, and narrow riparian zones). Nonpoint nutrients from upstream sources may have contributed to the abundance of the bluehead chub; 38 percent of all the fish collected were this species. The number of intolerant species was also lower than expected.

Town Fork Creek, SR 1917

This 11 meter wide (130 square mile drainage area) site was located below the town of Walnut Cove's WWTP. Though the riparian areas were extensive, forested areas were adjacent to the site, and the source of the stream lay within a state park, habitat scored low (46 of a possible 100 points). Shading of the stream was minimal, substrate was entirely sand, and bank erosion was extensive. Instream habitat included some woody debris but lacked rocks, gravel, and roots mats. DO was 7.1 mg/l, pH was 7.2, conductivity was 57 µmhos/cm, the current was normal, and the water was turbid at the time of sampling.

The site was inaccessible for sampling in 1999, but was rated Good-Fair in 1994. 2004 sampling resulted in a Good rating, despite poor habitat and recent high water. Differences in sampling methods (an EPT sample was collected in 1994 and a Full Scale in 2004) make direct comparisons difficult, but improvement was clear. The BI in 2004 was 5.5, the EPT BI was 4.84 (versus 4.59 in 1994), and EPT richness was 35 (compared to 15 in 1994). Intolerant taxa collected in 2004 but not in 1994 include the intolerant mayflies *Macdunnoa brunnea* and *Serratella serratoides*, the fairly intolerant stonefly *Leuctra*, and the intolerant caddisflies *Brachycentrus numerosus*, and *Symphitopsyche sparna*.

Special Studies

Snow Creek at SR 1673

Snow Creek was resurveyed in September 2000 to evaluate whether the stream should be added to the 303(d) list based on the Fair rating it was assessed during the 1999 basin survey (Biological Assessment Unit Memorandum B-000929). The 2000 collection received a Good rating, preventing Snow Creek from being added to the 303(d) list.

Town Fork Creek TMDL Stressor Study

2004 sampling was performed to assess the water quality status of the upper portion of Town Fork Creek. Town Fork Creek had been sampled in conjunction with a Wildlife Resources Commission (WRC) study (Biological Assessment Unit Memorandum B-950919B). The Poor rating that resulted from sampling at SR 1970 less than 500 meters from the outfall of an impoundment resulted in the 303(d) listing of Town Fork Creek. The current sampling served to compare water quality conditions above and below the impoundment created by the SR 1970 dam. Good ratings were assessed at sites on Town Fork Creek and Brushy Fork Creek above the impoundment (Biological Assessment Unit Memorandum B-050329). More than four miles below the dam at SR 1961, Town Fork Creek was given a Good-Fair rating. The study concluded that the atypical sample site location was the greatest contributor to an erroneous perception of a highly impaired benthic community of Town Fork Creek at SR 1970.

ROANOKE RIVER SUBBASIN 02

Description

The northwestern half of this subbasin is located in the Northern Inner Piedmont Level IV ecoregion; the southeastern half lies within the Triassic Basins ecoregion (Griffith *et al*. 2002). This subbasin contains a very short reach (approximately 10 miles) of the Dan River and the entire North Carolina section of the Mayo River (Figure 3). However, most of the Mayo River's watershed is in Virginia. Other large tributaries include Big Beaver Island, Hogans, and Jacobs Creeks. [Note: there is a much larger Hogans Creek in Subbasin 03; its watershed includes eastern and southern Rockingham and northwestern Caswell counties.]

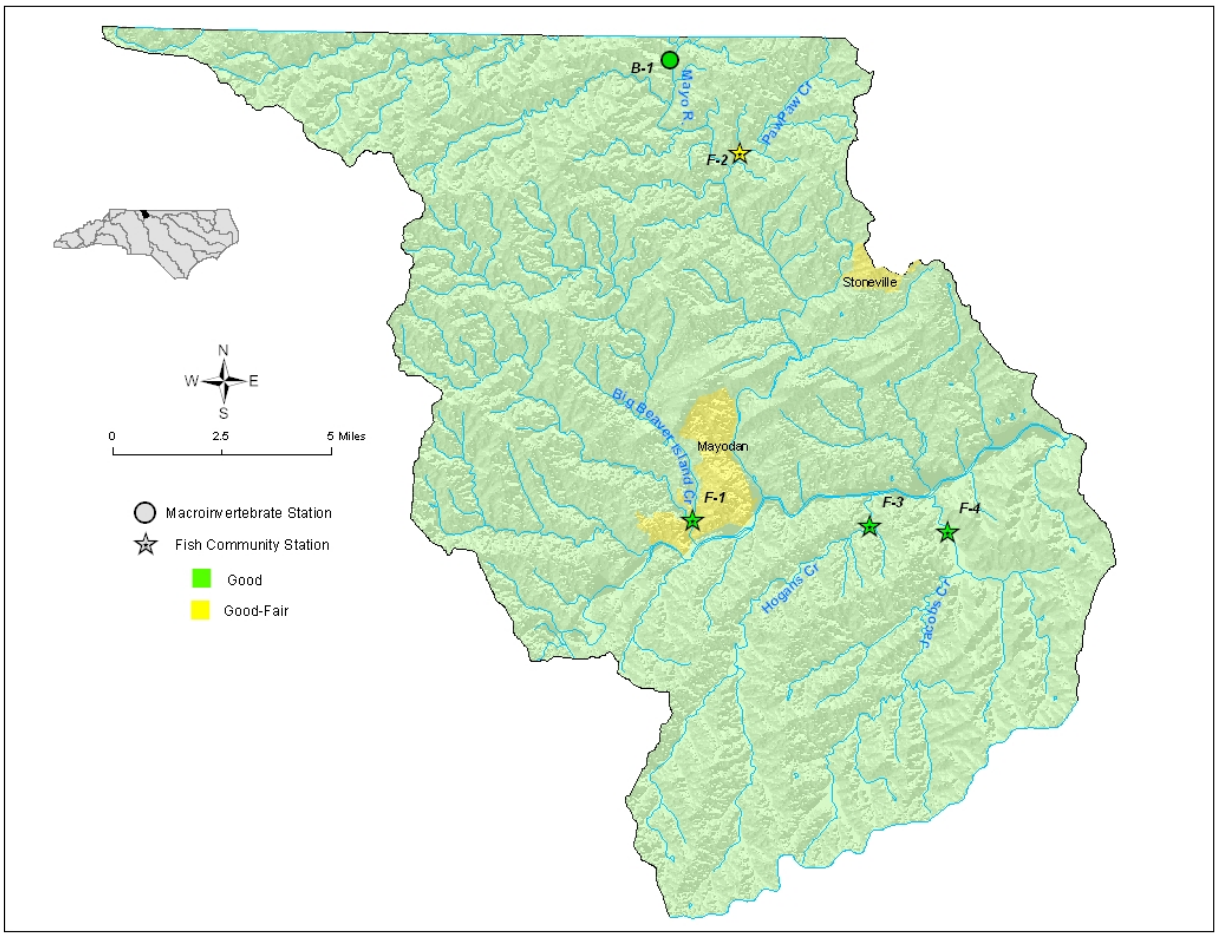


Figure 3. Sampling sites in Subbasin 02 in the Roanoke River basin.

The Towns of Madison and Mayodan are the only two large municipal areas in the subbasin. More than three-fourths of the land is forested (Table 3).

Table 3. Land use in Subbasin 02. Based upon CGIA coverage 1993 - 1995 (total area = 231 square miles (NCDENR 2001a).

Land use	Percent
Water	0.8
Cultivated crop	3.6
Pasture	18.2
Urban	1.3
Forest	76.1

There are 11 NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The largest facilities are the Town of Madison's WWTP (0.8 MGD to the Dan River) and the Town of Mayodan's WWTP (3 MGD to the Mayo River), both facilities are required to monitor their effluent's toxicity.

Overview of Water Quality

The streams in subbasin 02 have either Water Supply or C use designations. The Mayo River downstream of Avalon Dam to the dam at the Mayodan water supply intake has a supplemental designation of CA (critical area). No streams are 303(d) listed.

There is one ambient monitoring station in the subbasin- the Mayo River at SR 1358 near Price. Since 1999, exceedances of water quality standards or action levels have been recorded for pH (once), turbidity (four times), iron (10 times), and fecal coliform (11 times).

The Mayo River has historically been sampled for macroinvertebrates at two sites: SR 1358 and SR 2177. At SR 1358, current basin sampling produced a Good rating (Table 4, in part). Good bioclassifications were assigned during both the 1999 and 1994 basin assessments, indicating consistent water quality conditions at the site.

Three of the four fish community sites were sampled for the first time in 2004; Pawpaw Creek was last sampled in 1990. There are no NPDES facilities within the watersheds of the fish community sites on Big Beaver Island and Pawpaw Creeks (Basinwide Information Management System query December 2004).

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

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Mayo R	Rockingham	SR 1358	Good	Good
F-1	Big Beaver Island Cr	Rockingham	US 311	---	Good
F-2	Pawpaw Cr	Rockingham	SR 1360	---	Good-Fair
F-3	Hogans Cr	Rockingham	NC 704	---	Good
F-4	Jacobs Cr	Rockingham	NC 704	---	Good

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

River and Stream Assessment

Lack of a point of safe access to the basin site on the Mayo River at SR 2177 prevented sampling in 2004. Replacement sites upstream of SR 2177 were in too close proximity to either dams on the Mayo River or to the SR 1358 Mayo River basin site. If safe access to the SR 2177 site is not available during the next basin assessment, it may be necessary to drop this site from regular basinwide sampling.

Mayo River, SR 1358

The Mayo River drains southwestern Henry County, Virginia and northwestern Rockingham County and Northeastern Stokes County in North Carolina. At SR 1358, the river is greater than 25 meters wide and encompasses 261 square miles of drainage area. Except for a gravel road leading to a canoe launch, forest completely surrounded the sampling reach. Habitat scored high (82), reflecting good instream habitat (an abundance of rocks, sticks, leaf packs, and root mats), stable and well vegetated banks, productive riffles, but few pools and a relatively significant amount of sand. Flow was normal and the water was somewhat turbid at the time of sampling. Periphyton was moderate, and *Podostemum* was abundant.

A Good rating was assessed at this site, just as it was in 1999. Though EPT taxa richness was similar (32 in 1999 compared to 33 in 2004), the BI increased from 4.26 to 4.71, and EPT BI climbed from 3.44 to 4.13 in 2004. There were increases in the number of stonefly taxa (from 4 to 6, including intolerant *Leuctra* and *Pteronarcys*) and caddisfly taxa (from 9 to 13, including the addition of intolerant *Micrasema watauga*, *Neophylax oligius*, *Pycnopsyche*, and *Symphitopsyche sparna*), while the number of mayfly taxa fell from 19 to 14 in 2004. Overall, it appears as if there was a shift in the fauna in 2004 towards a slightly more tolerant community.

Mayo River, SR 2177

An attempt to sample the Mayo River at SR 2177 failed because the site was inaccessible at the time of sampling. Public utilities construction activities (sewer lines were being routed across the river) blocked the safest access point, and extremely high and unstable banks made alternate entryways unsafe. There were no bridge crossings between SR 2177 and the confluence with the Dan River, so the next upstream site (NC 135) was considered. That site was found unsatisfactory upon the discovery of a small hydro dam less than a mile upstream. Dams effectively act as barriers to downstream drift of benthic macroinvertebrates, and the site was situated too close to the impoundment to allow for recolonization in the short distance between the impoundment and NC 135. Therefore, a representative sample could not be taken, and the NC 135 option was not considered. For future basin surveys, the preferred site for the lower portion of the river is at SR 2177, if it is safely accessible.

Big Beaver Island Creek, US 311

This tributary to the Dan River drains north-central Stokes and north-west Rockingham counties, including the western area of the Towns of Madison and Mayodan. The monitoring site was located approximately 0.8 miles above the creek's mouth.

Despite having some substantial nonpoint source erosion and riparian bank stability problems (habitat score = 49), the fish community was rated Good (NCIBI = 52). Twenty-two species were present and the cobble and coarse woody debris riffles supported five species of darters and one endemic species.

Pawpaw Creek, SR 1360

This small creek is a tributary to the Mayo River in northwestern Rockingham County. The monitoring site was located approximately 0.6 miles above the creek's mouth.

In 2004, the fish community was rated only Good-Fair (NCIBI = 44), despite having overall high quality habitats (habitat score = 80). This site was one of only two sites in the upper river basin in Stokes and Rockingham counties where no intolerant species were collected (the other site being North Double Creek in Subbasin 01). Only three species of darters and one endemic species were collected. Nonpoint sources of nutrient may be contributing to the abundance of the bluehead chub at this site; 34 percent of all the fish collected were this species.

In 1990 (the only previous time the site had been sampled), the community was rated Good (NCIBI = 48). Five species (four species of suckers and one species of darter) that were collected in 1990 were not collected in 2004 including the bigeye jumprock, a state Threatened species. In 1990, the community was sampled below the bridge and in 2004, above the bridge. The habitats above the bridge were primarily shallow riffles and runs with few and shallow pools. Below the bridge, deeper pools and runs may have been more common and are a preferred habitat for suckers, including the bigeye jumprock. From a trophic standpoint, the community has not changed, but the loss of intolerant species, endemic species, and species of suckers from this site warrants further investigation

Hogans Creek, NC 704

The watershed of Hogans Creek drains rural, southwest Rockingham County; it is a tributary to the Dan River. The monitoring site was located approximately 1.1 miles above the creek's mouth. There are three, small NPDES permitted facilities for mobile home parks within the creek's watershed. One of the facilities does not have a flow limit in its permit, the other two have flow limits of 0.0176 and 0.018 MGD. All of the facilities are on unnamed tributaries to Hogans Creek. Quail Acres Mobile Home Park (NC0059251), located approximately 10 miles upstream, had repeated violations in 2004 for ammonia nitrogen. Another facility, Gold Hill Mobile Home Park, also located approximately 10 miles upstream did not have any parameter violations in 2004. The closest facility, located approximately 4.5 miles upstream, also did not have any parameter violations in 2004 (Basinwide Information Management System queries December 2004).

Even with these three small facilities in the watershed, at this crossing, the instream, riparian, and watershed characteristics are of exceptionally high quality (habitat score = 95; Appendix F-1) and qualified the site as a new fish community regional reference site. The habitat score was the highest score of any fish community site in the basin in 2004.

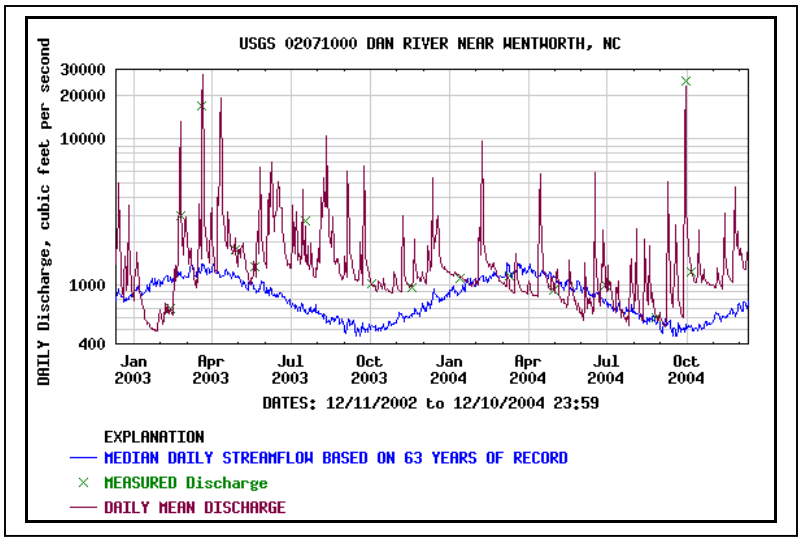
In 2004, the fish community was rated only Good (NCIBI = 48), despite having very high quality habitats. Only one species of sunfish, one intolerant species, and one endemic species were collected. It is possible that the site had extremely low flows during the 2002 drought and had yet to fully recover. Few species with multiple age classes were collected and this impact on the fish community has been documented at other sites in the Piedmont in other basins. The dominant species were the margined madtom and the redlip shiner.

Jacobs Creek, NC 704

The watershed of Jacobs Creek is adjacent to that of Hogans Creek. It is also a tributary to the Dan River in rural southwestern Rockingham County. The monitoring site was located approximately 1.7 miles above the creek's mouth. There are two small NPDES facilities within the creek's watershed. One facility (NC0037001), located approximately six miles above the site, discharges 0.0037 MGD to UT Huffines Mill Creek; it had no permit violations in 2003 and 2004. The other facility is a combustion turbine power plant (NC0086665) that discharges non-contact cooling water to an unnamed tributary to Jacobs Creek; it had no permit violations in 2003 or 2004 (Basinwide Information Management System queries December 2004).

This site suffers from very substantial nonpoint source erosion, sedimentation, bank "blowouts", deep scour pools, and riparian bank instability (habitat score = 40, the lowest of any fish community site in the basin in 2004). Prolonged high water (possibly from early spring 2003 to early spring 2004) (Figure 4) may have contributed to the severe bank erosion, sedimentation, and resulted in the low number of fish that were collected (only 176). However, the fish community was still rated Good (NCIBI = 50) with four species of suckers, including one endemic species), and four species of darters collected.

Figure 4. **Flows of the Dan River near Wentworth, NC, December 11, 2002 to December 10, 2004.**



ROANOKE RIVER SUBBASIN 03

Description

Most of this subbasin is located primarily in the Northern Inner Piedmont Level IV ecoregion, except for the Dan River corridor which lies within the Triassic Basins ecoregion (Griffith *et al*. 2002). This subbasin contains approximately 25 miles of the Dan River, prior to its flowing back into Virginia (Figure - 5). The Smith River is a major tributary of the Dan River in this subbasin, but most of its watershed is in Virginia and flow into North Carolina is regulated by upstream releases from Philpott Reservoir. Other smaller tributaries include Matrimony Creek, Rockhouse Creek, and Wolf Island Creek, and Hogans Creek.

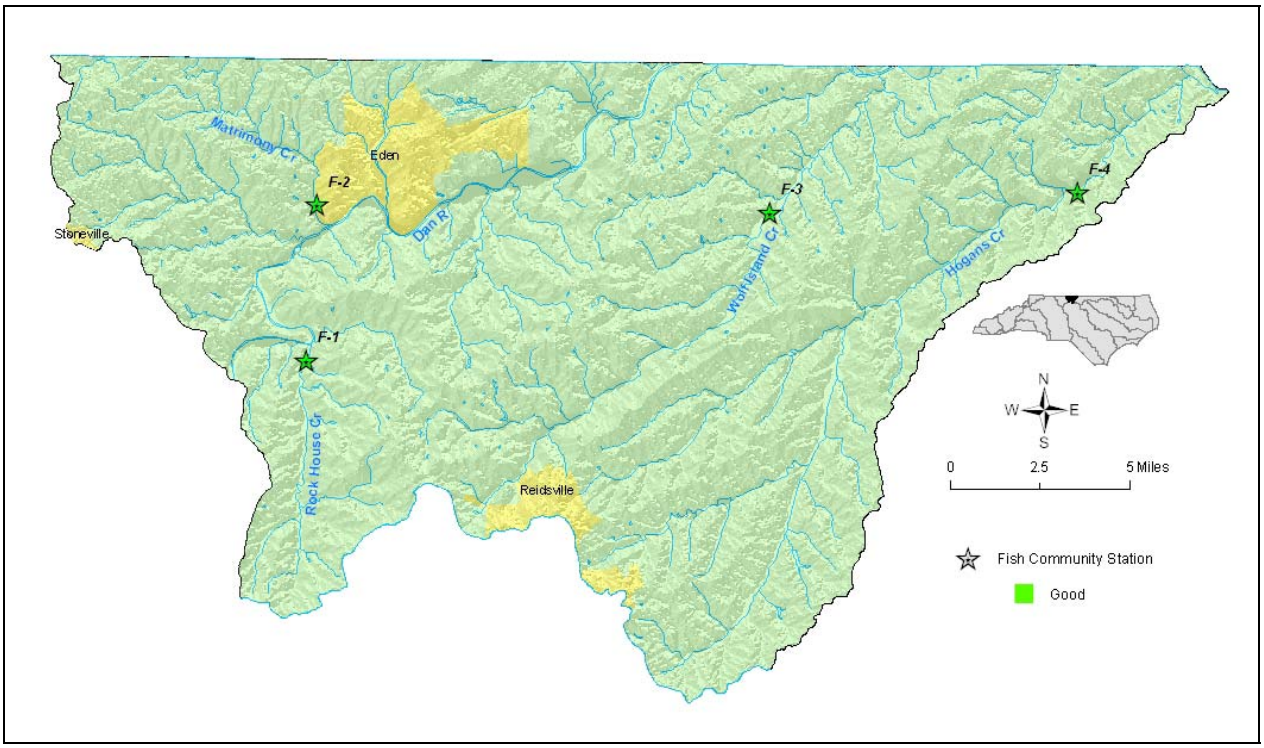


Figure 5. Sampling sites in Subbasin 03 in the Roanoke River basin.

Approximately three-fourths of the subbasin is forested (Table 5). The Towns of Eden and Reidsville are the only two major municipal areas in the subbasin.

Table 5. Land use in Subbasin 03. Based upon CGIA coverage 1993 - 1995 (total area = 340 square miles (NCDENR 2001a).

Land use	Percent
Water	1.2
Cultivated crop	3.3
Pasture	19.4
Urban	2.1
Forest	74.0

There are 21 NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The Smith River is also affected by upstream dischargers in Virginia, especially the Town of Martinsville's WWTP. The largest facilities discharge to the Dan River; they include two Town of Eden's WWTPs (0.5 and 13.5 MGD), Fieldcrest/Cannon (0.5 MGD), and Miller

Brewing Company (5.2 MGD). Four facilities are required to monitor their effluent's toxicity: Duke Power's Dan River Station, Miller Brewing Company, and both Town of Edens WWTP.

Overview of Water Quality

The majority of streams in subbasin 03 have either C or Water Supply use designations. The Dan River has the supplemental classification of CA (critical area) for the reach downstream of Matrimony Creek to Mill Branch, where the Town of Eden has located its water supply intake. The Smith River also has a CA designation for the reach from SR 1714 to the Fieldcrest Mills water supply intake. Portions of the Dan River and the Smith River in subbasin 03 are 303(d) listed and overlap with CA supplemental classification areas. The Dan River from 0.7 miles upstream of Jacobs Creek to 0.8 miles below Matrimony Creek is impaired by turbidity, potentially from dredge mining sources. The Smith River is listed in three segments. For the segment from the Virginia State line to 0.8 miles downstream of SR 1714 in Rockingham County, sources are listed as out of jurisdiction. From 0.8 miles downstream of SR 1714 to Fieldcrest Mills water supple intake, listed sources for the Smith River include urban runoff, storm sewers, and out of state jurisdiction sources. The Smith River is also listed from the Fieldcrest Mills water supply intake to the Dan River, with urban runoff and storm sewers suggested as potential sources.

There are five ambient monitoring stations located in subbasin 03. The Dan River at SR 2150 near Wentworth has exceeded water quality standards of action levels in the past five years for turbidity (seven times), total iron (10 times), zinc (two times), and fecal coliform (11 times). Exceedances in turbidity (four records), iron (eight times), and fecal coliform (five times) were recorded for the Smith River at SR 1714 near Eden. The Smith River at CS 14 experienced exceedances in copper once, iron threes times, manganese once, zinc twice, and fecal coliform once since the last basin survey. Values for the Dan River at SR 1716 near Mayfield have exceeded evaluation levels for turbidity (eight times), copper (twice), iron (nine times), zinc (once), and fecal coliform (12 times) in the past five years. Exceedances at the Dan River at NC 57 at the Virginia state line at Milton have occurred for turbidity (seven times), copper (twice), iron (14 times), and fecal coliform (eight times).

All of the fish community sites were sampled for the first time in 2004; Wolf Island Creek was sampled much further downstream in Caswell County in 1994 (Table 6). There are no NPDES facilities within the watersheds of the fish community sites on Rockhouse and Matrimony Creeks (Basinwide Information Management System query December 2004; VA DEQ pers. com October 2004).

Table 6. Waterbodies monitored in Subbasin 03 in the Roanoke River basin for basinwide assessment, 1999 and 2004.

Map #[1]	Waterbody	County	Location	1999	2004
F-1	Rockhouse Cr	Rockingham	SR 2127	---	Good
F-2	Matrimony Cr	Rockingham	NC 770	---	Good
F-3	Wolf Island Cr	Rockingham	SR 1767	---	Good
F-4	Hogans Cr	Caswell	SR 1330	---	Good

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

River and Stream Assessment

The basin site on the Smith River at NC 14 was sampled for benthos during the 1995 basinwide cycle, but was not sampled in 2004 due to lack of safe access. A number of replacement sites were investigated, but safety issues and private property prevented access to a suitable location. Locating a point of access in this area for future basinwide sampling may be difficult due to the dams on the Smith River between Virginia and its confluence with the Dan River.

Rock House Creek, SR 2127

The watershed of Rock House Creek is adjacent to that of Jacobs Creek in Subbasin 02. It is also a tributary to the Dan River in rural central Rockingham County. The monitoring site was approximately 0.6 miles above its mouth.

The creek exhibits some substantial nonpoint source erosion impacts such as sedimentation and riparian bank instability problems (habitat score = 49). Also, nonpoint nutrients from upstream sources may have contributed to the abundance of the bluehead chub; 37 percent of all the fish collected were this species. Despite the sedimentation, the fish community was rated Good (NCIBI = 48) and one endemic species was collected.

Matrimony Creek, NC 770

The watershed of Matrimony Creek, a tributary to the Dan River, drains the western portion of the Town of Eden, the extreme northern edge of Rockingham County, and a southern portion of Henry County, Virginia. The monitoring site was approximately 1.1 miles above its mouth.

In 2004, the fish community was rated Good (NCIBI = 52). Twenty-two species, including five species of darters and two endemic species were collected. The numerically dominant species was the fantail darter.

Wolf Island Creek, SR 1767

The headwaters of Wolf Island Creek begin northwest of the Town of Reidsville. The creek, a tributary to the Dan River; drains the northeast corner of Rockingham County. In its headwaters, are two small NPDES facilities. One facility (NC0034410), located approximately 25 miles above the site, discharges 0.018 MGD to UT Carroll Creek; it had no permit violations in 2003 and 2004. The other facility (NC0078271), located approximately 22 miles above the site discharges 0.0084 MGD to Carroll Creek. It had four permit violations in 2003 and 2004 for flow, pH, and fecal coliform bacteria (Basinwide Information Management System queries December 2004). Like Jacobs Creek (Subbasin 02), Wolf Island Creek appeared to have been impacted by very substantial nonpoint source erosion such as sedimentation, bank "blowouts", deep scour pools, and channel and riparian bank instabilities (habitat score = 42). Prolonged high water (possibly from early spring 2003 to early spring 2004) may have contributed to the severe bank erosion despite the riparian zones being wide and growing mature trees. The scouring high water may have also contributed to the low number of fish that were collected (only 177) and the few species that were represented by multiple age groups. However, the fish community was still rated Good (NCIBI = 50) with six species of suckers (the most species at any site in the basin in 2004, including one endemic species).

Hogans Creek, SR 1330

East and south of the Wolf Island Creek watershed, lies the large watershed of Hogans Creek. It was the largest watershed (92.6 square miles) evaluated for fish community assessments in 2004. The creek is also a tributary to the Dan River and drains southeastern Rockingham and northwestern Caswell counties. In its headwaters are two small NPDES facilities. One facility (NC0077135), located approximately 15 miles above the site, discharges 0.022 MGD to UT Lick Fork Creek; it had no permit violations in 2003 and 2004. The other facility (NC0002828), located approximately 18 miles above the site, discharges 0.005 MGD to UT Lick Fork Creek; it also had no permit violations in 2003 and 2004 (Basinwide Information Management System queries December 2004).

The fish community was rated Good (NCIBI = 52) in 2004. The numerically dominant species was the swallowtail shiner.

Special Studies

Fish Community Urbanization Study

Jones Creek at SR 2571, Rockingham County, was sampled by NC DWQ in 2004 as part of a North Carolina State University fish community urbanization study (unpublished data). The stream is a tributary to upper Hogans Creek. The community was rated Good (NCIBI = 52). Nonpoint nutrients from upstream sources may have contributed to the abundance of the bluehead chub; 39 percent of all the fish collected were this species. The collection of the creek chubsucker and the speckled killifish from this site represented new distributional records for this species in Rockingham County.

Dan River, SR 1761
As directed by recommendations in the Basin Water Quality Plan and by Winston-Salem Regional Office personnel, a new basin site was selected for the Dan River to address turbidity and fecal coliform concerns that resulted in the river's 303(d) listing. The preferred site was located at SR 1761 in Rockingham County. Safe access to the stream was not available and the river was too deep to safely sample benthos. Alternate locations could not be found in the area to conform to benthos sampling requirements as well as address regional office and planning staff concerns.

UT Hogans Creek, SR 1503
The regional office also requested samples following mitigation on UT Hogans Creek be taken in 2004. Lack of flow near SR 1503 prohibited sampling of the site for post- mitigation comparison.

Rock House Creek, SR 2127
Rock House Creek was sampled in April of 2001 as a potential reference for the Little Troublesome Creek (Cape Fear River Basin, subbasin 01) Watershed Assessment and Restoration Project. Sampling in April of 2001 resulted in a Good-Fair rating with BI and EPT BI values of 5.0 and 3.8, respectively, and EPT abundance of 23.

ROANOKE RIVER SUBBASIN 04

Description

This subbasin is located primarily in the Northern Inner Piedmont Level IV ecoregion with its eastern edge bordering the Southern Inner Piedmont (Griffith *et al*. 2002). This subbasin contains an eight mile reach of the Dan River and three of its larger tributaries: Moon, Rattlesnake, and Country Line Creeks (Figure 6). The Dan River in this subbasin flows into North Carolina from Virginia after receiving effluent from the Town of Danville's Northside WWTP and urban runoff and then flows once again back into Virginia. The Dan River traverses the northeast corner of the subbasin and Caswell County. It meets the confluence of Moon Creek just inside the subbasin boundary then downstream of the confluence with Country Line Creek, returns to Virginia where it ultimately meets the Roanoke River. Tributary streams within this subbasin are low gradient with a sand bottom.

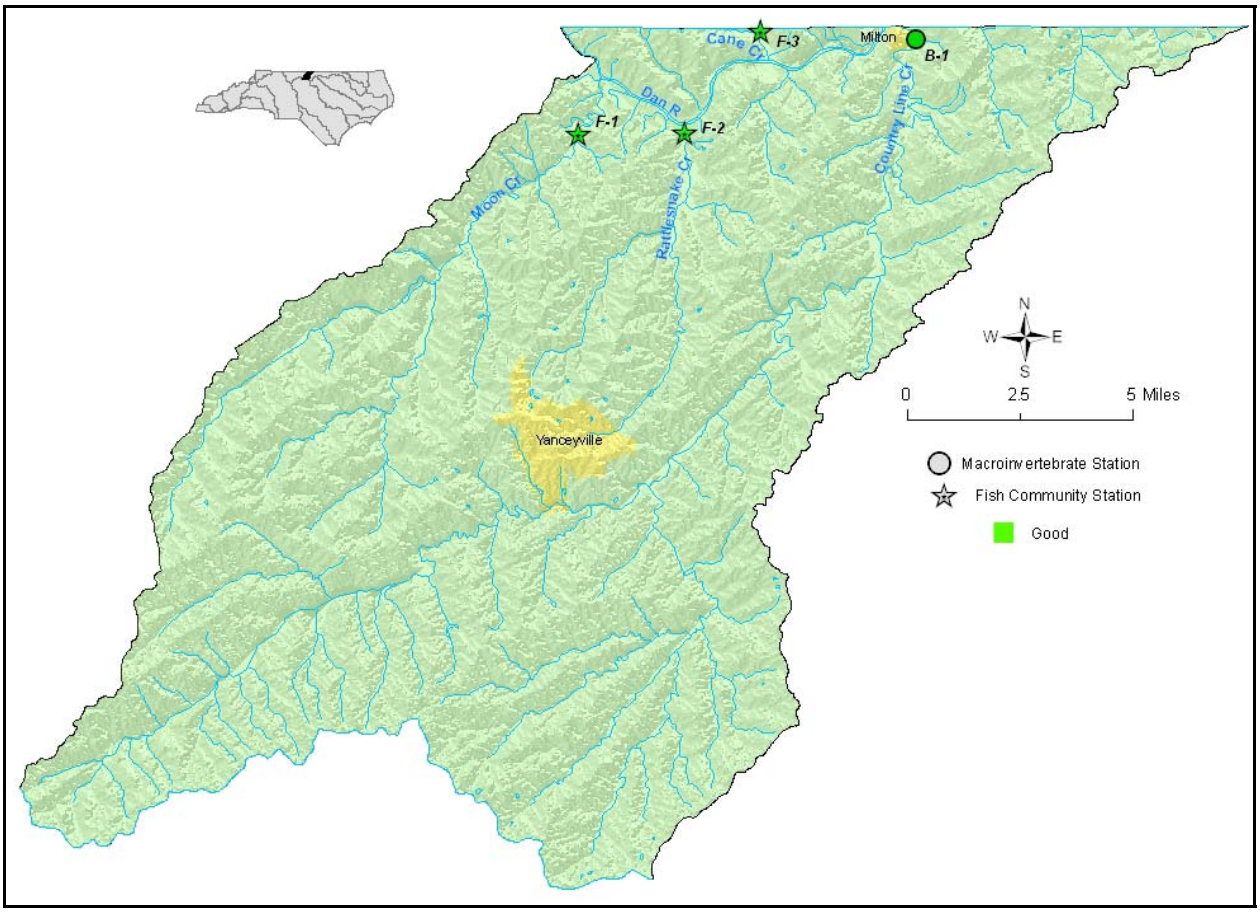


Figure 6. Sampling sites in Subbasin 04 in the Roanoke River basin.

Danville, Yanceyville, and Milton are the major towns in this subbasin although urban areas make up less than one percent of the landuse. Though the spread of urban and suburban development has occurred in these areas as elsewhere in the state, most of the land use has remained forest and, to a lesser extent, agriculture-based (Table 7).

Table 7. Land use in Subbasin 04. Based upon CGIA coverage 1993 - 1995 (total area = 239 square miles (NCDENR 2001a).

Land use	Percent
Water	1.0
Cultivated crop	2.3
Pasture	20.4
Urban	0.5
Forest	75.9

There are four NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The Town of Yanceyville's WTP discharges 0.015 MGD into Fullers Creek. The other facilities discharge into Country Line Creek and each has a permitted flow less than 1 MGD: North Carolina Department of Correction's Blanch Youth Center WWTP, the Town of Yanceyville's WWTP, and the Town of Milton's WWTP. The Town of Yanceyville's WWTP is the only facility required to monitor its effluent's toxicity.

Overview of Water Quality

The majority of streams in this subbasin are designated by C or water supply classifications. Country Line Creek, Hostler Branch, and Nats Fork have High Quality Water supplemental classifications. Portions of Country Line Creek (Farmer Lake) and Fullers Creek associated with the Yanceyville water supply are additionally designated Critical Areas. There are no 303(d) listed streams in this subbasin.

In this subbasin during 2004, three tributary sites were monitored for fish community assessments and one site each for benthic macroinvertebrates and ambient chemistry monitoring (Table 8, in part). The Dan River at Milton had statistically significant increasing trends in copper, iron, and turbidity during the past five years. There were also statistically significant exceedance for iron and turbidity at this site.

All of the sites monitored for either fish or benthic community assessments were rated Good in 2004 (Table 8); Country Line and Moon Creeks had been rated Good-Fair in 1994. However, each of the four streams showed evidence of long-term chronic erosion and nonpoint source sedimentation. Such evidence includes a substrate of primarily sand with instream bar development; an absence of riffles and deeply entrenched channel with unstable, vertical, and sparsely vegetated banks.

Table 8. Waterbodies monitored in Subbasin 04 in the Roanoke River basin for basinwide assessment, 1999 and 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Country Line Cr	Caswell	NC 57	---[2]	Good
F-1	Moon Cr	Caswell	SR 1511	---[2]	Good
F-2	Rattlesnake Cr	Caswell	SR 1523	---	Good
F-3	Cane Cr	Caswell	SR 1527	---[3]	Good

[1]B = benthic macroinvertebrate monitoring site; F = fish community monitoring sites.
[2]County Line and Moon Creeks were rated Good-Fair in 1994.
[3]Cane Creek was rated Good in 1994.

River and Stream Assessment

Country Line Creek at NC 57, Caswell County was to have been sampled for fish community assessments in 2004, However, the stream was too wide to be sampled with a staff of four persons; it had been sampled in 1994. Moon and Cane Creek were last sampled in 1994. There are no NPDES facilities within the watersheds of the fish community sites on Moon, Rattlesnake, or Cane Creeks (Basinwide Information Management System query December 2004; VA DEQ pers. com. October 2004).

Moon Creek, SR 1511

The watershed of Moon Creek is adjacent to that of Hogans Creek in Subbasin 03. It is also a tributary to the Dan River in rural northwestern Caswell County. The monitoring site was approximately 2.5 miles above its mouth.

In 2004, the community was rated Good (NCIBI = 46, a low Good), but this may be biased by the few number of fish in the sample. This site had the fewest fish of any site in the basin in 2004 (n = 104). It was also only one of three streams (the other two were Little Island and Nutbush Creeks in Subbasin 06) which did not have any suckers and also had the fewest species represented by multiple age classes (38 percent) of any site in the basin in 2004. The dominant species were the satinfin shiner, redbreast sunfish, and swallowtail shiner. In 1994, the community was rated Good-Fair (NCIBI = 44), but this was based upon a sample size of 405 fish. The most abundant species then was the satinfin shiner.

The NCIBI metric differences (number of fish, number of species of suckers, percentage of omnivores+herbivores, percentage of insectivores, and percentage of piscivores) between the 2004 and 1994 were substantial. The community at this site seems to be very unstable which could be related to the instream and riparian habitats (Appendix F-1) and lingering effects from the 2002 drought. Like other streams in Subbasins 02 - 04, the creek appeared to have been impacted by very substantial nonpoint source erosion including sedimentation, a shifting sand substrate, bank “blowouts”, scour pools, and channel and riparian bank instabilities (habitat score = 45).

Rattlesnake Creek, SR 1523

East of the Moon Creek watershed, lies the watershed of Rattlesnake Creek. It is also a tributary to the Dan River in rural northwestern Caswell County. The monitoring site was approximately 0.2 miles above its mouth. The headwaters of the creek arise in the Town of Yanceyville.

Like so many other streams in Subbasins 02 - 04, Rattlesnake Creek appeared to have been impacted by very substantial nonpoint source erosion including sedimentation, bank “blowouts”, deep scour pools, entrenchment, and channel and riparian bank instabilities (habitat score = 47). The community, despite the habitat problems, was rated Good (NCIBI = 48). The most abundant species was the satinfin shiner.

Cane Creek, SR 1527

Except for an 0.8 mile reach of the creek, the majority of the creek's watershed lies in southwestern Pittsylvania County, Virginia. The monitoring site is at the state line, approximately 0.8 miles above its mouth.

Despite its small drainage area, the fish community at this site was very diverse. Based upon the data collected in 1994 and 2004, 30 species of fish are known from this site. However, no intolerant species have been collected from this site. In 2004 and in 1994, the community was rated Good (NCIBI = 46). The most abundant species in 1994 was the bluehead chub; in 2004 the most abundant species were the bluehead chub and satinfin shiner. In 2004 the trophic metrics were more similar to those at reference sites than they were in 1994, but these improvements were offset by a decrease in the diversity of suckers, an increase in the abundance of tolerant fish, and a decrease in the percentage of fish with multiple age classes. Like other streams in the area, the banks are sloughing, the substrate is sand, and a large quantity of the bedload undoubtedly shifts and is transported during high flow events.

Country Line Creek, NC 57

Country Line Creek was last sampled in 1994. Low flows prevented sampling in 1999, so the Dan River at NC 57 was sampled as an alternate location. The river is large at that location, so the site is only accessible during very low flows and should not be substituted for basinwide sampling. Because flows were normal in 2004, sampling took place at the Country Line Creek location.

Country Line Creek is approximately 12 meters wide and has a drainage area of 138 square miles. Mostly forest and some rural residential areas were adjacent to the reach. Banks were deeply incised and showed signs of moderate erosion, while the channel was filled with sediment, and bar development was noted; the habitat score was 50. Habitat deficiencies included sandy substrate, marginal instream habitat, and insufficient pools, riffles, bank vegetation, and canopy. The conductivity was 110 µmhos/cm, the water was clear, and aufwuchs was abundant at the time of sampling.

This site was rated Good in 2004, an improvement from 1994's Good-Fair assessment. This was due to the addition of two stonefly taxa and eight caddisfly taxa. EPT BI was 4.82 in 2004 (vs. 4.43 in 1994) and EPT taxa richness was 24 (vs. 14 in 1994). Included in the list of intolerant taxa for the current collection were the stoneflies *Acroneuria abnormis*, *Leuctra*, and *Pteronarcys dorsata*; and the caddisflies *Pycnopsyche*, *Brachycentrus numerosus*, and *Neophylax oligius*.

Special Studies

Country Line Creek, SR 1129

During 2004, Basinwide Planning Unit staff requested a site be sampled on Country Line Creek upstream of Farmer Lake to address Best Management Practice (BMP) development in conjunction with forestry activities in the upper watershed. The benthic community was rated Good with a BI of 4.89 and EPT taxa richness of 24 (Biological Assessment Unit Memorandum B-050329). Monitoring results from the Country Line Creek site at NC 57 were similar overall (also a Good rating, BI of 4.82, and EPT taxa richness of 24), although there was a shift in the EPT community. The SR 1129 site had fewer caddisflies (6 vs. 12 at NC 57) and a greater number of mayflies and stoneflies (12 vs. 8 and 6 vs. 4, respectively).

ROANOKE RIVER SUBBASIN 05

Description

This subbasin traverses three Level IV ecoregions – the Northern Inner Piedmont, the Southern Outer Piedmont, and the Carolina Slate Belt (Griffith *et al*. 2002). This subbasin contains the watersheds of Hyco and Mayo Reservoirs and the Hyco River before it flows into Virginia (Figure 7). Major tributaries include North Hyco, South Hyco, and Marlowe Creeks. Reedy Fork and North Hyco Creeks in southeast Caswell County and South Hyco Creek in southwest Person County originate in the Southern Outer Piedmont and flow northeast to feed Hyco Reservoir. Storys Creek (including Roxboro Lake) and Marlowe Creek are also located in the Southern Outer Piedmont in Person County. Mayo Reservoir, also in Person County, lies within the Carolina Slate Belt ecoregion. Hyco Reservoir lies mostly in the Northern Inner Piedmont ecoregion, as does the Hyco River, which runs from the outflow of the reservoir into Virginia where it meets the Roanoke River.

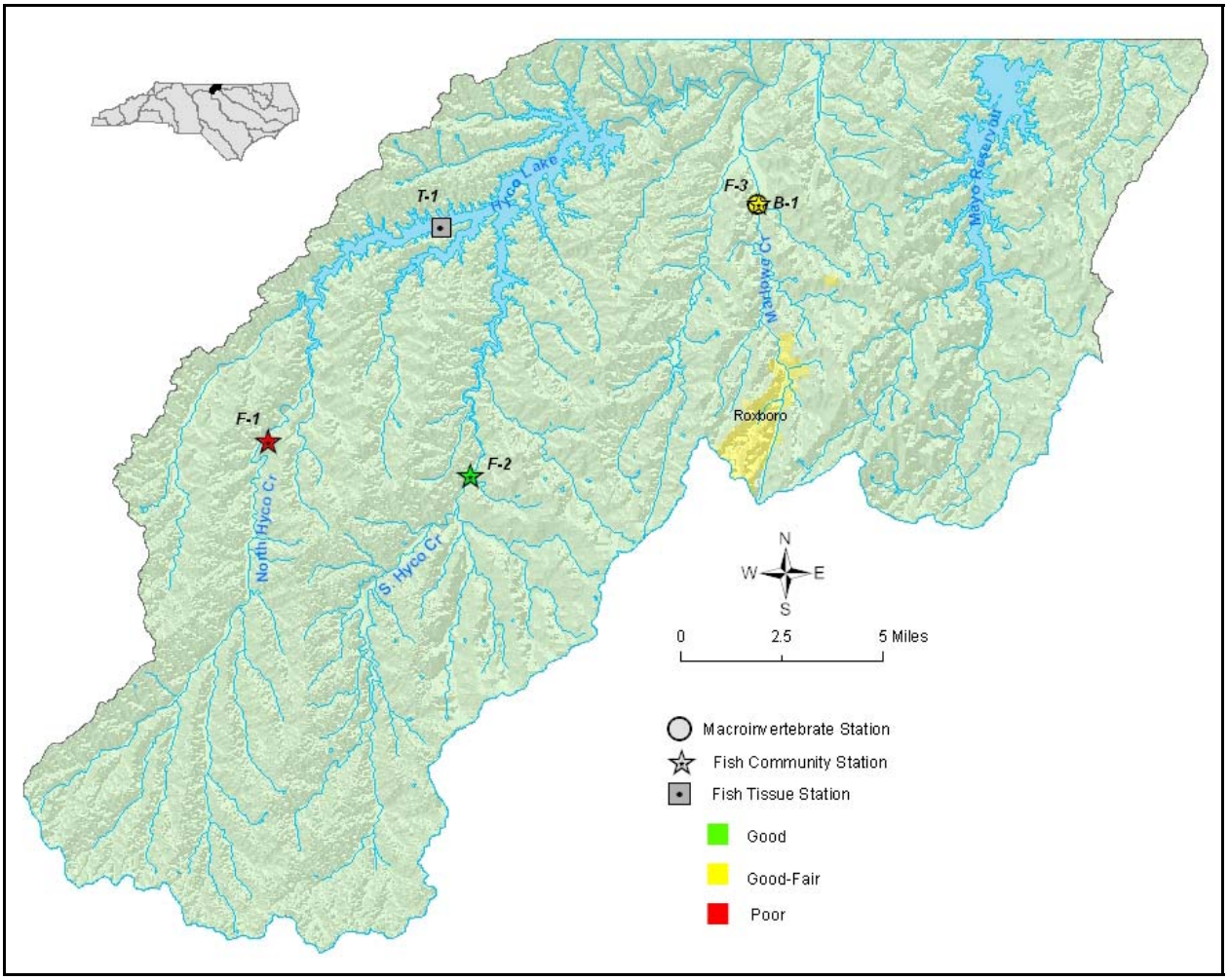


Figure 7. Sampling sites in Subbasin 05 in the Roanoke River basin.

Approximately 70 percent of the subbasin is forested (Table 9). The Town of Roxboro is the largest municipal area in the subbasin. There are 14 NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The City of Roxboro is the largest municipal wastewater facility in the subbasin, discharging 5.0 MGD into Marlowe Creek. Progress Energy's Roxboro and Mayo electric generating plants discharge, by design and permit, cooling water

(into Hyco Reservoir) and ash pond effluent (into Mayo Reservoir). The Town of Roxboro's WWTP, two discharges from the Roxboro Plant, the Mayo Plant, and Cogentrix are required to monitor their effluent's toxicity.

Table 9. Land use in Subbasin 05. Based upon CGIA coverage 1993 - 1995 (total area = 337 square miles (NCDENR 2001a).

Land use	Percent
Water	4.5
Cultivated crop	2.4
Pasture	19.8
Urban	1.3
Forest	71.9

Overview of Water Quality

The majority of streams in subbasin 05 are designated by B, C, or Water Supply classifications. Several streams were given HQW supplemental classifications as well: South Hyco, Sugartree, Double, Broachs Mill, and Snipe Creeks and Lick Branch. South Hyco Creek (near the City of Roxboro water supply intake), and portions of Storys and Satterfield Creeks associated with Roxboro City Lake were designated as HQW-CA.

In this subbasin during 2004, five sites were monitored for ambient chemistry monitoring, three sites for fish community assessments, and one site for benthic macroinvertebrate assessment (Table 10, in part). Ambient monitoring ceased at North Hyco Creek (at US 158, Caswell County) in June 2000 and is thus an incomplete record compared to that at the other four sites (Hyco River near McGhees Mill and at US 501 (in Virginia), and Marlowe and Mayo Creeks).

Table 10. Waterbodies monitored in Subbasin 05 in the Roanoke River basin for basinwide assessment, 1999 and 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Marlowe Cr	Person	SR 1322	Fair	Good-Fair
F-1	N Hyco Cr	Caswell	US 158	---	Poor
F-2	S Hyco Cr	Person	US 158	---	Good
F-3	Marlowe Cr	Person	SR 1322	---[2]	Good-Fair
T-1	Hyco Res	Person			

[1]B = benthic macroinvertebrate monitoring site; F = fish community monitoring sites; T = tissue contaminant monitoring site.
[2]Marlow Creek was rated Good-Fair in 1994.

Marlowe Creek from its source to Storys Creek is on the 303(d) list. Impairment is based on biological integrity and copper action level violations. Listed sources include municipal pretreatment (industrial dischargers), minor non-municipal, and collection system failures. During the assessment period Marlowe Creek was monitored for fish community, benthic macroinvertebrate, and ambient chemistry. Based upon biological data the creek was rated Good-Fair. The median conductivity was only exceeded by that in Nutbush Creek (Subbasin 06). The median total phosphorous concentration was the greatest of any site in the basin over the five year period. There were also statistically significant exceedances for copper and fecal coliform bacteria.

The fish community in North Hyco Creek was rated Poor due to issues related to flow, recolonization sources, and habitat alterations. South Hyco Creek was rated Good but showed evidence of long-term chronic erosion and nonpoint source sedimentation such as a substrate of primarily sand; a paucity of riffles and unstable, vertical, and sparsely vegetated banks.

River and Stream Assessment

Two of the three fish community sites were sampled for the first time in 2004. Marlowe Creek was last sampled in 1994. There are no NPDES facilities within the watersheds of the fish community sites on North Hyco or South Hyco Creeks (Basinwide Information Management System query December 2004).

North Hyco Creek, US 158

North Hyco Creek is a tributary to Hyco Reservoir, an impoundment of the Hyco River. There are no municipalities in the creek's watershed which drains rural southeastern and eastern Caswell County.

The habitat score and characteristics for this site (51) were similar to many of those at other sites in Subbasins 02 – 05. However, the fish community was rated Poor (NCIBI = 30), the lowest score and rating of any stream in the basin in 2004 (Appendix F-2). No intolerant species were present, there were fewer fish and species than expected, very skewed trophic metrics (few omnivores and primarily insectivores), an elevated incidence of disease, and fewer than expected species with multiple age classes. The numerically dominant species were the fantail darter and bluegill.

Reasons for the low rating were not clear. It was possible that the stream has yet to recover from the 2002 drought, but the watershed drainage area is 45.9 square miles and streams of much smaller size in this and in other Piedmont basins have already recovered. It is also possible that the there are few upstream sources for recolonization and recolonization from downstream sources is hindered by Hyco Reservoir (located approximately 2.5 miles downstream). There was also an old sand dipping operation on the right bank near the beginning of the reach. These three factors -- flow, recolonization sources, and habitat alterations – may all play a role in structuring the fish community at this site. This creek and others within it's watershed should be resampled in 2005 to verify the 2004 results and to identify, if possible, the factor(s) causing the low fish community rating.

South Hyco Creek, US 158

South Hyco Creek is a tributary to Hyco Reservoir, an impoundment of the Hyco River. This site approximately 0.5 miles above the backwaters of the reservoir. There are no municipalities within the creek's watershed, which drains rural southwestern Person County. The stream is also classified as High Quality Waters based upon its WS-II supplemental classification.

The habitat score and characteristics for this site (51) were similar to many of those at other sites in Subbasins 02 – 05. In 2004 the fish community was rated Good (NCIBI = 52). The most abundant species was the satinfin shiner.

Marlowe Creek, SR 1322

The watershed of Marlowe Creek drains three Level IV ecoregions -- the Northern Inner Piedmont, the Southern Outer Piedmont, and the Carolina Slate Belt (Griffith *et al*. 2002). It also includes the northern part of the City of Roxboro. The creek is a tributary to the Hyco River and was sampled approximately 4.5 miles below the city's WWTP. This facility (NC0021024) discharges 5 MGD to the creek with a $7Q_{10}$ instream waste concentration of 99.87 percent. The facility had five permit violations in 2003 and 2004 including failures of its quarterly toxicity test and fecal coliform bacteria and cyanide exceedances in its wastewater (Basinwide Information Management System query December 2004). During fish community sampling in 2004, the specific conductance at this site was elevated (220 µmhos/cm) reflecting the WWTP discharge. During benthic macroinvertebrate sampling later in the summer the conductivity was 340 µmhos/cm. In the summer of 1999, prior to the upgrades at the facility, the conductivity was 836 µmhos/cm

Other permitted dischargers upstream of this site are the City of Roxboro's water treatment plant (NC003042 to UT Marlowe Creek) and a power generating facility (NC0065081 to UT Mitchell Creek). Neither of the facilities has a flow limit in its permit and neither facility had parameter violations in 2003 and 2004 (Basinwide Information Management System queries December 2004).

In 2004 the fish community was rated Good-Fair (NCIBI = 42). More fish were collected at this site (n = 1,027) than at any other site in the basin. No intolerant species were present and only one species of darter was collected. The percentage of omnivores+herbivores was 60 percent, was the greatest of any site in the basin in 2004, and reflected the nutrient inputs from the WWTP. As expected, the numerically dominant species was the bluehead chub; 50 percent of all the fish were of this species. In 1994, the community was also rated Good-Fair (NCIBI = 40). However, in 1994 there were far fewer species, fish, suckers, and omnivores+herbivores than in 2004.

During benthic macroinvertebrate sampling the habitat scored 66, reflecting eroding banks, substrate comprised mostly of sand and some gravel, marginal instream habitat (undercut banks and root mats dominant), few pools, and unproductive riffles. Riparian areas were intact and bank vegetation was generally healthy, however. The water was clear and the current was low at the time of sampling.

In 2004 the benthic macroinvertebrate community was rated Good-Fair, an improvement over the Fair rating in 1999. Both ratings were borderline Fair/Good-Fair and exhibited a tolerant benthic assemblage overall. The 2004 sample had higher BI and EPT BI values than in 1999 (6.43 vs. 6.34 and 5.93 vs. 5.74, respectively). However, the 2004 collection also had greater EPT taxa richness, with 13 taxa present compared to nine taxa in 1999. A number of midges tolerant to organic enrichment and toxics were present in 2004, namely: *Conchapelopia*, *Microtendipes*, *Polypedilum*, *Cricotopus bicinctus*, and *Cricotopus varipes*. The only notably intolerant specimen in the 2004 collection was the caddisfly *Neophylax oligius* and it was not present in 1999.

Special Studies

Storys Creek

The Raleigh Regional Office requested an additional site on Storys Creek (downstream of the confluence with Marlowe Creek) during basinwide sampling. Storys Creek sampling was requested as possible upstream/downstream stressor study sites. Unfortunately, access was limited by private land and a lack of road crossings.

Marlowe Creek, SR 1351

Upgrades were made to the Roxboro WWTP in the summer of 2003, and more intensive sampling of Marlowe Creek was requested by RRO to determine if improvements at the facility allowed for improvements in the benthic community. An upstream site was located at SR 1351 (above the WWTP approximately 300 meters) to compare to results at the basin site at SR 1322 (approximately 6 kilometers, or 3 miles, downstream of the facility). Unfortunately, improvements following upgrades at the Roxboro WWTP may have been masked by urban pressures upstream, as the stream's origin lies in the city center of Roxboro. While urban effects are evident at the upstream location, downstream the cumulative effect of the influences of the city of Roxboro and the WWTP may be difficult to separate. The upstream site (SR 1351) was rated Fair (borderline with Good-Fair) with a BI of 6.67 and EPT richness of 14 (Biological Assessment Unit Memorandum B-050329). However, overall habitat scored slightly higher (79 vs. 66), conductivity was approximately two-thirds lower (98 µmhos/cm vs. 340 µmhos/cm at SR 1322), and the benthic collection included intolerant taxa not present at the downstream basin site which rated Good-Fair.

ROANOKE RIVER SUBBASIN 06

Description

This subbasin is divided between the Carolina Slate Belt and the Northern Outer Piedmont Level IV ecoregions (Griffith *et al*. 2002). This subbasin contains many small to medium-sized headwater tributaries of John H. Kerr Reservoir, an impoundment of the Roanoke River (Figure 8). Grassy Creek's headwaters lie in Granville County in the Carolina Slate Belt ecoregion. The stream flows northeast to Kerr Reservoir. Little Grassy Creek is a tributary to Grassy Creek. Island Creek and its tributaries (Gill and Little Island Creeks) originate on both sides of the Granville-Vance county line and flow north-northeast to Kerr Reservoir. Nutbush Creek, which enters Kerr Reservoir from south-southwest in the Northern Outer Piedmont ecoregion of Vance County, originates in the Town of Henderson.

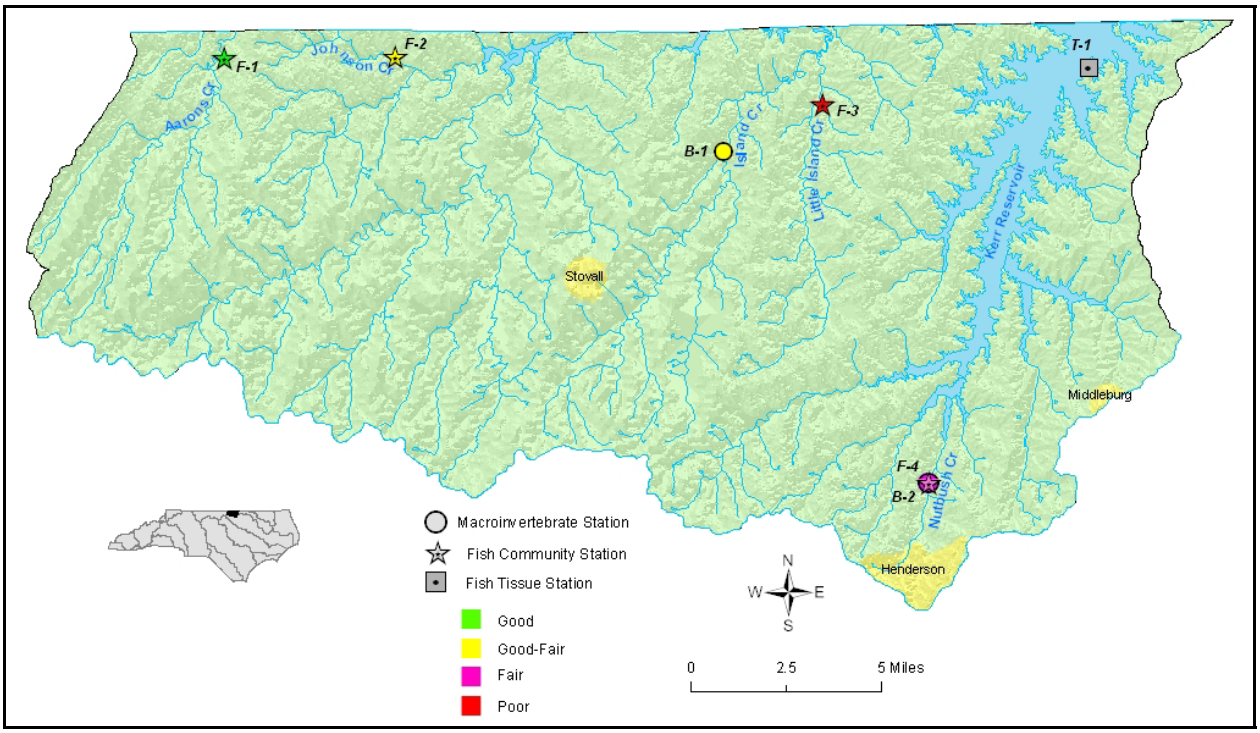


Figure 8. Sampling sites in Subbasin 06 in the Roanoke River basin.

Many of the smaller streams may become intermittent during the summer and may dry up during periods of extended drought. These tributaries include Aarons, Grassy, Island, and Nutbush Creeks. Approximately three-fourths of the subbasin is forested (Table 11). The Town of Henderson is the only metropolitan area in the subbasin. There are three NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The Town of Henderson's WWTP is authorized to discharge 4.14 MGD into Nutbush Creek. The facility is also required to monitor the effluent's toxicity.

Table 11. Land use in Subbasin 06. Based upon CGIA coverage 1993 - 1995 (total area = 329 square miles (NCDENR 2001a).

Land use	Percent
Water	6.4
Cultivated crop	8.6
Pasture	9.0
Urban	1.1
Forest	75.0

Overview of Water Quality

The majority of streams in this subbasin are designated by B, C, or water supply classifications. Anderson Swamp Creek additionally carries a CA classification. In this subbasin during 2004, four sites were monitored for fish community assessments, two for benthic macroinvertebrates, and one for ambient chemistry (Table 12, in part).

Nutbush Creek is on the 303(d) list based on biological data with potential sources listed as major municipal point sources and urban runoff/ storm sewers. During the assessment period the creek was monitored for fish community, benthic macroinvertebrate, and ambient chemistry. Based upon biological data the creek was rated Fair. The median conductivity and nitrite+nitrate-nitrogen concentration were the greatest of any site in the basin during the five year period. In addition, the median total phosphorous concentration was the second greatest of any site in the basin over the same period. However, there were no statistically significant exceedances for any water quality variables from 1999 – 2004.

In 2004 the ratings of the fish and benthic communities in Aarons, Johnson, Island, and Little Island Creeks ranged from Poor to Good. The communities and the lower than expected ratings are affected by flow in these streams that can become very reduced during dry periods. Recolonization of the lower reaches of the streams are also hindered by the barrier of the backwaters of Island Creek and Kerr Reservoirs.

Table 12. Waterbodies monitored in Subbasin 06 in the Roanoke River basin for basinwide assessment, 1999 and 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Island Cr	Granville	SR 1445	---[2]	Good-Fair
B-2	Nutbush Cr	Vance	SR 1317	Fair	Fair
F-1	Aarons Cr	Granville	SR 1400	---	Good
F-2	Johnson Cr	Granville	SR 1440	---	Good-Fair
F-3	L Island Cr	Vance	SR 1348	---	Poor
F-4	Nutbush Cr	Vance	SR 1317	---[2]	Fair
T-1	Kerr Res	Vance			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; T = tissue contaminant monitoring site.
[2]Island and Nutbush Creeks were rated Good-Fair in 1994.

River and Stream Assessment

Three of the four fish community sites were sampled for the first time in 2004; Nutbush Creek was last sampled in 1990. Grassy Creek at SR 1436, Granville County was not sampled for fish community assessments in 2004. In 1999 while conducting site selections for regional reference sites, the stream was determined to be too wide to be sampled with a staff of four persons; it had been sampled in 1994. Island Creek at SR 1445, Granville County was sampled in June 1999 as part of a special study on fish community regional sites and will be sampled again as a basinwide site in 2008. There are no NPDES facilities within the watersheds of the fish community sites on Aarons, Johnson or Little Island Creeks (Basinwide Information Management System query December 2004; VA DEQ pers. com. October 2004).

Aarons Creek, SR 1400

The rural watershed of Aarons Creek drains the extreme northeast corner of Person County and the extreme northwest corner of Granville County. The creek flows northward into Virginia. Aarons Creek, from the confluence of Crooked Fork (just upstream of NC 96) to the NC/VA state line, is considered to be a Aquatic Habitat Site of regional significance because of the presence of four species of rare freshwater mussels in the creek (Sarah McRae, Natural Heritage Program, pers. com. February 15, 2005). At this crossing, the instream, riparian, and watershed characteristics are of high quality (habitat score = 84; Appendix F-1) and qualified the site as a new fish community regional reference site.

In 2004, the fish community was rated Good (NCIBI = 46, a low Good). The dominant species were the crescent shiner and fantail darter; 64 percent of all the fish collected were of these two species. It is possible that the flow in this stream becomes very reduced during dry periods and this may have caused the lower than expected NCIBI score and rating.

Johnson Creek, SR 1440

The rural watershed of Johnson Creek drains the extreme north central part of Granville County and a small portion of southeast Mecklenburg County, Virginia. The creek is a tributary to Grassy Creek and to Kerr Reservoir. At this crossing, the instream, riparian, and watershed characteristics are of moderate quality (habitat score = 76; Appendix F-1) and qualified the site as a new fish community regional reference site.

In 2004, the fish community was rated only Good-Fair (NCIBI = 44). The dominant species was the fantail darter; 56 percent of all the fish collected were of this species. Fewer than expected total species, darters, sunfish, suckers, intolerant species, and omnivores+herbivores were collected. Only 13 species were present. Also, only one species of darter was collected. Crescent shiners, which were so abundant in nearby Aarons Creek, were absent from Johnson Creek. It is very probable that the flow in this stream becomes very reduced during dry periods (the watershed drainage area at this site is only 7.6 square miles) and downstream reaches of the stream (for example below the site at SR 1431) are affected by the backwaters of Kerr Reservoir. These factors may have caused the lower than expected NCIBI score and rating for this regional reference site.

Island Creek, SR 1445

The stream at this site is eight meters wide and encompasses 32.5 square miles of drainage area. Adjacent land use is largely forest, with a small portion of active crops. Habitat at this site was given a score of 61 overall. Riparian areas were intact (though narrow on the right bank), instream habitat included a variety of types, and the substrate was a good mix of gravel, cobble, and boulders. However, riffles were infrequent and moderately embedded and pools were infrequent. Banks were severely eroded with sparse vegetation, the channel appeared filled in with sediment in places, and the stream was only partially shaded. The current was low, aufwuchs was moderate, the water was slightly turbid, and conductivity was 95 µmhos/cm at the time of sampling.

The benthic macroinvertebrate community was rated Good-Fair, the same rating it had received in 1994. Lack of flow prevented sampling in 1999. The EPT BI was slightly higher in 2004 than in 1994, 5.48 and 5.11, respectively. However, the number of EPT taxa, 17, was the same for the two samples. Ten mayfly taxa were present for both samples, but no stoneflies were collected in 2004 (compared to two in 1994), and two more caddisfly taxa were present over 1994's collection of five. The community at this site was generally tolerant, as the single intolerant taxa collected in 2004 was *Leucrocuta*.

Little Island Creek, SR 1348

Draining rural northwestern Vance County, Little Island Creek is a tributary to Island Creek, Island Creek Reservoir, and ultimately Kerr Reservoir. The creek straddles the border between the Carolina Slate Belt and the Northern Outer Piedmont ecoregions (Griffith *et al*. 2002). However, at the monitoring site, substrate was sand and gravel and lacked the angular rocks and riffles characteristics of many Carolina Slate Belt streams; the habitat score was 47.

This site and the lower part of the adjacent Island Creek watershed encompass the defunct Tungsten Queen Mine, an inactive hazardous site (NCDENR's Division of Waste Management, NCD082362989) (Figure 9). The mine ceased operations in 1971 but at one time was one of the largest tungsten mines in the country. The tailings (sands) in Little Island Creek appear to be similar to those at the tungsten mine and may have similar contaminant metals of concern including lead, arsenic, antimony, cadmium, and zinc. The surface water, ground water, sediments, and fish in Little Island Creek have not been monitored but have the potential to be contaminated with these metals. Currently, the area including the tailings (sands) is under a remedial action by the Inactive Hazardous Site Branch of Superfund (Keith Snavley, DWM, pers. com., February 14, 2005).

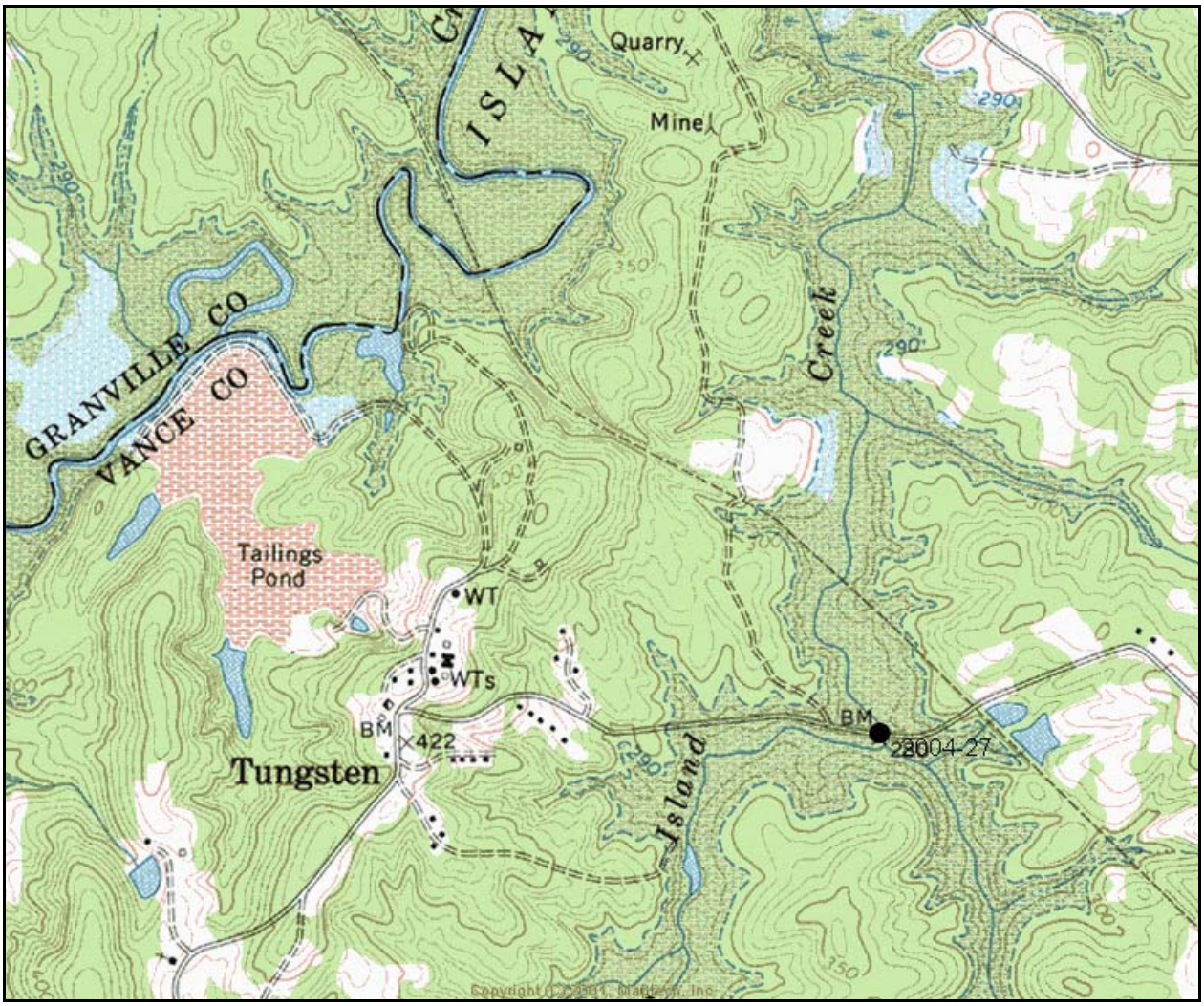


Figure 9. Location of monitoring site on Little Island Creek (2004-27) in relation to the Tungsten Queen Mine tailings pond.

In 2004, the fish community was rated Poor (NCIBI = 30). The dominant species was the rosefin shiner. Fewer than expected total species, fish, darters, suckers, intolerant species, and omnivores+herbivores were collected. Only 111 fish representing 13 species were present. This was the only site in the basin where the Carolina darter was collected (one specimen was collected). Little Island Creek was also only one of three sites in the basin (the other two sites being Moon and Nutbush Creeks) where suckers were absent. The incidence of disease (4.5 percent) was also elevated.

Like other streams in this subbasin, it is probable that the flow in this stream becomes very reduced during dry periods. Recolonization of the stream from downstream sources is also hindered by the barrier of the backwaters of Island Creek Reservoir. These three factors -- flow, recolonization sources, and potential impacts from the abandoned tailings – may all play a role in structuring the fish community at this site. This creek should be resampled in 2005 to verify the 2004 results and to identify, if possible, the factor(s) causing the low fish community rating.

Nutbush Creek, SR 1317

Nutbush Creek is a small tributary to Kerr Reservoir, although its reservoir arm is larger than any of the others. The creek drains the northern portion of the Town of Henderson and receives the effluent from the town's WWTP. The monitoring site is approximately 1.3 miles below the facility which discharges 4.14 MGD at a 97 percent instream waste concentration. The facility had only three permit violations between 2002 – 2004. The most recent violation was in September 2004 and involved a quarterly toxicity test (Basinwide Information Management System query December 2004).

During fish community sampling in 2004, the specific conductance at this site was elevated (467 µmhos/cm), reflected the WWTP discharge, and was the greatest of any fish community site in the basin in 2004. During benthic macroinvertebrate sampling later in the summer the conductivity was 501 µmhos/cm; in the summer of 1999 the conductivity was 601 µmhos/cm. Heavy filamentous algal growths were also present on the bedrock in the lower reaches of the site. Unlike other streams in this subbasin that may have reduced flow during dry periods, this stream keeps flowing because of the upstream discharge.

In 2004, the fish community was rated Fair (NCIBI = 38). The dominant species was the omnivorous spottail shiner; 56 percent of all the fish were of this species, and only 13 species were present. It was also only one of four sites in the basin where suckers were absent. Intolerant species were also absent. In 1994, the community was rated Good-Fair (NCIBI = 44) and the dominant species was the swallowtail shiner. However, in 1994 there were far fewer omnivores+herbivores than in 2004.

During benthic macroinvertebrate sampling, the habitat scored 50, reflecting an abundance of sand, few riffles (the single riffle was bedrock), few pools, modest instream habitat (roots were abundant, however), and severely eroding, sparsely vegetated banks. The current was moderate and the water was slightly turbid at the time of sampling. An elevated pH of 8.0 s.u. could also be traced to the WWTP, as the addition of lime is a component of the treatment process.

The benthic macroinvertebrate community was rated Fair in 2004, just as it did in 1999. The BI was 7.0 (elevated from 6.73 in 1999), the EPT BI was 6.7 (vs. 6.8), total taxa richness increased from 41 to 63, and EPT taxa richness marginally improved (9 compared to 8 in 1999). The benthic community was entirely comprised of tolerant taxa. Indicators of organic enrichment (*Dicrotendipes neomodestus* and *Procladius*), toxics (*Cricotopus infuscatus*), and a combination of both (*Chironomus*, *Polypedilum*, *Rheocricotopus robacki*, *Rheotanytarsus*, and *Tanytarsus*) were present in 2004.

Special Studies

Fish Community Reference Sites

Grassy Creek at SR 1300, Granville County and Island Creek at SR 1445, Granville County, were sampled and evaluated as possible fish community regional reference sites in June 1999. The community at Grassy Creek was rated Good (NCIBI = 46) but even though the community at Island Creek was rated Excellent (NCIBI = 54), watershed characteristics precluded designating it as a reference site (Biological Assessment Unit Memoranda F-20000922 and F-20010403). These two streams will again become basinwide monitoring sites in 2008.

Grassy Creek, SR 1436

Basinwide Planning Unit staff recommended that Grassy Creek at SR 1436 be added to the basinwide monitoring cycle to address data gaps associated with heavy agriculture and timber areas in Granville County. The site rated Fair, exhibiting an overall tolerant benthic community (Biological Assessment Unit Memorandum B-050329). It was recommended that this site not be made a permanent basin site, as it

exhibited unstable hydrology. Grassy Creek appeared to be a Carolina Slate Belt-type stream and was therefore expected to undergo periods of interrupted flow, as indicated by low flow taxa.

Mountain Creek, SR 1300
Benthic macroinvertebrate sampling of Mountain Creek was requested by staff from the Raleigh Regional Office to document effects of spray fields. Despite a fair amount of rain four days prior to sampling, flow was only evident at constrictions or in areas of steep grade at the time of sampling. Deeply incised and eroding banks suggested flashiness and unstable hydrology. Due to the lack of flow, the site could not be rated and the effects of spray fields on Mountain Creek could not be properly assessed.

Nutbush Creek, NC 39
Sampling of Nutbush Creek at NC 39 above the Town of Henderson's WWTP was requested by staff from the Raleigh Regional Office to evaluate the effects of the facility on water quality. Lime is added by the facility, and during dry months, the majority of the stream below the facility is comprised of effluent. Urban influences are also of concern, as the headwaters of the stream lie in the Town of Henderson.

Though this site could not be rated (Biological Assessment Unit Memorandum B-050329), the current NC 39 collection showed minimal differences in the benthic community compared to prior collections at this site as well as collections at the basin site downstream of the WWTP at SR 1317. Both sites have consistently received Fair ratings since 1988 (except for a single sample at SR 1317 that resulted in a Poor rating). Comparisons between the NC 39 (upstream) and SR 1317 (downstream) sites in 2004 indicate elevated pH (8.0 versus 6.9) and specific conductance (501 µmhos/cm versus 68) downstream of the WWTP. Differences in flow regimes were also evident. Lack of flow and low DO (4.8 mg/l upstream versus 7.2 mg/l downstream) was evident in the upper watershed, while flow was sufficient downstream due to the addition of effluent. The benthic community is degraded at both sites, but upstream urban impacts on the community made further impacts from the facility difficult to differentiate.

ROANOKE RIVER SUBBASIN 07

Description

Roanoke River Subbasin 07 lies entirely within the Northern Outer Piedmont ecoregion (Griffith *et al.* 2002). Streams in the ecoregion are of low to moderate gradient, with substrates of sand, gravel and cobble. Surface material is composed of sandy clay and sandy saprolite with rock outcrops and boulders. Bedrock is primarily gneiss and schist with intrusions of granite. The ecoregion receives 112 to 117 cm of annual precipitation. Potential vegetation for the ecoregion consists primarily of white oak, southern red oak, black oak, and mockernut and pignut hickories.

Subbasin 07 consists mainly of Lake Gaston and many small tributaries to the reservoir (Figure 10). The subbasin is three-quarters forested. Other land cover is agricultural with a small amount of residential development. Small towns in the subbasin include Norlina, Macon, and Littleton. There are no active NPDES permitted dischargers in the subbasin (Basinwide Information Management System query December 16, 2004).

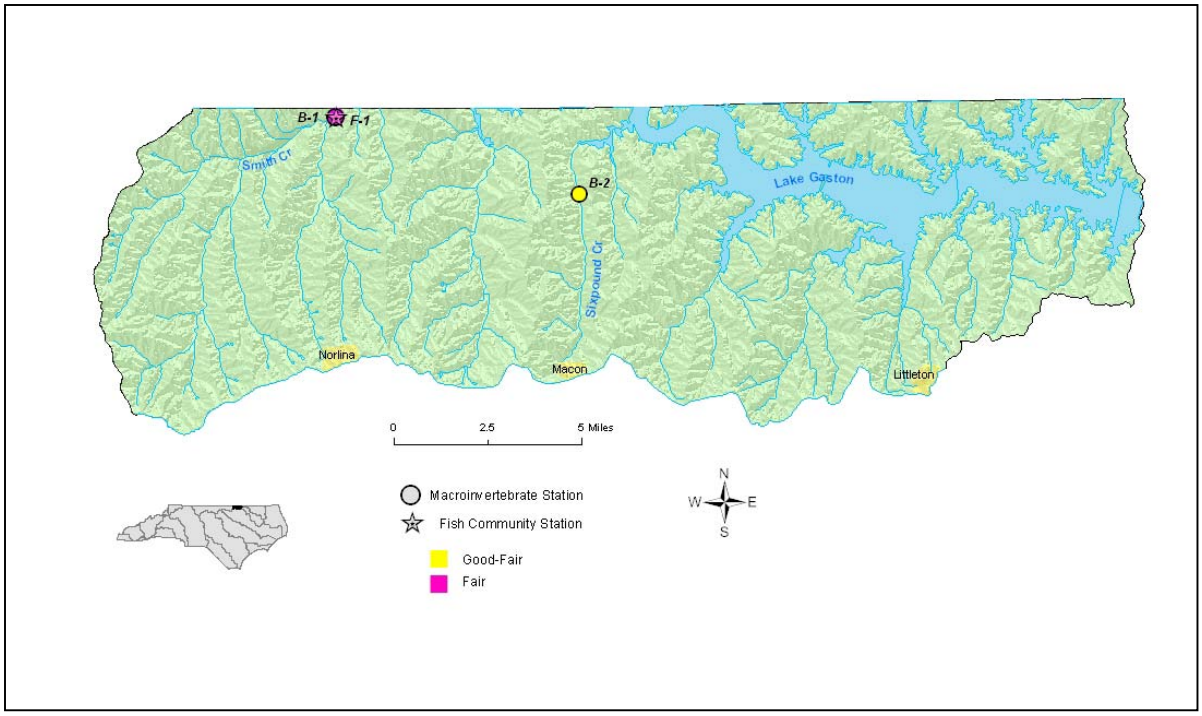


Figure 10. Sampling sites in Subbasin 07 in the Roanoke River basin.

Overview of Water Quality

Smith Creek is 303(d) listed from its source to the North Carolina-Virginia border, a distance of 10.4 miles. Listing was due to low dissolved oxygen (beginning in 2002) and impaired biological integrity (beginning in 1998). Ambient monitoring on Smith Creek at US 1 recorded dissolved oxygen levels below the minimum standards 30% of the time and iron levels exceeded the standards 96% of the time for water samples taken between 1999 and 2004.

The Smith Creek watershed was evaluated during a TMDL study in April 2004 (Biological Assessment Unit Memorandum B-041110). The study indicated reduced flow as a source of biological impairment in the watershed, perhaps due to damming of streams by beavers. Increasing conductivity may indicate additional anthropogenic stress to streams in the watershed.

Though retaining its Fair bioclassification for benthos in 2004 (Table 13) as for 1999, there are indications in the benthic community of degrading water quality between the two sampling events for the basinwide site on Smith Creek at US 1. The fish community also indicates degradation from the previous sampling event: the fish community rated Good-Fair in 1994 but only Fair in 2004.

The basinwide benthic site at Sixpound Creek retained the rating from the previous sampling event in 1999, with a bioclassification of Good-Fair.

Table 13. Waterbodies monitored in Subbasin 07 in the Roanoke River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Smith Cr	Warren	US 1	Fair	Fair
B-2	Sixpound Cr	Warren	SR 1306	Good-Fair	Good-Fair
F-1	Smith Cr	Warren	US 1	---	Fair

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

River and Stream Assessment

Hawtree Creek at SR 1304 was not sampled for fish community assessments in 2004 due to a lack of flow and the presence of vast wetlands in the area. Likewise, Sixpound Creek at SR 1306 was not sampled for fish due to an absence of flow; beaver dams had obstructed the flow and altered the hydrology of the creek. Sixpound Creek was last sampled in May 1994.

Smith Creek, US 1

Smith Creek at US 1 has a drainage area of 51.1 square miles. Draining the extreme northwest corner of Warren County, Smith Creek is a tributary to Lake Gaston. This eight meter wide stream had a substrate comprised entirely of sand. It is forested, with a full canopy and a wide, intact riparian zone (>18 meters in width). The main habitats for macroinvertebrate colonization were woody debris (e.g. sticks, leaf snags and logs), and undercut banks. Pools were absent; riffles were infrequent and short. The aquatic macrophyte *Vallisneria* (also known as wild celery and tape grass) was present. Bank erosion was moderate. The habitat scored 61 by the benthic biologists, and 77 (using Piedmont habitat criteria) by the fish biologists. Conductivity as measured by the benthic field crew was 95 µmhos/cm.

This site is a basinwide macroinvertebrate site, but was sampled in April 2004 for a TMDL stressor study (Biological Assessment Unit Memorandum B-041110). It was not sampled for benthos during the summer basinwide sampling period. The benthic community rated Fair in 2004, as it has for each sampling event since 1984. The biotic index has changed little and indicates a community tolerant to pollutants.

There were two indications that the benthic community had been further stressed in 2004 beyond previous years. First, *Cheumatopsyche* was the only caddisfly taxon found at the site in 2004. The lack of Trichoptera diversity at this site is atypical with respect to past years. In 1984, 1989, 1994 and 1999, there were six, seven, three, and eight taxa, respectively. Second, *Cricotopus bicinctus* (a midge tolerant of pollutants) was abundant in 2004, yet was only reported from this location as Rare for the previous sampling effort in 1999.

Fels (1997) and Griffith *et al*. (2002) show this stream within the Piedmont (specifically, the Northern Outer Piedmont Level IV ecoregion). However, instream and riparian habitat characteristics and tannin-stained waters are also representative of a Coastal Plain stream (Tables 1 and 2 in Appendix F-1), which is reflected by the fish community. In addition to its Piedmont fish fauna, affinities to Coastal Plain fish communities included the presence of the eastern mudminnow and bluespotted sunfish (1994 record), the rarity or absence of bluehead chub and crescent shiner, and the presence of only one species of darter (the tessellated darter which is usually found below the Fall Line in this river basin).

The fish community was rated Fair (NCIBI = 38) in 2004. Intolerant species were absent. There was a high percentage of diseased fish (5.99 percent, the highest of any site in the basin in 2004), and a low percentage of fish with multiple age classes (39 percent, the second lowest of any site in the basin in 2004). Like Coastal Plain streams there was a low percentage of omnivores+herbivores and a high percentage of piscivores. The most abundant species was the bluegill, which comprised 67 percent of all the fish collected.

In 1994 the fish community was rated Good-Fair (NCIBI = 42). The numerically dominant species was the bluegill, which comprised 39 percent of all the fish collected. The major difference between the two sampling periods was the greater incidence of disease in 2004 than in 1994.

Sixpound Creek, SR 1306

When sampled for benthos in summer 2004, Sixpound Creek was 5 meters wide, very sandy and very slow moving, especially near a beaver dam at the bridge. There was enough silt on the bottom to make the water turbid when walking around. The habitat score (46) was very low due to lack of riffles, eroding banks, few pools, and homogeneous substrate. Conductivity was 65 μmhos/cm.

This site has been sampled with three different methods during the basinwide surveys, so metrics are not directly comparable. However, the Fair rating assigned in 1994 improved to Good-Fair in 1999. This rating was retained in 2004, based on 15 EPT taxa and a Biotic Index value of 6.43. The slow flow and sandy substrate produce a benthic community that is more similar to a coastal plain or swamp stream, even though the site is in the Piedmont and Piedmont criteria were used to evaluate the stream. The alderfly *Sialis* was extremely abundant, followed in dominance by the mayfly *Stenonema modestum*, and the dragonfly *Boyeria vinosa*. Even though dissolved oxygen was 6.3 mg/L when sampled, the presence of nine odonate taxa, few filter-feeding caddisflies, a very abundant midge (*Phaenopsectra*), and only one stonefly specimen indicate stress due to low flow and low DO. No nutrient enrichment indicators were found. The caddisflies present were mainly edge species and included three species of *Oecetis*: *O. nocturna*, *O. persimilis*, and *O.* Sp F.

Special Studies

Smith Creek

The Smith Creek watershed was evaluated during a TMDL study in April 2004 (Biological Assessment Unit Memorandum B-041110). Smith Creek is 303(d) listed from its source to the North Carolina-Virginia border, a distance of 10.4 miles. One cause of impairment may be low dissolved oxygen. Thirty percent of the observations for the five-year period of this report were less than 5.0 mg/L (Ambient Monitoring Data, Station N6400000). According to the 2002 North Carolina Impaired Waters List possible sources for the impairment were agriculture and associated erosion and sedimentation. There are currently no permitted dischargers listed within the Smith Creek watershed.

The four sites in the watershed which were sampled for macroinvertebrates include: Newman's Creek at SR 1218; Smith Creek at SR 1217; Smith Creek at SR 1208; and Smith Creek at US 1 (the basinwide sampling site). Smith Creek at US 1 continues to receive a Fair bioclassification, the same rating it has received since 1984. The three other benthic samples taken upstream in the watershed revealed that upper reaches of the watershed are also degraded. The site on Smith Creekat SR 1208 had the highest bioclassification of the four sites with a rating of Good-Fair. The site also had the highest habitat score (72 out of 100), suggesting that the riparian and instream habitats may be limiting the benthic communities at the other sites since land use is similar among all sites.

Lack of flow or very low flow conditions precluded benthic sampling from occurring at four tributaries to Smith Creekthat were suggested for investigation. The fact that beaver dams were documented at Blue Mud Creek and Malones Creek suggests that such dams may occur throughout the watershed and may contribute to the low flow or stagnant conditions seen at some sites (e.g. Cabin Branch). Terrapin Creek, a tributary to Blue Mud Creek, had a high conductivity (93 µmhos/cm) compared to tributaries of similar size in the Smith Creek watershed.

Low, or no flow conditions leading to both reduced edge habitat and low dissolved oxygen levels are the likely cause of the biological impairment in the Smith Creek watershed. During the first five years (1973 through 1977 inclusive) of ambient monitoring on record for the station on Smith Creekat US 1, dissolved oxygen measurements were never below 5 mg/L. However, during the five-year period of this report, dissolved oxygen levels measured below 5 mg/L 17 times with seven of those 17 measurements below 4 mg/L. The current and historically low dissolved oxygen and minimal flows (even in the spring 2004 sampling) at Smith Creek at US 1 and the nearby tributary Blue Mud Creek suggest that beaver impoundments may be one stressor of this system. The beaver population has been increasing in North Carolina, and beavers are common in Warren County according to the Wildlife Resources Commission. The steady increase in conductivities over time however, point to anthropogenic influences as a potential secondary stressor.

ROANOKE RIVER SUBBASIN 08

Description

Roanoke River Subbasin 08 is comprised of five ecoregions (Griffith *et al.* 2002): Northern Outer Piedmont; Rolling Coastal Plain; Southeastern Floodplains and Low Terraces; Mid-Atlantic Flatwoods; and Mid-Atlantic Floodplains and Low Terraces. Generally, the five ecoregions are characterized by streams of low to moderate gradient, with substrates composed of silt, sand, gravel, and cobble.

The main water bodies in the subbasin are Roanoke Rapids Lake and approximately 60 miles of the Roanoke River (Figure 11). With the exception of the towns of Roanoke Rapids and Weldon, most of the land cover in the subbasin is forest or cultivated crops. However, at 65% of total land area, the proportion of forested lands is the least of any of the subbasins. Twenty-eight percent of the subbasin is cultivated cropland, the greatest proportion of this type of land use in any of the subbasins.

There are 14 NPDES permitted dischargers in this subbasin (Basinwide Information Management System query December 16, 2004). The largest facilities are Champion International's Roanoke Rapids paper mill (28 MGD), the Town of Roanoke Rapids' WWTP (8.3 MGD), Perdue Farms' Lewiston facility (3.0 MGD), the Town of Weldon's WWTP (1.2 MGD), and the North Carolina Department of Correction's Caledonia WWTP (0.8 MGD). These facilities discharge into the Roanoke River. Seven of the 14 facilities are also required to monitor their discharge's toxicity.

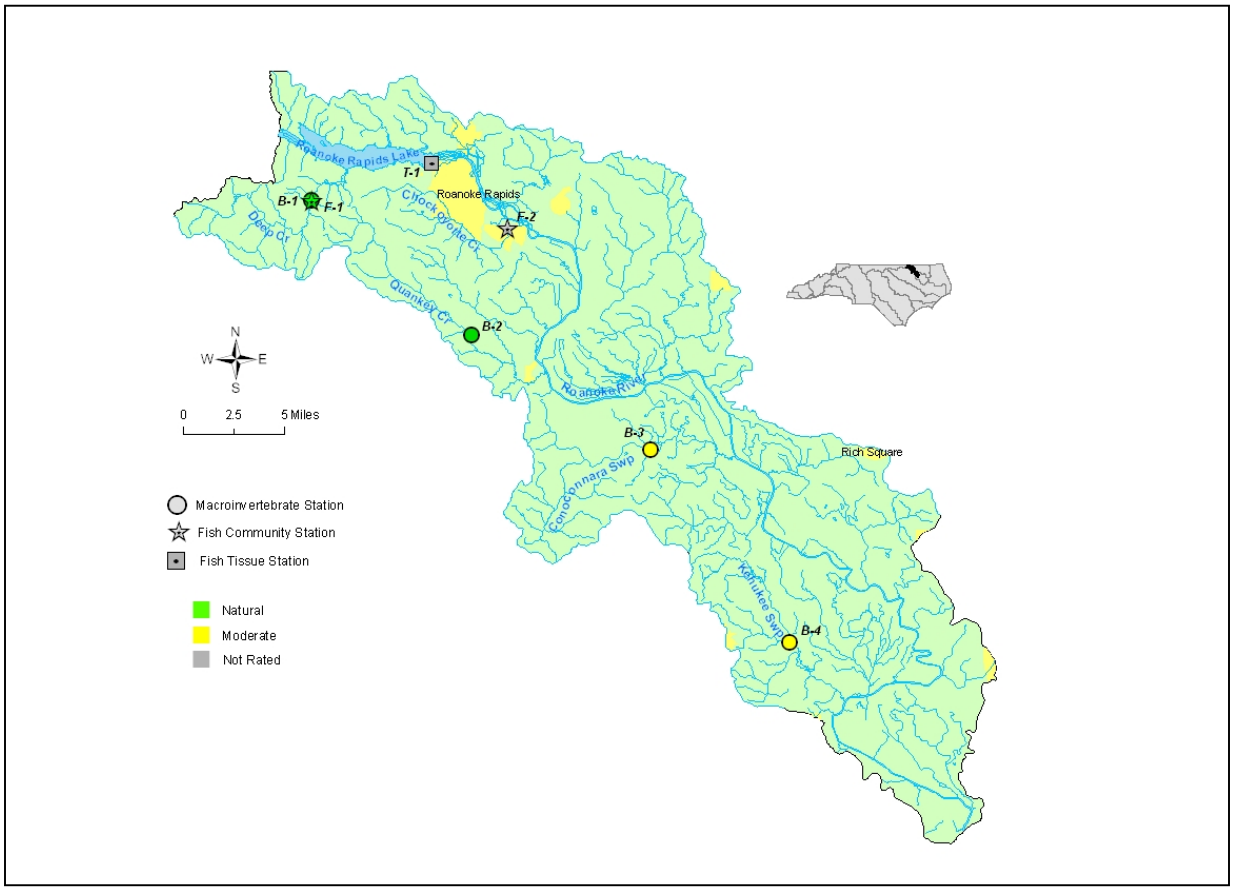


Figure 11. Sampling sites in Subbasin 08 of the Roanoke River basin.

Overview of Water Quality

Benthic criteria for swamp streams have been developed since the previous basinwide report for the Roanoke River basin. Where appropriate, those criteria were applied to sites unrated in the previous report (Quankey Creek, Conoconnara Swamp, Kehukee Swamp).

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 mainstem of the river was not sampled for benthos in 2004.

Deep Creek was sampled for benthos using swamp criteria in winter 2004, and was assessed a Natural bioclassification. Though sampled during the summer of 1994 and 1999, the stream was not rated in those two previous years due to a lack of sufficient flow. The fish community retained the classification of Good that it was assessed during the previous collection in 1994.

Chockoyotte Creek was sampled for fish in 2004, but was not assigned a classification due to questions regarding the applicability of Piedmont criteria to this site.

Quankey Creek was 303(d) listed 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 swamp criteria. Based on Quankey Creek at NC 903—above the 303(d) listed segment—receiving a Natural rating in 1999 and 2004, and Little Quankey Creek receiving a Moderate rating in 2004 using swamp criteria, it is suggested that the 1991 Fair rating using Coastal Plain criteria on Quankey Creek at NC 561 was inappropriate.

The decline in the benthic rating at Conoconnara Swamp, from a Natural bioclassification in 1999 to that of Moderate in 2004, may indicate increasing stress on the benthic community.

In 2004 Kehukee Swamp retained the Moderate bioclassification that it was assessed in 1999, based upon the benthic invertebrate community.

Table 14. Waterbodies monitored in Subbasin 08 in the Roanoke River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Deep Cr	Halifax	US 158	Not Rated	Natural
B-2	Quankey Cr	Halifax	NC 903	Natural	Natural
B-3	Conoconnara Swp	Halifax	NC 561	Natural	Moderate
B-4	Kehukee Swp	Halifax	SR 1804	Moderate	Moderate
F-1	Deep Cr	Halifax	US 158	---	Good
F-2	Chockoyotte Cr	Halifax	US 158	---	Not Rated

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

River and Stream Assessment

Quankey Creek at NC 561 was not sampled for benthic invertebrates in 2004 due to unnecessary redundancy with two sites above the town of Halifax WWTP. The basinwide site will remain at NC 903 as the site there better represents streams within that watershed than does the site at NC 561.

Oconochee Creek at SR1126 was not sampled in 2004 due to a lack of visible flow. The site should be sampled in future basinwide assessments.

None of the Roanoke River sites in this subbasin were sampled in summer 2004 due to resource constraints and to high flows. The two sites (at the town of Halifax and at US 258) should be sampled in future basinwide assessments.

Quankey Creek at SR 1619 was not sampled for fish community assessment in 2004 due to a lack of flow. It had been last sampled in September 1994. Habitat characteristics and examples of high and low quality habitats at fish community sites in the basin are presented in Appendix D.

The only NPDES permitted facility upstream of a basinwide fish site is approximately 5.5 miles upstream of the site on Chockoyotte Creek at US 158 (Basinwide Information Management System query December 2004). The facility (NC0079014) does not have a flow limit in its permit to discharge to UT Chockoyotte Creek. There was one total suspended solids monitoring violation at the facility in 2002, none in 2003 and 2004.

Deep Creek, US 158

The watershed of Deep Creek straddles the Northern Outer Piedmont and the Rolling Coastal Plain ecoregions (Griffith *et al*. 2002). Draining north-central Halifax County, the creek is a tributary to Roanoke Rapids Lake.

The wetted width of the stream at this site was seven meters at the time of benthic sampling. The drainage area is 23.3 square miles. Overall, the habitat was favorable; stream bank erosion was the primary concern. The substrate was comprised mostly of sand. A small amount of gravel and rubble was found in occasional riffles. The habitat scored 77.

Deep Creek appeared to have characteristics of both a coastal and swamp stream. This site was sampled during summer in 1994 and 1999, but was not rated due to flow concerns. Deep Creek may stop flowing during summer months in low rainfall years, but maintains its flow during other years. In winter 2004, this site scored Natural using swamp region A criteria. Twenty-three EPT taxa were collected, which is high for a swamp stream. *Eccoptura xanthenes*, an intolerant long-lived stonefly, indicated good water quality and quantity. The mayfly, *Stenonema modestum*, was abundant and indicated sufficient flow throughout the year. Seven winter stonefly taxa, eight caddisfly taxa, and seven mayfly taxa were collected in Deep Creek. The diversity and abundance of EPT taxa was an indication of good water quality.

The fish community was rated Good (NCIBI = 46) in 2004 and in 1994 (NCIBI = 50). This site had the greatest species diversity (n = 28) and greatest sunfish diversity (n = 7) of any site in the basin in 2004. Combining the 1994 data with that of 2004, 29 species have been collected at this site. There was evidence of damage within the riparian zone, such as deadfalls from Hurricane Isabel (September 2003), but the community seemed to have recovered from its flooding effects. The most abundant species was the redbreast sunfish (22 and 24 percent of all the fish collected in 1994 and 2004, respectively).

Chockoyotte Creek, US 158

The watershed of Chockoyotte Creek drains the Towns of Roanoke Rapids, Weldon, and South Weldon, including the Interstate 95 and US 158 corridor. The creek is a tributary to the Roanoke River and flows through the Rolling Coastal Plain and borders the Northern Outer Piedmont ecoregion.

During fish community sampling, the instream and riparian habitats in Chockoyotte Creek were analyzed with Piedmont and Coastal Plain criteria (Tables 1 and 2 in Appendix F-1); the habitat scores were 60 and 89, respectively. Although some Piedmont species were present (e.g., bluehead chub and Roanoke darter), others had more Coastal Plain affinities (e.g., bluespotted sunfish, yellow bullhead, and eastern mudminnow). Because of its ecoregion location, habitat characteristics (including at least three types of macrophytes present), and species composition, the fish community was not rated with the NCIBI. The most abundant species were the American eel and redbreast sunfish (74 percent of all the fish collected were these two species). Because of the numerous dams on the Roanoke River impeding upstream migrations and colonization of historical habitats, this was the only site where American eels were collected. The overall community was abundant, diverse (19 species, including 5 species of sunfish), and the species were well represented by multiple age groups. There was no evidence of instream or riparian damage from Hurricane Isabel (September 2003).

Quankey Creek, NC 903

The substrate of Quankey Creek was mostly sand, but did contain small amounts of gravel, which were found in riffle areas. The overall channel width was six meters and the drainage area at this site is approximately 34 square miles. The habitat scored 81, which reflected an overall favorable habitat.

Typical of many streams in Swamp Region A, Quankey Creek appeared to possess characteristics of both coastal and swamp streams. Quankey Creek rated Natural in 1999 and in 2004 using swamp criteria. Past field observations indicated that this stream ceased to flow during many summers, but the consistent flow in winter and sufficient habitat (2004 score = 81) supported a more diverse benthic community than typical swamps. *Stenonema modestum*, a fairly tolerant mayfly, was abundant indicating consistent flow throughout the year. However, no long-lived stoneflies were collected. The total number of taxa (53) was high in 2004 and the EPT taxa richness (17) was also high. In 1999, the winter sampling produced a total taxa value of 40 and an EPT taxa richness of nine. A high diversity of winter stoneflies (seven) was collected in 2004. The high diversity of stoneflies and high EPT taxa richness indicated no major water quality concerns in the stream. A single specimen of the crayfish *Cambarus latimanus* was found at this site, the first of such identified from the Roanoke basin. The crayfish specimen may represent an introduction of this species into Quankey Creek.

Conoconnara Swamp, NC 561

In 2004, the braided channel width was approximately nine meters. Substrate was mostly gravel with smaller amounts of silt and sand. Mature cypress trees were abundant in the riparian zone. The overall habitat score was 75; a narrow riparian zone on the left bank and the open canopy slightly decreased the habitat score. The drainage area at this location is 35.8 square miles.

In 2004, Conoconnara Swamp scored Moderate using Region B swamp criteria. In 1999, it scored Natural, indicating a decline in the benthic community. The BI increased from 6.4 in 1999 to 7.2 in 2004 and the EPT BI increased from 6.8 to 7.3. Low EPT taxa richness is typical of swamp streams; five EPT taxa were collected in 1999 and three EPT taxa were collected in 2004. The only abundant EPT taxon collected in 2004 was the caddisfly *Ironoquia punctatissima*, which can be found in temporary streams. Midges and blackflies were the dominant taxa. In 1999, the unusual mayfly *Leptophlebia bradleyi* was collected, but was not found in 2004. The decline in the benthic community could be a sign of increasing stress in the watershed and warrants future monitoring.

Kehukee Swamp, SR 1804

The substrate was mostly sand with a small amount of gravel. Flow was diminished above and below the site due to beaver activity, but there was consistent visible flow at the sampling location, partly due to a constriction in the stream. The stream width averaged six meters. Undercut banks and root mats were rare; woody debris comprised the best habitat. The riparian zone was wide and intact on both sides of the stream. The habitat scored 71. The drainage area is approximately 19 square miles at this location.

Kehukee Swamp drains a watershed mixed with forestry and row crops. It received a Moderate score in 1999 and in 2004, using criteria for Region A swamps. As observed in 1999, there was adequate flow but limited EPT taxa. A total of seven EPT taxa were collected in 2004 and eight EPT taxa were collected in 1999. The only two EPT taxa that were abundant in 2004 were *Leptophlebia* and *Cheumatopsyche*, both moderately tolerant. Blackflies and midges were the dominant taxa. The total taxa richness (59) was greater in 1999 than in 2004 (46), mostly due to a more varied assemblage of odonates and beetles. In addition, no heptageniid mayflies were collected in 2004, though *Stenonema modestum* and *Stenacron interpunctatum* were both collected in 1999. However, the BI was similar for both years (7.1 in 1999 and 7.0 in 2004).

Special Studies

Little Quankey Creek, NC 903

Upon request from the Raleigh Regional Office, Little Quankey Creek was sampled in conjunction with the basinwide sampling of Quankey Creek. Little Quankey Creek is a tributary to Quankey Creek and receives flow from the Halifax Correctional Center (0.018 MGD). Both creeks appear to have characteristics of coastal A streams (which have flow throughout the year), and swamp streams (which tend to stop flowing during the summer months). The substrate of Quankey and Little Quankey Creeks were both sandy with a small amount of gravel and silt. Little Quankey Creek received a habitat score of 72, which was mainly due to high erosion potential and a narrow riparian zone.

Little Quankey Creek scored Moderate, while the basinwide site on Quankey Creek scored Natural, the highest possible bioclassification for swamp streams. Little Quankey Creek's Moderate bioclassification was mostly due to a lower habitat score and slightly lower total taxa than Quankey Creek. Seventeen EPT taxa were collected in both streams, including intolerant and moderately tolerant taxa. Notable intolerant EPT taxa collected in Little Quankey Creek included *Perlinella drymo*, *Strophopteryx*, *Shipsa rotunda*, and *Suwallia*, which are all intolerant winter stoneflies. No long-lived stoneflies, which require adequate flow year round, were collected. Little Quankey Creek has a much smaller drainage area (10.5 square miles) than Quankey Creek (33.6 square miles) and receives flow from the Halifax Correctional Center. Quankey Creek's larger drainage area most likely helps support a greater benthic fauna. Both Quankey and Little Quankey Creeks supported a relatively unimpacted benthic fauna. However, the sample from Little Quankey Creek indicated a slightly more tolerant macroinvertebrate community (Biological Assessment Unit Memorandum B-040709).

Chockoyotte Creek, Country Club Road

The Raleigh Regional Office requested a sample from Chockoyotte Creek, which drains the cities of Roanoke Rapids and Weldon. Chockoyotte Creek scored Moderate using Region A swamp criteria. However, the habitat was severely impacted (2004 habitat score = 49) by an absence of instream habitat, sedimentation, bank erosion, partial shading, and inadequate riparian zones.

It appeared that the stream was once dammed at the sampling location and there were remains of large concrete blocks and rocks. There were also large areas of dried sediment from the once dammed area. The number of total taxa was fairly high, but midges comprised 17 of the 52 taxa. EPT total taxa richness was 11 and all of the taxa were moderately-tolerant to tolerant; no intolerant taxa were collected. Blackflies were the dominant taxa. Upstream and downstream of the sampling reach were areas of no visible flow. Although Chockoyotte Creek rated Moderate, it has a highly degraded habitat due to urban impacts from the cities of Roanoke Rapids and Weldon. The drainage area at this location is 20.4 square miles (Biological Assessment Unit Memorandum B-040709).

ROANOKE RIVER SUBBASIN 09

Description

This subbasin is located entirely within the coastal plain and comprised of the Mid-Atlantic Flatwoods and the Mid-Atlantic Floodplains and Low Terraces level four ecoregions (Figure 12). The Mid-Atlantic Flatwoods are wide, low elevation areas with poorly drained soils which require artificial drainage for agricultural and forestry operations (Griffith *et al.* 2002). Compared with the Carolina Flatwoods level four ecoregion, the Mid-Atlantic Flatwoods tend to be biologically less diverse in terms of plants and aquatic macroinvertebrates. Pines such as longleaf, pond, and loblolly are the predominant vegetation with some oaks and hickories. The Mid-Atlantic Floodplains and Low Terraces are major river floodplains and associated low terraces. Large, sluggish rivers, deep-water swamps, oxbow lakes, and alluvial deposits with abrupt textural changes characterize the Mid-Atlantic Floodplains and Low Terraces. Cypress-gum swamps are common, along with bottomland hardwoods of wetland oak, green ash, red maple, and hickory. In this subbasin, extensive floodplain forests that are inundated during high flows when the river is at bankfull border the Roanoke River. When the river level drops, water returns to the main channel through only a few connections, locally called "guts".

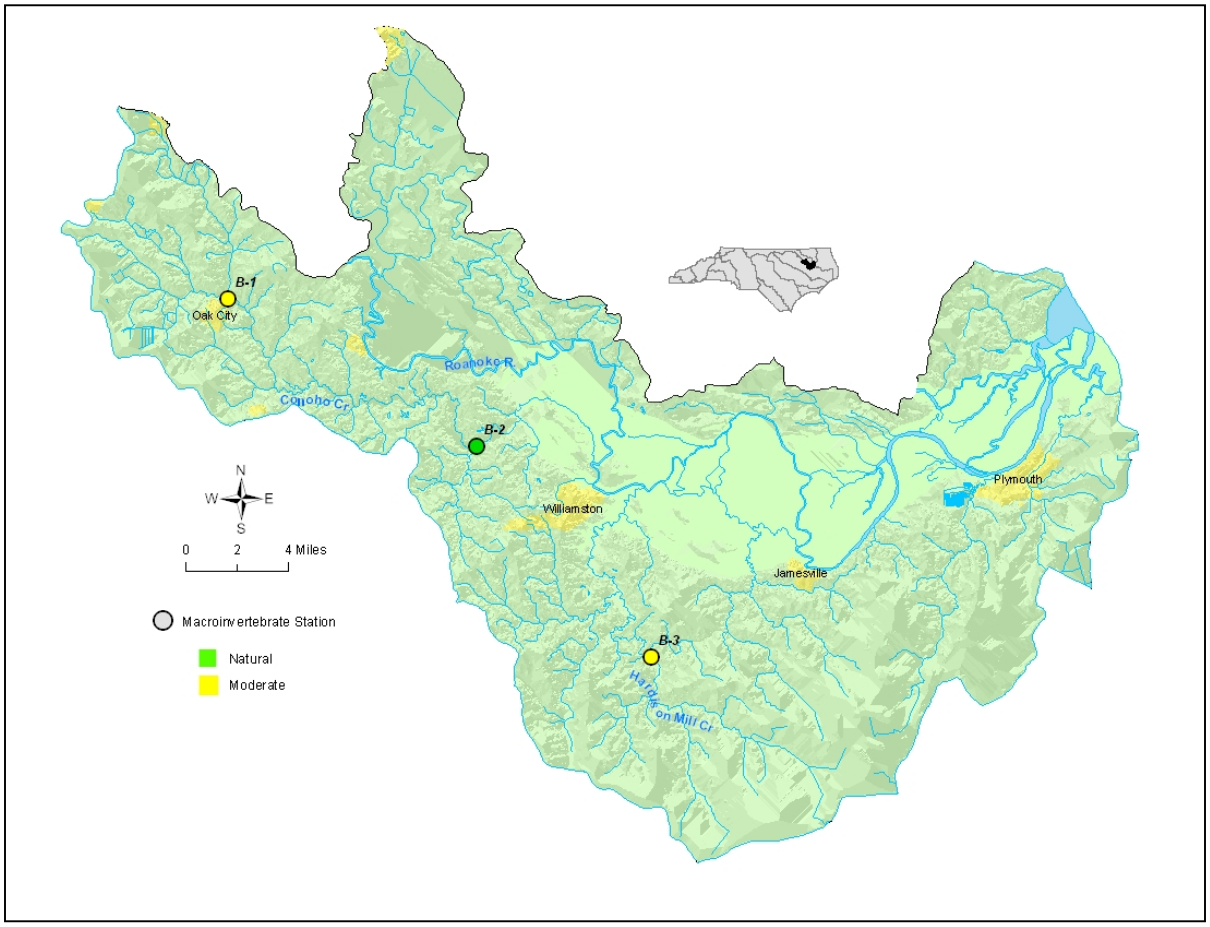


Figure 12. Sampling sites in Subbasin 09 of the Roanoke River basin.

Subbasin 09 consists of the Roanoke River and its tributaries in Martin, Bertie, Washington, Halifax, and Beaufort counties. The two largest towns are Williamston and Plymouth. Primary land uses are agriculture and forest. Predominant crops are corn, peanuts, and cotton. There are eight NPDES permitted dischargers in the subbasin. The largest facilities are Weyerhaeuser (82.5 MGD), Williamston's

WWTP (2.0 MGD), Plymouth's WWTP (0.8 MGD), and McMurray Fabrics (0.45 MGD), all of which discharge to the Roanoke River. A number of public and private groups have participated in the complex task of protecting significant natural areas along the Roanoke River corridor. In 1989, the Nature Conservancy purchased 10,626 acres in Bertie and Martin counties to create the Roanoke River National Wildlife Refuge and to add land to the state-owned Roanoke River Wetlands. Overall, the Nature Conservancy owns 51,000 acres throughout Bertie, Halifax, Martin, Washington, and Northampton counties.

Overview of Water Quality

Streams in this subbasin are designated by B, C or swamp water classifications. Welch Creek, Albermarle Sound at Batchelor Bay, and portions of the Roanoke and Cashie Rivers are 303(d) listed as impaired for fish consumption due to atmospheric deposition of mercury.

Three ambient monitoring stations are located in subbasin 09. The Roanoke River at US 13/17 near Williamston has exceeded water quality standards of action levels in the past five years for dissolved oxygen (five times), total copper (one time), total iron (12 times), and fecal coliform (two times). Exceedances in total iron (seven times) were recorded for the Roanoke River at NC 45 near Sans Souci. The Roanoke River above Welch Creek near Plymouth experienced exceedances in total iron ten times since the last basin survey.

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, only three sites were sampled for benthic macroinvertebrates in 2004 using Region B swamp criteria (Table 15). Benthic criteria for swamp streams have been developed since the previous basinwide report for the Roanoke River basin. Where appropriate, those criteria were applied to sites unrated in the 2000 report (Conoho Creek, Hardison Mill Creek). All three sites retained the rating from the previous sampling period in 1999. The lower portion of Conoho Creek was found to represent near natural conditions while the upper portion of Conoho Creek and Hardison Mill Creek received a Moderate rating suggesting water quality or habitat problems.

Table 15. Waterbodies monitored in Subbasin 09 in the Roanoke River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1[2]	Conoho Cr	Martin	NC 11/42	Moderate	Moderate
B-2	Conoho Cr	Martin	SR 1417	Natural	Natural
B-3	Hardison Mil Cr	Martin	SR 1528	Moderate	Moderate

[1]B = Benthic macroinvertebrate monitoring sites.
[2]Previous basinwide site on Conoho Creek at NC 125/903 was moved to NC 11/42 in 2004.

River and Stream Assessment

Of the ten sites previously sampled in 1999, seven sites were not sampled in 2004 due to a lack of visible flow.

Conoho Creek at NC 11/42

To better characterize the watershed, the Washington Regional Office requested a sample on Conoho Creek near the Town of Oak City. This sample was collected in conjunction with the Conoho Creek basinwide site located downstream at SR 1417. The previous basinwide site on Conoho Creek at NC 125/903 was not sampled in 2004. For future basinwide sampling, the Conoho Creek at NC 11/42 site will replace the Conoho Creek at NC 125/903 site. Conoho Creek at NC 11/42 rated Moderate, whereas the downstream site (SR 1417) rated Natural. However, considering the range of Moderate scores, NC 11/42 nearly scored Natural. The habitat rated higher at this upstream site (76) than at the downstream basinwide site (70), mostly due to a wider and more intact riparian zone. The conductivity was slightly lower at this upstream location (92 μmhos/cm) than at the downstream site (105 μmhos/cm). The drainage area at NC 11/42 is 38.5 square miles.

Four EPT taxa were collected, and these were all moderately-tolerant to tolerant. Thirty-one total taxa were collected. A more intolerant benthic fauna was found at the lower site than at NC 11/42. *Platycentropus* and *Polycentropus*, swamp fauna caddisflies, were collected at SR 1417 but were not collected at NC 11/42. In addition, a more varied mollusk assemblage was collected at the downstream site. The larger drainage area (increased flow and dilution of impacts) at the downstream site may contribute to the better benthic community at SR 1417. (Biological Assessment Unit Memorandum B-040726) Future basinwide sampling may want to include this location at NC 11/42, which provides benthic samples in the upper and lower portion of the Conoho Creek watershed.

Conoho Creek, SR 1417

Conoho Creek was over 100 meters wide at the bridge and quickly braided into several channels below the bridge, each up to 25 meters wide. The habitat scored 70, mainly due to an absence of favorable habitat, erosional areas, and a narrow riparian zone. Sticks and snags provided the best habitat for benthos. The drainage area at this location is approximately 98.2 square miles. The conductivity at this site was 105 μmhos/cm and the pH was 6.7.

This site rated Natural using Swamp Region B criteria, the same rating it received in 1999. Macroinvertebrate diversity (38 total taxa and 6 EPT S) was high, indicating a naturally functioning swamp. The caddisflies *Polycentropus, Platycentropus*, and *Ptilostomis* were collected at this site. Much of the total taxa were comprised of beetles, crustaceans, midges, and oligochaetes, which are all typical swamp fauna.

Hardison Mill Creek at NC 1528

In 2004, the average depth was 1.2 meters and the width was eight meters with some braiding. The drainage area at this location was 49.7 square miles. The habitat has declined dramatically from a score of 94 in 1999 to 65 in 2004. The reasons for this decline included a large clear cut area on the right bank and adjacent riparian zone (not shown in picture). Cutting was in progress during the sampling effort. Organic microhabitats (e.g. leaf packs, undercut banks and root mats) were lacking and benthic substrates were nearly all detritus.

In 2004, Hardison Mill Creek was Moderate using Region B swamp criteria. This equals the bioclassification it received in 1999. The biotic index was slightly higher in 2004 (7.5) than in 1999 (7.3), still indicating stressed conditions. Compared to 1999, the 2004 samples differed in the number of EPT taxa by only one (i.e. two in 2004, three in 1999) and the EPT abundance was reduced (two in 2004 versus 12 in 1999). The major difference between 1999 and 2004 in those two metrics is that in 1999, *Ironoquia punctatissima* was abundant, while none were collected in 2004. There were 36 total taxa collected in 2004 compared with 27 in 1999 with the largest difference was seen in the Chironomidae family of aquatic macroinvertebrates. A total of 20 taxa in this group were collected in 2004 compared with seven in 1999. Species not commonly encountered in North Carolina that were collected in 2004 included *Tvetenia* sp NC (Epler), and *T*. sp GA (Epler); the latter is common in swamps. Advances in taxonomy allowed these species to be separated from *Tvetenia bavarica* grp, as they were identified in samples previous to 2004.

ROANOKE RIVER SUBBASIN 10

Description

This subbasin is located entirely within the coastal plain and comprised of the Mid-Atlantic Flatwoods and the Mid-Atlantic Floodplains and Low Terraces level four ecoregions. The Mid-Atlantic Flatwoods are wide, low elevation areas with poorly drained soils which require artificial drainage for agricultural and forestry operations. Compared with the Carolina Flatwoods level four ecoregion, the Mid-Atlantic Flatwoods tend to be biologically less diverse in terms of plants and aquatic macroinvertebrates. Pines such as longleaf, pond, and loblolly are the predominant vegetation with some oaks and hickories. The Mid-Atlantic Floodplains and Low Terraces are major river floodplains and associated low terraces. Large, sluggish rivers, deep-water swamps, oxbow lakes, and alluvial deposits with abrupt textural changes characterize the Mid-Atlantic Floodplains and Low Terraces. Cypress-gum swamps are common, along with bottomland hardwoods of wetland oaks, green ash, red maple, and hickories (Griffith et al. 2002).

Subbasin 10 consists of the Cashie River and its tributaries and is located entirely within Bertie County (Figure 13). Most of these streams are slow moving and often stop flowing in the summer, making water quality assessments more difficult. Land use in the area is primarily forest with a mix of agricultural activities such as animal operations and timber harvest. Windsor is the largest town in this subbasin. Of the three dischargers in the subbasin, only the Town of Windsor's WWTP (1.15 MGD), which discharges into a UT to Cashie River, is considered a major discharger.

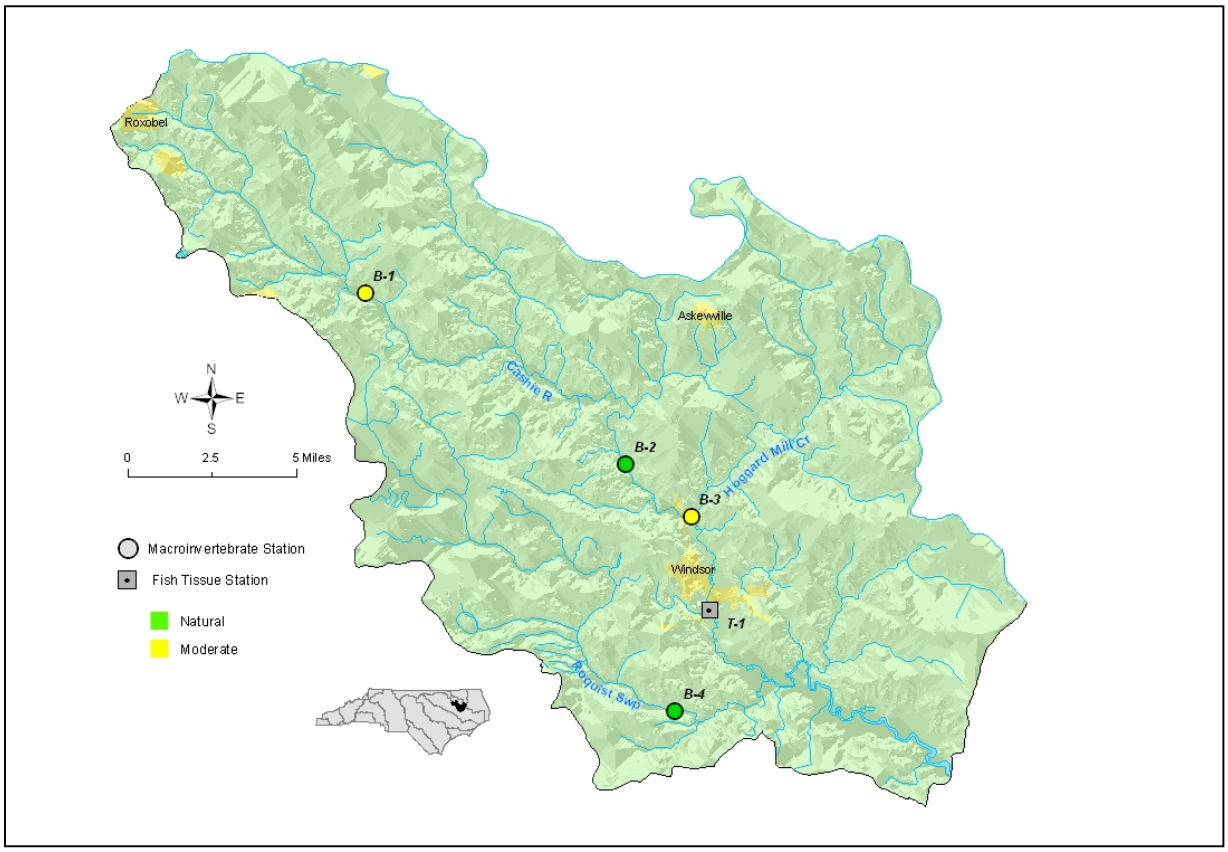


Figure 13. Sampling sites in Subbasin 10 of the Roanoke River basin.

Overview of Water Quality

Streams in this subbasin are designated by B, C or swamp water classifications. Approximately 47 miles of the Cashie River from its source to the thoroughfare between the Cashie and Roanoke Rivers has been 303(d) listed as impaired for fish consumption due to atmospheric deposition of mercury.

One ambient monitoring station is located in subbasin 10. The Cashie River at SR 1219 near Lewiston has exceeded water quality standards of action levels in the past five years for turbidity (one time), total iron (27 times), total copper (one time), and fecal coliform (two times).

Tributaries to the Roanoke River in this subbasin are swampy and may experience periods of very little or no flow. Of the five sites sampled for benthic macroinvertebrates in 1999, only one site was not sampled in 2004 due to low flow or no flow conditions. Benthic criteria for swamp streams have been developed since the previous basinwide report for the Roanoke River basin. Where appropriate, those criteria were applied to sites unrated in the 2000 report (Conoho Creek, Hoggard Mill Creek, and Roquist Creek). In 1999, all four sites were rated as natural. In 2004, the lower portion of Cashie River and Roquist Swamp retained their 1999 Natural ratings. However, the ratings for the upper portion of the Cashie River and Hoggard Mill Creek decreased to Moderate, indicating a possible decline in water quality or habitat (Table 16).

Table 16. Waterbodies monitored in Subbasin 10 in the Roanoke River basin for basinwide assessment, 1999 - 2004.

Map #[1]	Waterbody	County	Location	1999	2004
B-1	Cashie R	Bertie	SR 1219	Natural	Moderate
B-2	Cashie R	Bertie	SR 1257	Natural	Natural
B-3	Hoggard Mill Cr	Bertie	SR 1301	Natural	Moderate
B-4	Roquist Cr	Bertie	US 13/17	Natural	Natural

1 B = benthic macroinvertebrate monitoring sites.

River and Stream Assessment

Wading Place Creek at NC 308 was sampled for benthos during the 1999 basin assessment, but lack of flow in the winter of 2004 prevented sampling at this location for the current basinwide sampling cycle. Because suitable flow was not found in the winter (when flow is most likely to be ideal for sampling) at this site, it is improbable that the stream will have ample flow for sampling in the future. Location of an alternate site is recommended for future basinwide sampling cycles.

Cashie River at SR 1219

The Cashie River at SR 1219 averaged one meter in depth with some areas as deep as two meters. The stream was braided and approximately 20 meters wide. The drainage area at this location was 35.4 square miles. Beaver activity was observed consistent with the 1999 sampling. The habitat scores differed considerably (94 in 1999 versus 78 in 2004). The habitat score decreased here due to both a homogeneous benthic substrate of detritus and to the lack of favorable reach available for colonization. Low water depths in 1999 versus high levels in 2004 may account for some of the differences.

The Cashie River rated Moderate in 2004, a decrease from a Natural rating in 1999. This decline appears to be the result in the lower number of macroinvertebrate taxa, with 29 collected in 2004 versus 41 in 1999. The biotic index of both samples was identical in both years (7.5) suggesting that water quality may not have decreased as much as the loss of nearly 30% of the taxa may suggest. Although a

50% reduction in EPT taxa, from six in 1999 to three in 2004, was observed, there was only a decrease of three, (from 10 to seven) in EPT abundance. This site has been sampled four times (1983 and 1984 in summer; 1999 and 2004 in winter) with the 2004 results showing the lowest number of total taxa thus far. This is a concern since swamp site diversity is nearly always greater in the winter when flow is sustained than in summer, when they are stagnant. However, high water may have limited the collection effort. One species not commonly encountered in North Carolina that was collected in 2004 was *Tvetenia* sp NC (Epler). *Procladius* sp. (tolerance value = 9.1), common in 2004 and not collected in 1999, is tolerant of heavily polluted conditions. But, as in 1999, the overall benthic macroinvertebrate fauna does not signal a specific nutrient-loading problem from the upstream Lewiston/Woodville WWTP.

Cashie River at SR 1257

The habitat scored slightly lower in 2004 (70) than 1999 (81), mainly due to infrequent pools, and a homogeneous substrate made up of detritus. Water levels were high in 2004 compared with 1999, a more normal flow year. The average midstream depth was 1.5 meters with pools greater than two meters. The width was eight meters, however this braided river was out of its banks and spread out onto the floodplain. The drainage area was 108.6 square miles.

The Cashie River rated Natural in 2004, which was no change from 1999. The biotic index differed little in 2004 (6.5) from 1999 (6.8). Nearly the same numbers of taxa were collected in 2004 (35) as in 1999 (34). EPT richness remained the same (7) and EPT abundance was equivalent (36 in 2004 versus 38 in 1999). The most noticeable differences between years were seen in the Chironmidae community. Twelve taxa were collected in 2004 while only four were found in 1999. *Cricotopus bicinctus* and *Orthocladius obumbratus* (tolerance value = 8.5 each) were abundant in 1999 but absent in 2004. In 2004, the abundant chironomids were *Tvetenia* sp NC (Epler), and *Orthocladius oliveri*.

Hoggard Mill Creek at SR 1301

The habitat scores were nearly identical at Hoggard Mill Creek in1999 (90) and 2004 (89). The siltation seen in 1999 was not apparent in 2004, possibly due to high water levels. The effects of Hurricane Isabel were very apparent at this site especially the considerable blow down. At the time of sampling, water levels were high compared to 1999 in this 20 meter wide braided stream. The average depth was one meter, with a maximum depth of 1.5 meters. The drainage area at this location was 48.2 square miles.

Hoggard Mill Creek rated Moderate in 2004, a decrease from Natural in 1999. The biotic index rose from 6.8, the lowest in the subbasin in 1999, to 7.1 indicating a more pollution tolerant community. Sixteen fewer total taxa were found in 2004 (30) than 1999 (46). Only three of the seven EPT taxa collected in 1999 were found in 2004. *Amphinemura*, *Ceraclea cama, Ironoquia punctatissima* and *Playcentropus* were absent in 2004. EPT abundance also decreased from 38 to 12 between 1999 and 2004.

Roquist Swamp at US 13/17

The habitat score at Roquist Swamp decreased from 88 in 1999 to 80 in 2004, likely due to pool infrequency with the high water levels compared to 1999. Substrate was comprised of homogenous silt and fine particles. This braided swamp stream had good flow and averaged one meter in depth and was 5.5 meters wide. The pH of 6.2 in 1999 was unusually high, given that this site drains a pocosin. In 2004, the pH measured 5.7, typical of other swamp streams in this subbasin. The drainage area at this location was 45.7 square miles.

Roquist Swamp rated Natural in 2004, the same as in 1999. This swamp appears to be stable with no change in the biotic index from 1999 to 2004 (7.0 in both years). The total taxa increased by seven in 2004 (38) from 1999 (31). The number of EPT taxa remained the same between both years (4) but the EPT abundance was much higher in 1999 (31) than 2004 (6). The largest difference was in the Chrionomidae community, 16 taxa were collected in 2004 compared with the six in 1999. Species not commonly encountered in North Carolina that were collected in 2004 included Genus nr *Nanocladius* B, *Tvetenia* sp NC (Epler), and *T*. sp GA (Epler); the latter is known to occur in swamps.

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GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL *a*	Chlorophyll *a*.
Class C Waters	Freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum.
Conductivity	In this report, synonymous with specific conductance and reported in the units of μmhos/cm at 25 ^{o}C. Conductivity is a measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts.
Division	The North Carolina Division of Water Quality.
D.O.	Dissolved Oxygen.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include Southern Outer Piedmont, Carolina Flatwoods, Sandhills, and Slate Belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters. Waters which are rated as excellent based on biological and physical/chemical characteristics through Division monitoring or special studies; primary nursery areas designated by the Marine Fisheries Commission; and all Class SA waters.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).

NPDES	National Pollutant Discharge Elimination System.
NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs.
NTU	Nephelometric Turbidity Unit.
ORW	Outstanding Resource Waters. Unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.
Parametric Coverage	A listing of parameters measured and reported.
SOC	A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits.
Total S (or S)	The number of different taxa present in a benthic macroinvertebrate sample.
UT	Unnamed tributary.
WWTP	Wastewater treatment plant.

Appendix A. Summary of Benthic Macroinvertebrate Data.

Based on benthic macroinvertebrate data, water quality in the Roanoke River basin is Good near the headwaters (subbasins 01-04), while in the lower reaches (subbasins 05-10) overall water quality is generally Good-Fair. Since 1999, 39 benthic macroinvertebrate basinwide samples have been collected with one (3%) receiving an Excellent bioclassification, nine (23%) resulting in Good bioclassifications, six (15%) resulting in Good-Fair bioclassifications, three (8%) receiving Fair bioclassifications, 11 receiving Natural bioclassifications (28%), and six receiving Moderate bioclassifications (15%). In addition, three summer swamp samples resulted in Not Rated designations (8%). Comparisons of benthos data from 1999 to 2004 between repeat sites reveal that one site (Dan River at NC 704) improved from Good to Excellent, two sites (North Double Creek and Country Line Creek) improved from Good-Fair to Good, one site (Marlowes Creek) improved from Fair to Good-Fair, while two swamp sites (Hoggard Mill and Conoconnara Swamp) declined from Natural to Moderate. All remaining sites maintained the same bioclassification from 1999 to 2004. Overall, water quality in this basin has improved slightly since 1999.

Several rare invertebrate taxa were collected in the Roanoke River basin in 2004 including the mayflies *Macdunnoa brunnea* (Town Fork Creek), *Acerpenna macdunnoughi* (Island Creek) and the caddisflies *Platycentropus, Ceraclea excisa* (Quankey Creek), and *Brachycentrus lateralis* (Dan and Mayo Rivers). In addition, a morphologically unique and un-described species of *Polycentropus* was collected from Hardison Mill Creek during winter swamp sampling.

Appendix B. Benthic Macroinvertebrate Sampling Methods and Criteria.

Standard Qualitative (Full Scale) or EPT Methods

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Biological Assessment Unit's standard qualitative (Full Scale) sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDENR 2003). The samples are picked on-site. The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1 - 2 specimens), Common (3 - 9 specimens), or Abundant (≥ 10 specimens).

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

Swamp Stream Method

The Biological Assessment Unit defines “swamp streams” as those streams that are within the coastal plain ecoregion and that normally have no visible flow during a part of the year. This low flow period usually occurs during the summer, but flowing water should be present in swamp streams during the winter. Sampling during winter, high flow periods provides the best opportunity for detecting differences in communities from what is natural, and only winter (February to early March) benthos data can be used when evaluating swamp streams. The swamp stream must have visible flow in this winter period, with flow comparable to a coastal plain stream that would have acceptable flow for sampling in summer. Swamp streams with pH values of 4 s.u. or lower cannot be rated, and even those below 4.5 s.u. are difficult to evaluate.

The swamp sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. Nine sweep samples (1 series of 3 by each field team member) are collected from each of the following habitats: macrophytes, root mats/undercut banks, and detritus deposits. If one of these habitat types is not present, a sweep from one of the other habitats is substituted. A sweep is defined as the area that can be reached from a given standing location. Each sweep should be emptied into a tub before the next sweep is collected, to prevent clogging of the net, but all three sweeps can be combined in the same tub. Three log/debris washes are also collected. Visual collections are the final technique

used at each site. Samples are picked on site. The primary output for this sampling method is a taxa list with an indication of relative abundance (Rare, Common, Abundant) for each taxon.

Habitat Evaluation

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

Data Analysis

Standard Qualitative (Full Scale) or EPT Criteria

Criteria for bioclassifications for standard qualitative and EPT samples are given in Tables B-1 – B-3. EPT S and the NCBI are used for rating standard qualitative samples. Bioclassifications for EPT samples are based solely on EPT S.

Table B-1. Criteria for Standard Qualitative (Full Scale) Method.

Score	BI Values			EPT Values		
	Mountain	Piedmont	Coastal Plain (CA)	Mountain	Piedmont	Coastal Plain (CA)
5	<4.00	< 5.14	< 5.42	> 43	> 33	> 28
4.6	4.00 – 4.04	5.14 - 5.18	5.42 - 5.46	42-43	32 - 33	28
4.4	4.05 – 4.09	5.19 - 5.23	5.47 - 5.51	40-41	30 - 31	27
4	4.10 – 4.83	5.24 - 5.73	5.52 - 6.00	34-39	26 - 29	22 - 26
3.6	4.84 – 4.88	5.74 - 5.78	6.01 - 6.05	32-33	24 - 25	21
3.4	4.89 – 4.93	5.79 - 5.83	6.06 - 6.10	30-31	22 - 23	20
3	4.94 – 5.69	5.84 - 6.43	6.11 - 6.67	24-29	18 - 21	15 - 19
2.6	5.70 – 5.74	6.44 - 6.48	6.68 - 6.72	22-23	16 - 17	14
2.4	5.75 – 5.79	6.49 - 6.53	6.73 - 6.77	20-21	14 - 15	13
2	5.80 – 6.95	6.54 - 7.43	6.78 - 7.68	14-19	10 - 13	8 - 12
1.6	6.96 – 7.00	7.44 - 7.48	7.69 - 7.73	12-13	8 - 9	7
1.4	7.01 – 7.05	7.49 - 7.53	7.74 - 7.79	10-11	6 - 7	6
1	> 7.05	> 7.53	> 7.79	0-9	≤ 5	≤ 5

Table B-2. EPT Taxa Richness Criteria for EPT Samples.

Bioclassification	EPT Values		
	Mountain	Piedmont	Coastal Plain (CA)
Excellent	>35	> 27	> 23
Good	28-35	21 - 27	18 - 23
Good-Fair	19-27	14 - 20	12 - 17
Fair	11-18	7 - 13	6 - 11
Poor	0-10	≤ 6	≤ 5

Table B-3. Biotic Index corrections for non-summer data. Summer = Jun – Sep; Fall = Oct – Nov; Winter = Dec – Feb; and Spring = Mar – May.

Region	Season		
	Fall	Winter	Spring
Piedmont	+0.1	+0.1	+0.2
Coastal A	+0.2	+0.2	+0.3

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

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

Swamp Stream Criteria

Swamp stream criteria evaluate a stream based on three benthic macroinvertebrate metrics (Total taxa richness, EPT taxa richness, and Biotic Index) and the coastal plain form habitat value. The values for each of these metrics is used to derive a score for each metric, using the tables and graphs below. There are only three possible scores for each metric. A score of 5 is assigned if the metric value falls within the range for Natural, a score of 3 is assigned to values in the range for Moderate and a score of 1 is assigned to values in the range given for Severe. The final site score is derived by the formula:

Site Score = [(2xBI score + Habitat Score + EPT S score + Taxa Richness Score) – 5]/2

Stress ratings based on the scores are: Natural (9 - 10), Moderate (4 - 8) and Severe (1 - 3).

Table B-4. Benthic macroinvertebrate basinwide monitoring data collected in the Roanoke River basin, 1999-2004. Current basin sites are in bold.

Subbasin/ Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPT BI	BioClass
30201									
Dan R	NC 704	Stokes	22-(1)	7/7/04	91	45	3.89	3.42	Excellent
		Stokes	22-(1)	8/23/99	85	41	4.20	3.31	Good
		Stokes	22-(1)	8/16/99	74	32	4.16	3.19	Good
Dan R	SR 1695	Stokes	22-(8)	7/7/04	87	43	4.80	4.07	Good
		Stokes	22-(8)	8/23/99	72	37	4.58	3.96	Good
N Double Cr	SR 1504	Stokes	22-10	6/28/04	31	31	--	3.42	Good
		Stokes	22-10	8/23/99	25	25	--	3.95	Good-Fair
Snow Cr	SR 1673	Stokes	22-20	7/7/04	31	31	--	4.33	Good
		Stokes	22-20	9/13/00	29	29	--	4.10	Good
		Stokes	22-20	8/23/99	18	18	--	4.37	Fair
Town Fork Cr	SR 1998	Stokes	22-25	5/18/04	87	35	4.84	3.86	Good-Fair
Town Fork Cr	SR 1961	Stokes	22-25	5/25/04	67	26	5.10	4.69	Good-Fair
Town Fork Cr	SR 1917	Stokes	22-25	5/25/04	80	35	5.30	4.84	Good
Brushy Fk	SR 1998	Stokes	22-25-1	5/18/04	86	37	5.10	4.06	Good-Fair
30202									
Mayo R	SR 1358	Rockingham	22-30-(1)	7/8/04	77	33	4.71	4.13	Good
		Rockingham	22-30-(1)	8/23/99	70	32	4.26	3.44	Good
Mayo R	SR 2177	Rockingham	22-30-(10)	8/24/99	52	21	5.23	4.26	Good-Fair
30203									
Rock House Cr	SR 2127	Rockingham	22-34-(2)	4/12/01	81	23	5.00	3.80	Good-Fair
Smith R	NC 14	Rockingham	22-40-(3)	9/13/99	51	18	5.24	3.68	Fair
30204									
Dan R	NC 57	Caswell	22-(39)	8/24/99	66	32	5.42	4.52	Good
Country Line Cr	SR 1129	Caswell	22-56-(1)	7/1/04	24	24	--	4.89	Good
Country Line Cr	NC 57	Caswell	22-56-(3.7)	7/1/04	24	24	--	4.82	Good
30205									
Marlowes Cr	SR 1351	Person	22-58-12-6	6/30/04	66	14	6.67	5.87	Fair
Marlowes Cr	SR 1322	Person	22-58-12-6	6/30/04	56	13	6.43	5.93	Good-Fair
		Person	22-58-12-6	8/25/99	53	9	6.34	5.74	Fair
30206									
Grassy Cr	SR 1436	Granville	23-2-(1)	6/30/04	13	13	--	5.05	Not Rated
Mountain Cr	SR 1300	Granville	23-2-3	7/2/04	13	13	--	5.40	Not Rated
Island Cr	SR 1445	Granville	23-4	6/29/04	17	17	--	5.48	Good-Fair
		Granville	23-4	8/24/94	17	17	--	5.11	Good-Fair
Nutbush Cr	NC 39	Vance	23-8-(1)	6/29/04	70	12	7.34	6.84	Fair
Nutbush	SR 1317	Vance	23-8-(1)	6/29/04	63	9	7.00	6.70	Fair
		Vance	23-8-(1)	8/25/99	41	8	6.73	6.76	Fair
30207									
Smith Cr	SR 1217	Warren	23-10	4/26/04	69	18	6.29	5.09	Fair
Smith Cr	SR 1208	Warren	23-10	4/26/04	87	22	6.03	4.87	Good-Fair
Smith Cr	US 1	Warren	23-10	4/26/04	50	10	6.43	5.13	Fair

Subbasin/ Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPT BI	BioClass
Smith Cr	US 1	Warren	23-10	7/16/99	59	12	6.56	5.52	Fair
Newmans Cr	SR 1218	Warren	23-10-2	4/27/04	76	15	6.30	5.32	Fair
Sixpound Cr	SR 1306	Warren	23-13	6/29/04	62	15	6.43	5.44	Good-Fair
		Warren	23-13	7/16/99	54	14	5.50	5.05	Good-Fair
30208									
Deep Cr	US 158	Halifax	23-24(1)	2/23/04	62	23	5.28	4.10	Natural
				7/15/99	58	11	6.41	5.17	Not Rated
Chockoyotte Cr	Country Club Rd	Halifax	23-29	2/23/04	52	11	6.72	5.40	Moderate
Quankey Cr	NC 903	Halifax	23-30	2/23/04	53	17	5.82	4.05	Natural
				2/16/99	40	9	6.66	5.93	Natural
Quankey Cr	NC 561	Halifax	23-30	9/1/99		9		5.51	Fair
L Quankey Cr	NC 903	Halifax	23-30-1	2/23/04	46	17	5.65	4.49	Moderate
Oconeechee Cr	SR 1126	Northhampton	23-31	2/16/99	22	4	6.48	6.88	Natural
Conoconnara Swp	NC 561	Halifax	23-33	2/24/04	30	3	7.22	7.26	Moderate
				2/16/99	31	5	6.45	6.81	Natural
Kehukee Swp	SR 1804	Halifax	23-42	2/24/04	46	7	7.03	5.89	Moderate
				9/2/99	6	6	6.19	6.19	Not Rated
				2/11/99	59	8	7.11	6.64	Moderate
30209									
Conoho Cr	NC 11/42	Martin	23-49	2/4/04	31	4	7.64	7.10	Moderate
Conoho Cr	NC 125/903	Martin	23-49	2/1/99	29	3	7.29	7.58	
Conoho Cr	SR 1417	Martin	23-49	2/4/04	38	6	6.68	5.40	Natural
				2/1/99	39	5	6.27	4.80	
Hardison Mill Cr	SR 1528	Martin	23-50-3	2/4/04	36	2	7.49	5.20	Moderate
				2/1/99	27	3	7.29	7.67	Moderate
30210									
Cashie R	SR 1219, be WWTP	Bertie	24-2-(1)	2/23/04	29	3	7.47	7.03	Moderate
		Bertie	24-2-(1)	2/11/99	41	6	7.51	7.24	Natural
Cashie R	SR 1257	Bertie	24-2-(1)	2/24/04	35	7	6.51	4.90	Natural
	SR 1257	Bertie	24-2-(1)	2/15/99	34	7	6.80	6.09	Natural
Hoggard Mill Cr	SR 1301	Bertie	24-2-6	2/23/04	30	3	7.13	5.65	Moderate
		Bertie	24-2-6	2/15/99	46	7	6.81	6.38	Natural
Roquist Swp	US 13/17	Bertie	24-2-8	2/24/04	38	4	7.01	6.46	Natural
	US 13/17	Bertie	24-2-8	2/11/99	31	4	6.99	5.50	Natural
Wading Place Cr	NC 308	Bertie	24-2-8	3/8/99	35	3	7.31	7.45	Moderate

Appendix C. Fish Community Assessment

In 2004, 30 sites were sampled in mid- to late April and in late May; 23 of the sites had not been previously sampled. Fish communities in the basin were last sampled in 1994. Except for one Coastal Plain site, all the sites were in the Piedmont. The most commonly collected species in 2004 were the bluehead chub and redbreast sunfish (collected at 28 of the 30 sites); the most abundant species was the bluehead chub.

All streams in the Piedmont were evaluated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendices F-2 – F-4); Chockoyotte Creek was not rated because metrics and criteria have yet to be developed for Coastal Plain streams. The Piedmont NCIBI ratings ranged from Poor to Excellent with the scores ranging from 22 to 54 (Figures F-1 and F-2). The two streams rated Excellent were Archies and Peters Creeks. Based upon the fish community ratings, degraded streams (bioclassifications of Fair or Poor) included North Hyco, Little Island, Nutbush, and Smith Creeks. North Hyco and Little Island Creeks along with Pawpaw and North Double Creeks should be re-sampled in 2005 to verify their ratings.

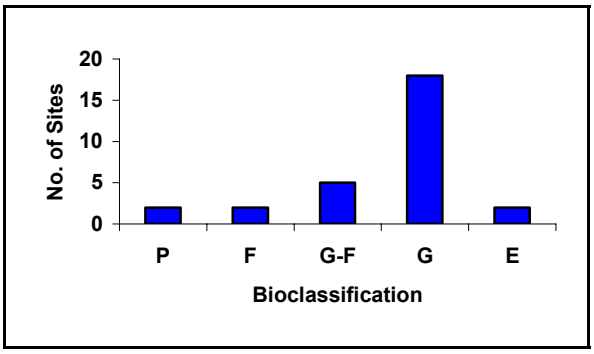

Figure C-1. Distribution of the ratings of 29 fish community basinwide sites in the Piedmont portion of the Roanoke River basin, 2004. Abbreviations are: P = Poor, F = Fair, G-F = Good-Fair, G = Good, and E = Excellent.

Habitat characteristics and examples of high and low quality habitats at fish community sites in the basin are presented in Appendix F-1. The instream and riparian habitat assessment scores at the 22 sites ranged from 40 to 95. Fish communities rated Excellent were found where the habitats were of moderate to high quality; communities rated Fair or Poor were, with one exception, found where the habitats were of lower quality. Even though many of the fish communities were rated Good, there were substantial habitat problems stemming from long-term nonpoint erosion, sedimentation, and bank instability. Streams with moderate to high quality habitats but lower than expected ratings may have yet to recover from the 2002 drought or be affected by seasonally low flows.

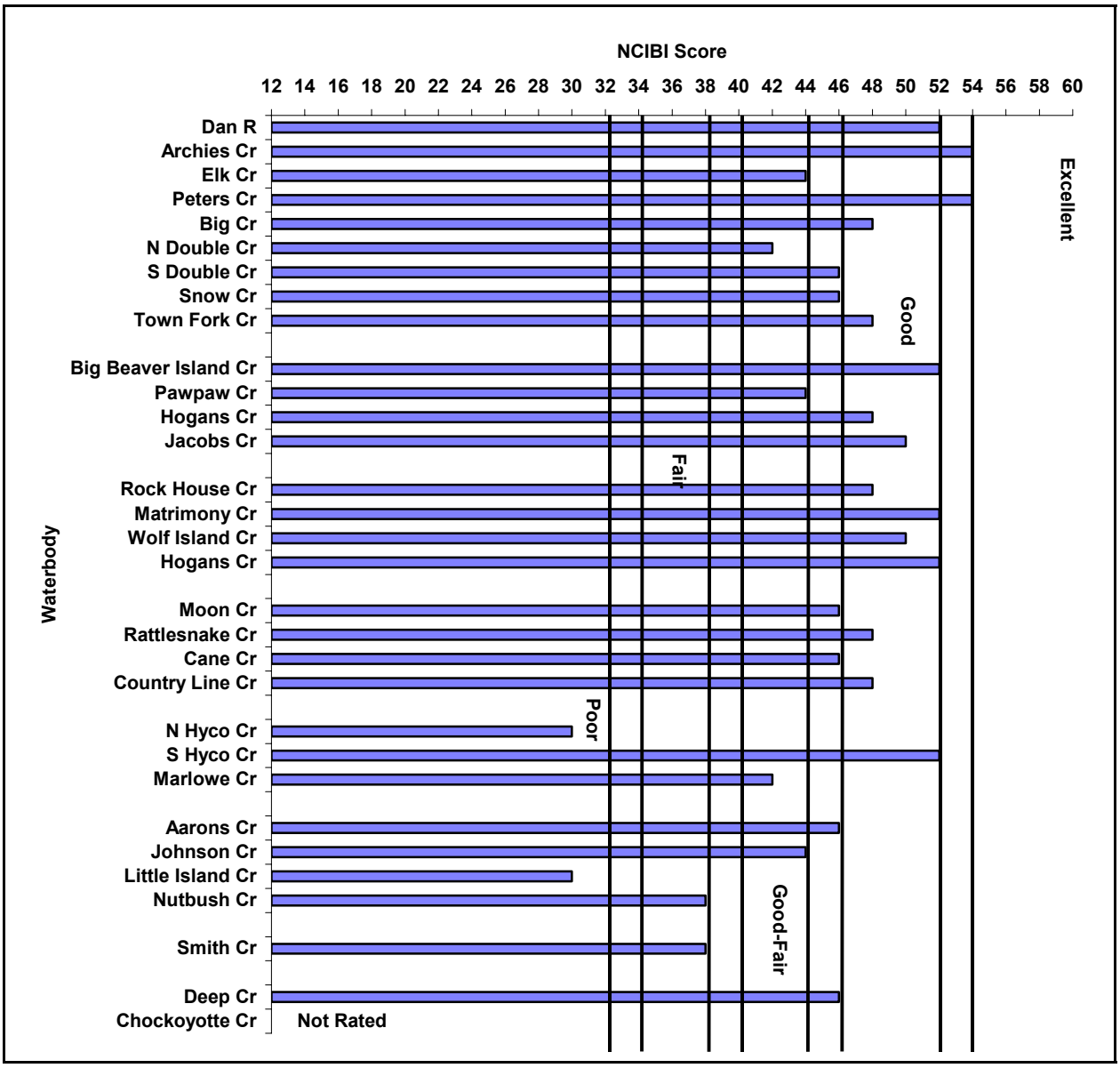

Figure C-2. NCIBI scores and ratings of 30 fish community basinwide sites in the Roanoke River basin, 2004.

Appendix D. Habitat evaluations and stream and riparian habitats at fish community monitoring sites in the Roanoke River basin.

Habitat Assessments

A method has been developed by the Biological Assessment Unit to evaluate the physical habitats of a stream (NCDENR 2001c). The habitat score, which ranges between 1 and 100, is based on the evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but criteria have not been developed to assign impairment ratings. Habitat metric scores for all fish community sites in the Roanoke River basin which were evaluated in 2004 are listed in Tables D-2 and D-3.

Fish community sampling was conducted in 2004 at 30 sites; 29 within the Piedmont and 1 within the Coastal Plain. Habitat scores ranged from 40 (Jacobs Creek) to 95 (Hogans Creek (Rockingham County) (Table D-1). In the Piedmont, 21 streams had overall moderate to high quality habitats (score ≥ 65); whereas 17 streams had overall low to poor quality habitats (score < 65). Major differences between the two types were in the instream habitats, substrates, riffles, and bank stabilities (TableD-4). Differences were not as pronounced in the abundance of pools, extent of canopy cover, or width of riparian zones. Low scores were attributable to chronic erosion and nonpoint source sedimentation.

Table D-1. Rankings of 29 waterbodies in the Piedmont region of the Roanoke River basin according to the total habitat scores, 2004.

Subbasin	Waterbody	Location	County	Score
		High to Moderate Quality Habitats		
2	Hogans Cr	NC 704	Rockingham	95
1	Archie's Cr	SR 1416	Stokes	85
6	Aarons Cr	SR 1400	Granville	84
1	Peters Cr	SR 1497	Stokes	83
2	Pawpaw Cr	SR 1360	Rockingham	80
7	Smith Cr	US 1	Warren	77
6	Johnson Cr	SR 1440	Granville	76
1	Dan R	SR 1416	Stokes	74
1	North Double Cr	SR 1504	Stokes	70
		Low to Poor Quality Habitats		
1	Elk Cr	SR 1433	Stokes	62
8	Deep Cr	US 158	Halifax	61
3	Matrimony Cr	NC 770	Rockingham	57
1	Snow Cr	SR 1652	Stokes	55
5	Marlowe Cr	SR 1322	Person	55
3	Hogans Cr	SR 1330	Caswell	54
4	Cane Cr	SR 1527	Caswell	54
1	Town Fork Cr	SR 1955	Stokes	53
6	Nutbush Cr	SR 1317	Vance	53
5	South Hyco Cr	US 158	Person	51
5	North Hyco Cr	US 158	Caswell	51
2	Big Beaver Island Cr	US 3111	Rockingham	49
3	Rockhouse Cr	SR 2127	Rockingham	48
1	Big Cr	SR 1471	Stokes	47
4	Rattlesnake Cr	SR 1523	Caswell	47
6	Little Island Cr	SR 1348	Vance	47
1	South Double Cr	SR 1483	Stokes	46
4	Moon Cr	SR 1511	Caswell	45
3	Wolf Island Cr	SR 1767	Rockingham	42
2	Jacobs Cr	NC 704	Rockingham	40

Table D-2. Habitat evaluations at 30 basinwide fish community sites in the Piedmont region of the Roanoke River basin, 2004.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030201															
	Dan R	SR 1416	Stokes	14	4	16	13	4	14	6	6	7	2	2	74
	Archie's Cr	SR 1416	Stokes	6	5	17	12	10	12	6	7	8	5	3	85
	Elk Cr	SR 1433	Stokes	4	5	16	10	8	16	2	2	2	0	1	62
	Peters Cr	SR 1497	Stokes	11	5	16	12	6	14	6	7	9	3	5	83
	Big Cr	SR 1471	Stokes	8	5	12	3	6	2	3	3	7	3	3	47
	North Double Cr	SR 1504	Stokes	7	4	14	8	7	6	6	6	10	3	5	70
	South Double Cr	SR 1483	Stokes	7	5	14	4	6	1	3	3	7	1	2	46
	Snow Cr	SR 1652	Stokes	8	5	12	4	6	5	3	3	7	5	5	55
	Town Fork Cr	SR 1955	Stokes	9	5	14	5	6	5	3	3	7	3	2	53
030202															
	Big Beaver Island Cr	US 311	Rockingham	8	5	12	4	6	4	2	2	7	2	5	49
	Pawpaw Cr	SR 1360	Rockingham	6	5	16	14	4	14	6	6	8	2	5	80
	Hogans Cr	NC 704	Rockingham	8	5	20	14	8	14	7	7	10	5	5	95
	Jacobs Cr	NC 704	Rockingham	9	5	8	3	10	2	0	0	6	1	5	40
030203															
	Rockhouse Cr	SR 2127	Rockingham	8	5	12	4	4	2	3	3	7	4	4	48
	Matrimony Cr	NC 770	Rockingham	8	5	14	6	6	5	3	3	9	3	3	57
	Wolf Island Cr	SR 1767	Rockingham	9	5	10	3	10	2	0	0	2	5	5	42
	Hogans Cr	SR 1330	Caswell	9	5	12	3	6	3	3	3	10	5	4	54
030204															
	Moon Cr	SR 1511	Caswell	9	4	11	3	10	2	2	2	7	2	2	45
	Rattlesnake Cr	SR 1523	Caswell	4	5	11	3	4	1	3	3	9	5	3	47
	Cane Cr	SR 1527	Caswell	4	5	12	4	9	4	3	3	9	4	3	54
030205															
	North Hyco Cr	US 158	Caswell	10	4	10	3	10	1	3	3	7	5	5	51
	South Hyco Cr	US 158	Person	10	5	13	3	10	1	3	3	5	4	4	51
	Marlowe Cr	SR 1322	Person	8	5	12	4	6	5	4	4	8	5	2	55
030206															
	Aarons Cr	SR 1400	Granville	7	5	16	12	10	15	3	3	10	5	5	84
	Johnson Cr	SR 1440	Granville	7	5	18	12	6	7	4	4	10	5	5	76
	Little Island Cr	SR 1348	Vance	6	5	12	3	6	0	2	2	9	5	3	47
	Nutbush Cr	SR 1317	Vance	6	5	11	3	4	3	6	6	5	5	5	53
030207															
	Smith Cr	US 1	Warren	7	5	18	3	10	12	5	5	9	5	5	77
030208															
	Deep Cr	US 158	Halifax	9	5	16	3	9	3	4	4	7	5	5	61
	Chockoyotte Cr	US 158	Halifax	7	5	16	3	6	2	6	6	7	4	5	60
Maximum possible scores					**5**	**20**	**15**	**10**	**16**	**7**	**7**	**10**	**5**	**5**	**100**

[1]also evaluated with Coastal Plains habitat criteria (Table 2).

Table D-3. Habitat evaluations at two basinwide fish community sites in the Coastal Plain region of the Roanoke River basin, 2004.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030207														
	Smith Cr	US 1	Warren	7	15	20	7	10	7	7	9	5	5	85
030208														
	Chockoyotte Cr	US 158	Halifax	7	15	18	13	9	9	9	7	4	5	89
Maximum possible scores					**15**	**20**	**15**	**10**	**10**	**10**	**10**	**5**	**5**	**100**

[1]also evaluated with Piedmont habitat criteria (Table 1).

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Table D-4. Mean habitat scores for 29 fish community sites in the Piedmont portion of the Roanoke River basin, 2004.

Habitat characteristics	Low - Poor Quality Habitat	Moderate - High Quality Habitat	Maximum score
Instream habitat	12.2	16.8	20
Substrate	3.9	11.1	15
Riffle	3.4	12.0	16
Bank stability (right and left)	5.6	11.1	14

Characteristics of moderate to high quality habitat Piedmont streams are (Figure D-1):

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

FigureD-1. Instream habitats composed of boulder, cobble, and gravel rocks, sticks, leafpacks, snags, logs, and root mats and wide riparian zones offering a good tree canopy, Hogans Creek, NC 704, Rockingham County.

Characteristics of low to poor quality habitat Piedmont streams are (Figure D-2):

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

Figure D-2. Sandy substrates with few riffles and eroding and sloughing banks, Wolf Island Creek, SR 1767, Rockingham County.

Habitat and NCIBI Relationships
Fish communities in the Piedmont which were rated Excellent were found where the habitats were of moderate to high quality (Table 5). Communities rated Fair or Poor were, with one exception, found where the habitats were of lower quality.

Table D-5. NCIBI ratings and habitat quality for 29 streams in the Piedmont region of the Roanoke River basin, 2004.[1]

NCIBI Rating	Waterbodies with Low to Poor Quality Habitat (Score < 65)	Waterbodies with Moderate to High Quality Habitat (Score ≥ 65)
Excellent	---	Archies, Peters
Good	Big, S. Double, Snow, Town Fork, Big Beaver Island, Jacobs, Rockhouse, Matrimony, Wolf Island, Hogans (Caswell Co.), Moon, Rattlesnake, Cane, S Hyco, Deep	Dan, Hogans (Rockingham Co.), Aarons
Good-Fair	Elk, Marlowe	N. Double, Pawpaw, Johnson
Fair	Nutbush	Smith
Poor	N Hyco, Little Island	---

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

It seems that many fish communities in the basin are still rated Good, even though there were substantial habitat problems stemming from long-term nonpoint erosion, sedimentation, and bank instability. Streams with moderate to high quality habitats but lower than expected ratings may have yet to recover from the 2002 drought or be affected by seasonally low flows.

Appendix E. Fish community sampling methods and criteria.

In 2004, fish community assessments were performed at 30 sites in the basin, 29 in the Piedmont and 1 in the Coastal Plain. The drainage areas of the assessed watersheds ranged from 6.5 to 92.6 square miles. Twenty-three of the 29 Piedmont sites had never been sampled, including all of the sites in Subbasin 01. Three of the sites were on the impaired streams list (Table E-1) and had been last sampled in 1994. Some of these unassessed sites were in rural watersheds where there were no NPDES dischargers and were selected as potential candidates for regional reference sites. One site was sampled at more appropriately-sized location (Wolf Island Creek) and Island Creek, although sampled during the first cycle of basinwide monitoring in 1994, was not resampled in 2004 because there were already sufficient data collected in 1999 to assess this stream. Basinwide fish community sampling was not conducted in 1999, rather special studies were performed to refine and calibrate the assessment program.

Table E-1. Fish community sites monitored in 2004 that are on the state's 303(d) list of impaired waters (NCDENR 2003).

Subbasin/ Waterbody	Reach Affected	Cause(s) or Suspected Cause(s) of Impairment	Potential Sources
030205			
Marlowe Cr	From source to Storys Cr	1. Copper 2. Cause unknown	1. Municipal pretreatment (industrial); minor non municipal 2. Minor industrial point sources; collection system failure urban runoff/storm sewers
030206			
Nutbush Cr	From source to Crooked Run	Cause unknown	Major municipal point sources; urban runoff/storm sewers
030207			
Smith Cr	From source to NC-VA state line	1. Dissolved oxygen 2. Cause unknown	1. Erosion and sedimentation, agriculture 2. Agriculture; erosion and sedimentation

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

NCIBI Analysis
The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr, *et al*. (1986) (Appendix 8). The IBI method was developed for assessing a stream's biological integrity by examining the structure and health of its fish community. The scores derived from this index are a measure of the ecological health of the waterbody and may not directly correlate to water quality. For example, a stream with excellent water quality, but with poor or fair fish habitat, would not be rated excellent with this index. However, in many instances, a stream which rated excellent on the NCIBI should be expected to have excellent water quality.

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

The assessment of biological integrity using the North Carolina Index of Biotic Integrity (NCIBI) is provided by the cumulative assessment of 12 parameters or metrics. 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 recently been revised (NCDENR 2001b). Currently, the focus of using and applying the NCIBI has been restricted to wadeable streams that can be sampled by a crew of four persons. The bioclassifications and criteria have also been recalibrated against regional reference site data (Biological Assessment Unit Memorandum F-010105) (Tables E-2 – E-5).

Table E-2. Revised 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
$\leq$ 32	Poor

Table E-3. Regional reference site/sample used in calibrating the North Carolina Index of Biotic Integrity in the Roanoke River basin.

Subbasin/ Waterbody	Station	County	Date
030206			
Grassy Cr	SR 1300	Granville	06/09/1999

Criteria and ratings are applicable only to wadeable streams in the Piedmont region of the basin and are the same as those for the Tar, Neuse, and Cape Fear River basins. The definition of the Piedmont for these basins is based on a map of North Carolina watersheds by Fels (1997). 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.

Blackspot and Other Diseases

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

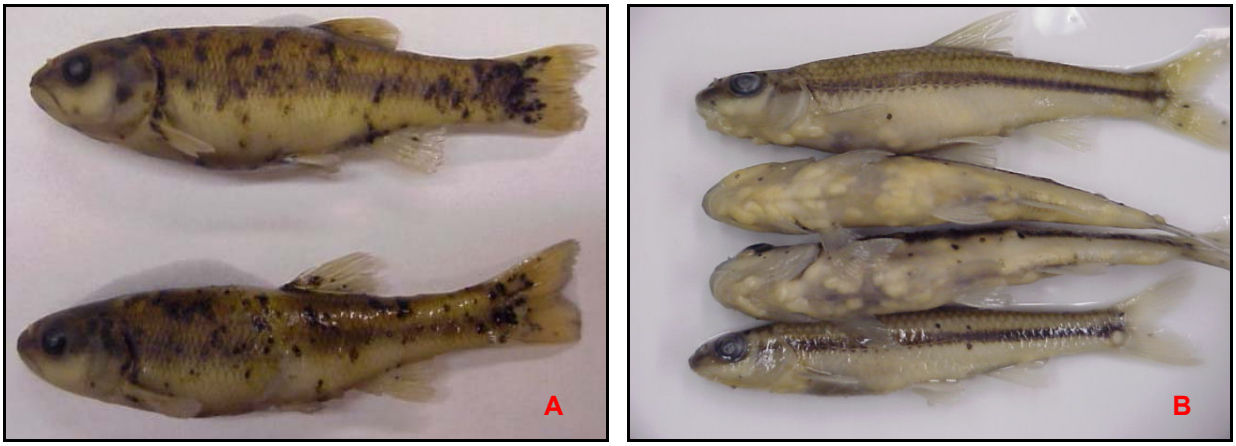

Figure E-1. Heavy infestation of blackspot disease in creek chub (A) and yellow grub in bigeye chub (B).

Although some researchers incorporate the incidence of black spot and yellow grub into indices of biotic integrity (e.g., Steedman 1991), others, because of a lack of a consistent, inverse relationship to environmental quality, do not (e.g., Sanders *et al*. 1999). The diseases are not considered in the NCIBI because it is widespread, affecting fish in all types of streams. This disease was noted in Peters, Big, Snow, Town Fork, Big Beaver Island, and Rock House Creeks. Species affected (although not at all sites) included bluehead chub, white shiner, crescent shiner, redlip shiner, northern hogsucker, Roanoke hogsucker, margined madtom, fantail darter, and Johnny darter.

Other diseases observed in 2004 included:

- scoliosis in redbelly dace in Matrimony Creek; and
- "Popeye" or exophthalmos in many bluegill from Rock House, Matrimony, Rattlesnake, Cane, North Hyco, South Hyco, Aarons, Johnson, Little Island, Smith, and Chockoyotte Creeks. The disease can be caused by bacterial and viral infections as well as nematode infections (Figure E-2).

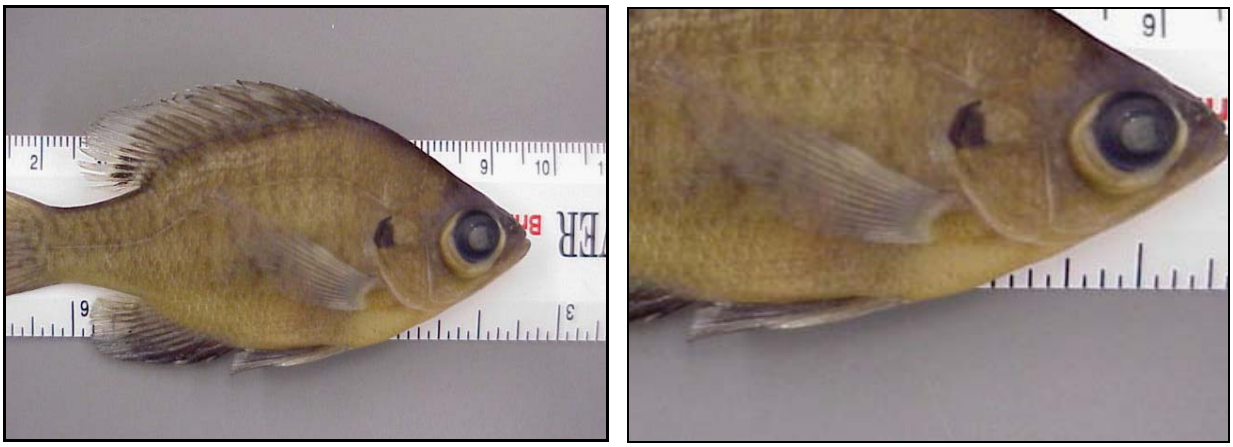

Figure E-2. **Popeye caused by nematode infection in bluegill, Hardee Creek (Pitt County, Tar River basin).**

Table E-4. Scoring criteria for the NCIBI for wadeable streams in the Outer Piedmont of the Cape Fear, Neuse, Roanoke, and Tar River basins ranging between 3.1 and 328 mi^2.

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**		
	Roanoke	Neuse, Roanoke, and Tar	
	≥ 2 species	≥ 3 species	5
	1 species	1 or 2 species	3
	0 species	0 species	1
4	**No. of species of sunfish**		
	≥ 4 species		5
	3 species		3
	0, 1, or 2 species		1
5	**No. of species of suckers**		
	Cape Fear	Neuse, Roanoke, and Tar	
	≥ 2 species	≥ 3 species	5
	1 species	1 or 2 species	3
	0 species	0 species	1
6	**No. of intolerant species**		
	Cape Fear	Neuse, Roanoke, and Tar	
	≥ 1 species	≥ 3 species	5
	no middle score	1 or 2 species	3
	0 species	0 species	1
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 E-5. Tolerance ratings and adult trophic guild assignments for fish in the Roanoke River basin. Species collected in 2004 are highlighted in blue. Species collected in 2004 are highlighted in blue. Common and scientific names follow Nelson, et al. (2004), except for *Scartomyzon*.

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Petromyzontidae	**lampreys**		
Petromyzon marinus	sea lamprey	Intermediate	Parasitic
Acipenseridae	**sturgeons**		
Acipenser oxyrinchus	Atlantic sturgeon	Intermediate	Insectivore
Lepisosteidae	**gars**		
Lepisosteus osseus	longnose gar	Tolerant	Piscivore
Amiidae	**bowfins**		
Amia calva	bowfin	Tolerant	Piscivore
Anguillidae	**freshwater eels**		
Anguilla rostrata	American eel	Intermediate	Piscivore
Clupeidae	**herrings**		
Alosa aestivalis	blueback herring	Intermediate	Insectivore
A. mediocris	hickory shad	Intermediate	Insectivore
A. pseudoharengus	alewife	Intermediate	Insectivore
A. sapidissima	American shad	Intermediate	Insectivore
Dorosoma cepedianum	gizzard shad	Intermediate	Omnivore
D. petenense	threadfin shad	Intermediate	Omnivore
Cyprinidae	**carps and minnows**		
Campostoma anomalum	stoneroller	Intermediate	Herbivore
Carassius auratus	goldfish	Tolerant	Omnivore
Clinostomus funduloides	rosyside dace	Intermediate	Insectivore
Cyprinella analostana	satinfin shiner	Tolerant	Insectivore
C. lutrensis	red shiner	Tolerant	Insectivore
Cyprinus carpio	common carp	Tolerant	Omnivore
Exoglossum maxillingua	cutlip minnow	Intolerant	Insectivore
Hybognathus regius	eastern silvery minnow	Intermediate	Herbivore
Luxilus albeolus	white shiner	Intermediate	Insectivore
L. cerasinus	crescent shiner	Intermediate	Insectivore
Lythrurus ardens	rosefin shiner	Intermediate	Insectivore
Nocomis leptocephalus	bluehead chub	Intermediate	Omnivore
N. raneyi	bull chub	Intermediate	Omnivore
Notemigonus crysoleucas	golden shiner	Tolerant	Omnivore
Notropis alborus	whitemouth shiner	Intermediate	Insectivore
N. altipinnis	highfin shiner	Intermediate	Insectivore
N. amoenus	comely shiner	Intermediate	Insectivore
N. chalybaeus	ironcolor shiner	Intolerant	Insectivore
N. chiliticus	redlip shiner	Intermediate	Insectivore
N. hudsonius	spottail shiner	Intermediate	Omnivore
N. procne	swallowtail shiner	Intermediate	Insectivore
Phoxinus oreas	mountain redbelly dace	Intermediate	Herbivore
Pimephales promelas	fathead minnow	Tolerant	Omnivore
Semotilus atromaculatus	creek chub	Tolerant	Insectivore
Catostomidae	**suckers**		
Carpiodes cyprinus	quillback	Intermediate	Omnivore
Catostomus commersonii	white sucker	Tolerant	Omnivore
Erimyzon oblongus	creek chubsucker	Intermediate	Omnivore
Hypentelium nigricans	northern hog sucker	Intermediate	Insectivore
H. roanokense	Roanoke hog sucker	Intermediate	Insectivore
Ictiobus bubalus	smallmouth buffalo	Intermediate	Omnivore
Moxostoma collapsum	notchlip redhorse	Intermediate	Insectivore
M. erythrurum	golden redhorse	Intermediate	Insectivore
M. macrolepidotum	shorthead redhorse	Intermediate	Insectivore
M. pappillosum	v-lip redhorse	Intermediate	Insectivore
Scartomyzon ariommum	bigeye jumprock	Intolerant	Insectivore
S. cervinus	black jumprock	Intermediate	Insectivore
Thoburnia hamiltoni	rustyside sucker	Intolerant	Insectivore

Table E-5 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Ictaluridae	**catfishes**		
Ameiurus brunneus	snail bullhead	Intermediate	Insectivore
A. catus	white catfish	Tolerant	Omnivore
A. melas	black bullhead	Tolerant	Insectivore
A. natalis	yellow bullhead	Tolerant	Omnivore
A. nebulosus	brown bullhead	Tolerant	Omnivore
A. platycephalus	flat bullhead	Tolerant	Insectivore
Ictalurus furcatus	blue catfish	Intermediate	Piscivore
I. punctatus	channel catfish	Intermediate	Omnivore
Noturus gilberti	orangefin madtom	Intolerant	Insectivore
N. gyrinus	tadpole madtom	Intermediate	Insectivore
N. insignis	margined madtom	Intermediate	Insectivore
Pylodictis olivaris	flathead catfish	Intermediate	Piscivore
Esocidae	**pikes**		
Esox americanus americanus	redfin pickerel	Intermediate	Piscivore
E. niger	chain pickerel	Intermediate	Piscivore
Umbridae	**mudminows**		
Umbra pygmaea	eastern mudminnow	Intermediate	Insectivore
Salmonidae	**trouts and salmons**		
Oncorhynchus mykiss	rainbow trout	Intolerant	Insectivore
Salmo trutta	brown trout	Intermediate	Piscivore
Aphredoderidae	**pirate perches**		
Aphredoderus sayanus	pirate perch	Intermediate	Insectivore
Amblyopsidae	**cavefishes**		
Chologaster cornuta	swampfish	Intermediate	Insectivore
Atherinopsidae	**new world silversides**		
Menidia beryllina	inland silverside	Intermediate	Insectivore
Fundulidae	**topminnows**		
Fundulus diaphanus	banded killifish	Intermediate	Insectivore
F. lineolatus	lined topminnow	Intermediate	Insectivore
F. rathbuni	speckled killifish	Intermediate	Insectivore
Poeciliidae	**livebearers**		
Gambusia holbrooki	eastern mosquitofish	Tolerant	Insectivore
Cottidae	**sculpins**		
Cottus caeruleomentum	Blue Ridge sculpin	Intermediate	Insectivore
Moronidae	**temperate basses**		
Morone chrysops	white bass	Intermediate	Piscivore
M. saxatilis	striped bass	Intermediate	Piscivore
Centrarchidae	**sunfishes and black basses**		
Acantharchus pomotis	mud sunfish	Intermediate	Insectivore
Ambloplites cavifrons	Roanoke bass	Intermediate	Piscivore
A. rupestris	rock bass	Intolerant	Piscivore
Centrarchus macropterus	flier	Intermediate	Insectivore
Enneacanthus chaetodon	blackbanded sunfish	Intermediate	Insectivore
E. gloriosus	bluespotted sunfish	Intermediate	Insectivore
E. obesus	banded sunfish	Intermediate	Insectivore
Lepomis auritus	redbreast sunfish	Tolerant	Insectivore
L. cyanellus	green sunfish	Tolerant	Insectivore
L. gibbosus	pumpkinseed	Intermediate	Insectivore
L. gulosus	warmouth	Intermediate	Insectivore
L. macochirus	bluegill	Intermediate	Insectivore
L. marginatus	dollar sunfish	Intermediate	Insectivore
L. microlophus	redear sunfish	Intermediate	Insectivore
Lepomis sp.	hybrid sunfish	Tolerant	Insectivore
Micropterus dolomieu	smallmouth bass	Intolerant	Piscivore

Table E-5 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
M. punctulatus	spotted bass	Intermediate	Piscivore
M. salmoides	largemouth bass	Intermediate	Piscivore
Pomoxis annularis	white crappie	Intermediate	Piscivore
P. nigromaculatus	black crappie	Intermediate	Piscivore
Percidae	**darters and perches**		
Etheostoma collis	Carolina darter	Intermediate	Insectivore
E. flabellare	fantail darter	Intermediate	Insectivore
E. fusiforme	swamp darter	Intermediate	Insectivore
E. nigrum	johnny darter	Intermediate	Insectivore
E. olmstedi	tessellated darter	Intermediate	Insectivore
E. podostemone	riverweed darter	Intolerant	Insectivore
E. serrifer	sawcheek darter	Intolerant	Insectivore
E. vitreum	glassy darter	Intermediate	Insectivore
Perca flavescens	yellow perch	Intermediate	Piscivore
Percina nevisense	chainback darter	Intolerant	Insectivore
P. roanoka	Roanoke darter	Intolerant	Insectivore
Sander vitreus	walleye	Intermediate	Piscivore
Sciaenidae	**drums and croakers**		
Aplodinotus grunniens	freshwater drum	Intermediate	Insectivore
Elassomatidae	**pygmy sunfishes**		
Elassoma zonatum	banded pygmy sunfish	Intermediate	Insectivore

Appendix F. Fish community data collected from the Roanoke River basin, 1990 - 2004. Current basinwide sites are in bold font.

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
030201						
Dan R	SR 1416	Stokes	22-(1)	04/19/04	52	Good
Archies Cr	SR 1415	Stokes	22-2	04/19/04	54	Excellent
Elk Cr	SR 1433	Stokes	22-5	04/20/04	44	Good-Fair
Peters Cr	SR 1497	Stokes	22-6	04/21/04	54	Excellent
Big Cr	SR 1471	Stokes	22-9	04/20/04	48	Good
N Double Cr	SR 1504	Stokes	22-10	04/20/04	42	Good-Fair
S Double Cr	SR 1483	Stokes	22-11	04/20/04	46	Good
Snow Cr	SR 1652	Stokes	22-20	04/21/04	46	Good
Town Fork Cr	SR 1955	Stokes	22-25	04/21/04	48	Good
030202						
Big Beaver Island Cr	US 311	Rockingham	22-29	04/22/04	52	Good
Pawpaw Cr	SR 1360	Rockingham	22-30-6-(1)	04/22/04	44	Good-Fair
				08/03/90	48	Good
Hogans Cr	NC 704	Rockingham	22-31	04/22/04	48	Good
Jacobs Cr	NC 704	Rockingham	22-32-(0.5)	04/22/04	50	Good
030203						
Rock House Cr	SR 2127	Rockingham	22-34-(2)	04/23/04	48	Good
Matrimony Cr	NC 770	Rockingham	22-38	04/23/04	52	Good
Wolf Island Cr	SR 1767	Rockingham	22-48	04/23/04	50	Good
Wolf Island Cr	NC 700	Caswell	22-48	10/05/94	54	Excellent
Hogans Cr	SR 1330	Caswell	22-50	05/25/04	52	Good
Jones Cr	SR 2571	Rockingham	22-50-3	06/08/04	48	Good
030204						
Moon Cr	SR 1511	Caswell	22-51	04/30/04	46	Good
				09/07/94	44	Good-Fair
Rattlesnake Cr	SR 1523	Caswell	22-52	05/25/04	48	Good
Cane Cr	SR 1527	Caswell	22-54	05/25/04	46	Good
				10/05/94	46	Good
Country Line Cr	NC 57	Caswell	22-56-(3.7)	09/07/94	48	Good
030205						
N Hyco Cr	US 158	Caswell	22-58-1	04/30/04	30	Poor
S Hyco Cr	US 158	Person	22-58-4-(3)	04/30/04	52	Good
Marlowe Cr	SR 1322	Person	22-58-12-9	04/28/04	42	Good-Fair
				09/07/94	40	Good-Fair
030206						
Aarons Cr	SR 1400	Granville	22-59	04/28/04	46	Good
Grassy Cr	SR 1300	Granville	23-2-(1)	06/09/99	46	Good
Grassy Cr	SR 1436	Granville	23-2-(1)	06/02/94	50	Good
Johnson Cr	SR 1440	Granville	23-2-7-(1)	04/28/04	44	Good-Fair
Island Cr	SR 1445	Granville	23-4	06/09/99	54	Excellent
				06/02/94	50	Good
Little Island Cr	SR 1348	Vance	23-4-3	04/29/04	30	Poor
Nutbush Cr	SR 1317	Vance	23-8-(1)	04/29/04	38	Fair
				10/04/94	44	Good-Fair
030207						
Smith Cr	US 1	Warren	23-10	04/29/04	38	Fair
				05/12/94	42	Good-Fair
Sixpound Cr	SR 1306	Warren	23-13	05/12/94	42	Good-Fair
030208						
Deep Cr	US 158	Halifax	23-24-(1)	05/26/04	46	Good
				09/21/94	50	Good
Chockoyotte Cr	US 158	Halifax	23-29	05/26/04	---	Not Rated
Quankey Cr	SR 1619	Halifax	23-30	09/21/94	38	Fair
Conoconnara Swp	NC 561	Halifax	23-33	09/21/94	---	Not Rated
Kehukee Swp	SR 1804	Halifax	23-42	10/27/94	---	Not Rated
030210						
Cashie R	SR 1257	Bertie	24-2-(1)	10/26/94	---	Not Rated

Appendix G. Fish community metric values from 30 wadeable streams in the Piedmont and Coastal Plain region of the Roanoke River basinwide monitoring program, 2004.[1]

Subbasin Waterbody	Location	County	d. a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. Sunfish	No. Sp. Suckers	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
030201																
Dan R	SR 1416	Stokes	71.4	04/19/04	18	634	5	0	3	3	0	23	77	0.00	0.00	78
Archies Cr	SR 1415	Stokes	9.3	04/19/04	21	601	5	1	3	4	3	27	72	0.83	0.00	76
Elk Cr	SR 1433	Stokes	8.5	04/20/04	21	610	5	1	2	4	4	45	55	0.33	0.00	43
Peters Cr	SR 1497	Stokes	28.6	04/21/04	24	431	6	2	4	5	11	35	65	0.46	0.23	54
Big Cr	SR 1471	Stokes	32.7	04/20/04	17	413	4	3	3	2	26	44	56	0.00	0.00	76
N Double Cr	SR 1504	Stokes	12.4	04/20/04	18	539	3	1	2	0	9	45	54	0.19	0.00	61
S Double Cr	SR 1483	Stokes	16.4	04/20/04	22	216	5	2	4	2	38	26	74	0.00	0.00	55
Snow Cr	SR 1652	Stokes	22.7	04/21/04	16	249	2	1	2	1	29	30	70	0.00	0.00	81
Town Fork Cr	SR 1955	Stokes	28.0	04/21/04	21	306	3	3	5	1	26	43	57	0.00	0.00	52
030202																
Big Beaver Island Cr	US 311	Rockingham	23.8	04/22/04	22	247	5	3	3	2	13	27	73	0.00	0.40	59
Pawpaw Cr	SR 1360	Rockingham	8.1	04/22/04	18	527	3	3	1	0	4	38	62	0.00	0.00	72
Hogans Cr	NC 704	Rockingham	23.0	04/22/04	17	284	3	1	4	1	5	13	87	0.00	0.00	41
Jacobs Cr	NC 704	Rockingham	36.2	04/22/04	19	176	4	2	4	1	10	20	79	0.57	0.00	53
030203																
Rock House Cr	SR 2127	Rockingham	23.0	04/23/04	17	417	4	3	3	1	21	38	62	0.00	0.96	71
Matrimony Cr	NC 770	Rockingham	25.5	04/23/04	22	666	5	3	4	2	12	22	78	0.00	0.30	59
Wolf Island Cr	SR 1767	Rockingham	43.2	04/23/04	21	177	2	3	6	1	18	32	66	2.26	0.00	48
Hogans Cr	SR 1330	Caswell	92.6	05/25/04	20	178	4	3	3	2	31	11	87	1.69	0.00	45
030204																
Moon Cr	SR 1511	Caswell	47.2	04/30/04	16	104	3	4	0	1	41	13	86	1.92	0.00	38
Rattlesnake Cr	SR 1523	Caswell	23.7	05/25/04	19	184	2	4	1	1	36	19	79	1.63	2.72	53
Cane Cr	SR 1527	Caswell	19.6	05/25/04	24	256	2	4	1	0	37	29	70	0.78	1.17	42
030205																
N Hyco Cr	US 158	Caswell	45.9	04/30/04	15	154	2	3	3	0	22	9	91	0.00	3.25	47
S Hyco Cr	US 158	Person	56.5	04/30/04	21	237	2	4	3	0	30	10	88	2.11	2.11	62
Marlowe Cr	SR 1322	Person	17.8	04/28/04	21	1027	1	4	3	0	16	60	40	0.19	0.00	67
030206																
Aarons Cr	SR 1400	Granville	27.6	04/28/04	15	791	2	4	2	0	5	12	88	0.00	0.38	60
Johnson Cr	SR 1440	Granville	7.6	04/28/04	13	339	1	3	1	0	8	8	88	4.42	0.59	54
Little Island Cr	SR 1348	Vance	20.0	04/29/04	13	111	2	4	0	0	9	1	91	8.11	4.50	46
Nutbush Cr	SR 1317	Vance	6.5	04/29/04	13	392	1	3	0	0	10	63	33	3.83	0.00	54
030207																
Smith Cr	US 1	Warren	52.9	04/29/04	18	217	1	3	1	0	12	9	84	6.45	5.99	39
030208																
Deep Cr	US 158	Halifax	23.5	05/26/04	28	316	2	7	2	0	44	18	81	0.95	0.00	43
Chockoyotte Cr	US 158	Halifax	21.2	05/26/04	19	458	2	5	1	1	36	3	51	45.6	0.44	68

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

Appendix H. Fish distributional records for the Roanoke River basin.

Based upon Menhinick (1991), Rohde, *et al*. (1998, 2001, and 2003), NC DWQ's data, and data from other researchers, approximately 108 species have been collected from the Roanoke River basin in North Carolina (Table E-5). The known species assemblage includes 24 species of minnows, 13 species of suckers, 17 species of sunfish and bass, and 10 species of darters. A color variant of the margined madtom (the "speckled" madtom, *Noturus insignis* subspecies 1) was collected at the Dan River site. At least 25 of the 108 species (about 23 percent of the total basin fauna) are exotics that were introduced either as sportfish, baitfish, or for reasons unknown. Streams that did not have any exotics included North Double, Snow, and Hogans (Rockingham County) Creeks.

In 2004, 61 of the 108 species were collected during NC DWQ's fish community monitoring program. The most commonly collected species were the bluehead chub and the redbreast sunfish (collected at 28 of the 30 sites). The most abundant species was the bluehead chub which constituted almost one-quarter of all the fish collected. It was also the numerically dominant species at 15 of the 30 sites.

Eight of the 108 species have been given special protection status by the by the United States Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337 (LeGrand, *et al*. 2004; Menhinick and Braswell 1997) (Table 1). Additional information on these eight species may be found in Jenkins and Burkhead (1993), Menhinick and Braswell (1997), and Rohde, *et al*. (1998, 2001, and 2003). In 2004, five of the eight species were collected as part of the NC DWQ's fish community monitoring program (Table H-2). The rustyside sucker and the orangefin madtom were not collected in 2004 during the assessments of streams in Stokes County. Their continued status as State-Endangered is warranted.

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

Species	Common Name	State or Federal Status	State Rank[1]
Acipenser oxyrhynchus	Atlantic sturgeon	State - Special Concern	S3
Exoglossum maxillingua	cutlip minnow	State – Endangered (Proposed Special Concern)	S1
Scartomyzon ariommus	bigeye jumprock	State - Threatened	S2
Thoburnia hamiltoni	rustyside sucker	State - Endangered	S1
Noturus gilberti	orangefin madtom	State - Endangered	S1
Cottus caeruleomentum	Blue Ridge sculpin	State – Significantly Rare (Proposed Special Concern)	S1
Etheostoma collis population 2	Carolina darter	State - Special Concern	S2
Etheostoma podostemone	riverweed darter	State - Special Concern	S2

[1]S1 = critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina; S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; S3 = rare or uncommon in North Carolina (LeGrand et al 2004).

Table H-2. Number of specimens of species of fish listed as endangered, rare, threatened, or of special concern that were collected in the Roanoke River basin in North Carolina, 2004.

	Waterbody						
Species	Dan R	Archies Cr	Elk Cr	Peters Cr	Big Cr	Matrimony Cr	L Island Cr
Exoglossum maxillingua	65	11	1	---	---	---	---
Scartomyzon ariommus	---	---	---	2	---	---	---
Cottus caeruleomentum	55	---	---	---	---	---	---
Etheostoma collis population 2	---	---	---	---	---	---	1
Etheostoma podostemone	8	6	1	1	1	1	---

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

- Brown trout (wild) – Elk Creek (Stokes County);
- Comely shiner – Nutbush Creek (Vance County), Smith Creek (warren County), and Chockoyotte Creek (Halifax County); and
- Carolina darter – Little Island Creek (Vance County).

Appendix I. Water quality at fish community sites in the Roanoke River basin in 2004.

In 2004 water quality data were collected at every site during fish community assessments (Table I-1). Conductivity (specific conductance) ranged from 37 to 467 µmhos/cm at Archies and Nutbush Creeks, respectively (FigureI-1). Measurements were the greatest below wastewater treatment facilities on Marlowe and Nutbush Creeks. Conductivity was the lowest in Subbasin 01 and generally increased eastward across the basin. All dissolved oxygen concentrations were greater than the water quality standard of 5 mg/L. Dissolved oxygen saturation ranged from 72 percent at South Hyco Creek to 112 percent at North Double Creek. All pH measurements were within the water quality standard for non-swamp waters and ranged from 6.0 to 7.4 s.u. at Big Beaver Island and Nutbush Creeks, respectively.

Table I-1. Water quality measurements at 30 fish community sites in the Roanoke River basin, 2004.

Subbasin/ Waterbody	Location	County	Date	Temperature (˚C)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	Saturation (%)	pH (s.u.)
030201								
Dan R	SR 1416	Stokes	04/19/04	13.5	46	10.9	105	6.5
Archies Cr	SR 1415	Stokes	04/19/04	18.5	37	9.8	105	6.4
Elk Cr	SR 1433	Stokes	04/20/04	20.5	41	9.7	108	6.5
Peters Cr	SR 1497	Stokes	04/21/04	15.5	49	9.5	95	6.3
Big Cr	SR 1471	Stokes	04/20/04	15.3	47	9.6	96	6.2
N Double Cr	SR 1504	Stokes	04/20/04	16.4	49	11.0	112	6.8
S Double Cr	SR 1483	Stokes	04/20/04	18.2	46	10.0	106	6.1
Snow Cr	SR 1652	Stokes	04/21/04	17.4	55	9.8	102	7.0
Town Fork Cr	SR 1955	Stokes	04/21/04	20.2	84	9.5	105	7.0
030202								
Big Beaver Island Cr	US 311	Rockingham	04/22/04	16.8	62	9.0	93	6.0
Pawpaw Cr	SR 1360	Rockingham	04/22/04	14.6	53	9.1	89	6.4
Hogans Cr	NC 704	Rockingham	04/22/04	18.8	56	9.4	101	7.0
Jacobs Cr	NC 704	Rockingham	04/22/04	20.7	70	8.8	98	7.1
030203								
Rock House Cr	SR 2127	Rockingham	04/23/04	16.8	86	9.3	96	6.5
Matrimony Cr	NC 770	Rockingham	04/23/04	16.2	70	9.2	94	6.1
Wolf Island Cr	SR 1767	Rockingham	04/23/04	20.0	100	8.8	97	6.4
Hogans Cr	SR1330	Caswell	05/25/04	22.6	111	6.7	78	6.4
030204								
Moon Cr	SR1511	Caswell	04/30/04	17.5	89	8.2	86	7.2
Rattlesnake Cr	SR1523	Caswell	05/25/04	23.4	129	7.3	86	6.5
Cane Cr	SR1527	Caswell	05/25/04	24.8	128	6.9	83	6.3
030205								
N Hyco Cr	US 158	Caswell	04/30/04	17.0	107	8.0	83	7.2
S Hyco Cr	US 158	Person	04/30/04	16.2	106	7.1	72	6.7
Marlowe Cr	SR 1322	Person	04/28/04	12.4	220	9.6	90	6.6
030206								
Aarons Cr	SR 1400	Granville	04/28/04	15.4	77	9.0	90	6.3
Johnson Cr	SR 1440	Granville	04/28/04	16.8	129	9.7	100	6.7
Little Island Cr	SR 1348	Vance	04/29/04	12.9	106	8.8	83	6.4
Nutbush Cr	SR 1317	Vance	04/29/04	14.6	467	10.6	104	7.4
030207								
Smith Cr	US 1	Warren	04/29/04	18.0	91	6.9	73	6.3
030208								
Deep Cr	US 158	Halifax	05/26/04	23.9	86	6.3	75	6.5
Chockoyotte Cr	US 158	Halifax	05/26/04	27.7	123	7.2	92	6.8

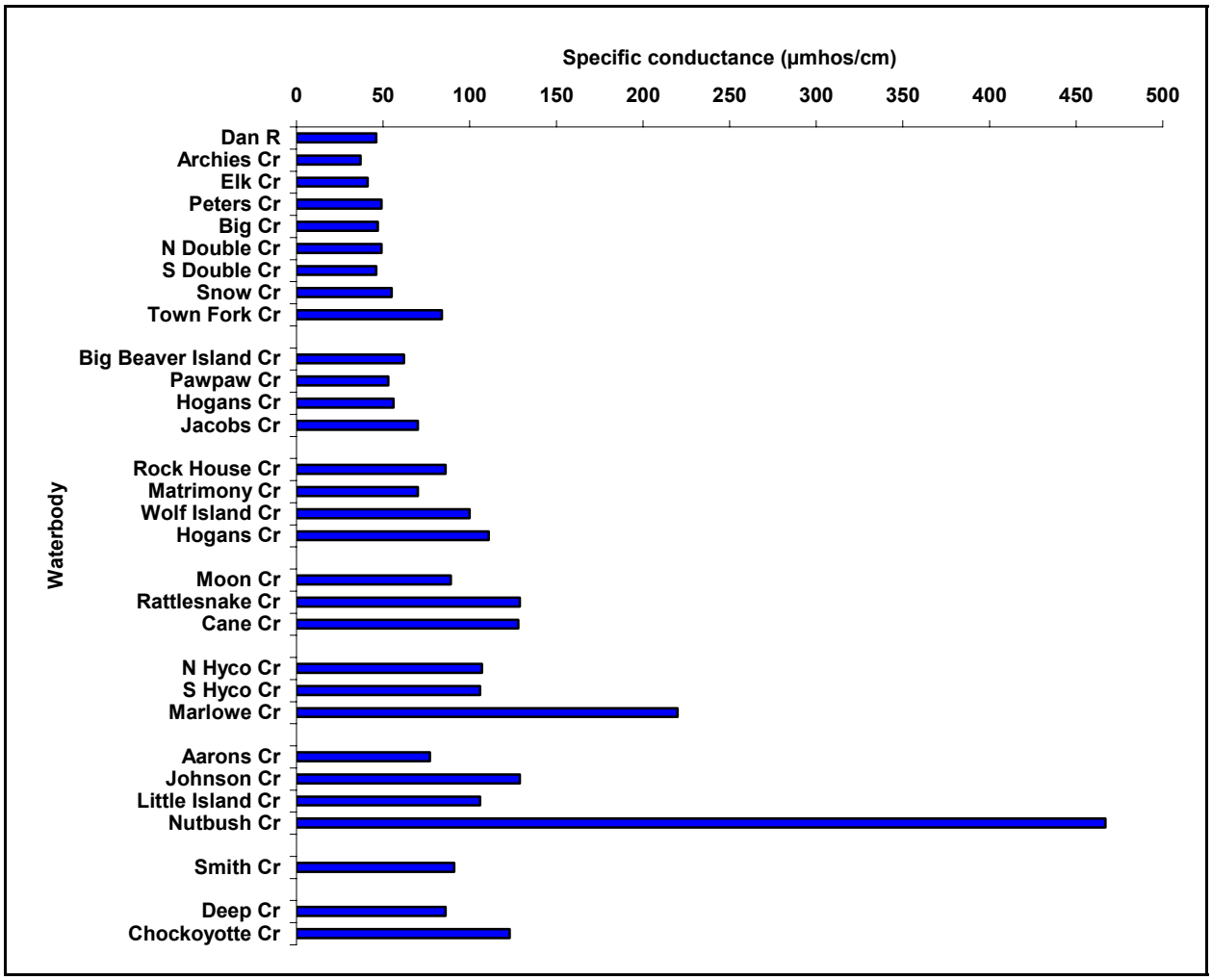

Figure I-1. Specific conductance at 30 fish community sites in the Roanoke River basin, 2004.

Appendix J. Web links.

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

NC Division of Waste Management (Queen Mine) -- http://www.wastenotnc.org/SFHOME/IHS_County_List.pdf

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

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

LAKE & RESERVOIR ASSESSMENTS – Roanoke River Basin

Roanoke Rapids Lake
Halifax/Northampton Counties

Assessment Overview

Eleven Roanoke River Basin lakes were sampled by the Division in June through September of 2004. Information from those lakes is discussed below and presented in a table later in this section and raw data as well as other information is available on the web at http://www.esb.enr.state.nc.us/. Generally, lake condition was similar to previous years. Farmer Lake and Lake Roxboro had elevated chlorophyll *a* and dissolved oxygen concentrations; however, all other parameters were normal. While blue-green algae dominated the phytoplankton assemblages in Farmer Lake, Lake Roxboro had a diverse assemblage including species that may cause taste and odor problems in drinking water.

Subbasin 030201

Hanging Rock Lake, Kernersville Reservoir and Belews Lake were monitored in this subbasin by DWQ in June, July, and August of 2004.

Hanging Rock Lake is a small reservoir located inside Hanging Rock State Park. Low chlorophyll *a* and nutrient concentrations were found throughout the summer of 2004 indicating low biological productivity. The NCTSI score also indicated low biological productivity and oligotrophic status. Water clarity was good with secchi disk readings ranging from 2.5 to 3 meters. Hanging Rock Lake fully supported all designed uses and, as has been seen in historical monitoring, exhibited excellent water quality.

Kernersville Reservoir is a backup water supply for the Town of Kernersville. Water quality monitoring indicated moderately high nutrient and chlorophyll *a* levels. The NCTSI score confirmed high biological productivity and eutrophic conditions. Water clarity was somewhat reduced and typical of a eutrophic lake with secchi disk readings generally less than one meter on most sampling visits. Manganese levels were equal to or above the water supply criteria of 200 *u*g/L on two sampling visits in 2004, but this is not unusual considering the small size of Kernersville Reservoir and potential for bottom disturbances, and the presence of manganese in local soil types.

Belews Lake water quality sampling indicated low concentrations of nutrients and chlorophyll *a*. The NCTSI scores indicated low biological productivity and oligotrophic conditions, as has been seen in historical sampling. Water clarity was good with secchi disk readings ranging from 2.5 to 4.0 meters throughout the summer. Water temperatures were seen above the state water quality standard for temperature on some sampling visits but this has been seen in historical sampling and is due to the discharge from Duke Power's Belews Creek Steam Station coal-fired power plant. A consumption advisory against eating fish contaminated with selenium due to a now closed coal ash disposal basin at the power plan was rescinded in August of 2000 since selenium levels have declined in the fish (Luanne Williams, NC Division of Public Health, personal communication). Additionally Duke Power has performed chemical treatment on about 100 acres in 2004 to control *Hydrilla* in Belews Lake (Rob Emens, N.C. Division of Water Resources, personal communication).

Duke Power has also conducted water quality sampling and benthic macroinvertebrate and fisheries monitoring of Belews Lake summarizing monitoring performed through the year 2000 (Duke Power, 2001). The dry fly ash discharge from the Belews Creek Steam Station was rerouted from Belews Lake to the Dan River in 1985. This monitoring has shown that Belews Lake water chemistry has improved since the mid 1980's. Sediment arsenic and selenium levels in the lake have remained elevated relative to non-impacted sites but have gradually declined. Selenium levels in benthic macroinvertebrates have also declined but levels in macroinvertebrates collected in the downstream portion of the lake were higher than those collected in the upstream portion of the lake. The benthic macroinvertebrate species diversity indicates that the Belews Creek Steam Station is not impacting the benthic macroinvertebrate community. Selenium concentrations in the fish in Belews Lake are not high enough to pose a threat to fish or human populations. The fish community in Belews Lake was found to be typical to that in a piedmont lake of similar productivity indicating no impact from the power plant.

Subbasin 030204

Farmer Lake was monitored in 2000, 2001, 2002, and 2004. Moderate nutrient and chlorophyll *a* levels were generally found each year indicating biological productivity. The NCTSI score calculated for 2004 placed Farmer Lake in a eutrophic status confirming biological productivity. High dissolved oxygen saturation values have also been found indicating algal activity. Algal analyses of samples collected in August of 2004 at the upper lake and in mid-lake indicated a moderate to severe blue-green algal bloom at both stations. The algal bloom was composed primarily of the blue-green algae *Cylindrospermopsis*. Some strains of this species have the ability to produce toxins but there have been no reports in North Carolina of humans becoming ill from blue-green toxins or evidence that this strain exhibited any toxicity. Water clarity in this lake is somewhat reduced due to sedimentation, especially at the most upstream station where secchi disk readings were consistently less than one meter.

Subbasin 030205

Lake Roxboro, Lake Isaac Walton, Mayo Lake and Hyco Lake were monitored in this subbasin.

Lake Roxboro was monitored in 2000, 2001, 2002, and 2004. This water quality monitoring indicated moderate to elevated nutrient and chlorophyll *a* concentrations. Some exceedances of the state standard for chlorophyll *a* were also found at this reservoir. The NCTSI score for Lake Roxboro indicated eutrophic conditions and high biological productivity. High dissolved oxygen saturation values were also found confirming algal activity. Algal analyses of samples collected in the summer of 2004 indicated moderate algal blooms all three months. These blooms were composed of a diverse assemblage and included species associated with agricultural runoff and species that may cause taste and odor problems in drinking water.

Lake Isaac Walton was monitored in June, July, August, and September of 2004. Moderate nutrient and chlorophyll *a* concentrations were generally found in the lake each month. The NCTSI score calculated indicated slightly eutrophic conditions. A couple of high manganese values were found in the lake above the state standard for water supply reservoirs but these values were probably due to high amounts of naturally occurring manganese in local soil types and the small size of the lake indicating a potential for disturbance of the bottom sediments and does not indicate a cause for concern.

Mayo Lake was monitored by DWQ in June, July, and September of 2004. Water quality sampling indicated low to moderate nutrient and chlorophyll *a* concentrations. The NCTSI score for Mayo Lake also confirmed moderate biological productivity with a mesotrophic status. Mayo Lake has generally rated as oligotrophic (low biological productivity) in historical sampling. Water clarity was very good in this lake (secchi range = 1.8 to 3.5 meters), as has been seen in historical sampling. The aquatic weed *Hydrilla* was observed in the lake, especially in the cove areas, but not yet at problematic conditions. No aquatic weed control measures are currently in place. A Progress Energy power plant is located near the dam at this lake and most of the shoreline was forested.

Progress Energy has conducted water quality sampling applicable to the basinwide schedule of this report and published reports for this data (Progress Energy 2001, 2002, 2003, 2004). In 2000, concentrations of most limnological and trace element variables were highest near the power plant ash pond discharge and decreased rapidly with distance away from the discharge. All trace element concentrations were below the state water quality standards except for two arsenic values near the ash pond discharge. Arsenic concentrations in the sediments and tissues of zooplankton and benthic invertebrates were seen to follow an increasing trend during the period of 1996-2000 at the station near the ash pond discharge. Selenium concentrations in fish muscle tissues were also higher at the station near the ash pond discharge. The fish community composition was determined to be typical of a southeastern reservoir during 2000.

In 2001, concentrations of most limnological and trace element variables were again highest near the ash pond discharge and decreased with distance away from the discharge. Arsenic concentrations were detected above the water quality standard once during the year at the station nearest the ash pond discharge. Arsenic and selenium concentrations in the sediments and tissues of zooplankton and benthic invertebrates at the station near the ash pond discharge were greater than at other stations. Selenium concentrations in the sediments near the ash pond discharge were elevated in 2001. No significant accumulation of arsenic in fish tissues was evident at the station nearest the ash pond discharge in 2001. Greater concentrations of

selenium were detected in the tissues of largemouth bass and catfish collected near the ash pond discharge however concentrations were well below detrimental thresholds. Fish community composition was typical of those found in southeastern reservoirs.

In 2002, trace element and most limnological variables remained highest near the ash pond discharge and decreased rapidly with distance. Arsenic concentrations were detected above the water quality standard once in 2002 at the station near the ash pond discharge. Arsenic and selenium concentrations in the sediments and tissues of zooplankton and benthic invertebrates were also higher at the station near the ash pond discharge than at other locations in the lake. No higher concentrations of arsenic were found in the fish tissue at the station near the ash pond discharge than at other locations in the lake but selenium concentrations in fish tissue at this station were higher than at other locations. Selenium concentrations in the fish tissue were below thresholds considered detrimental. The fish community composition was found to be healthy and typical of that found in a southeastern lake.

In 2003, trace element and most limnological variables were again highest near the ash pond discharge and decreased rapidly with distance. Higher precipitation in the spring resulted in greater than expected concentrations of many water quality variables in sampling performed in April and June. Arsenic was found above the water quality standard at the station near the ash pond discharge in April and June. Arsenic and selenium concentrations in the sediments near the ash pond discharge were higher than at other locations. Selenium concentrations in fish tissue were also higher near the ash pond discharge but were below thresholds considered detrimental. Significant arsenic concentrations in the fish tissue at the station near the ash pond discharge were not found. Fish community composition was healthy and typical of a southeastern lake. Benthic invertebrates also had higher arsenic concentrations at the station near the ash pond discharge.

Hyco Lake was monitored by DWQ in June, July, and September of 2004. Low concentrations for most nutrient parameters and chlorophyll *a* were generally found each month. The NCTSI scores calculated for this lake indicated moderate biological productivity and mesotrophic conditions. Water clarity was generally good in this lake with secchi disk readings ranging from 1.3 to 2.9 meters. A consumption advisory against eating fish contaminated with selenium due to a now closed coal ash disposal basin at the power plan was rescinded in August of 2001 since selenium levels have declined in the fish (Luanne Williams, NC Division of Public Health, personal communication).

Progress Energy has conducted water quality sampling of Hyco Lake applicable to the basinwide schedule of this report and published reports for this data (Progress Energy 2001, 2002, 2003, 2004). Historical problems of selenium accumulation due to the power plant discharge were addressed in 1990 with a conversion to a dry fly ash handling system. In 2000, selenium concentrations in surface water were well below the state standard. Selenium levels in plankton, benthic invertebrates, and in the liver and muscle tissue of fish (white catfish, bluegill, largemouth bass) were seen to follow a declining trend. The fish community was also seen to have shifted from a selenium tolerant community to a more balanced community typical of piedmont lakes of similar biological productivity.

In 2001, selenium concentrations were below the state water quality standard. No consistent trends were seen for selenium concentrations in the sediments or in plankton, benthic invertebrates or fish over the past 5 years. The mean selenium concentration in 2001 in all media was similar or less than the respective concentration in 2000. The fish community was seen to be normal and typical of that found in other piedmont lakes. Good reproduction of

largemouth bass and bluegill was indicated by the large number of young fish collected during sampling.

In 2002, all trace element and selenium concentrations were below applicable state water quality standards and action levels. All other limnological variables were noted to be within the range expected for a piedmont reservoir. Trace element concentrations in the sediments and tissues of aquatic organisms were well below detrimental levels. Similar to previous years, arsenic and selenium concentrations were higher in the sediments and tissues of benthic invertebrates at the station nearest the ash pond discharge. Fish muscle selenium concentrations were higher near the ash pond discharge, however both arsenic and selenium concentrations continued a decreasing trend over the past ten years. The fish community was seen to be typical of that found in a piedmont lake with the young fish collected indicating successful reproduction.

In 2003, all limnological parameters were within the range of values found in a typical piedmont lake. Trace element concentrations in the surface waters, sediments and tissues of aquatic organisms were well below detrimental thresholds. As has been seen in past years, arsenic and selenium concentrations in the sediments and tissues of aquatic invertebrates were higher at the station near the ash pond discharge than at the upstream station in the lake. Arsenic and selenium concentrations in fish tissue were not significantly different between the station located near the ash pond discharge and the upstream station. The fish community found was typical of a piedmont reservoir and good numbers of young bluegill and largemouth bass collected indicated successful reproduction.

Subbasin 030206

Kerr Reservoir was monitored by DWQ in June, July, and August of 2004. Moderate nutrient and chlorophyll *a* levels were found. The NCTSI score calculated for Kerr Reservoir also indicated moderate biological productivity and mesotrophic status. This lake has historically rated either mesotrophic or slightly eutrophic (biologically productive) in historical water quality sampling. Some high dissolved oxygen saturation values were found in 2004 indicating algal activity, although no visible algal blooms or chlorophyll *a* water quality standards violations were found.

Subbasin 030207

Lake Gaston was monitored by DWQ in June, July, and August of 2004. Moderate nutrient and chlorophyll *a* levels were found. The NCTSI scores calculated for this lake reflect mesotrophic conditions and moderate biological productivity. This lake has generally rated as mesotrophic since sampling was first performed in 1981. The aquatic weed *Hydrilla* was observed in the lake in 2004, especially near the shoreline in the upstream part of the lake. Aquatic weed control measures to attempt to control the *Hydrilla* that is present in this lake have been made by a contractor in recent years. These measures included the stocking of grass carp and chemical spraying (Rob Emens, N.C. Division of Water Resources, personal communication).

Subbasin 030208

Roanoke Rapids Lake was monitored by DWQ in June, July, and August of 2004. Low nutrient and chlorophyll *a* concentrations found indicated low biological productivity with respect to algal activity. The NCTSI score reflected this low biological productivity with slightly oligotrophic conditions found. Water clarity was generally good in this lake with secchi disk readings greater than 2 meters on most occasions. Large areas of aquatic weeds were observed in Roanoke Rapids Lake in 2004, primarily in the center of the lake. These weeds were Hydrilla, Egeria (Brazilian Elodea) and Mariophyllum spicatum (Eurasian Watermilfoil). No aquatic weed control measures have been made at this reservoir due to economic reasons (Rob Emens, N.C. Division of Water Resources, personal communication).

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LAKES ASSESSMENT – ROANOKE RIVER BASIN

Subbasin		030201			030204		030205			030206	030207	030208
Waterbody		***Hanging Rock Lake***	***Kernersville Reservoir***	***Belews Lake***	***Farmer Lake***	***Lake Roxboro***	***Lake Isaac Walton***	***Mayo Lake***	***Hyco Lake***	***Kerr Reservoir***	***Lake Gaston***	***Roanoke Rapids Lake***
Classification		B	WS IV, CA	WS-IV, B	W- II HQW, CA	WS-II B HQW	W- II HQW, CA	WS-V	WS-V B	B, C	WS-IV, V B, CA	W- IV, B , CA
Trophic Status (NC TSI)		Oligotrophic	Eutrophic	Oligotrophic	Eutrophic	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Oligotrophic
Mean Depth (meters)		1.0	5.0	15.0	5.5	6.0	3.5	9.0	6.1	10.7	6.0	5.0
Volume ($10^6 m^3$)		0.003	0.4	228.0	6.5	11.0	0.3	105.0	99.0	448.0	512.0	96.0
Watershed Area (mi^2)		0.8	3.5	46.3	48.3	23.9	196.1	51.4	188.0	7610.8	8293.4	8294.2
Sampling Dates		10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04	10/1/99-9/31/04
Number of Samples (click here to see data)		n =12	n =8	n =40	n =36	n =33	n =12	n =9	n =12	n =24	n =27	n =9
Water Quality Standards												
Chlorophyll *a*	>10% above standard (N>9) = Y; exceeding 40 ug/L but not 10% of time = C	NE (n=7)	NE	N	C	C	N	NE	N	N	N	NE
Dissolved Oxygen	Below standard >10% of samples (N>9)	N	NE	N	N	N	N	NE	N	N	N	NE
pH	Below or above standard >10% of samples (N>9)	N	NE	N	N	N	N	NE	N	N	N	NE
Turbidity	>10% above standard (N>9)	N	NE	N	N	E	N	NE	N	N	N	NE
Temperature	Minor and infrequent excursions of temperature standards due to anthropogenic activity. No impairment of species evident. (N>9)	N	NE	Y	N	N	N	NE	N	N	N	NE
Metals (excluding copper, iron & zinc)	>10% above standard (N>9)	NS	NE	N	N	N	N	NE	N	NS	N	NE
Other Data												
% Saturation DO	>10% above >120%	N	NE	N	Y	Y	N	NE	N	N	N	NE
Algae	Documented blooms during 2 or more sampling events in 1 year with historic blooms	N	N	N	N	N	N	N	N	N	N	N
Fish	Kills related to eutrophication	N	N	N	N	N	N	N	N	N	N	N
Chemically/ Biologically Treated	For algal or macrophyte control - either chemicals or biologically by fish, etc.	N	N	Y	N	N	N	N	N	N	Y	N
Aesthetics complaints	Documented sheens, discoloration, etc. - written complaint and follow-up by a state	N	N	N	N	N	N	N	N	N	N	N
TSI	Increase of 2 trophic levels from one 5-yr period to next	N	N	N	N	N	N	N	N	N	N	N
Historic DWQ Data	Conclusions from other reports (link to other reports)	N	N	N	N	N	N	N	N	N	N	N
AGPT	Algal Growth Potential Test 5-9 mg/L = C 10 mg/L or more = P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Macrophytes	Limiting access to public ramps, docks, swimming areas; reducing access by fish and other aquatic life to habitat	N	N	N	N	N	N	N	N	N	P	P
Taste and Odor	Public complaints = P; Potential based on algal spp = C	N	N	N	N	N	N	N	N	N	N	N
Sediments	Clogging intakes – dredging program necessary = P Public/agency complaints – visual	N	N	N	N	N	N	N	N	N	N	N

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

Assessment Methodology

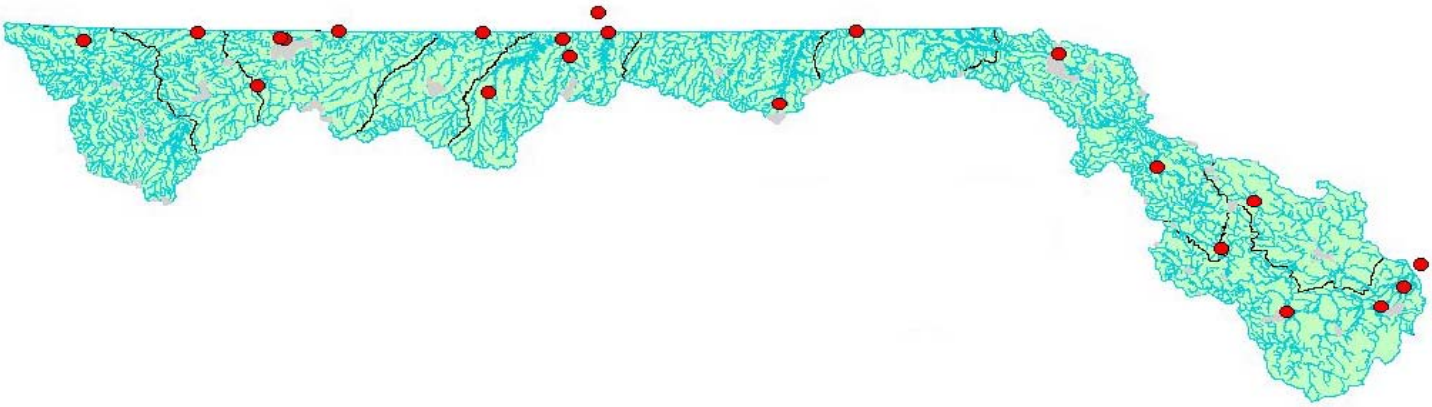
Like streams, lakes are classified for a variety of uses. Most of the lakes monitored as part of North Carolina's Ambient Lakes Monitoring Program are classified for recreation (B & SB) and water supply (WS-I through WS-V). The surface water quality numeric standard specifically associated with recreation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

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

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

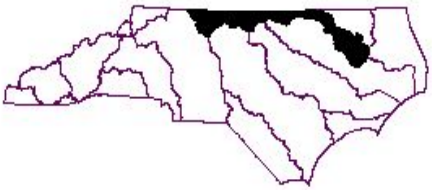
The following sources of information are used in determining lake use support through the weight of evidence approach:

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



Roanoke River Basin
Ambient Monitoring System Report

September 1, 1999 through August 31, 2004



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Evaluation Levels

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

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Summary

A general understanding of human activities and natural forces that affect pollution loads and their potential impacts on water quality can be obtained through routine sampling from fixed water quality monitoring stations. During this assessment period (September 1, 1999 through August 31, 2004) chemical and physical measurements were obtained by DWQ from 22 stations located throughout the Roanoke River Basin.

All results were compared to water quality evaluation levels. The water quality evaluation level may be an ecological evaluation level, a narrative or numeric standard, or an action level as specified in 15A NCAC 2B .0200 (Table 2). When more than 10 percent of the results exceeded the evaluation level, a binomial statistical test was employed to determine if there was sufficient statistical confidence (95% confidence) to conclude that the results statistically exceed the 10% criteria. When that is found to be true, it is termed a *statistically significant exceedance* (SSE). This criterion was applied to all parameters with an evaluation level, except fecal coliform bacteria, which varied based on the classification of the water body. See the Parameters section for an explanation of fecal coliform methods. The results of the data analysis are displayed in tables, box plots, scatter plots, and maps.

All data were collected between September 1, 1999 and August 31, 2004. Stations with SSEs were found for total iron (13 sites), turbidity (four sites), fecal coliform (two sites), dissolved oxygen (< 5.0 mg/L, one site), copper (one site), and water temperature (one site). For all parameters, seven additional 10 percent violations that were not SSEs also occurred.

Introduction

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

The data are used to identify long term trends within watersheds, to develop Total Maximum Daily Loads (TMDLs) and to compare measured values with water quality standards to identify possible areas of impairment. Parametric coverage is determined by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters added when justified (Table 1).

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

Water quality data are evaluated in five year periods. Some stations have little or no data for several parameters over the period. However, for the purpose of standardization, data summaries for each station are included in this report.

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

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

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

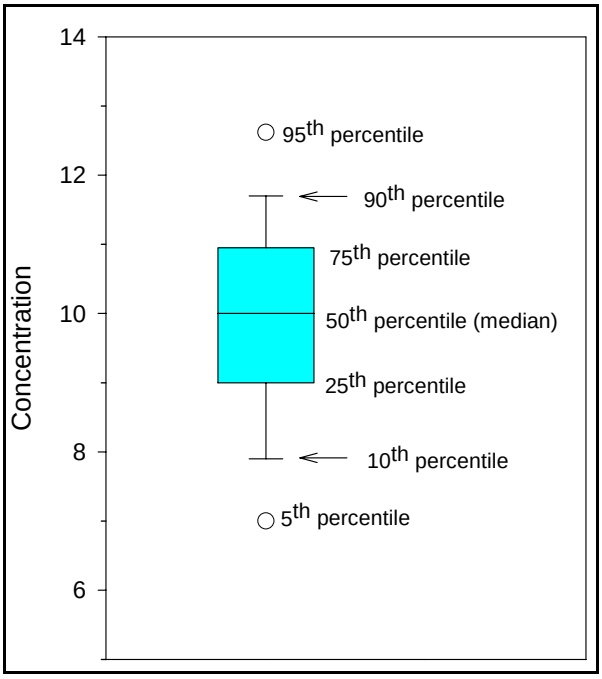


Figure 1. Explanation of box plots.

Table 2. Selected water quality standards for parameters sampled as part of the ambient monitoring system.[1]

Parameter (µg/L, unless noted)	Standards for All Freshwater: Aquatic Life	Human Health	Water Supply Classifications	Standards to Support Additional Uses: Trout Water	HQW	Swamp Waters
Arsenic		10				
Cadmium	2.0			0.4		
Chloride	230,000[2]		250,000			
Chlorophyll *a*, corrected	40[3]			15[3]		
Chromium, total	50					
Coliform, total (MFTCC/100 ml)[4]			50[3] (WS-I only)			
Coliform, fecal (MFFCC/100 ml)[5]		200[3]				
Copper, total	7[2]					
Dissolved oxygen (mg/L)	5.0[6,7]			6.0		[3, 7]
Hardness, total (mg/L)			100			
Iron	1,000[2]					
Lead	25[3]					
Manganese			200			
Mercury	0.012					
Nickel	88		25			
Nitrate nitrogen			10,000			
pH (units)	6.0 - 9.0[3, 7]					[3, 7]
Solids, total suspended (mg/L)					10 Trout, 20 other[8]	
Turbidity (NTU)	50, 25[3]			10[3]		
Zinc	50[2]					

[1]Standards apply to all classifications. For the protection of water supply and supplemental classifications, standards listed under Standards to Support Additional Uses should be used unless standards for aquatic life or human health are listed and are more stringent. Standards are the same for all water supply classifications (Administrative Code 15A NCAC 2B 0200, eff. April 1, 2001).
[2]Action level.
[3]Refer to 2B.0211 for narrative description of limits.
[4]Membrane filter total coliform count per 100 ml of sample.
[5]Membrane filter fecal coliform count per 100 ml of sample.
[6]An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.
[7]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3, if due to natural conditions.
[8]For effluent limits only, refer to 2B.0224(1)(b)(ii).

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

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

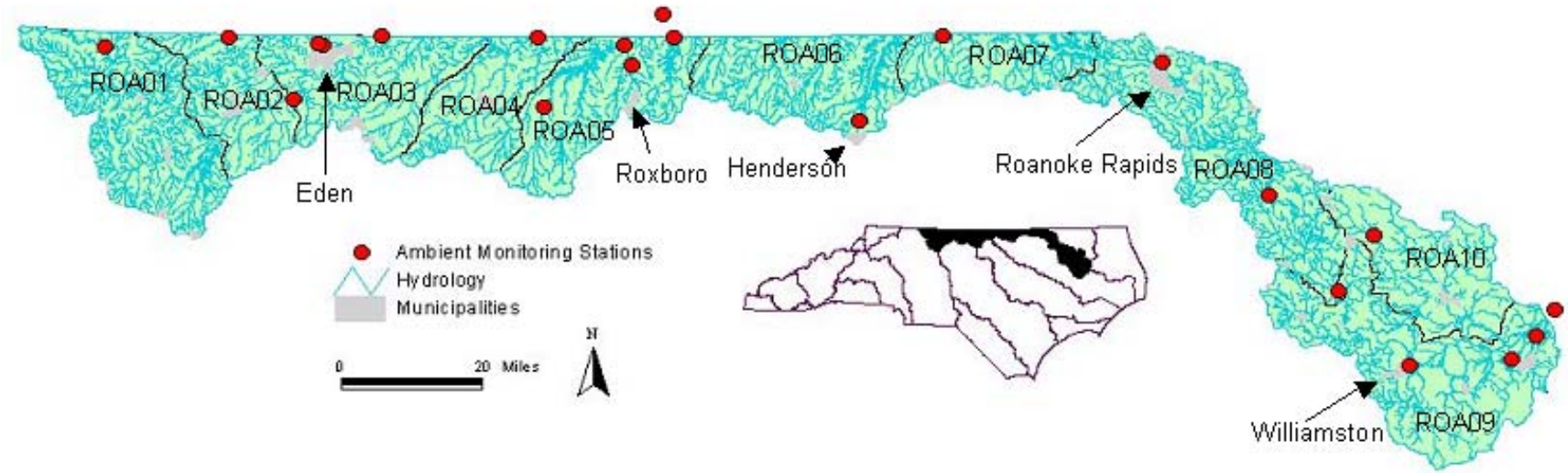


Figure 2. DWQ's ambient monitoring system within the Roanoke River Basin.

Table 3. Monitoring stations in the Roanoke River Basin, 1999 - 2004.

Subbasin	Station	Location	Class	County
01				
	N0150000	Dan River at NC 704 near Francisco	C Tr	Stokes
02				
	N1400000	Mayo River at SR 1358 near Price	WS-V	Rockingham
03				
	N2300000	Dan River at SR 2150 near Wentworth	WS-IV	Rockingham
	N2430000[1]	Smith River at SR 1714 near Eden	WS-IV	Rockingham
	N2450000[2]	Smith River at NC 14 at Eden	WS-IV	Rockingham
	N3000000	Dan River at SR 1761 near Mayfield	C	Rockingham
04				
	N3500000	Dan River at NC 57 at Va Line at Milton	C	Caswell
05				
	N4110000[3]	Hyco Creek at US 158 near Leasburg	C	Caswell
	N4250000	Hyco River Below Afterbay Dam near Mcghees Mill	C	Person
	N4400000[4]	Marlowe Creek at SR 1322 near Woodsdale	C	Person
	N4510000	Hyco River at US 501 near Denniston Va	III NT	Halifax
	N4590000	Mayo Creek at SR 1501 near Bethel Hill	C	Person
06				
	N5000000	Nutbush Creek at SR 1317 near Henderson	C	Vance
07				
	N6400000	Smith Creek at US 1 near Paschall	C	Warren
08				
	N7300000	Roanoke River at NC 48 at Roanoke Rapids	WS-IV CA	Halifax
	N8200000	Roanoke River at US 258 near Scotland Neck	C	Halifax
	N8300000	Roanoke River at NC 11 near Lewiston	C	Martin
09				
	N8550000	Roanoke River at US 13 And US 17 at Williamston	C	Martin
	N9250000	Roanoke River 1.3 Mi Ups Welch Creek near Plymouth	C Sw	Martin
	N9600000	Roanoke River at NC 45 at Sans Souci	C Sw	Bertie
	N9700000	Albemarle Sound at Batchelor Bay near Black Walnut	B Sw	Bertie
10				
	N8950000	Cashie River at SR 1219 near Lewiston	C Sw	Bertie

[1]Sample collection at station N2430000 began on 7/24/00.
[2]Sample collection at station N2450000 ceased on 6/21/00.
[3]Sample collection at station N4110000 ceased on 6/21/00.
[4]Sample collection at station N4400000 was temporarily suspended on 10/7/03.

Data Assessment and Interpretation

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

Percentile statistics were calculated for most of the data using JMP statistical software (version 5.01; SAS Institute, Cary, NC). Values less than the minimum reporting level (non-detects) were evaluated as equal to the reporting level. Box and whisker plots (constructed using SigmaPlot version 8.02) and maps are presented for most water quality parameters collected at each monitoring station. Significant trends in water quality parameters (constructed using Microsoft Excel) are illustrated as scatterplots. Significant trends are found by assessing the probability that the linear model explains the data no better then chance. If that chance is 5% or less (an observed significance probability of 0.05 or less) then that is considered evidence of a regression effect in this document. The strength of the regression effect is given as an r^2 value, the portion of the data that is explained by the linear model.

Analytical Considerations

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

1) Between February and April 2001, improved analytical techniques and protocols for nutrient samples were implemented. No nutrient samples were processed during the period when the techniques and protocols were being implemented.
2) In early 2001 the Laboratory Section reviewed their internal QA/QC programs and some of the analytical methods. This effort resulted in a temporary increase in reporting levels for certain parameters. New analytical equipment and methods were subsequently acquired to establish more accurate reporting levels and rigorous quality assurance. Because of the improvements, the reporting levels quickly declined back down to or near the previous reporting levels. Nutrients were especially affected by these changes (Table 60).

Table 4. Changes in the Laboratory Section's reporting levels for nutrients.

		Reporting level by date (mg/l)			
Parameter	**Method Code**	**Pre-2001**	**3/13/2001 to 3/29/2001**	**3/30/2001 to 7/24/2001**	**7/25/2001 to present**
NH_3	610	0.01	0.5	0.2	0.01
TKN	625	0.1	1.0	0.6	0.20
No_2+NO_3	630	0.01	0.5	0.15	0.01
TP	665	0.01	0.5	0.1	0.02

Providing Confidence in the Exceedances of Water Quality Standards

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

This document uses a nonparametric procedure (Lin *et al.* 2000) to identify when a sufficient number of exceedances have occurred that indicate a true exceedance probability of 10 percent. Calculating the minimum number of exceedances needed for a particular sample size was done using the BINOMDIST function in Microsoft Excel®. This statistical function suggests that at least three exceedances need to be observed in a sample of 10 in order to be [about] 95 percent confident that the results statistically exceed the water quality standard more than 10% of the time. For example, there is less statistical confidence associated with a 1 exceedance out of 10 (73 percent) than when there are 3 exceedances out of 10 (93 percent confidence (Table 5).

Table 5. Exceedance Confidence

Number of Samples	Number of Exceedances 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10	0.74	0.93	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
12	0.66	0.89	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
14	0.58	0.84	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
16	0.51	0.79	0.93	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
18	0.45	0.73	0.90	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	0.39	0.68	0.87	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
22	0.34	0.62	0.83	0.94	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
24	0.29	0.56	0.79	0.91	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26	0.25	0.51	0.74	0.89	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
28	0.22	0.46	0.69	0.86	0.94	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	0.18	0.41	0.65	0.82	0.93	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32	0.16	0.37	0.60	0.79	0.91	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	0.13	0.33	0.55	0.75	0.88	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36	0.11	0.29	0.51	0.71	0.85	0.94	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
38	0.10	0.25	0.46	0.67	0.83	0.92	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	0.08	0.22	0.42	0.63	0.79	0.90	0.96	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
42	0.07	0.20	0.38	0.59	0.76	0.88	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	0.06	0.17	0.35	0.55	0.73	0.85	0.93	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
46	0.05	0.15	0.31	0.51	0.69	0.83	0.92	0.96	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
48	0.04	0.13	0.28	0.47	0.65	0.80	0.90	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	0.03	0.11	0.25	0.43	0.62	0.77	0.88	0.94	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
52	0.03	0.10	0.22	0.40	0.58	0.74	0.86	0.93	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00
54	0.02	0.08	0.20	0.36	0.54	0.71	0.83	0.91	0.96	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00
56	0.02	0.07	0.18	0.33	0.51	0.67	0.81	0.90	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00
58	0.02	0.06	0.16	0.30	0.47	0.64	0.78	0.88	0.94	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00
60	0.01	0.05	0.14	0.27	0.44	0.61	0.75	0.86	0.93	0.97	0.99	0.99	1.00	1.00	1.00	1.00	1.00
62	0.01	0.05	0.12	0.24	0.40	0.57	0.72	0.84	0.91	0.96	0.98	0.99	1.00	1.00	1.00	1.00	1.00
64	0.01	0.04	0.11	0.22	0.37	0.54	0.69	0.81	0.90	0.95	0.98	0.99	1.00	1.00	1.00	1.00	1.00
66	0.01	0.03	0.09	0.20	0.34	0.51	0.66	0.79	0.88	0.94	0.97	0.99	0.99	1.00	1.00	1.00	1.00
68	0.01	0.03	0.08	0.18	0.31	0.47	0.63	0.76	0.86	0.93	0.96	0.98	0.99	1.00	1.00	1.00	1.00
70	0.01	0.02	0.07	0.16	0.29	0.44	0.60	0.74	0.84	0.91	0.96	0.98	0.99	1.00	1.00	1.00	1.00
72	0.00	0.02	0.06	0.14	0.26	0.41	0.57	0.71	0.82	0.90	0.95	0.97	0.99	1.00	1.00	1.00	1.00
74	0.00	0.02	0.05	0.13	0.24	0.38	0.54	0.68	0.80	0.88	0.94	0.97	0.99	0.99	1.00	1.00	1.00
76	0.00	0.01	0.05	0.11	0.22	0.35	0.51	0.65	0.77	0.86	0.93	0.96	0.98	0.99	1.00	1.00	1.00
78	0.00	0.01	0.04	0.10	0.20	0.33	0.48	0.62	0.75	0.85	0.91	0.95	0.98	0.99	1.00	1.00	1.00
80	0.00	0.01	0.04	0.09	0.18	0.30	0.45	0.59	0.72	0.83	0.90	0.95	0.97	0.99	0.99	1.00	1.00

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

Methods Used to Summarize Results

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

Piedmont soils are rich in iron and may confound the interpretation of aqueous iron concentrations. In addition, stations with a supplemental classification of "Swamp Water" and with proportions (%) of results, greater than 10 percent for dissolved oxygen (DO) less than 4.0 or 5.0 mg/L are not included. This is because the low concentrations may be the result of natural (i.e. swampy) conditions. Individual station summary sheets do provide information on iron and include proportions of dissolved oxygen less than 4 and 5 mg/L at stations with a supplemental classification of "Swamp Water".

Use Support Assessment Considerations

1) The dissolved freshwater oxygen concentrations of 5.0 and 4.0 mg/L are presented as evaluation levels. Instantaneous concentrations of 4.0 mg/L or less can occur and may be acceptable if caused by natural (e.g. swampy) conditions.
2) Action levels (copper, iron, and zinc) are used primarily as evaluation guidelines because results include fractions that may have little effect on aquatic life. Where appropriate, follow-up toxicological work will need to be conducted before use support determination can be made for these parameters.
3) The geometric mean and median statistics were calculated for fecal coliform results for each station.

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

Parameters

Dissolved Oxygen

Dissolved oxygen is one of the most important of all the chemical measurements. Dissolved oxygen provides valuable information about the ability of the water to support aquatic life and the capacity of water to assimilate point and nonpoint discharges. Water quality standards for dissolved oxygen vary depending on the classification of the body of water [see, for example: 15A NCAC 02B.0211(1)(b) and 15A NCAC 02B.0220 (1)(b)] but generally results less than 5.0 mg/L can be problematic. Consistent patterns of low concentrations of dissolved oxygen can be subject to intense management review and corrective actions, although patterns of low dissolved oxygen can occur naturally in and near swamp waters.

pH

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

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

Conductivity

In this report, conductivity is synonymous with specific conductance. It is reported in micromhos per centimeter (µmhos/cm) at 25°C. Conductivity is a measure of the ability of water to conduct an electric current. The presence of ions and temperature are major factors in the ability of water to conduct a current. Clean freshwater has a low conductivity, whereas high conductivities may indicate polluted water. Measurements reported are corrected for temperature, thus the range of values reported over a period of time indicate the relative presence of ions in water. Conductivities in US waters commonly vary between 50 to 1,500 µmhos/cm (APHA 1998). According to a USGS study completed in 1992, North Carolina streams have a natural conductance range of 17-65 µmhos/cm.

Conductivity can be used to evaluate variations in dissolved mineral concentrations (ions) among sites with varying degrees of impact resulting from point source discharges. Generally, impacted sites show elevated and widely ranging values for conductivity.

Turbidity

Turbidity data may denote episodic high values on particular dates or within narrow time periods. These can often be the result of intense or sustained rainfall events; however elevated values can occur at other times.

Metals

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

Except for Iron, most of the concentrations rarely exceeded the analytical reporting level. The incidence of concentrations greater than the reporting level is generally too low to interpret statistically.

Nutrients

Compounds of nitrogen and phosphorus are major components of living organisms and thus are essential to maintain life. These compounds are collectively referred to as “nutrients.” Nitrogen compounds include ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN) and nitrite+nitrate nitrogen (NO^2+NO_3-N). Phosphorus is measured as total phosphorus. When nutrients are introduced to an aquatic ecosystem from municipal and industrial treatment processes, or runoff from urban or agricultural land, the growth of algae (algal blooms) and other plants may be accelerated.

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

Fecal Coliform Bacteria

Concentrations of fecal coliform bacteria can vary greatly. The descriptive statistics used to evaluate fecal coliform bacteria data include the geometric mean and the median depending on the classification of the waterbody. For all sites in the Roanoke River Basin, the standard specified in Administrative Code 15A NCAC 02B.0211 (3)(e) (August 1, 2004) is applicable:

"Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be

caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method."

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

Freshwater sites where the geometric mean was greater that 200 colonies/100ml, or where the proportion of results was greater than 20 percent are indicated on the respective station summary sheets. There are no saltwater stations in the Roanoke River Basin.

Table 6. Summary of Evaluation Level Exceedances

Subbasin	Station	Class	Percentage of Results that Exceeded the Evaluation Limit											
			Dissolved Oxygen[1]	pH	Water Temperature	Turbidity	Hardness	Arsenic	Copper	Iron	Manganese	Nickel	Zinc	Fecal Coliform
1														
	N0150000	C Tr	0%	6%	**26%**	**24%**	NA	0%	4%	8%	NA	0%	0%	11%
2														
	N1400000	WS-V	0%	2%	0%	9%	8%	0%	0%	**44%**	0%	0%	0%	**24%**
3														
	N2300000	WS-IV	0%	0%	0%	**16%**	0%	0%	4%	**44%**	5%	0%	8%	**29%**
	N2430000	WS-IV	0%	0%	0%	**13%**	0%	0%	6%	**53%**	0%	0%	0%	15%
	N2450000	WS-IV	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	N3000000	C	0%	0%	0%	**18%**	NA	0%	8%	**38%**	NA	0%	4%	**27%**
4														
	N3500000	C	0%	0%	0%	**16%**	NA	0%	**11%**	**59%**	NA	0%	0%	16%
5														
	N4110000	C	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	N4250000	C	0%	0%	0%	0%	NA	0%	0%	**17%**	NA	0%	0%	10%
	N4400000	C	2%	0%	0%	4%	NA	0%	**29%**	**19%**	NA	0%	**14%**	**35%**
	N4510000	III NT	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	N4590000	C	2%	0%	0%	0%	NA	0%	4%	0%	NA	0%	0%	0%
6														
	N5000000	C	0%	0%	0%	0%	NA	8%	8%	8%	NA	0%	0%	9%
7														
	N6400000	C	**30%**	4%	0%	2%	NA	0%	4%	**96%**	NA	0%	0%	2%
8														
	N7300000	WS-IV CA	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	N8200000	C	2%	0%	0%	0%	NA	0%	4%	**20%**	NA	0%	0%	11%
	N8300000	C	4%	0%	0%	0%	NA	0%	4%	**48%**	NA	0%	0%	2%
9														
	N8550000	C	8%	0%	0%	0%	NA	0%	4%	**44%**	NA	0%	0%	4%
	N9250000	C Sw	NA	0%	0%	0%	NA	0%	0%	**37%**	NA	0%	0%	0%
	N9600000	C Sw	NA	0%	0%	0%	NA	0%	0%	**26%**	NA	0%	0%	0%
	N9700000	B Sw	NA	0%	0%	2%	NA	0%	4%	**36%**	NA	4%	4%	0%
10														
	N8950000	C Sw	NA	0%	2%	2%	NA	0%	3%	**93%**	NA	4%	4%	4%

Notes:

[1] The displayed results for Dissolved Oxygen are for the 5.0 mg/l standard (6.0 for trout waters). There were no SSEs for the 4.0 mg/l standard.

Bold entries indicate 10% (20% for Fecal Coliform) of results exceeded the evaluation level.

Underlined entries indicate 95% confidence that site conditions truly exceed the evaluation level at least 10% (20% for fecal coliform) of the time, with a minimum of 10 results required before determination.

<10: Less then ten results were recorded for this parameter at this station.

Water Quality Patterns in the Roanoke River Basin

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

Regional Patterns

Box and whisker plots were generated for each station for each water quality parameter that has an evaluation level, plus specific conductance, total nitrate/nitrite, total kjeldahl nitrogen, total ammonia, and total phosphorus. Maps were also generated for parameters with the most exceedences.

Average turbidity is significantly higher in subbasins 02, 03, and 04 then it is in the rest of the river basin. These subbasins also include three stations that have SSEs for turbidity. Severe drought during 2001 and 2002 did not prevent spikes of greater than 50, and spikes became a regular occurance after the drought ended in the winter of 2002/03.

Station N0150000 is designated as trout waters. The maximum water temperature for trout waters is specified in the regulations as 20 degrees Celcius. Each summer during the monitoring period, water temperatures at this site have exceeded the evaluation level. This station also had several pH readings that were below the minimum evaluation level. However, these low readings were at the beginning of the monitoring period. Since then pH readings at this site have trended significantly back to neutral pH.

Dissolved oxygen appeared to be good throughout the basin, except for one site, N6400000, Smith Creek, where it was somewhat depressed. This water body was listed as impaired in the 1996 and 2001 Roanoke River Basin Planning Documents. There are no NPDES permitted dischargers in the Smith Creek watershed; therefore most, if not all, impacts to this stream are from nonpoint sources of pollution, which may include several permitted agriculture operations in the area. In general, dissolved oxygen concentrations are highest at the headwaters, trend downward as you progress through the river system, and are lowest in the swamp waters of the lower Roanoke.

Fecal Coliform counts appear to be high in subbasins 02, 03, 04, and 05. There are four stations in this stretch with greater then 20% of measurements above 400 per 100mL. Only one station had a geomean above 200 per 100 mL.

Total copper concentrations are elevated in several locations scattered throughout the river basin. Some of these elevated concentrations appear to coincide with the end of the drought in the winter of 2002/2003.

Trends over Time

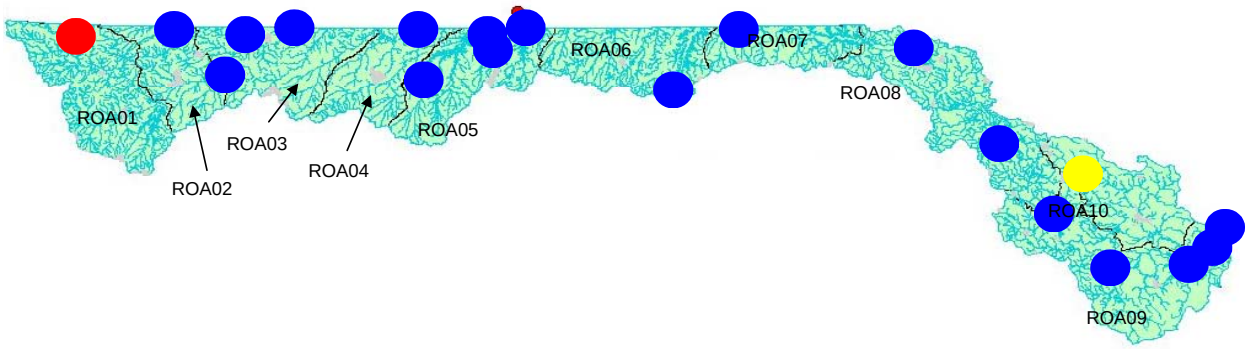
Several significant trends ($p < 0.05$) were identified over the monitoring period, in particular concerning dropping pH, rising turbidity, dropping nitrogen, and rising metals at one site. P and r^2 values are included on the time graphs.

At six sites falling pH trends were identified. It is unclear what may be causing this trend. Rising turbidity was likewise identified at six sites. This appears to be partially explained by the end of the drought in the winter of 2002/2003.

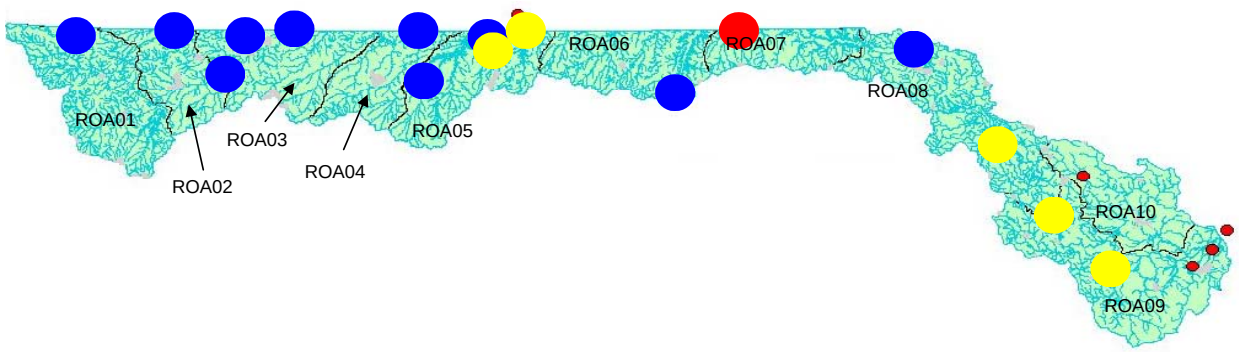
Six significant downward trends in nitrogen were identified. This appears to be due to changes in allowable nitrogen load in effluent permits.

One station, N3500000, located on the Dan River at NC 57 at the VA state line, showed increasing trends for total copper, total iron, and turbidity. This also appears to be related to the end of the drought, but the presence of copper activated by high flow is still problematic.

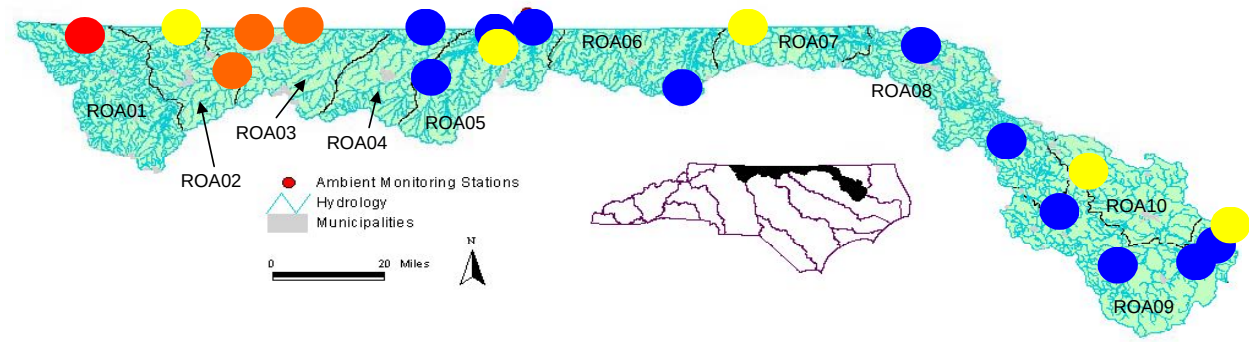
Water Temperature



Dissolved Oxygen



Turbidity

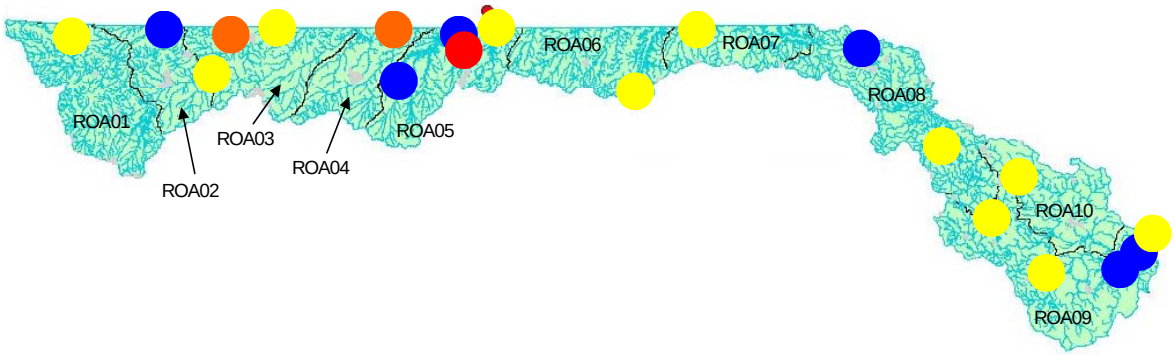


>20% Exceedances | 10% to 20% Exceedances | 0% to 10% Exceedances | No Exceedances

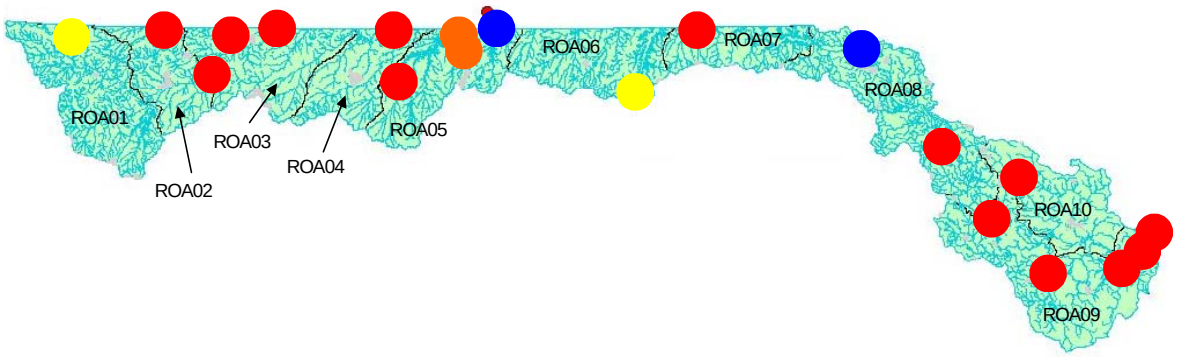
Note: Stations with no circle have no Evaluation Level for the given parameter.

Figure 3. Water Temperature, Dissolved Oxygen, and Turbidity in the Roanoke River Basin

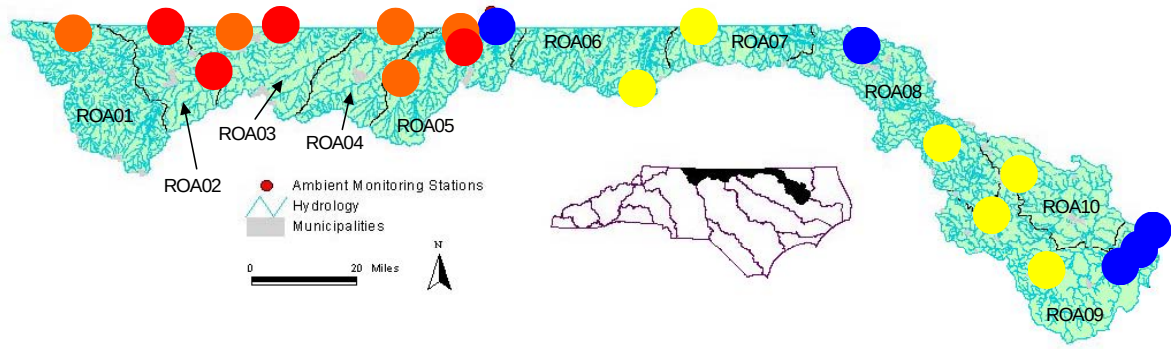
Total Copper



Total Iron



Fecal Coliform



>20% Exceedances 10% to 20% Exceedances 0% to 10% Exceedances No Exceedances

Note: Stations with no circle have no Evaluation Level for the given parameter.

Figure 4. Total Copper, Total Iron, and Fecal Coliform in the Roanoke River Basin

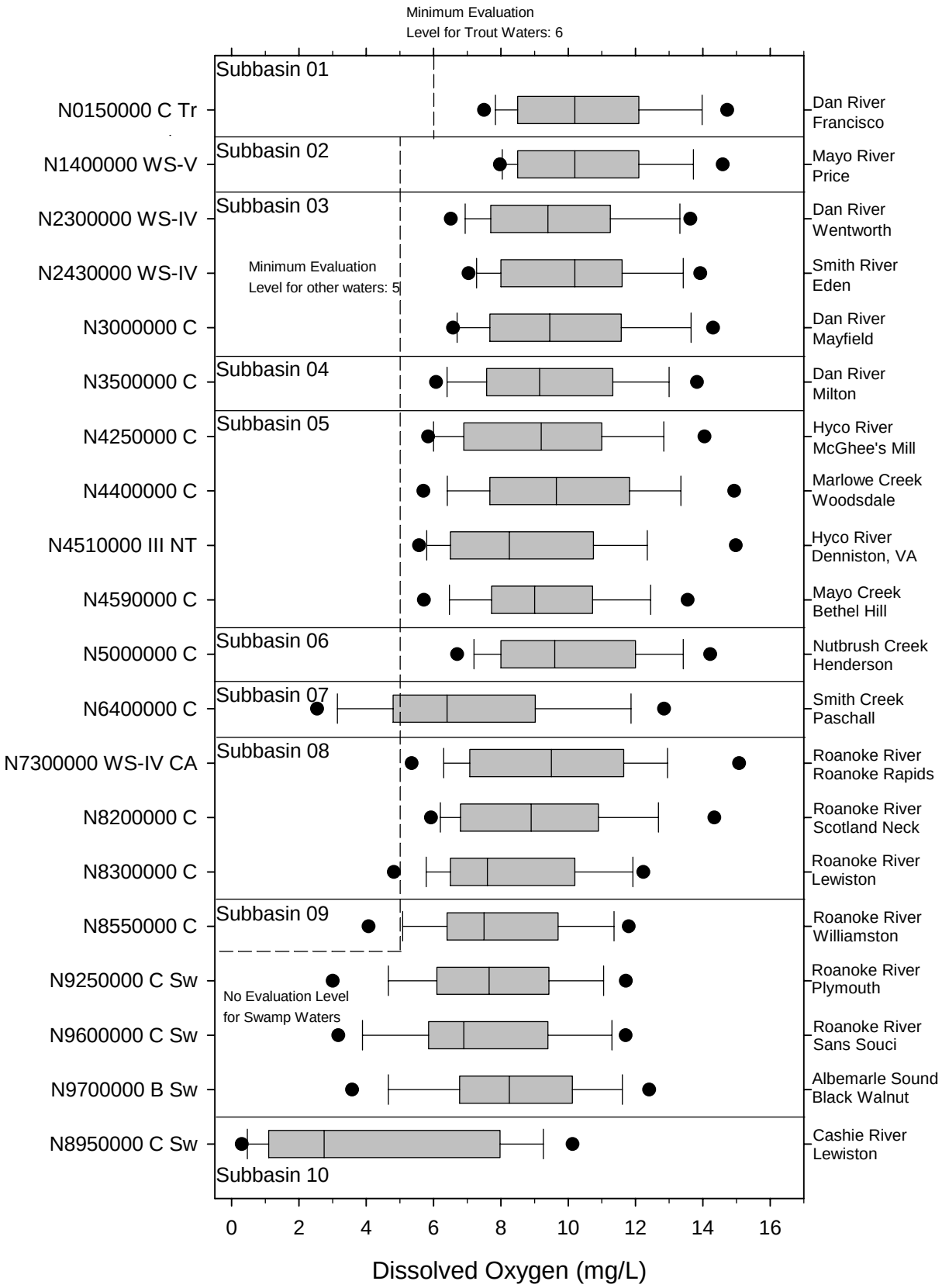


Figure 5. Box Plots for Dissolved Oxygen in the Roanoke River Basin

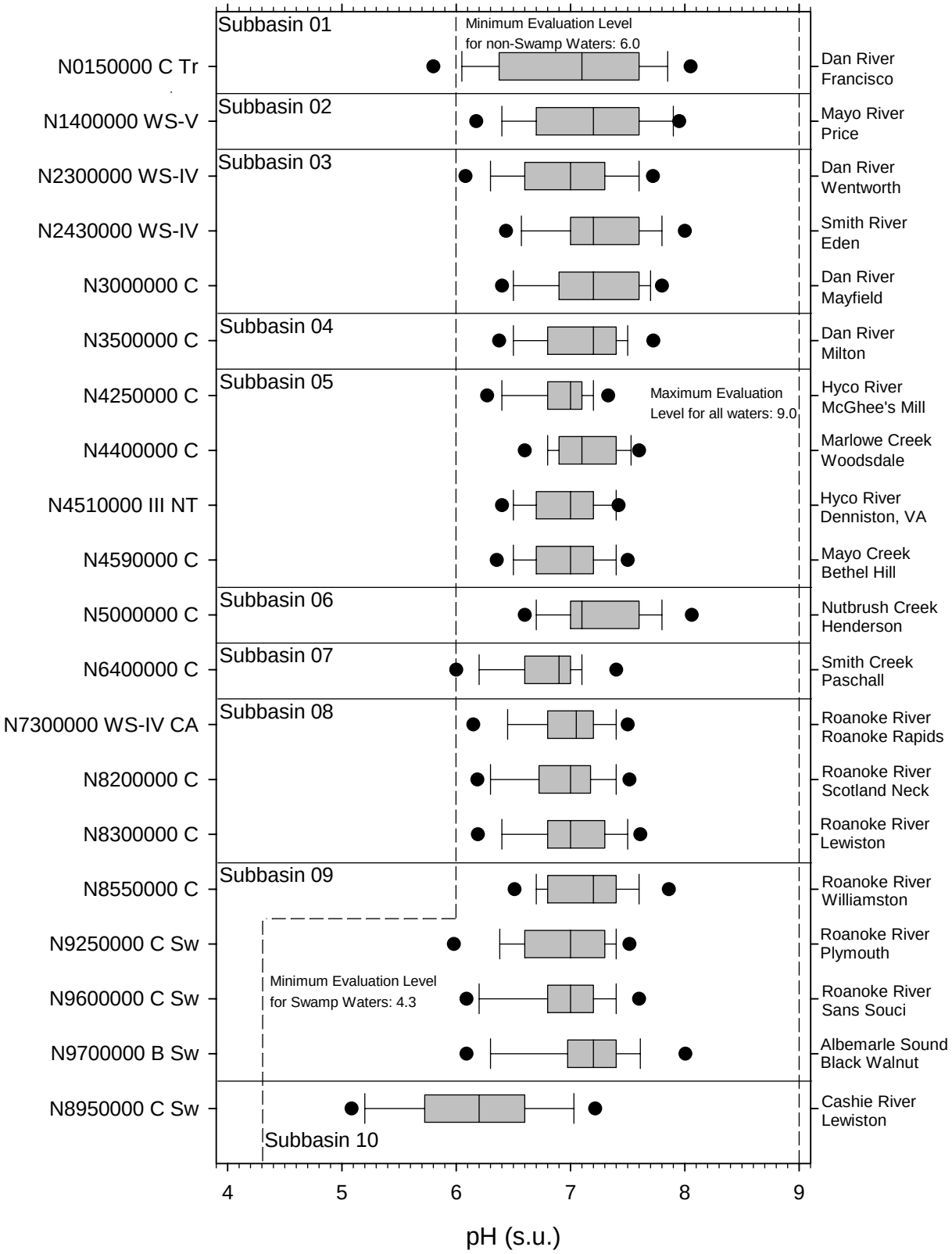


Figure 6. Box Plots for pH in the Roanoke River Basin

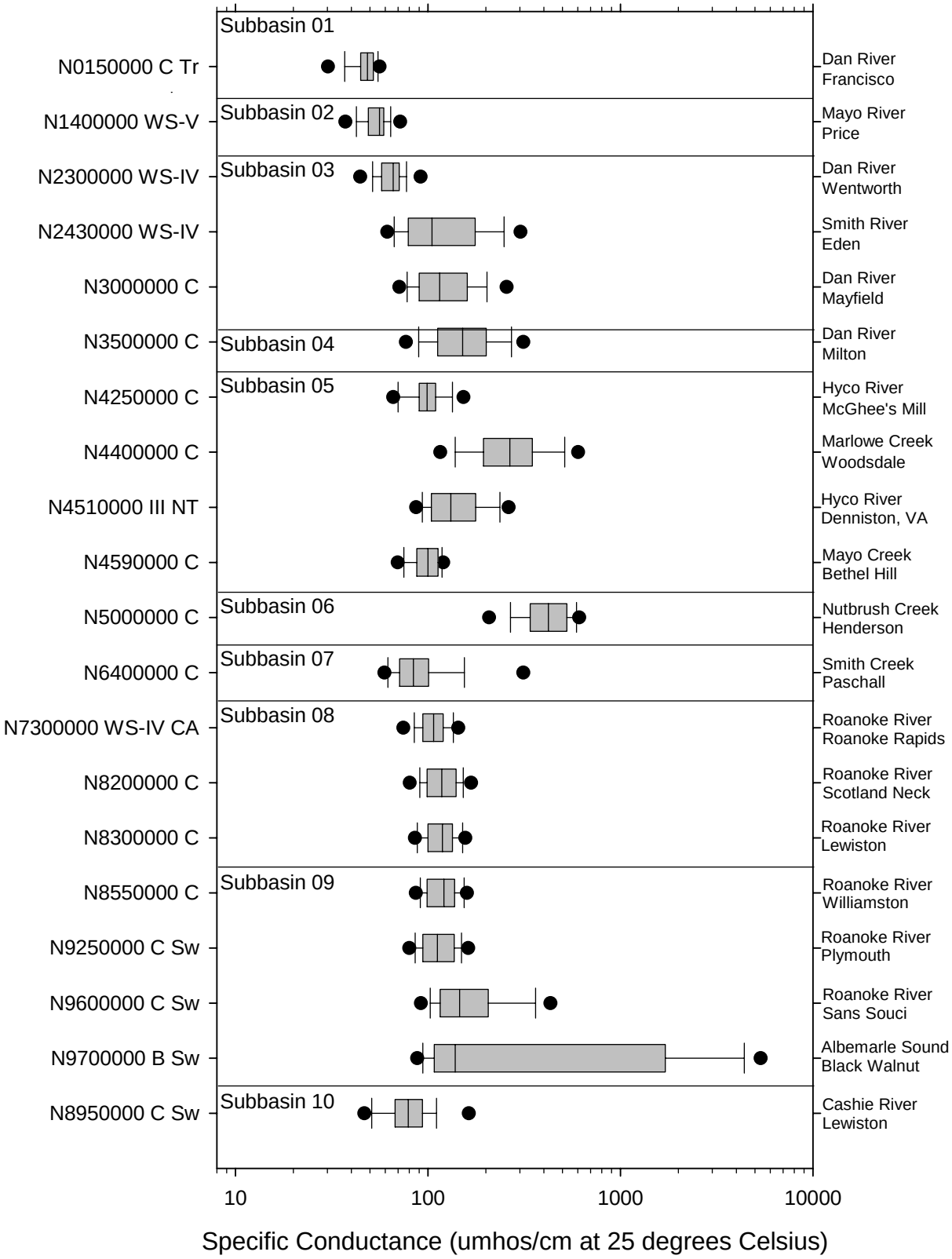


Figure 7. Box Plots for Specific Conductance in the Roanoke River Basin

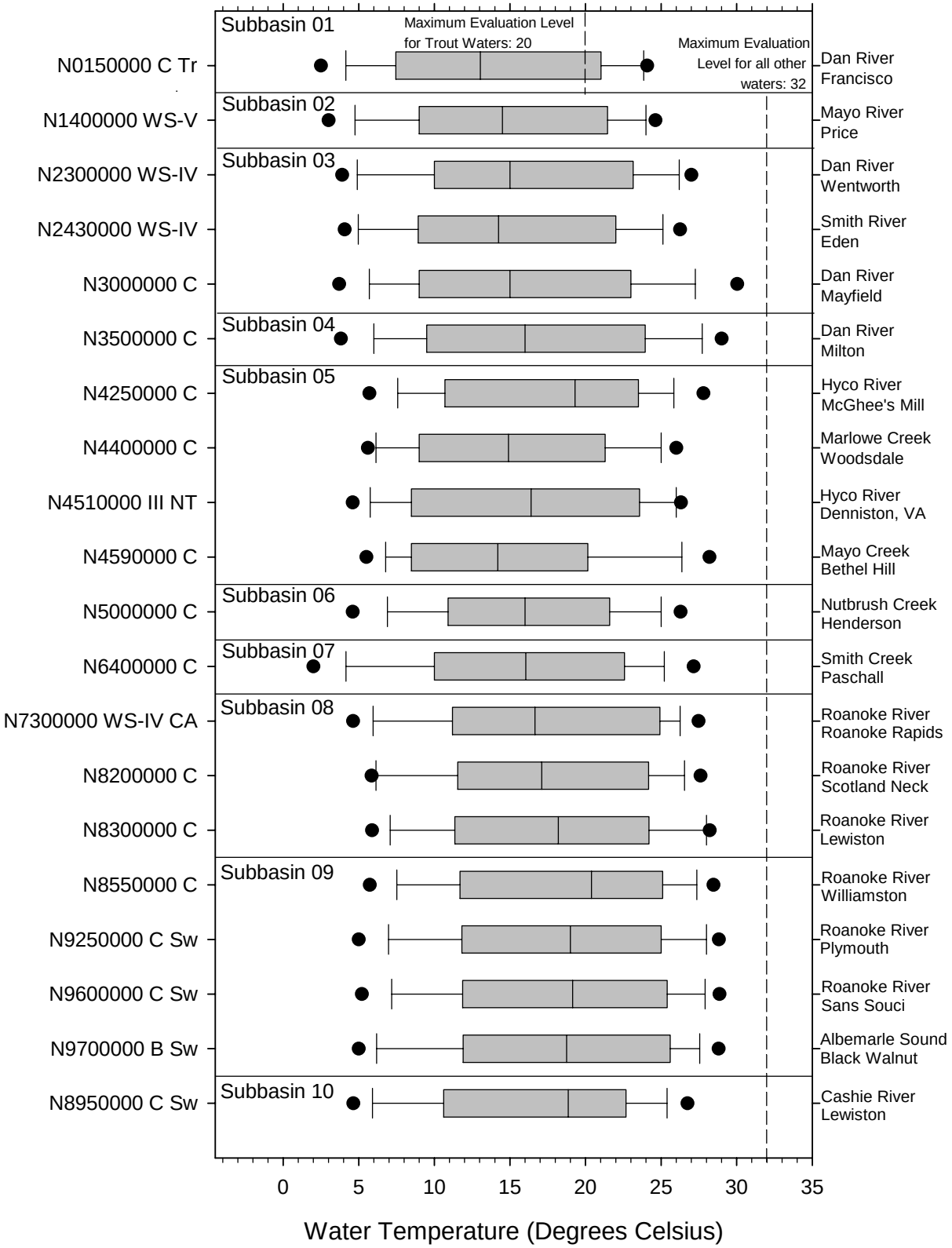


Figure 8. Box Plots for Water Temperature in the Roanoke River Basin

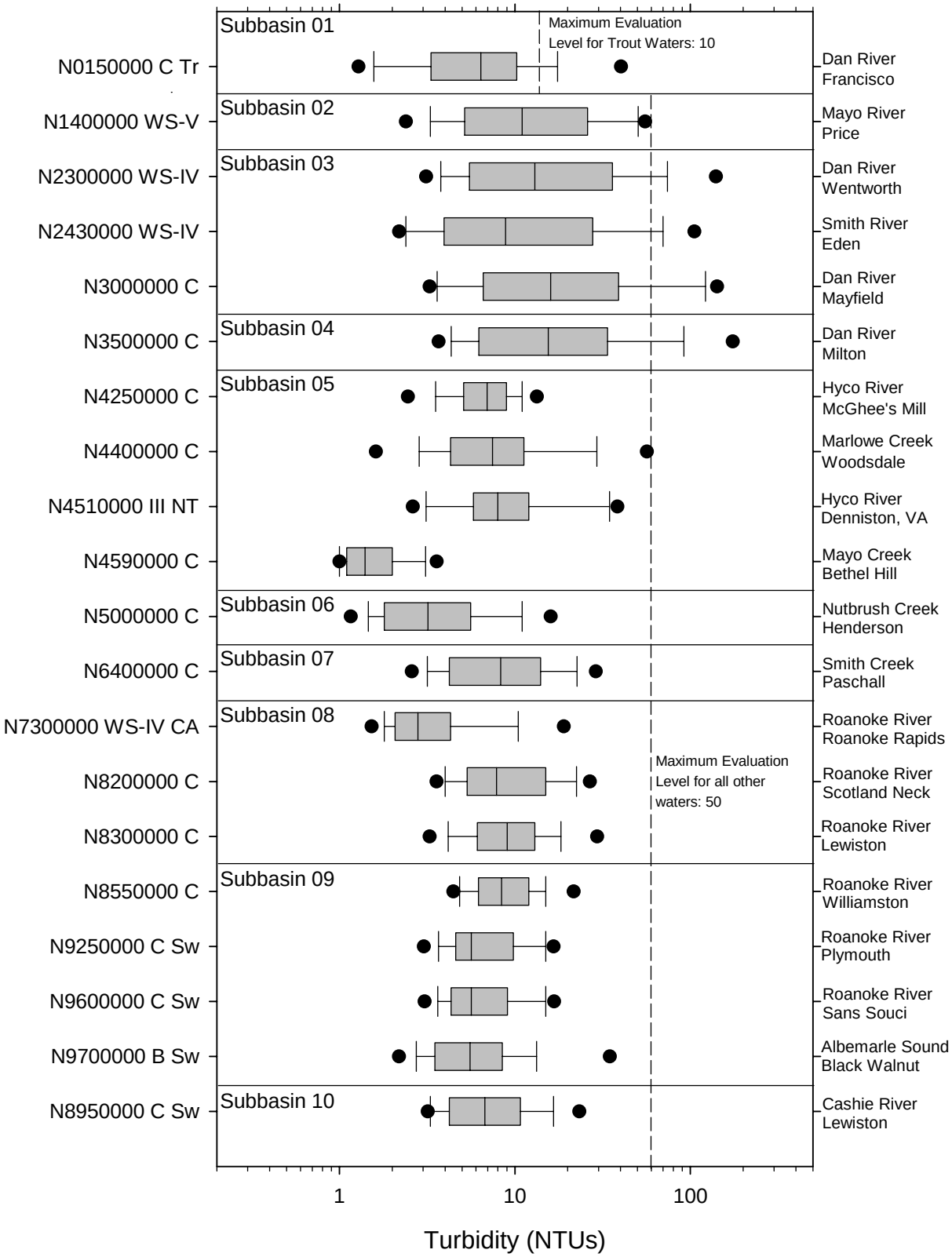


Figure 9. Box Plots for Turbidity in the Roanoke River Basin

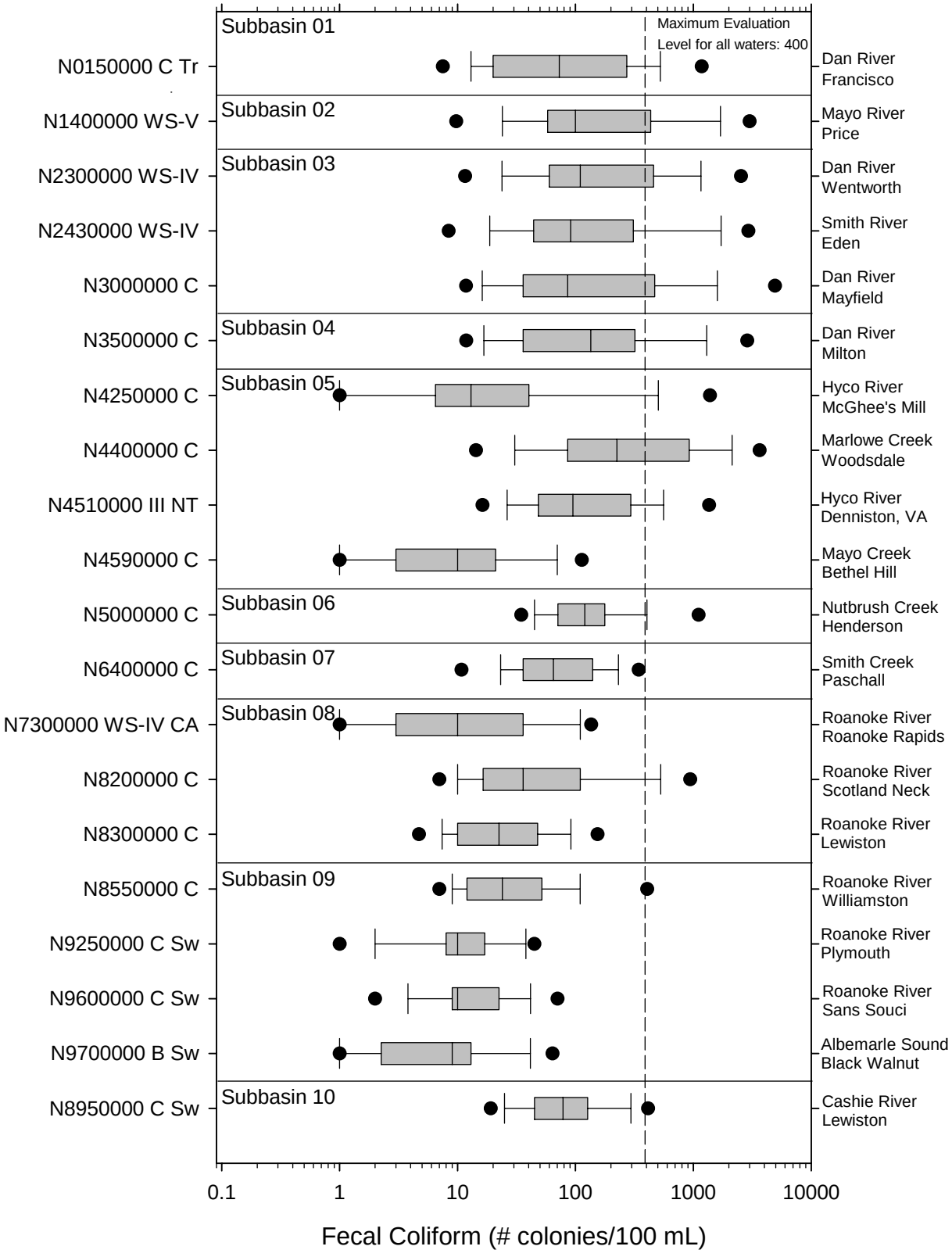


Figure 10. Box Plots for Fecal Coliform in the Roanoke River Basin

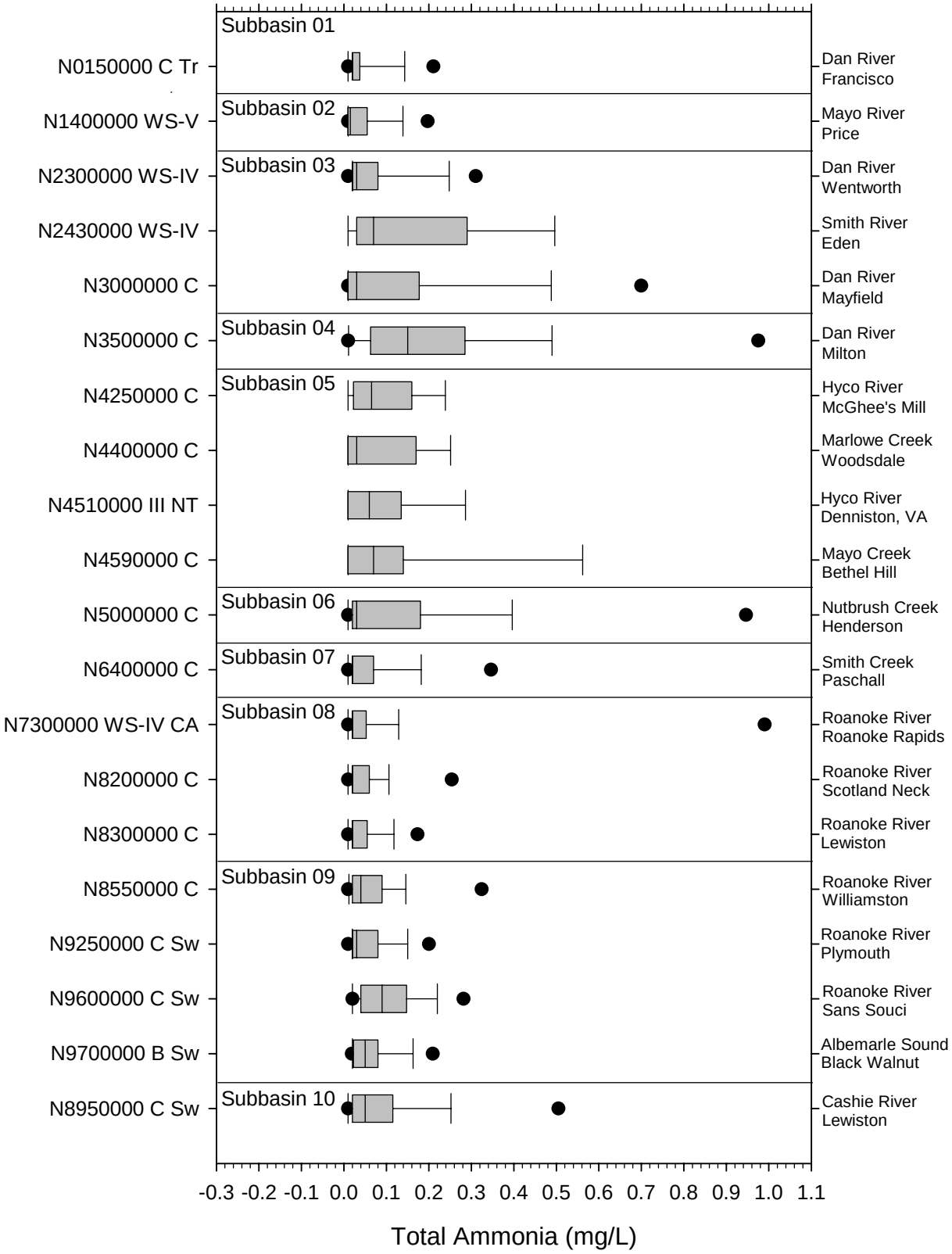


Figure 11. Box Plots for Total Ammonia in the Roanoke River Basin

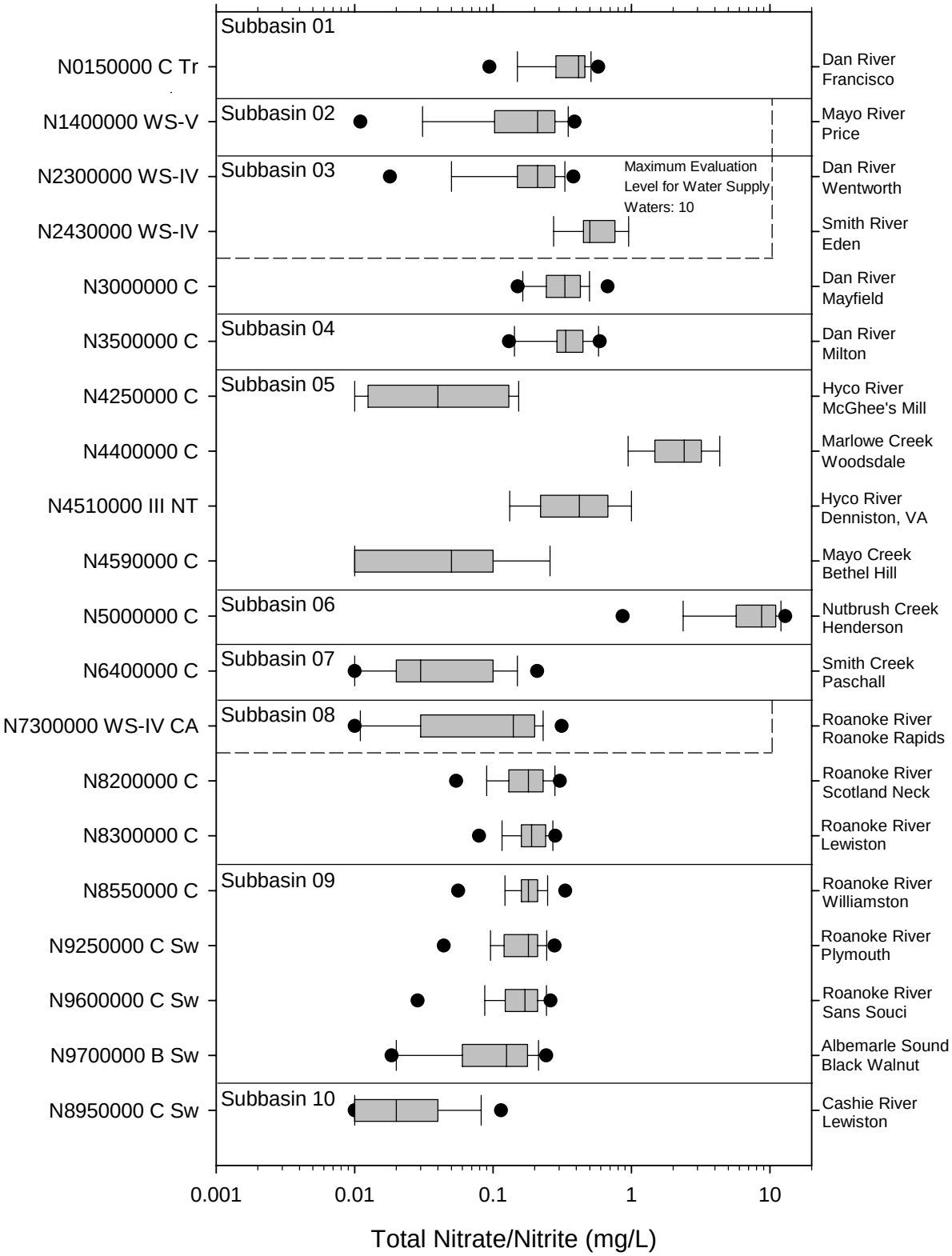


Figure 12. Box Plots for Total Nitrate/Nitrite in the Roanoke River Basin

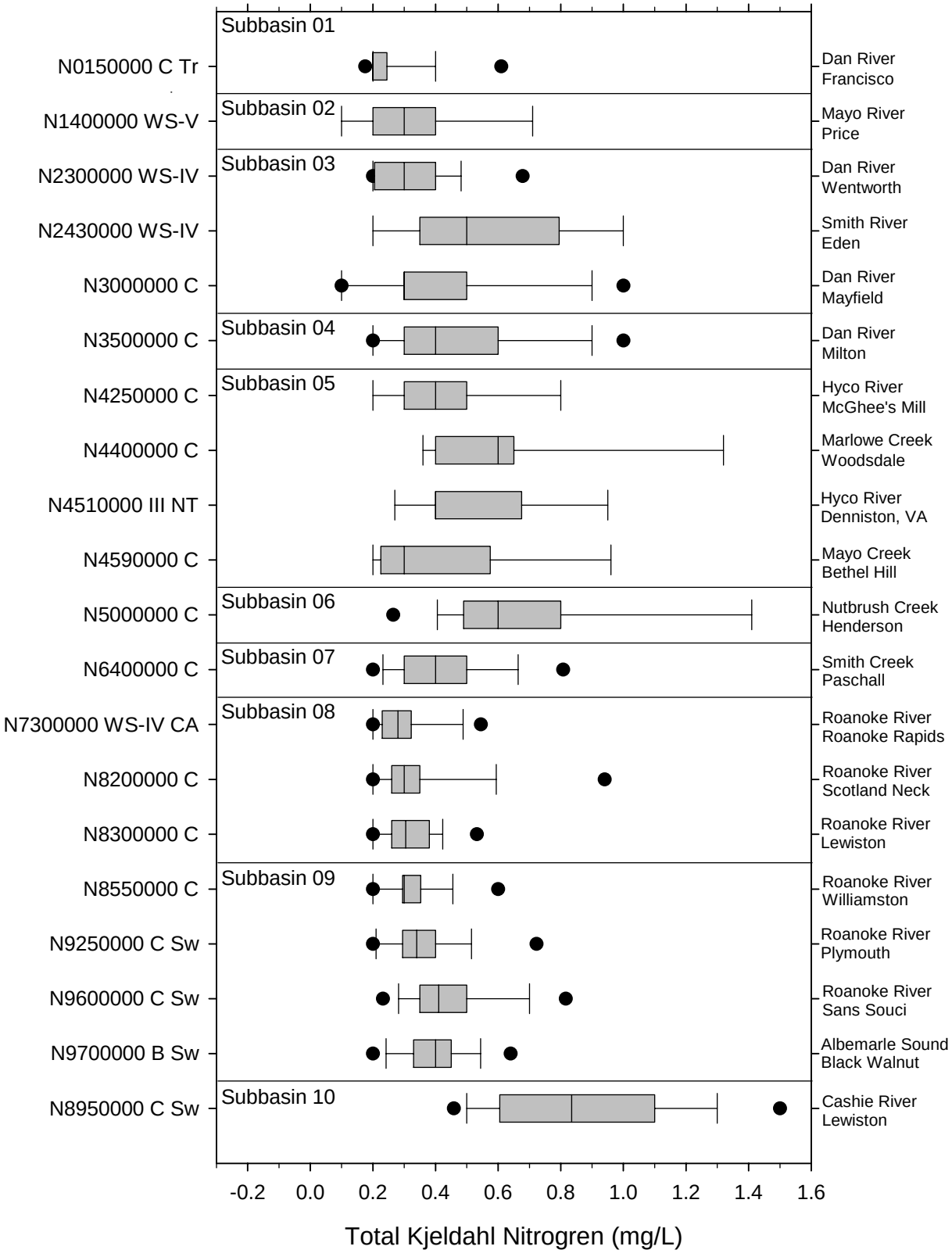


Figure 13. Box Plots for Total Kjeldahl Nitrogen in the Roanoke River Basin

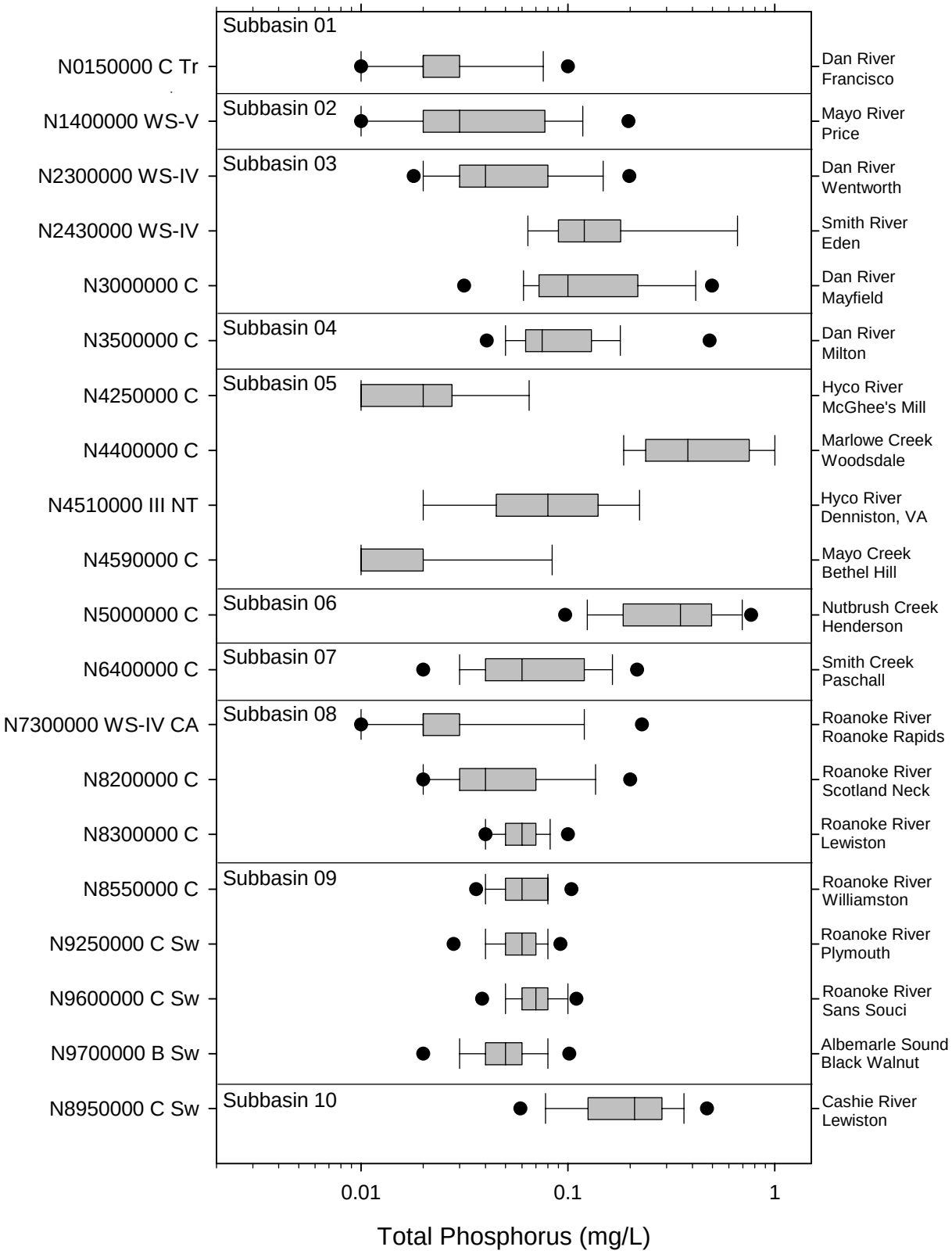


Figure 14. Box Plots for Total Phosphorus in the Roanoke River Basin

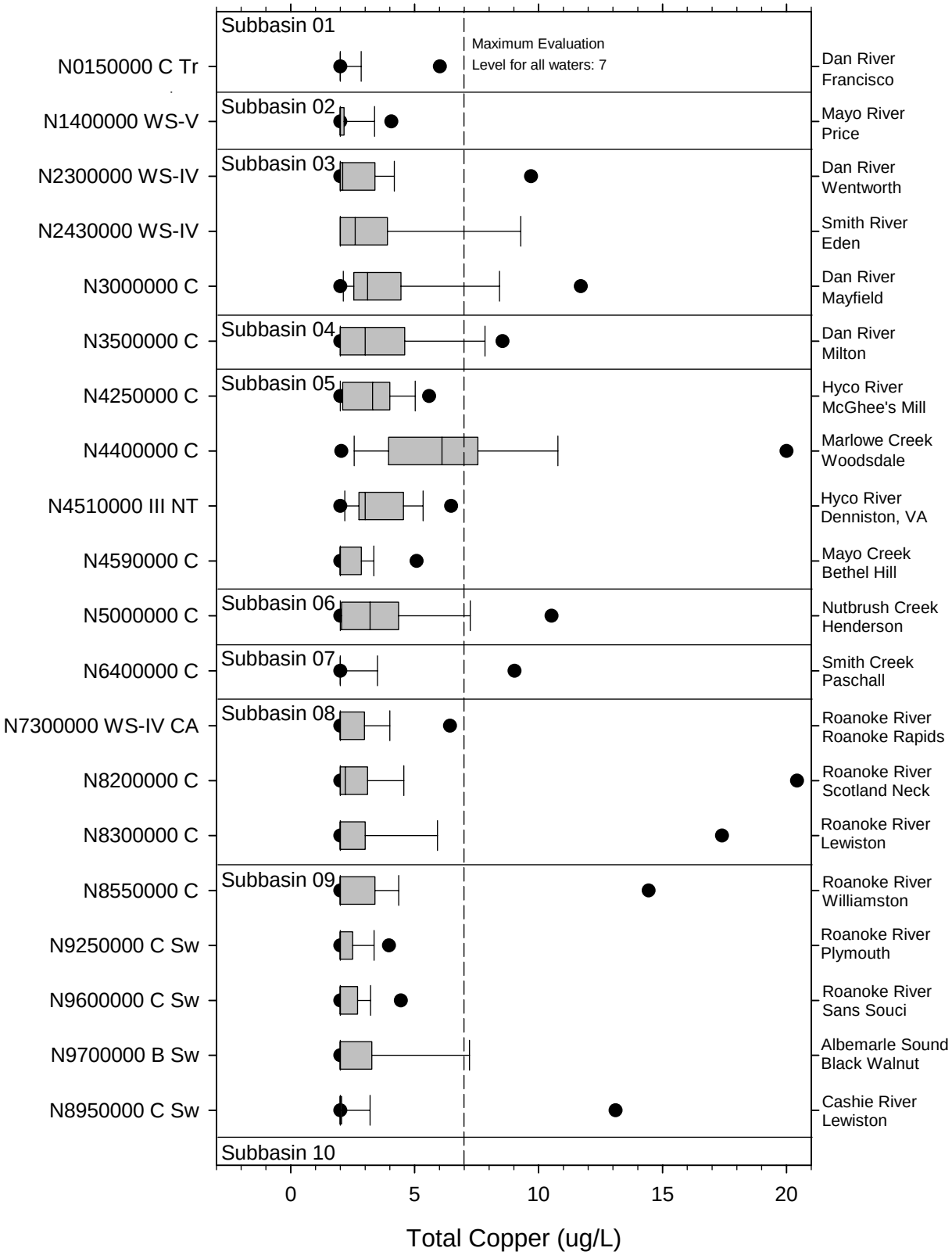


Figure 15. Box Plots for Total Copper in the Roanoke River Basin

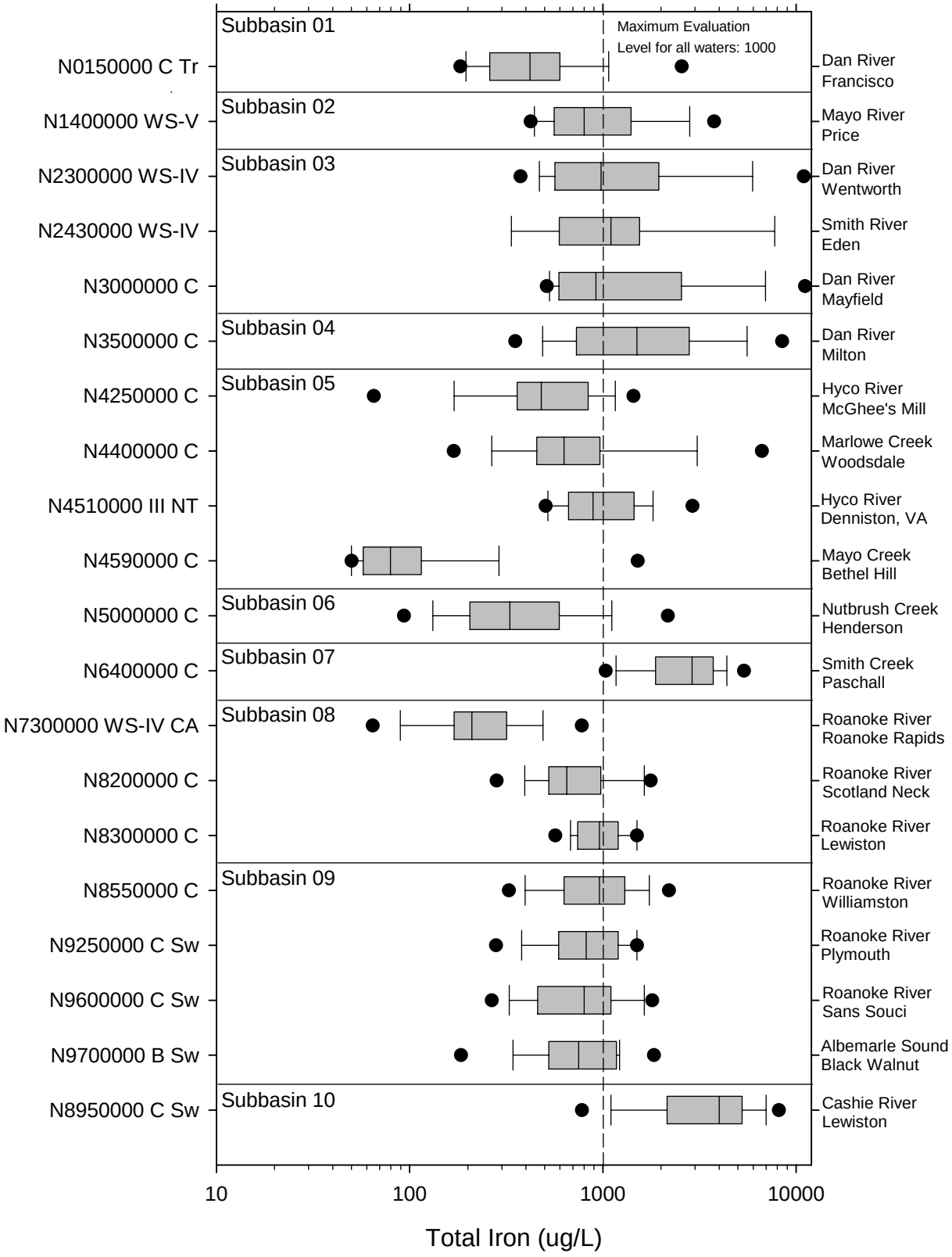


Figure 16. Box Plots for Total Iron in the Roanoke River Basin

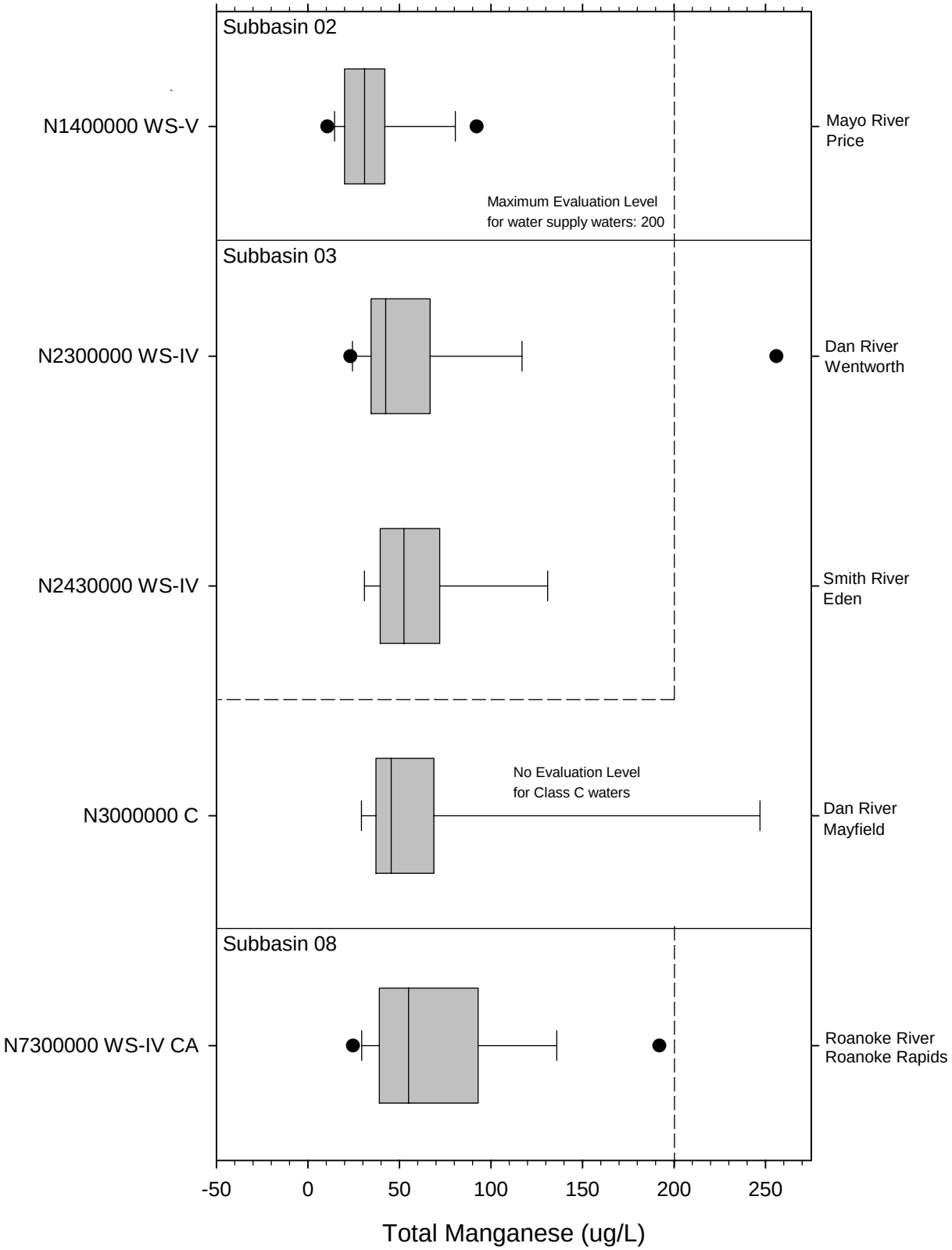


Figure 17. Box Plots for Total Manganese in the Roanoke River Basin

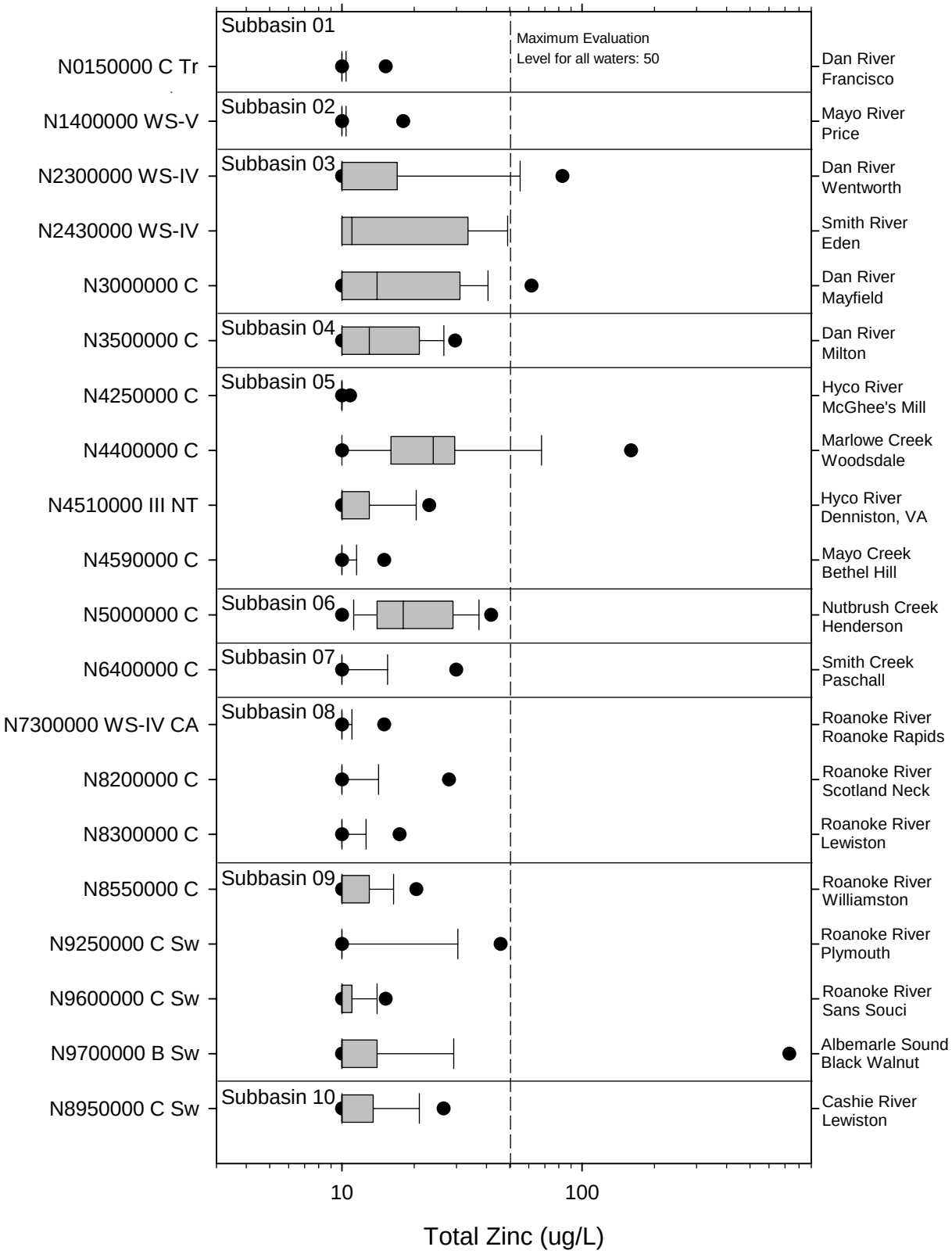
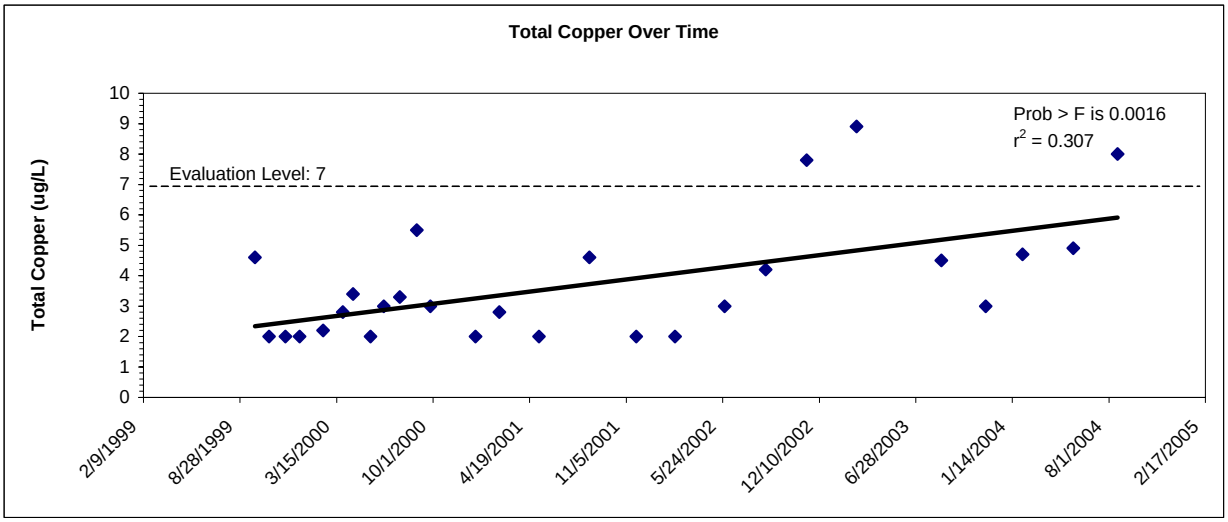
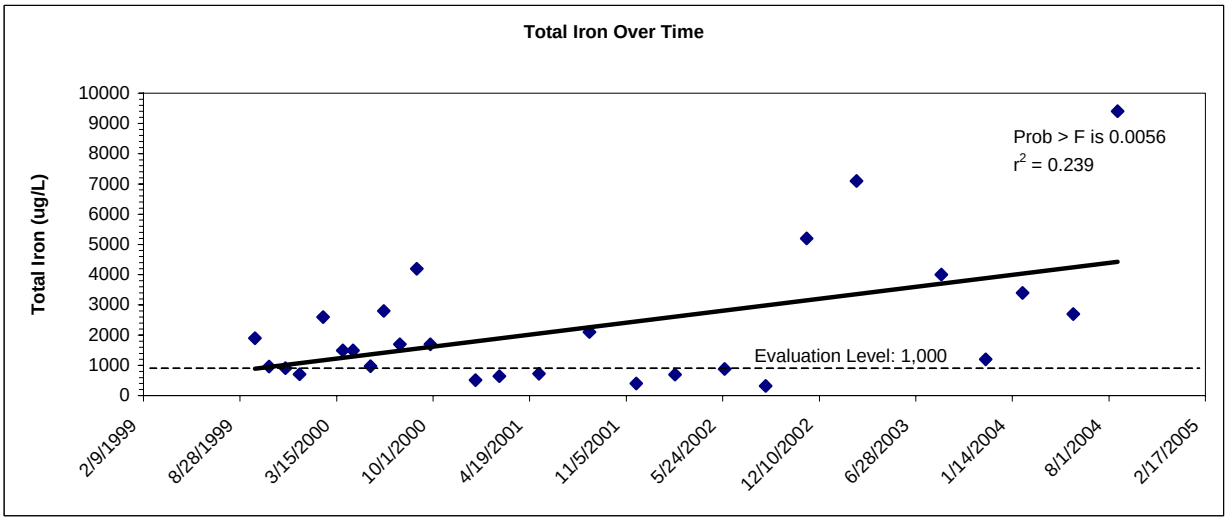


Figure 18. Box Plots for Total Zinc in the Roanoke River Basin





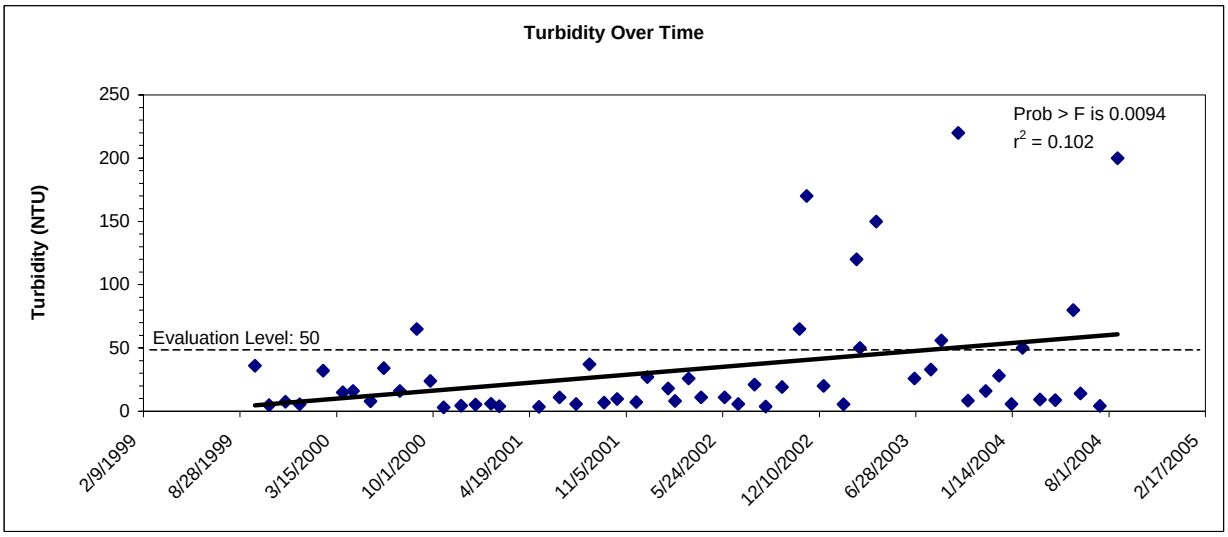
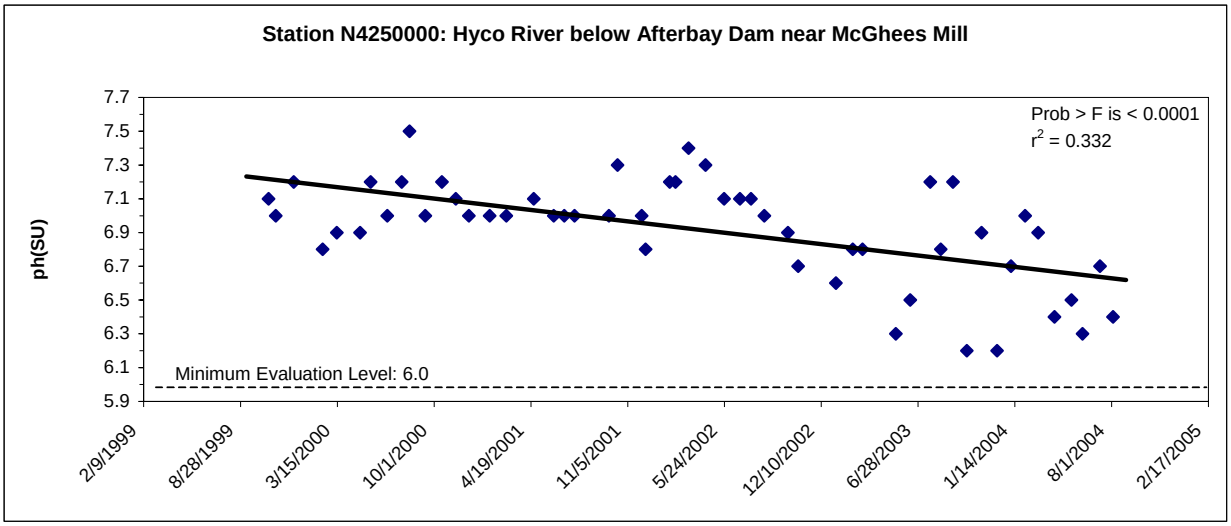
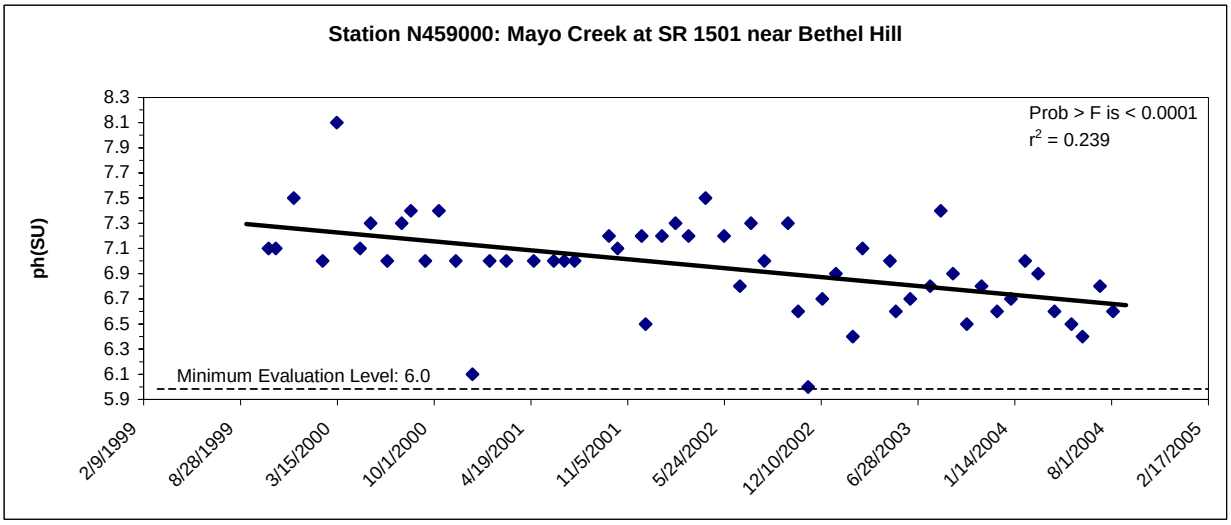


Figure 19. Trends in Selected Parameters for Station N3500000: Dan River at NC 57 at the VA State Line at Milton





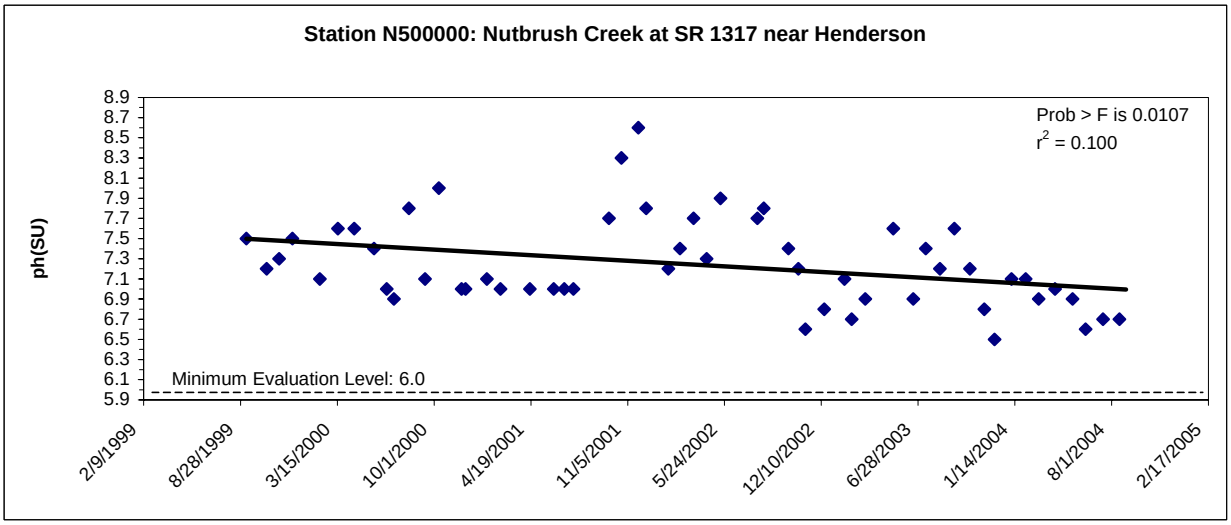
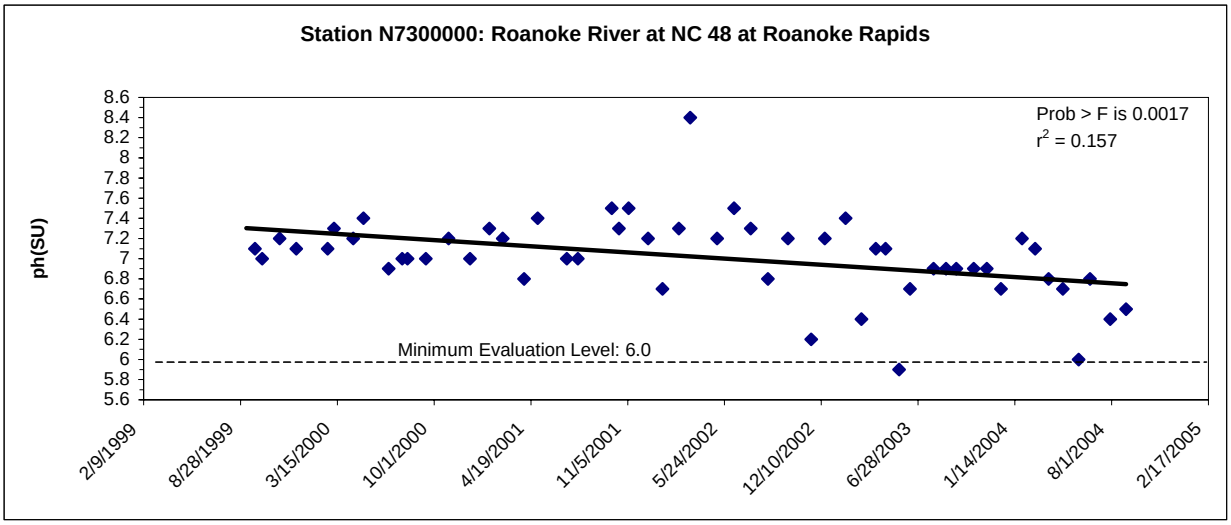
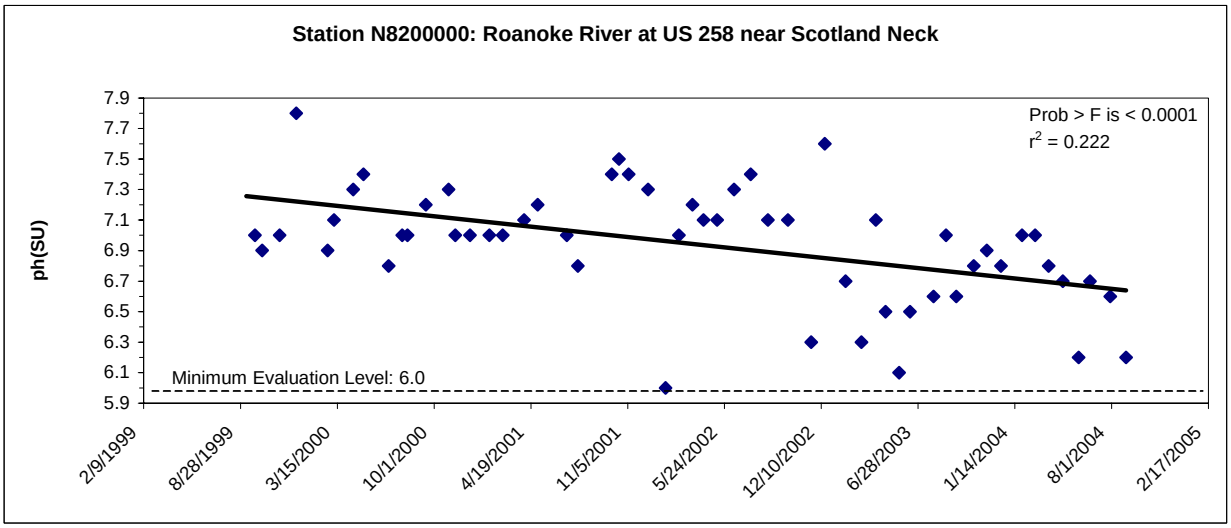


Figure 20. pH Trends at Selected Stations in the Roanoke River Basin





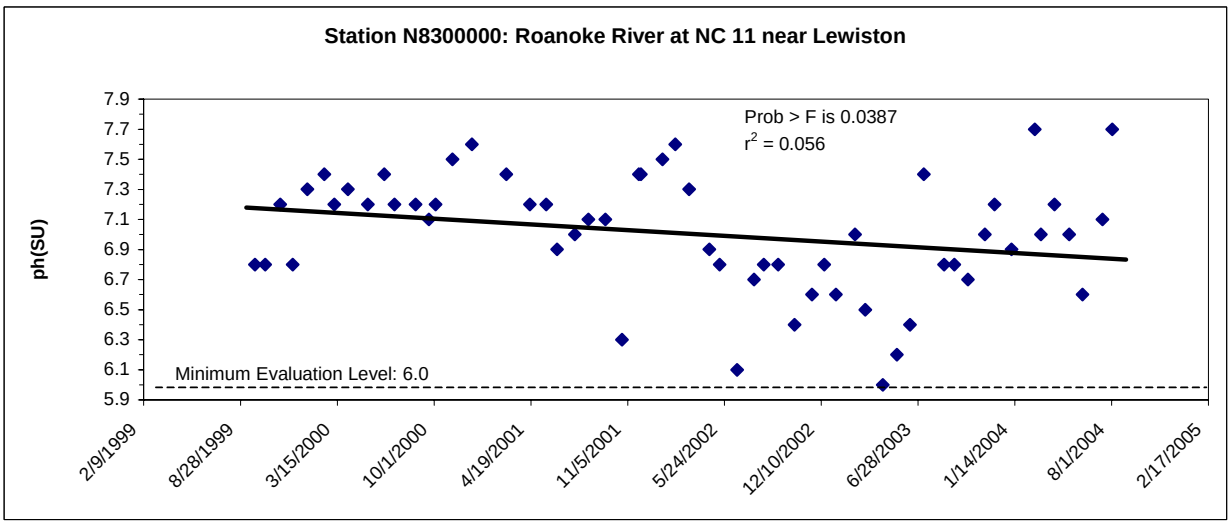
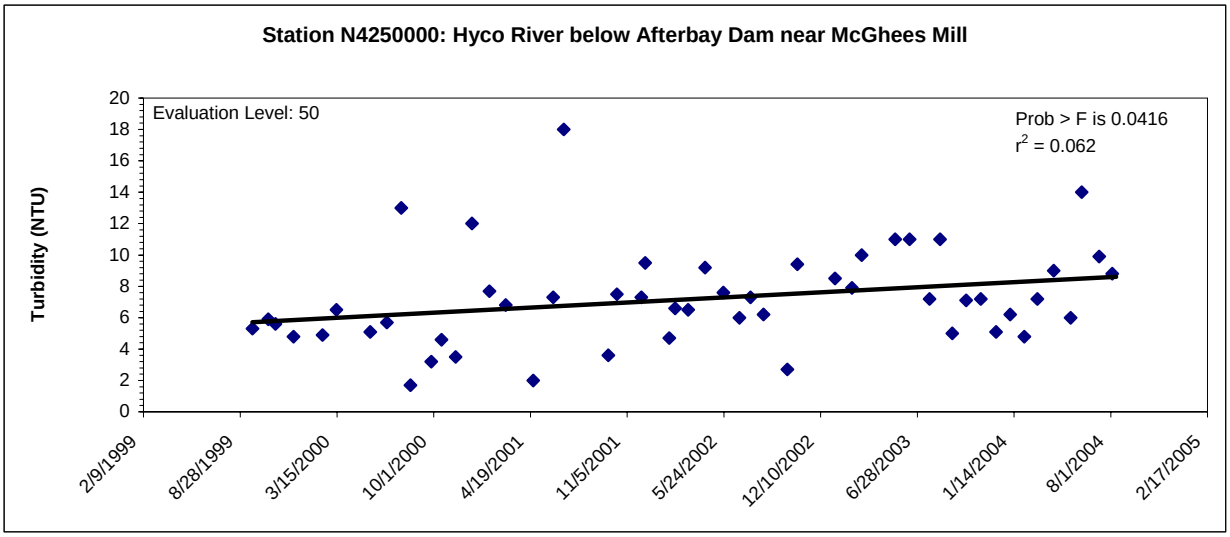
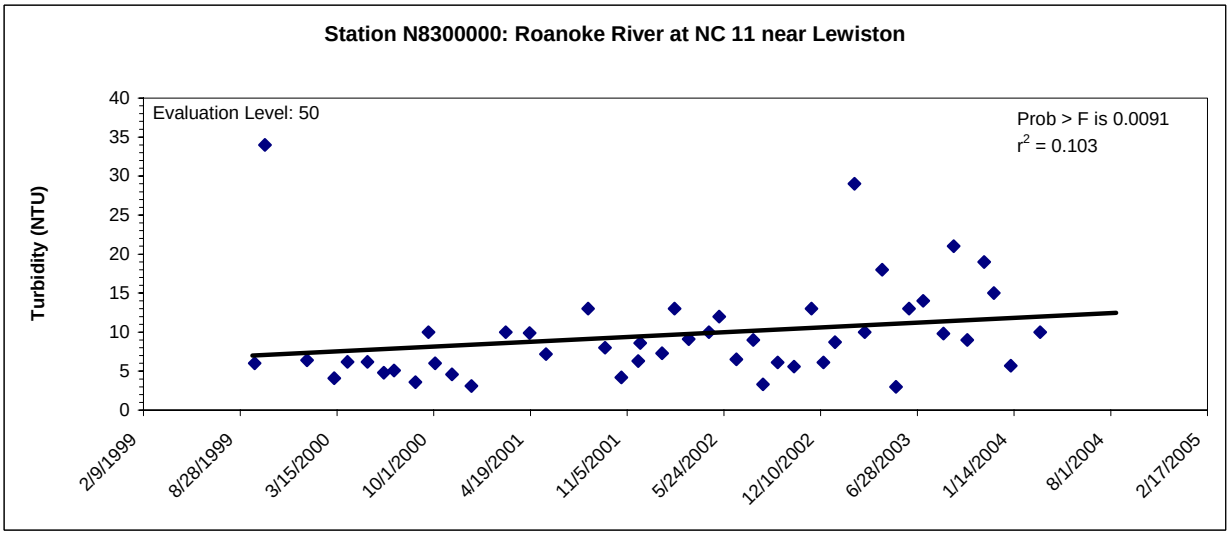


Figure 21. pH Trends at Selected Stations in the Roanoke River Basin





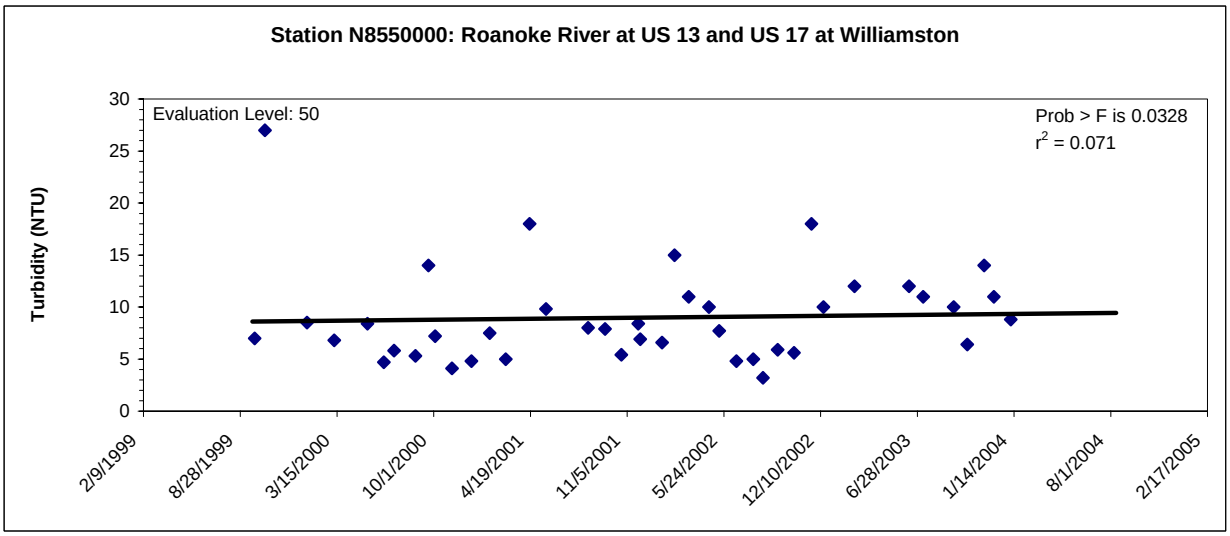
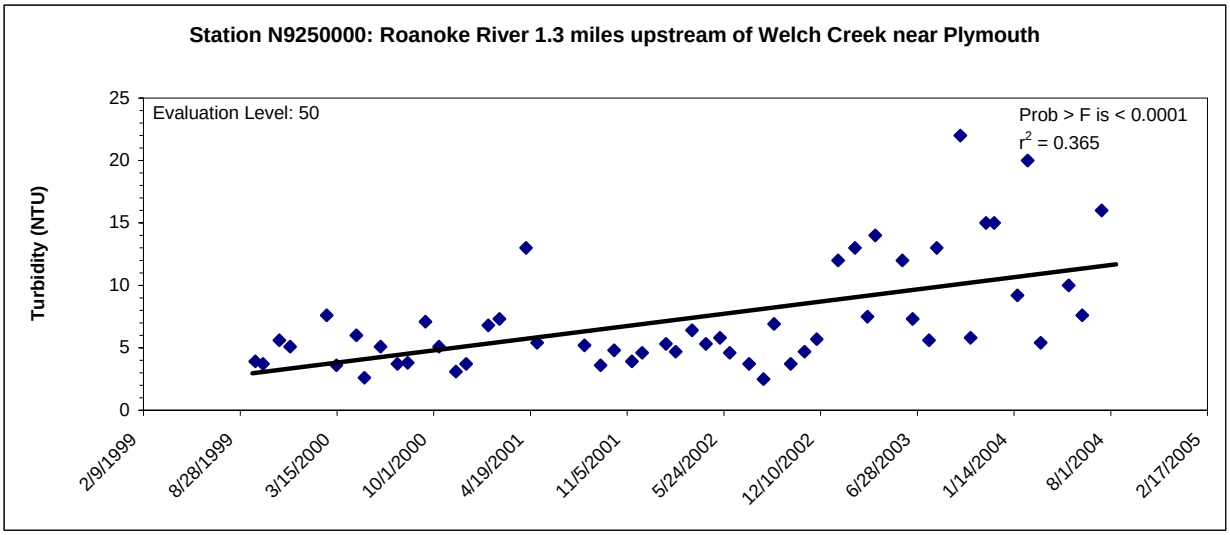
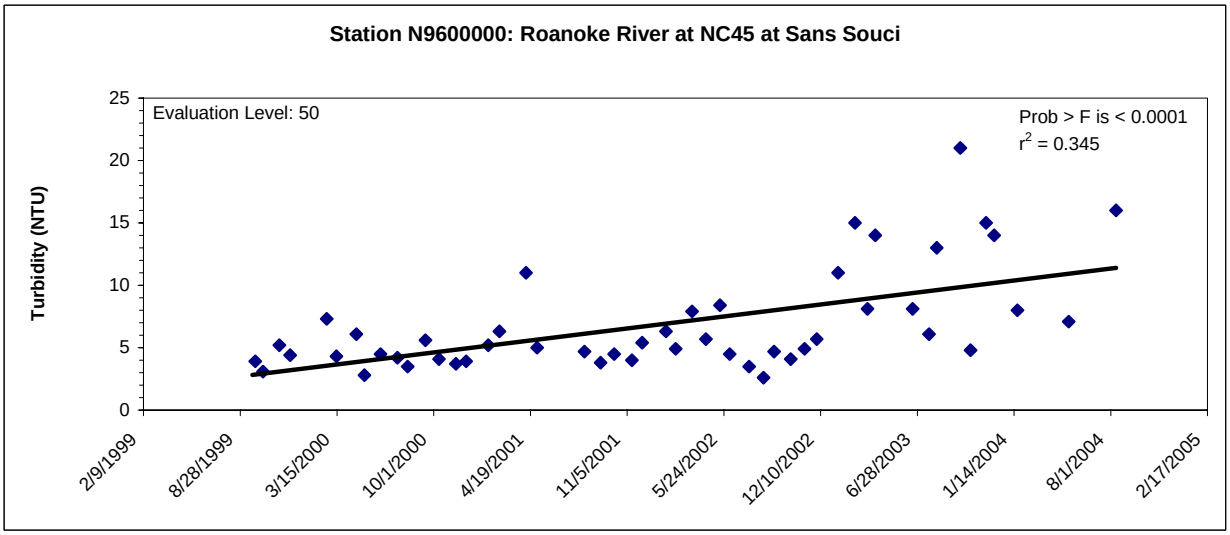


Figure 22. Turbidity Trends at Selected Stations in the Roanoke River Basin





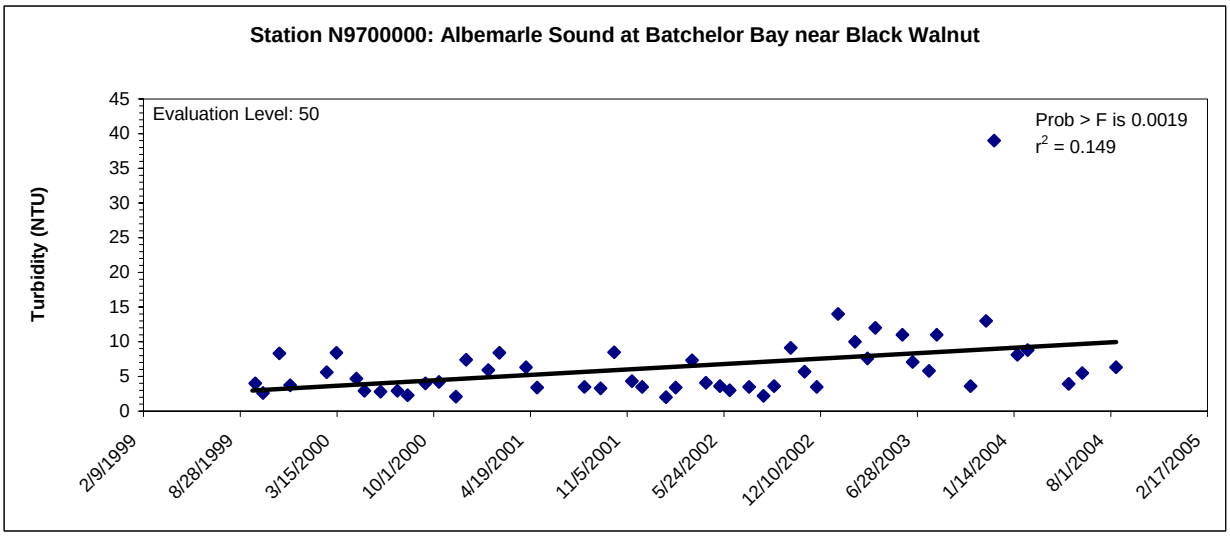
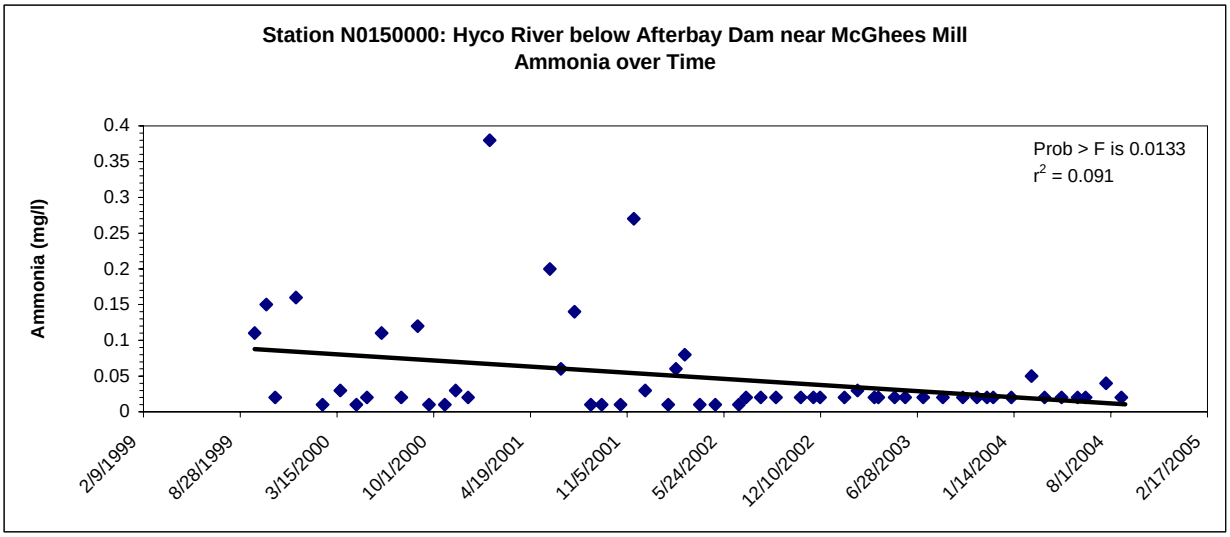
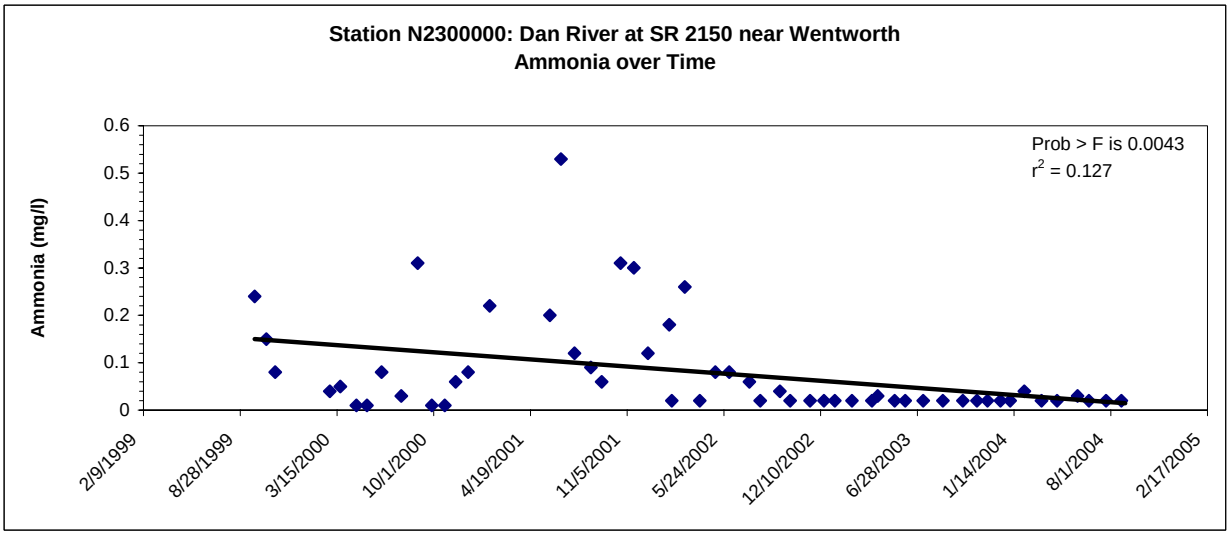


Figure 23. Turbidity Trends at Selected Stations in the Roanoke River Basin





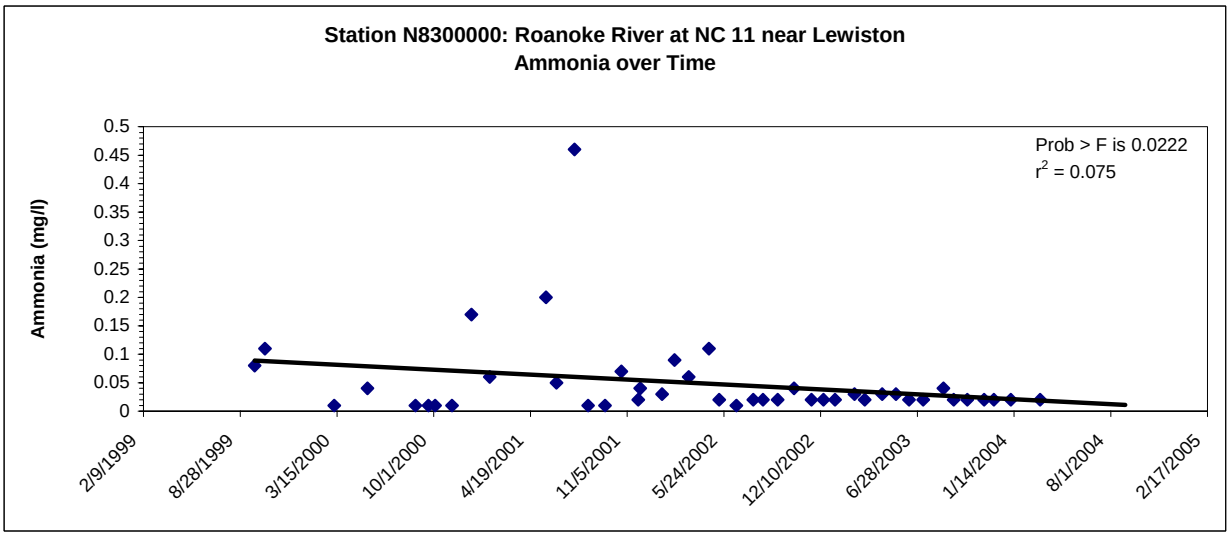
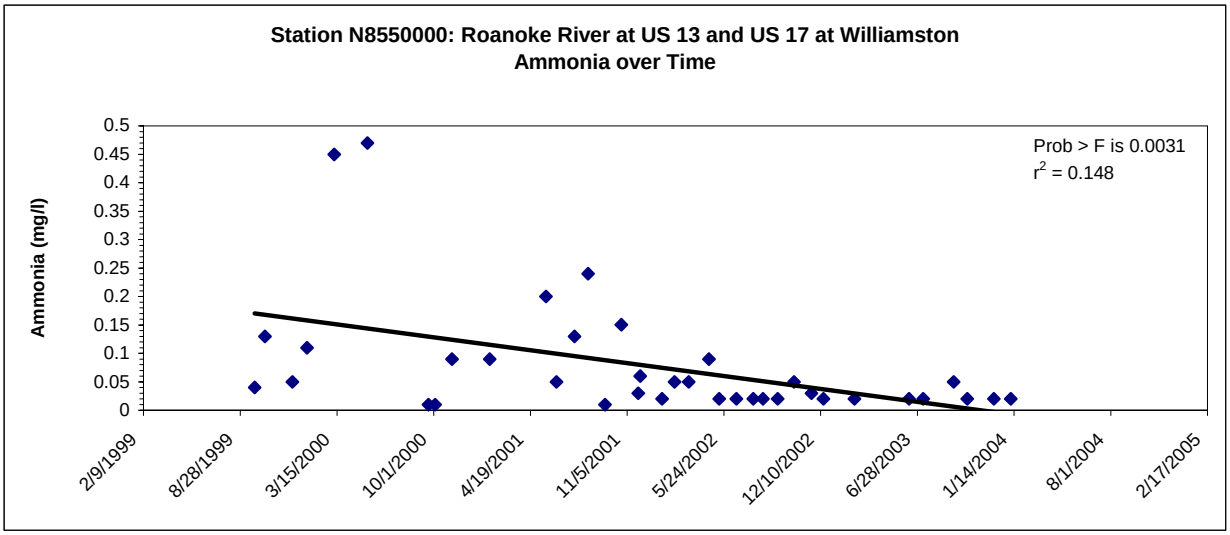
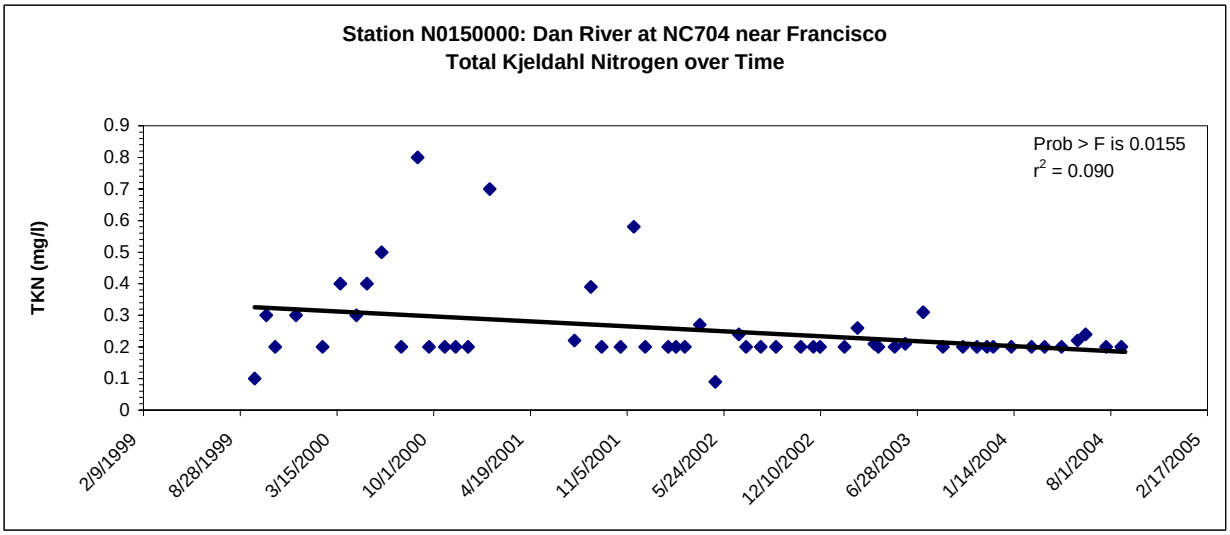


Figure 24. Nutrient Trends at Selected Stations in the Roanoke River Basin





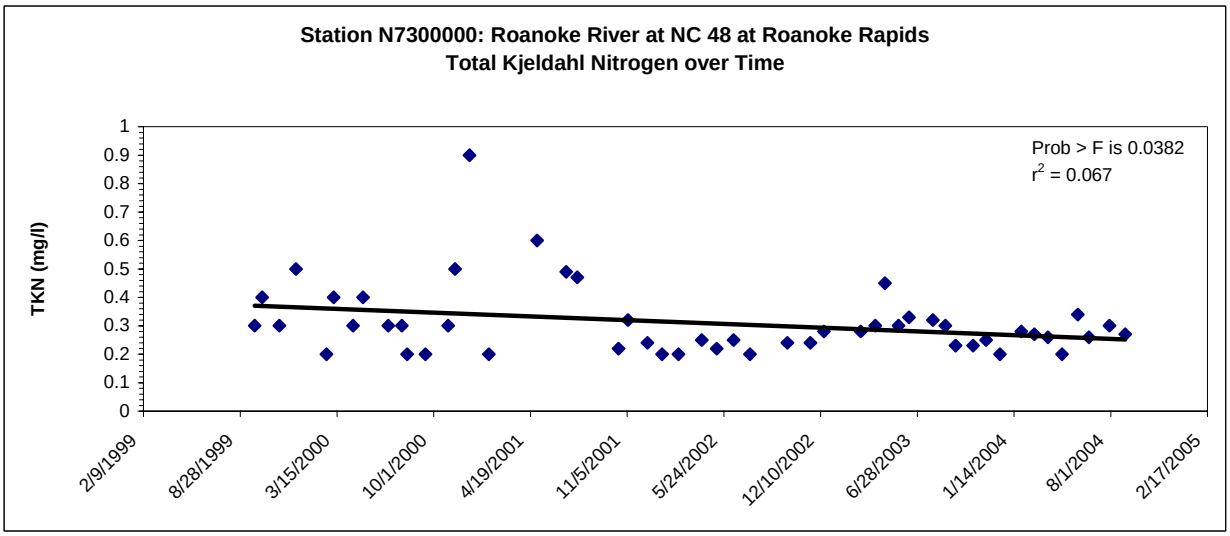
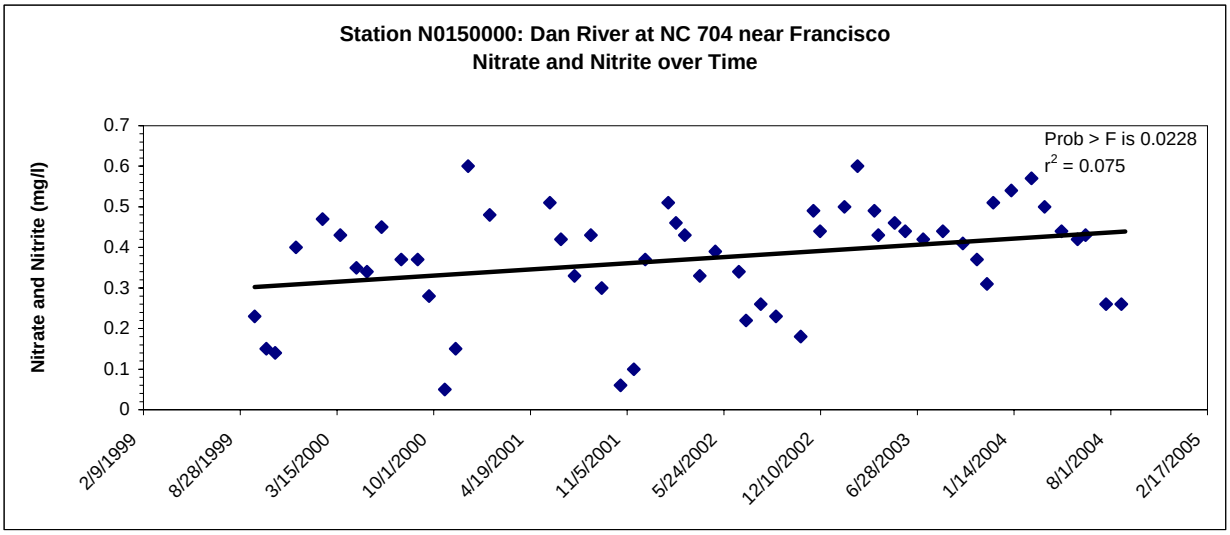


Figure 25. Nutrient Trends at Selected Stations in the Roanoke River Basin



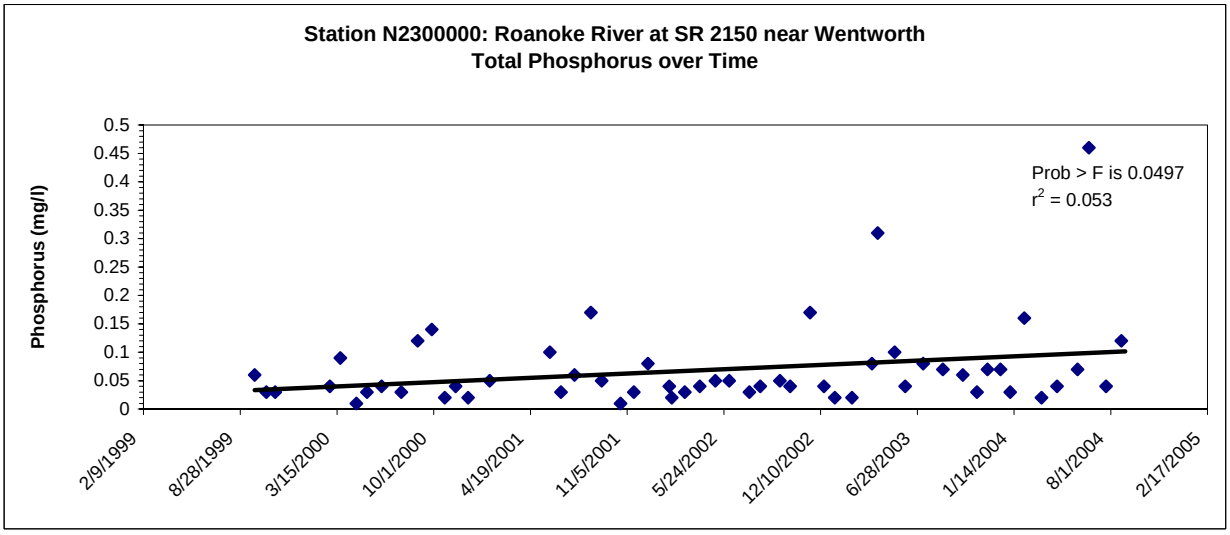


Figure 26. Nutrient Trends at Selected Stations in the Roanoke River Basin

Appendix A: AMS Station Summary Sheets

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: DAN RIV AT NC 704 NR FRANCISCO
Station #: N0150000 **Subbasin:** ROA01
Latitude: 36.51459 **Longitude:** -80.30282 **Stream class:** C Tr
Agency: NCAMBNT **NC stream index:** 22-(1)

Time period: 09/27/1999 to 08/23/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	53	0	<6	0	0		6.5	7.8	8.5	10.2	12.1	14	15
pH (SU)	54	0	<6	3	5.6		5.5	6	6.4	7.1	7.6	7.9	8.7
	54	0	>9	0	0		5.5	6	6.4	7.1	7.6	7.9	8.7
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				25	37	45	48	52	55	77
Water Temperature (°C)	54	0	>20	14	25.9	Yes	0.5	4.1	7.4	13.1	21	23.8	26.7
Other													
TSS (mg/L)	25	4	N/A				1	2	2	5	11	28	44
Turbidity (NTU)	58	1	>10	14	24.1	Yes	1	2	3	6	10	18	50
Nutrients (mg/L)													
NH3 as N	56	33	N/A				0.01	0.01	0.02	0.02	0.04	0.14	0.38
NO2 + NO3 as N	56	0	N/A				0.05	0.15	0.29	0.41	0.46	0.51	0.6
TKN as N	54	23	N/A				0.09	0.2	0.2	0.2	0.24	0.4	0.8
Total Phosphorus	56	11	N/A				0.01	0.01	0.02	0.02	0.03	0.08	0.12
Metals (ug/L)													
Aluminum, total (Al)	25	0	N/A				72	80	120	250	495	888	2900
Arsenic, total (As)	25	25	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	>0.4	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	21	>7	1	4		2	2	2	2	2	3	7
Iron, total (Fe)	25	0	>1000	2	8		180	196	260	420	600	1072	3100
Lead, total (Pb)	25	25	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	25	25	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	25	22	>50	0	0		10	10	10	10	10	10	17

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
54	72	6	11	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: MAYO RIV AT SR 1358 NR PRICE
Station #: N1400000 **Subbasin:** ROA02
Latitude: 36.53514 **Longitude:** -79.99117 **Stream class:** WS-V
Agency: NCAMBNT **NC stream index:** 22-30-(1)

Time period: 09/27/1999 to 08/23/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	53	0	<4	0	0		7.7	8	8.5	10.2	12.1	13.7	15
	53	0	<5	0	0		7.7	8	8.5	10.2	12.1	13.7	15
pH (SU)	54	0	<6	1	1.9		5.8	6.4	6.7	7.2	7.6	7.9	8.2
	54	0	>9	0	0		5.8	6.4	6.7	7.2	7.6	7.9	8.2
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				32	42	49	56	59	64	78
Water Temperature (°C)	54	0	>32	0	0		2.2	4.8	9	14.5	21.4	24	25
Other													
Chloride (mg/L)	10	0	>250	0	0		2	2	2	3	4	5	6
Hardness (mg/L as CaCO3)	13	0	>100	1	7.7		13	14	20	23	48	94	120
TSS (mg/L)	24	2	N/A				1	2	3	8	18	38	65
Turbidity (NTU)	58	0	>50	5	8.6		2	3	5	11	26	51	90
Nutrients (mg/L)													
NH3 as N	20	9	N/A				0.01	0.01	0.01	0.01	0.05	0.14	0.2
NO2 + NO3 as N	20	1	>10	0	0		0.01	0.03	0.1	0.21	0.28	0.35	0.39
TKN as N	18	1	N/A				0.1	0.1	0.2	0.3	0.4	0.71	0.8
Total Phosphorus	20	1	N/A				0.01	0.01	0.02	0.03	0.08	0.12	0.2
Metals (ug/L)													
Aluminum, total (Al)	25	0	N/A				88	110	170	520	1015	2040	3000
Arsenic, total (As)	25	25	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	18	>7	0	0		2	2	2	2	2	3	4
Iron, total (Fe)	25	0	>1000	11	44	Yes	420	442	560	800	1400	2820	4100
Lead, total (Pb)	25	25	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	23	0	>200	0	0		10	15	20	31	42	81	95
Mercury, total (Hg)	24	24	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	25	22	>50	0	0		10	10	10	10	10	10	21

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
54	144	13	24	No

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: DAN RIV AT SR 2150 NR WENTWORTH
Station #: N2300000 **Subbasin:** ROA03
Latitude: 36.41055 **Longitude:** -79.82693 **Stream class:** WS-IV
Agency: NCAMBNT **NC stream index:** 22-(31.5)

Time period: 09/27/1999 to 08/23/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	53	0	<4	0	0		6.2	6.9	7.7	9.4	11.2	13.3	13.9
	53	0	<5	0	0		6.2	6.9	7.7	9.4	11.2	13.3	13.9
pH (SU)	55	0	<6	0	0		6	6.3	6.6	7	7.3	7.6	7.8
	55	0	>9	0	0		6	6.3	6.6	7	7.3	7.6	7.8
Spec. conductance (umhos/cm at 25°C)	53	0	N/A				40	52	58	66	71	77	110
Water Temperature (°C)	54	0	>32	0	0		3	4.9	10	15	23.2	26.2	28
Other													
Chloride (mg/L)	13	0	>250	0	0		2	2	2	3	4	22	34
Hardness (mg/L as CaCO3)	14	0	>100	0	0		14	17	25	30	38	56	63
TSS (mg/L)	25	2	N/A				1	3	5	13	30	63	220
Turbidity (NTU)	55	0	>50	9	16.4	Yes	2	4	6	13	36	74	230
Nutrients (mg/L)													
NH3 as N	55	25	N/A				0.01	0.02	0.02	0.03	0.08	0.25	0.53
NO2 + NO3 as N	55	4	>10	0	0		0.01	0.05	0.15	0.21	0.28	0.33	0.39
TKN as N	53	9	N/A				0.2	0.2	0.2	0.3	0.4	0.48	1.1
Total Phosphorus	55	2	N/A				0.01	0.02	0.03	0.04	0.08	0.15	0.46
Metals (ug/L)													
Aluminum, total (Al)	25	0	N/A				83	170	265	650	1300	5720	11000
Arsenic, total (As)	25	25	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	11	>7	1	4		2	2	2	2	3	4	12
Iron, total (Fe)	25	0	>1000	11	44	Yes	360	470	565	980	1950	5960	13000
Lead, total (Pb)	25	25	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	22	0	>200	1	4.5		23	24	34	42	67	117	280
Mercury, total (Hg)	25	25	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	24	>25	0	0		10	10	10	10	10	10	11
Zinc, total (Zn)	25	15	>50	2	8		10	10	10	10	17	55	85

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
51	153	15	29	Yes

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: SMITH RIV AT SR 1714 NR EDEN
Station #: N2430000 **Subbasin:** ROA03
Latitude: 36.52087 **Longitude:** -79.75281 **Stream class:** WS-IV
Agency: NCAMBNT **NC stream index:** 22-40-(1)

Time period: 07/24/2000 to 08/23/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	47	0	<4	0	0		6.7	7.3	8	10.2	11.6	13.4	14.5
	47	0	<5	0	0		6.7	7.3	8	10.2	11.6	13.4	14.5
pH (SU)	46	0	<6	0	0		6.2	6.6	7	7.2	7.6	7.8	9
	46	0	>9	0	0		6.2	6.6	7	7.2	7.6	7.8	9
Spec. conductance (umhos/cm at 25°C)	47	0	N/A				58	67	79	105	176	248	346
Water Temperature (°C)	46	0	>32	0	0		2	5	8.9	14.2	22	25.1	27.5
Other													
Chloride (mg/L)	6	0	>250	0	0		4	4	11	26	38	44	44
Hardness (mg/L as CaCO3)	6	0	>100	0	0		21	21	23	38	53	63	63
Sulfate (mg/L)	5	1	>250	0	0		5	5	5	6	10	10	10
TSS (mg/L)	17	3	N/A				2	2	5	9	23	234	290
Turbidity (NTU)	48	0	>50	6	12.5	No	2	2	4	9	28	70	200
Nutrients (mg/L)													
NH3 as N	11	4	N/A				0.01	0.01	0.03	0.07	0.29	0.5	0.5
NO2 + NO3 as N	11	1	>10	0	0		0.25	0.27	0.45	0.5	0.76	0.95	0.99
TKN as N	9	1	N/A				0.2	0.2	0.35	0.5	0.79	1	1
Total Phosphorus	11	1	N/A				0.06	0.06	0.09	0.12	0.18	0.66	0.7
Metals (ug/L)													
Aluminum, total (Al)	17	0	N/A				69	110	245	650	890	5680	7200
Arsenic, total (As)	17	17	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	17	17	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	17	17	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	17	7	>7	1	5.9		2	2	2	3	4	9	10
Iron, total (Fe)	17	0	>1000	9	52.9	Yes	320	336	595	1100	1550	7760	10000
Lead, total (Pb)	17	16	>25	0	0		10	10	10	10	10	11	16
Manganese, total (Mn)	16	0	>200	0	0		26	31	40	52	72	131	180
Mercury, total (Hg)	17	17	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	17	17	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	17	8	>50	0	0		10	10	10	11	34	49	49

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
46	117	7	15	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: SMITH RIV AT NC 14 AT EDEN
Station #: N2450000 **Subbasin:** ROA03
Latitude: 36.52500 **Longitude:** -79.76600 **Stream class:** WS-IV
Agency: NCAMBNT **NC stream index:** 22-40-(1)

Time period: 10/27/1999 to 06/21/2000

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	7	0	<4	0	0		7	7	7.8	10.6	11.4	13.8	13.8
	7	0	<5	0	0		7	7	7.8	10.6	11.4	13.8	13.8
pH (SU)	7	0	<6	0	0		6.2	6.2	6.3	6.8	7.2	7.5	7.5
	7	0	>9	0	0		6.2	6.2	6.3	6.8	7.2	7.5	7.5
Spec. conductance (umhos/cm at 25°C)	7	0	N/A				99	99	131	150	168	273	273
Water Temperature (°C)	7	0	>32	0	0		4	4	6	10	21	24	24
Other													
Chloride (mg/L)	8	0	>250	0	0		8	8	17	20	25	45	45
Hardness (mg/L as CaCO3)	8	0	>100	0	0		29	29	29	32	36	48	48
Sulfate (mg/L)	6	0	>250	0	0		3	3	3	5	16	27	27
TSS (mg/L)	8	1	N/A				1	1	1	4	15	260	260
Turbidity (NTU)	8	0	>50	0	0		2	2	3	6	23	45	45
Nutrients (mg/L)													
NH3 as N	8	1	N/A				0.01	0.01	0.01	0.02	0.07	0.11	0.11
NO2 + NO3 as N	8	0	>10	0	0		0.3	0.3	0.43	0.56	0.66	0.79	0.79
TKN as N	8	0	N/A				0.2	0.2	0.3	0.35	0.4	0.4	0.4
Total Phosphorus	8	0	N/A				0.04	0.04	0.06	0.08	0.1	0.47	0.47
Metals (ug/L)													
Aluminum, total (Al)	8	0	N/A				75	75	84	435	1500	9800	9800
Arsenic, total (As)	8	8	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	8	8	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	8	8	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	8	4	>7	1	12.5		2	2	2	2	3	13	13
Iron, total (Fe)	8	0	>1000	3	37.5		450	450	475	815	1900	16000	16000
Lead, total (Pb)	8	8	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	8	0	>200	1	12.5		26	26	33	49	86	800	800
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	8	8	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	8	0	>50	2	25		16	16	20	31	50	82	82

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
8	53	1	12	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: DAN RIV AT SR 1761 NR MAYFIELD
Station #: N3000000 **Subbasin:** ROA03
Latitude: 36.54142 **Longitude:** -79.60525 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-(39)

Time period: 09/28/1999 to 08/23/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		6.2	6.7	7.7	9.4	11.6	13.7	14.9
	54	0	<5	0	0		6.2	6.7	7.7	9.4	11.6	13.7	14.9
pH (SU)	55	0	<6	0	0		6.2	6.5	6.9	7.2	7.6	7.7	8.4
	55	0	>9	0	0		6.2	6.5	6.9	7.2	7.6	7.7	8.4
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				63	78	90	115	160	202	340
Water Temperature (°C)	53	0	>32	0	0		2	5.7	9	15	23	27.3	30.2
Other													
Chloride (mg/L)	1	0	>230	0	0		22	22	22	22	22	22	22
TSS (mg/L)	24	2	N/A				1	2	5	11	35	94	210
Turbidity (NTU)	57	0	>50	10	17.5	Yes	3	4	7	16	39	122	230
Nutrients (mg/L)													
NH3 as N	20	8	N/A				0.01	0.01	0.01	0.03	0.18	0.49	0.71
NO2 + NO3 as N	20	1	N/A				0.15	0.16	0.24	0.33	0.43	0.5	0.68
TKN as N	19	1	N/A				0.1	0.1	0.3	0.3	0.5	0.9	1
Total Phosphorus	20	1	N/A				0.03	0.06	0.07	0.1	0.22	0.42	0.5
Metals (ug/L)													
Aluminum, total (Al)	24	0	N/A				120	185	280	510	2100	5400	7700
Arsenic, total (As)	25	25	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	2	>7	2	8		2	2	3	3	4	8	12
Iron, total (Fe)	24	0	>1000	9	37.5	Yes	510	530	592	920	2550	6950	12000
Lead, total (Pb)	25	25	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	25	25	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	25	11	>50	1	4		10	10	10	14	31	41	67

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
55	135	15	27	No

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: DAN RIV AT NC 57 AT VA LINE AT MILTON
Station #: N3500000 **Subbasin:** ROA04
Latitude: 36.54079 **Longitude:** -79.21422 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-(39)

Time period: 09/28/1999 to 08/19/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		6	6.4	7.6	9.2	11.3	13	14
	54	0	<5	0	0		6	6.4	7.6	9.2	11.3	13	14
pH (SU)	54	0	<6	0	0		6.1	6.5	6.8	7.2	7.4	7.5	8.2
	54	0	>9	0	0		6.1	6.5	6.8	7.2	7.4	7.5	8.2
Spec. conductance (umhos/cm at 25°C)	54	0	N/A				57	90	112	152	201	272	421
Water Temperature (°C)	53	0	>32	0	0		2	6	9.5	16	23.9	27.7	29.3
Other													
TSS (mg/L)	24	2	N/A				1	2	6	24	49	125	170
Turbidity (NTU)	56	0	>50	9	16.1	Yes	3	4	6	16	34	92	220
Nutrients (mg/L)													
NH3 as N	20	3	N/A				0.01	0.01	0.06	0.15	0.29	0.49	1
NO2 + NO3 as N	20	1	N/A				0.13	0.14	0.29	0.34	0.44	0.58	0.59
TKN as N	19	2	N/A				0.2	0.2	0.3	0.4	0.6	0.9	1
Total Phosphorus	20	1	N/A				0.04	0.05	0.06	0.07	0.13	0.18	0.5
Metals (ug/L)													
Aluminum, total (Al)	27	0	N/A				140	180	320	920	2800	4180	6700
Arsenic, total (As)	27	27	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	27	27	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	27	27	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	27	8	>7	3	11.1	No	2	2	2	3	5	8	9
Iron, total (Fe)	27	0	>1000	16	59.3	Yes	320	488	730	1500	2800	5580	9400
Lead, total (Pb)	27	27	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	27	27	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	27	27	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	27	12	>50	0	0		10	10	10	13	21	27	30

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
56	129	9	16	

Key:
result: number of observations
ND: number of observations reported to be below detection level (non-detect)
EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
Results not meeting EL: number and percentages of observations not meeting evaluation level
95% : States whether there is 95% statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
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Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: HYCO CRK AT US 158 NR LEASBURG
Station #: N4110000 **Subbasin:** ROA05
Latitude: 36.39900 **Longitude:** -79.19700 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-58-1

Time period: 09/28/1999 to 06/21/2000

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	7	0	<4	0	0		6.3	6.3	7.3	9	10.5	13	13
	7	0	<5	0	0		6.3	6.3	7.3	9	10.5	13	13
pH (SU)	7	0	<6	0	0		7	7	7	7.2	7.3	7.3	7.3
	7	0	>9	0	0		7	7	7	7.2	7.3	7.3	7.3
Spec. conductance (umhos/cm at 25°C)	7	0	N/A				92	92	92	99	110	112	112
Water Temperature (°C)	7	0	>32	0	0		4	4	7	14	24	25	25
Other													
TSS (mg/L)	8	0	N/A				2	2	6	13	29	41	41
Turbidity (NTU)	9	0	>50	0	0		6	6	7	10	21	22	22
Nutrients (mg/L)													
NH3 as N	9	3	N/A				0.01	0.01	0.01	0.02	0.08	0.21	0.21
NO2 + NO3 as N	9	2	N/A				0.01	0.01	0.02	0.06	0.08	0.16	0.16
TKN as N	9	0	N/A				0.2	0.2	0.2	0.2	0.3	0.7	0.7
Total Phosphorus	9	0	N/A				0.01	0.01	0.03	0.03	0.04	0.09	0.09
Metals (ug/L)													
Aluminum, total (Al)	9	0	N/A				210	210	230	420	1800	3700	3700
Arsenic, total (As)	9	9	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	9	9	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	9	9	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	9	5	>7	0	0		2	2	2	2	3	4	4
Iron, total (Fe)	9	0	>1000	8	88.9		920	920	1350	1600	2150	3900	3900
Lead, total (Pb)	9	9	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	9	9	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	9	9	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	9	0	>50	2	22.2		21	21	22	29	48	59	59

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
8	120	1	12	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: HYCO RIV BELOW AFTERBAY DAM NR MCGHEES MILL
Station #: N4250000 **Subbasin:** ROA05
Latitude: 36.52353 **Longitude:** -78.99600 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-58-(9.5)

Time period: 09/22/1999 to 08/04/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	53	0	<4	0	0		5.2	6	6.9	9.2	11	12.8	17.1
	53	0	<5	0	0		5.2	6	6.9	9.2	11	12.8	17.1
pH (SU)	53	0	<6	0	0		6.2	6.4	6.8	7	7.1	7.2	7.5
	53	0	>9	0	0		6.2	6.4	6.8	7	7.1	7.2	7.5
Salinity (ppt)	13	0	N/A				0	0	0	0	0.05	0.1	0.1
Spec. conductance (umhos/cm at 25°C)	53	0	N/A				66	70	90	99	110	134	211
Water Temperature (°C)	53	0	>32	0	0		2	7.6	10.7	19.3	23.5	25.8	29.5
Other													
Chloride (mg/L)	1	0	>230	0	0		8	8	8	8	8	8	8
TSS (mg/L)	24	1	N/A				1	2	4	5	7	10	10
Turbidity (NTU)	52	0	>50	0	0		2	4	5	7	9	11	18
Nutrients (mg/L)													
NH3 as N	16	4	N/A				0.01	0.01	0.02	0.06	0.16	0.24	0.33
NO2 + NO3 as N	16	6	N/A				0.01	0.01	0.01	0.04	0.13	0.15	0.16
TKN as N	15	0	N/A				0.2	0.2	0.3	0.4	0.5	0.8	1.1
Total Phosphorus	16	3	N/A				0.01	0.01	0.01	0.02	0.03	0.07	0.1
Metals (ug/L)													
Aluminum, total (Al)	23	1	N/A				50	116	290	430	590	796	1500
Arsenic, total (As)	23	22	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	23	23	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	23	23	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	23	4	>7	0	0		2	2	2	3	4	5	6
Iron, total (Fe)	23	0	>1000	4	17.4	No	54	170	360	480	840	1160	1500
Lead, total (Pb)	23	23	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	23	23	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	23	23	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	23	20	>50	0	0		10	10	10	10	10	10	11

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
50	18	5	10	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: MARLOWE CRK AT SR 1322 NR WOODSDALE
Station #: N4400000 **Subbasin:** ROA05
Latitude: 36.48325 **Longitude:** -78.97941 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-58-12-6

Time period: 09/22/1999 to 10/07/2003

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	46	0	<4	0	0		4.9	6.4	7.7	9.7	11.8	13.3	15
	46	0	<5	1	2.2		4.9	6.4	7.7	9.7	11.8	13.3	15
pH (SU)	46	0	<6	0	0		6.2	6.8	6.9	7.1	7.4	7.5	8.1
	46	0	>9	0	0		6.2	6.8	6.9	7.1	7.4	7.5	8.1
Salinity (ppt)	5	1	N/A				0	0	0	0.1	0.15	0.2	0.2
Spec. conductance (umhos/cm at 25°C)	46	0	N/A				63	138	194	266	348	514	670
Water Temperature (°C)	46	0	>32	0	0		4.6	6.1	9	14.9	21.3	25	26.3
Other													
TSS (mg/L)	22	2	N/A				1	1	2	4	10	37	110
Turbidity (NTU)	46	0	>50	2	4.3		1	3	4	7	11	29	90
Nutrients (mg/L)													
NH3 as N	18	7	N/A				0.01	0.01	0.01	0.03	0.17	0.25	0.35
NO2 + NO3 as N	18	0	N/A				0.44	0.94	1.47	2.4	3.2	4.34	6.5
TKN as N	17	0	N/A				0.2	0.36	0.4	0.6	0.65	1.32	2.6
Total Phosphorus	18	0	N/A				0.06	0.19	0.24	0.38	0.75	1	2.1
Metals (ug/L)													
Aluminum, total (Al)	21	0	N/A				53	144	190	300	575	2420	8000
Arsenic, total (As)	21	21	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	21	21	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	21	21	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	21	1	>7	6	28.6	Yes	2	3	4	6	8	11	21
Iron, total (Fe)	21	0	>1000	4	19	No	160	266	455	630	965	3080	7000
Lead, total (Pb)	21	19	>25	0	0		10	10	10	10	10	10	16
Mercury, total (Hg)	21	21	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	21	20	>88	0	0		10	10	10	10	10	10	15
Zinc, total (Zn)	21	3	>50	3	14.3	No	10	10	16	24	30	68	170

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
46	255	16	35	Yes

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: HYCO RIV AT US 501 NR DENNISTON VA
Station #: N4510000 **Subbasin:** ROA05
Latitude: 36.58805 **Longitude:** -78.89814 **Stream class:** III NT
Agency: NCAMBNT **NC stream index:**

Time period: 09/22/1999 to 08/04/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	56	0	N/A				4.5	5.8	6.5	8.2	10.8	12.3	16.1
pH (SU)	55	0	N/A				6.2	6.5	6.7	7	7.2	7.4	7.6
Salinity (ppt)	14	0	N/A				0	0	0	0.05	0.1	0.1	0.1
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				73	94	104	132	177	237	369
Water Temperature (°C)	56	0	N/A				2	5.8	8.5	16.4	23.6	26	28
Other													
Hardness (mg/L as CaCO3)	13	0	N/A				24	25	29	42	56	85	99
TSS (mg/L)	26	3	N/A				1	2	3	6	20	35	39
Turbidity (NTU)	55	0	N/A				2	3	6	8	12	35	100
Nutrients (mg/L)													
NH3 as N	17	4	N/A				0.01	0.01	0.01	0.06	0.13	0.29	0.63
NO2 + NO3 as N	17	0	N/A				0.02	0.13	0.22	0.42	0.68	1	1
TKN as N	16	0	N/A				0.2	0.27	0.4	0.4	0.67	0.95	1.3
Total Phosphorus	17	1	N/A				0.02	0.02	0.04	0.08	0.14	0.22	0.31
Metals (ug/L)													
Aluminum, total (Al)	25	0	N/A				59	144	225	410	665	1280	3600
Arsenic, total (As)	25	25	N/A				10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	N/A				2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	N/A				25	25	25	25	25	25	25
Copper, total (Cu)	25	2	N/A				2	2	3	3	5	5	7
Iron, total (Fe)	25	0	N/A				500	520	665	890	1450	1820	3300
Lead, total (Pb)	25	25	N/A				10	10	10	10	10	10	10
Manganese, total (Mn)	1	0	N/A				1100	1100	1100	1100	1100	1100	1100
Mercury, total (Hg)	25	25	N/A				0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	N/A				10	10	10	10	10	10	10
Zinc, total (Zn)	25	16	N/A				10	10	10	10	13	20	24

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
53	112	10	19	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: MAYO CRK AT SR 1501 NR BETHEL HILL
Station #: N4590000 **Subbasin:** ROA05
Latitude: 36.54021 **Longitude:** -78.87362 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 22-58-15-(3.5)

Time period: 09/22/1999 to 08/04/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	56	0	<4	1	1.8		3.5	6.5	7.7	9	10.7	12.5	15.8
	56	0	<5	1	1.8		3.5	6.5	7.7	9	10.7	12.5	15.8
pH (SU)	56	0	<6	0	0		6	6.5	6.7	7	7.2	7.4	8.1
	56	0	>9	0	0		6	6.5	6.7	7	7.2	7.4	8.1
Salinity (ppt)	14	0	N/A				0	0	0	0	0.03	0.1	0.1
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				20	75	88	100	113	118	160
Water Temperature (°C)	56	0	>32	0	0		4	6.8	8.5	14.2	20.2	26.4	29.4
Other													
Chloride (mg/L)	1	0	>230	0	0		6	6	6	6	6	6	6
TSS (mg/L)	26	7	N/A				1	1	2	2	4	6	15
Turbidity (NTU)	55	8	>50	0	0		1	1	1	1	2	3	4
Nutrients (mg/L)													
NH3 as N	17	6	N/A				0.01	0.01	0.01	0.07	0.14	0.56	0.65
NO2 + NO3 as N	17	6	N/A				0.01	0.01	0.01	0.05	0.1	0.26	0.53
TKN as N	16	1	N/A				0.2	0.2	0.23	0.3	0.58	0.96	1.8
Total Phosphorus	17	7	N/A				0.01	0.01	0.01	0.01	0.02	0.08	0.1
Metals (ug/L)													
Aluminum, total (Al)	24	10	N/A				50	50	50	58	88	190	1400
Arsenic, total (As)	24	24	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	24	24	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	24	24	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	24	14	>7	0	0		2	2	2	2	3	3	6
Iron, total (Fe)	24	5	>1000	1	4.2		50	50	58	80	115	290	1900
Lead, total (Pb)	24	24	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	24	24	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	24	24	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	24	19	>50	0	0		10	10	10	10	10	12	16

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
53	9	0	0	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: NUTBUSH CRK AT SR 1317 NR HENDERSON
Station #: N5000000 **Subbasin:** ROA06
Latitude: 36.36914 **Longitude:** -78.40834 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 23-8-(1)

Time period: 09/09/1999 to 08/17/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	55	0	<4	0	0		6.5	7.2	8	9.6	12	13.4	16.5
	55	0	<5	0	0		6.5	7.2	8	9.6	12	13.4	16.5
pH (SU)	55	0	<6	0	0		6.5	6.7	7	7.1	7.6	7.8	8.6
	55	0	>9	0	0		6.5	6.7	7	7.1	7.6	7.8	8.6
Salinity (ppt)	14	0	N/A				0	0	0.1	0.2	0.2	0.3	0.3
Spec. conductance (umhos/cm at 25°C)	53	0	N/A				120	268	340	423	528	592	737
Water Temperature (°C)	55	0	>32	0	0		2.8	6.9	10.9	16	21.6	25	28
Other													
TSS (mg/L)	25	5	N/A				1	1	2	3	4	7	16
Turbidity (NTU)	55	2	>50	0	0		1	1	2	3	6	11	19
Nutrients (mg/L)													
NH3 as N	33	11	N/A				0.01	0.01	0.02	0.03	0.18	0.4	0.96
NO2 + NO3 as N	33	0	N/A				0.31	2.36	5.7	8.7	11	12	15
TKN as N	32	1	N/A				0.2	0.41	0.49	0.6	0.8	1.41	4.7
Total Phosphorus	33	1	N/A				0.09	0.12	0.19	0.35	0.49	0.7	0.81
Metals (ug/L)													
Aluminum, total (Al)	25	2	N/A				50	53	92	170	375	658	2500
Arsenic, total (As)	25	23	>10	2	8		10	10	10	10	10	10	14
Cadmium, total (Cd)	25	25	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	5	>7	2	8		2	2	2	3	4	7	11
Iron, total (Fe)	25	0	>1000	2	8		82	132	205	330	595	1112	2500
Lead, total (Pb)	25	24	>25	0	0		10	10	10	10	10	10	25
Mercury, total (Hg)	25	25	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	25	2	>50	0	0		10	11	14	18	29	37	43

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
56	132	5	9	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: SMITH CRK AT US 1 NR PASCHALL
Station #: N6400000 **Subbasin:** ROA07
Latitude: 36.54087 **Longitude:** -78.19514 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 23-10

Time period: 09/09/1999 to 08/17/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	56	0	<4	7	12.5	No	1	3.1	4.8	6.4	9	11.9	13.2
	56	0	<5	17	30.4	Yes	1	3.1	4.8	6.4	9	11.9	13.2
pH (SU)	55	0	<6	2	3.6		5.6	6.2	6.6	6.9	7	7.1	7.6
	55	0	>9	0	0		5.6	6.2	6.6	6.9	7	7.1	7.6
Salinity (ppt)	14	0	N/A				0	0	0	0	0	0.05	0.1
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				42	62	71	84	101	155	1000
Water Temperature (°C)	56	0	>32	0	0		0	4.2	10	16.1	22.6	25.2	28
Other													
TSS (mg/L)	27	4	N/A				1	1	2	4	6	9	13
Turbidity (NTU)	56	0	>50	1	1.8		2	3	4	8	14	23	85
Nutrients (mg/L)													
NH3 as N	35	17	N/A				0.01	0.01	0.02	0.02	0.07	0.18	0.53
NO2 + NO3 as N	35	17	N/A				0.01	0.01	0.02	0.03	0.1	0.15	0.4
TKN as N	35	0	N/A				0.2	0.23	0.3	0.4	0.5	0.66	0.84
Total Phosphorus	35	2	N/A				0.02	0.03	0.04	0.06	0.12	0.16	0.28
Metals (ug/L)													
Aluminum, total (Al)	26	3	N/A				50	50	59	74	118	395	1700
Arsenic, total (As)	26	26	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	26	26	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	26	26	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	26	22	>7	1	3.8		2	2	2	2	2	4	12
Iron, total (Fe)	26	0	>1000	25	96.2	Yes	1000	1170	1875	2900	3725	4390	5800
Lead, total (Pb)	26	26	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	26	26	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	26	26	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	26	21	>50	0	0		10	10	10	10	10	16	32

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
55	70	1	2	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV AT NC 48 AT ROANOKE RAPIDS
Station #: N7300000 **Subbasin:** ROA08
Latitude: 36.48151 **Longitude:** -77.64526 **Stream class:** WS-IV CA
Agency: NCAMBNT **NC stream index:** 23-(25.5)

Time period: 09/27/1999 to 08/31/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	54	0	<4	0	0		5	6.3	7.1	9.5	11.7	12.9	16.1
	54	0	<5	0	0		5	6.3	7.1	9.5	11.7	12.9	16.1
pH (SU)	54	0	<6	1	1.9		5.9	6.5	6.8	7	7.2	7.4	8.4
	54	0	>9	0	0		5.9	6.5	6.8	7	7.2	7.4	8.4
Salinity (ppt)	14	0	N/A				0	0	0	0	0.1	0.15	0.2
Spec. conductance (umhos/cm at 25°C)	55	0	N/A				50	85	94	107	120	135	388
Water Temperature (°C)	54	0	>32	0	0		3	6	11.2	16.6	24.9	26.2	28.3
Other													
Chloride (mg/L)	15	0	>250	0	0		5	7	8	9	9	10	10
Hardness (mg/L as CaCO3)	13	1	>100	0	0		1	10	24	31	36	45	50
TSS (mg/L)	27	6	N/A				1	1	2	4	4	11	44
Turbidity (NTU)	54	1	>50	0	0		1	2	2	3	4	10	38
Nutrients (mg/L)													
NH3 as N	50	24	N/A				0.01	0.01	0.02	0.02	0.05	0.13	1.3
NO2 + NO3 as N	50	8	>10	0	0		0.01	0.01	0.03	0.14	0.2	0.23	2.8
TKN as N	50	4	N/A				0.2	0.2	0.23	0.28	0.32	0.49	0.9
Total Phosphorus	50	12	N/A				0.01	0.01	0.02	0.02	0.03	0.12	0.38
Metals (ug/L)													
Aluminum, total (Al)	24	2	N/A				50	52	81	115	188	295	880
Arsenic, total (As)	24	24	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	24	24	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	24	24	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	24	13	>7	0	0		2	2	2	2	3	4	7
Iron, total (Fe)	24	0	>1000	0	0		57	90	170	210	318	490	850
Lead, total (Pb)	24	24	>25	0	0		10	10	10	10	10	10	10
Manganese, total (Mn)	23	0	>200	0	0		24	29	39	55	93	136	200
Mercury, total (Hg)	24	24	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	24	24	>25	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	24	21	>50	0	0		10	10	10	10	10	11	16

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
53	10	0	0	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV AT US 258 NR SCOTLAND NECK
Station #: N8200000 **Subbasin:** ROA08
Latitude: 36.20925 **Longitude:** -77.38387 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 23-(26)

Time period: 09/27/1999 to 08/31/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	55	0	<4	0	0		4.9	6.2	6.8	8.9	10.9	12.7	16.3
	55	0	<5	1	1.8		4.9	6.2	6.8	8.9	10.9	12.7	16.3
pH (SU)	56	0	<6	0	0		6	6.3	6.7	7	7.2	7.4	7.8
	56	0	>9	0	0		6	6.3	6.7	7	7.2	7.4	7.8
Salinity (ppt)	14	0	N/A				0	0	0	0	0.1	0.1	0.1
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				35	91	99	118	140	153	172
Water Temperature (°C)	56	0	>32	0	0		3	6.1	11.5	17.1	24.2	26.5	28.6
Other													
TSS (mg/L)	18	0	N/A				6	6	9	12	18	42	45
Turbidity (NTU)	54	0	>50	0	0		4	4	5	8	15	22	45
Nutrients (mg/L)													
NH3 as N	51	20	N/A				0.01	0.01	0.02	0.02	0.06	0.11	0.34
NO2 + NO3 as N	51	0	N/A				0.02	0.09	0.13	0.18	0.23	0.28	2.8
TKN as N	51	4	N/A				0.2	0.2	0.26	0.3	0.35	0.59	2.5
Total Phosphorus	51	2	N/A				0.01	0.02	0.03	0.04	0.07	0.14	4
Metals (ug/L)													
Aluminum, total (Al)	25	0	N/A				150	186	270	380	625	1100	1100
Arsenic, total (As)	25	25	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	25	25	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	25	25	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	25	10	>7	1	4		2	2	2	2	3	5	27
Iron, total (Fe)	25	0	>1000	5	20	Yes	270	394	525	650	975	1640	1800
Lead, total (Pb)	25	25	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	25	25	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	25	25	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	25	21	>50	0	0		10	10	10	10	10	14	33

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
53	46	6	11	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV AT NC 11 NR LEWISTON
Station #: N8300000 **Subbasin:** ROA08
Latitude: 36.01400 **Longitude:** -77.21487 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 23-(26)

Time period: 09/27/1999 to 08/02/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	57	0	<4	2	3.5		2.5	5.8	6.5	7.6	10.2	11.9	12.6
	57	0	<5	2	3.5		2.5	5.8	6.5	7.6	10.2	11.9	12.6
pH (SU)	57	0	<6	0	0		6	6.4	6.8	7	7.3	7.5	7.7
	57	0	>9	0	0		6	6.4	6.8	7	7.3	7.5	7.7
Salinity (ppt)	55	24	N/A				0.02	0.03	0.04	0.07	0.2	0.2	0.2
Spec. conductance (umhos/cm at 25°C)	57	0	N/A				78	88	100	119	134	151	920
Water Temperature (°C)	57	0	>32	0	0		3.3	7.1	11.3	18.2	24.2	28	28.4
Other													
TSS (mg/L)	27	0	N/A				2	4	10	13	18	25	28
Turbidity (NTU)	56	0	>50	0	0		3	4	6	9	13	18	34
Nutrients (mg/L)													
NH3 as N	57	21	N/A				0.01	0.01	0.02	0.02	0.05	0.12	0.46
NO2 + NO3 as N	57	0	N/A				0.03	0.12	0.16	0.19	0.24	0.27	0.31
TKN as N	56	4	N/A				0.2	0.2	0.26	0.31	0.38	0.42	1.2
Total Phosphorus	57	1	N/A				0.03	0.04	0.05	0.06	0.07	0.08	0.12
Metals (ug/L)													
Aluminum, total (Al)	27	0	N/A				150	318	450	670	810	894	990
Arsenic, total (As)	27	27	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	27	27	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	27	27	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	27	14	>7	1	3.7		2	2	2	2	3	6	25
Iron, total (Fe)	27	0	>1000	13	48.1	Yes	520	680	740	960	1200	1500	1500
Lead, total (Pb)	27	27	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	27	27	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	27	27	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	27	20	>50	0	0		10	10	10	10	10	13	19

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
56	24	1	2	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV AT US 13 AND US 17 AT WILLIAMSTON
Station #: N8550000 **Subbasin:** ROA09
Latitude: 35.85986 **Longitude:** -77.04009 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 23-(26)

Time period: 09/27/1999 to 08/02/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	53	0	<4	1	1.9		3.4	5.1	6.4	7.5	9.7	11.4	12.2
	53	0	<5	4	7.5		3.4	5.1	6.4	7.5	9.7	11.4	12.2
pH (SU)	53	0	<6	0	0		6.2	6.7	6.8	7.2	7.4	7.6	8.1
	53	0	>9	0	0		6.2	6.7	6.8	7.2	7.4	7.6	8.1
Salinity (ppt)	51	24	N/A				0.03	0.03	0.05	0.07	0.2	0.2	0.2
Spec. conductance (umhos/cm at 25°C)	53	0	N/A				82	91	99	121	138	154	890
Water Temperature (°C)	53	0	>32	0	0		4.8	7.5	11.7	20.4	25.1	27.4	29
Other													
TSS (mg/L)	25	0	N/A				1	3	8	12	19	29	52
Turbidity (NTU)	52	0	>50	0	0		3	5	6	8	12	15	50
Nutrients (mg/L)													
NH3 as N	51	14	N/A				0.01	0.01	0.02	0.04	0.09	0.15	0.47
NO2 + NO3 as N	51	0	N/A				0.03	0.12	0.16	0.18	0.21	0.25	0.38
TKN as N	50	4	N/A				0.16	0.2	0.3	0.3	0.35	0.46	0.8
Total Phosphorus	51	1	N/A				0.02	0.04	0.05	0.06	0.08	0.08	0.15
Metals (ug/L)													
Aluminum, total (Al)	27	0	N/A				180	230	350	510	760	1040	1600
Arsenic, total (As)	26	26	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	27	27	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	27	27	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	27	13	>7	1	3.7		2	2	2	2	3	4	21
Iron, total (Fe)	27	0	>1000	12	44.4	Yes	290	396	630	960	1300	1740	2400
Lead, total (Pb)	27	27	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	27	27	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	27	27	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	27	15	>50	0	0		10	10	10	10	13	16	22

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
51	28	2	4	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: CASHIE RIV AT SR 1219 NR LEWISTON
Station #: N8950000 **Subbasin:** ROA10
Latitude: 36.12376 **Longitude:** -77.12140 **Stream class:** C Sw
Agency: NCAMBNT **NC stream index:** 24-2-(1)

Time period: 09/27/1999 to 08/02/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	56	0	N/A				0.2	0.5	1.1	2.8	8	9.3	11.4
pH (SU)	56	0	<4.3	0	0		4.9	5.2	5.7	6.2	6.6	7	7.8
	56	0	>9	0	0		4.9	5.2	5.7	6.2	6.6	7	7.8
Salinity (ppt)	53	24	N/A				0.01	0.01	0.03	0.05	0.2	0.2	0.2
Spec. conductance (umhos/cm at 25°C)	56	0	N/A				29	51	68	79	94	111	800
Water Temperature (°C)	56	0	>32	1	1.8		3.2	5.9	10.6	18.9	22.7	25.4	32.2
Other													
TSS (mg/L)	28	1	N/A				1	1	3	6	9	13	23
Turbidity (NTU)	56	0	>50	1	1.8		3	3	4	7	11	17	55
Nutrients (mg/L)													
NH3 as N	57	15	N/A				0.01	0.01	0.02	0.05	0.11	0.25	1
NO2 + NO3 as N	57	36	N/A				0.01	0.01	0.01	0.02	0.04	0.08	0.44
TKN as N	56	0	N/A				0.4	0.5	0.61	0.83	1.1	1.3	1.6
Total Phosphorus	57	0	N/A				0.05	0.08	0.12	0.21	0.28	0.36	0.64
Metals (ug/L)													
Aluminum, total (Al)	29	0	N/A				110	170	190	260	445	810	2400
Arsenic, total (As)	29	29	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	29	29	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	29	29	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	29	21	>7	1	3.4		2	2	2	2	2	3	22
Iron, total (Fe)	29	0	>1000	27	93.1	Yes	750	1100	2150	4000	5250	7000	8900
Lead, total (Pb)	29	29	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	28	28	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	29	29	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	29	15	>50	0	0		10	10	10	10	14	21	31

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
56	82	2	4	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV 1.3 MI UPS WELCH CRK NR PLYMOUTH
Station #: N9250000 **Subbasin:** ROA09
Latitude: 35.86767 **Longitude:** -76.78541 **Stream class:** C Sw
Agency: NCAMBNT **NC stream index:** 23-(53)

Time period: 09/28/1999 to 08/12/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	58	0	N/A				0.3	4.7	6.1	7.6	9.4	11	12.2
pH (SU)	58	0	<4.3	0	0		5.5	6.4	6.6	7	7.3	7.4	7.9
	58	0	>9	0	0		5.5	6.4	6.6	7	7.3	7.4	7.9
Salinity (ppt)	57	24	N/A				0.02	0.03	0.04	0.07	0.2	0.2	0.5
Spec. conductance (umhos/cm at 25°C)	58	0	N/A				71	86	94	112	137	149	297
Water Temperature (°C)	58	0	>32	0	0		4	7	11.8	19	25	28	29.6
Other													
Chlorophyll A (ug/L)	42	4	>40	0	0		1	1	2	3	6	10	17
TSS (mg/L)	28	1	N/A				1	2	3	6	8	13	21
Turbidity (NTU)	56	0	>50	0	0		2	4	5	6	10	15	22
Nutrients (mg/L)													
NH3 as N	55	14	N/A				0.01	0.02	0.02	0.03	0.08	0.15	0.4
NO2 + NO3 as N	55	2	N/A				0.01	0.1	0.12	0.18	0.21	0.24	0.32
TKN as N	54	4	N/A				0.2	0.21	0.3	0.34	0.4	0.51	0.8
Total Phosphorus	55	1	N/A				0.01	0.04	0.05	0.06	0.07	0.08	0.24
Metals (ug/L)													
Aluminum, total (Al)	27	0	N/A				170	188	260	290	520	812	890
Arsenic, total (As)	27	27	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	27	27	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	27	27	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	27	19	>7	0	0		2	2	2	2	2	3	4
Iron, total (Fe)	27	0	>1000	10	37	Yes	240	380	590	820	1200	1500	1500
Lead, total (Pb)	27	27	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	27	27	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	27	27	>88	0	0		10	10	10	10	10	10	50
Zinc, total (Zn)	27	22	>50	0	0		10	10	10	10	10	30	47

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
57	10	0	0	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ROANOKE RIV AT NC 45 AT SANS SOUCI
Station #: N9600000 **Subbasin:** ROA09
Latitude: 35.91469 **Longitude:** -76.72252 **Stream class:** C Sw
Agency: NCAMBNT **NC stream index:** 23-(53)

Time period: 09/28/1999 to 08/12/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	58	0	N/A				0.2	3.9	5.9	6.9	9.4	11.3	11.9
pH (SU)	58	0	<4.3	0	0		5.7	6.2	6.8	7	7.2	7.4	7.9
	58	0	>9	0	0		5.7	6.2	6.8	7	7.2	7.4	7.9
Salinity (ppt)	57	20	N/A				0.03	0.04	0.05	0.14	0.2	0.2	0.49
Spec. conductance (umhos/cm at 25°C)	58	0	N/A				89	103	116	146	206	363	941
Water Temperature (°C)	58	0	>32	0	0		5	7.2	11.9	19.1	25.4	27.9	30.5
Other													
Chlorophyll A (ug/L)	42	2	>40	0	0		1	1	2	4	7	10	19
TSS (mg/L)	28	0	N/A				1	2	3	5	8	12	20
Turbidity (NTU)	56	0	>50	0	0		3	4	4	6	9	15	30
Nutrients (mg/L)													
NH3 as N	56	4	N/A				0.01	0.02	0.04	0.09	0.15	0.22	0.3
NO2 + NO3 as N	56	1	N/A				0.02	0.09	0.12	0.17	0.21	0.24	0.29
TKN as N	55	1	N/A				0.2	0.28	0.35	0.41	0.5	0.7	0.9
Total Phosphorus	56	1	N/A				0.02	0.05	0.06	0.07	0.08	0.1	0.25
Metals (ug/L)													
Aluminum, total (Al)	27	0	N/A				130	188	260	310	390	522	680
Arsenic, total (As)	27	27	>10	0	0		10	10	10	10	10	10	10
Cadmium, total (Cd)	27	27	>2	0	0		2	2	2	2	2	2	2
Chromium, total (Cr)	27	27	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	27	15	>7	0	0		2	2	2	2	3	3	5
Iron, total (Fe)	27	0	>1000	7	25.9	Yes	230	328	460	800	1100	1640	1800
Lead, total (Pb)	27	27	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	27	27	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	27	27	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	27	19	>50	0	0		10	10	10	10	11	14	16

Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
57	13	0	0	

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

Ambient Monitoring System Station
NCDENR, Division of Water
Basinwide Assessment

Location: ALBEMARLE SOUND AT BATCHELOR BAY NR BLACK WALNUT
Station #: N9700000 **Subbasin:** ROA09
Latitude: 35.96509 **Longitude:** -76.67454 **Stream class:** B Sw
Agency: NCAMBNT **NC stream index:** 24

Time period: 09/28/1999 to 08/12/2004

	# result	# ND	EL	Results not meeting #	%	95%	Min	Percentile 10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	58	0	N/A				0.2	4.7	6.8	8.2	10.1	11.6	13.1
pH (SU)	58	0	<4.3	0	0		5.8	6.3	7	7.2	7.4	7.6	8.2
	58	0	>9	0	0		5.8	6.3	7	7.2	7.4	7.6	8.2
Salinity (ppt)	57	15	N/A				0.03	0.04	0.05	0.2	0.91	2.5	3.38
Spec. conductance (umhos/cm at 25°C)	58	0	N/A				81	94	108	138	1710	4396	6108
Water Temperature (°C)	58	0	>32	0	0		4	6.2	11.9	18.8	25.6	27.6	29.4
Other													
Chloride (mg/L)	1	0	>230	0	0		9	9	9	9	9	9	9
Chlorophyll A (ug/L)	40	3	>40	0	0		1	1	2	4	9	14	15
TSS (mg/L)	27	1	N/A				1	1	2	4	10	16	52
Turbidity (NTU)	56	0	>50	1	1.8		2	3	4	6	8	13	81
Nutrients (mg/L)													
NH3 as N	56	12	N/A				0.01	0.02	0.02	0.05	0.08	0.16	0.45
NO2 + NO3 as N	56	6	N/A				0.01	0.02	0.06	0.12	0.18	0.21	490
TKN as N	55	2	N/A				0.2	0.24	0.33	0.4	0.45	0.54	0.82
Total Phosphorus	56	1	N/A				0.01	0.03	0.04	0.05	0.06	0.08	0.29
Metals (ug/L)													
Aluminum, total (Al)	28	0	N/A				130	130	202	250	522	801	860
Arsenic, total (As)	28	28	>10	0	0		10	10	10	10	10	10	50
Cadmium, total (Cd)	28	28	>2	0	0		2	2	2	2	2	2	10
Chromium, total (Cr)	28	28	>50	0	0		25	25	25	25	25	25	25
Copper, total (Cu)	28	17	>7	1	3.6		2	2	2	2	3	7	34
Iron, total (Fe)	28	0	>1000	10	35.7	Yes	180	343	525	750	1175	1220	2200
Lead, total (Pb)	28	28	>25	0	0		10	10	10	10	10	10	50
Mercury, total (Hg)	28	28	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	28	27	>88	1	3.6		10	10	10	10	10	14	180
Zinc, total (Zn)	28	17	>50	1	3.6		10	10	10	10	14	29	1300

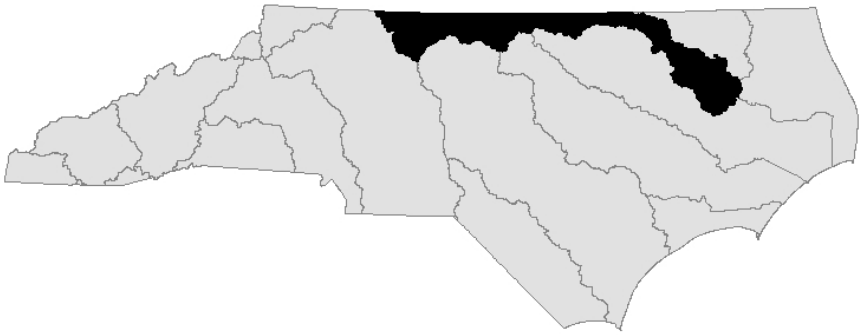
Fecal coliform (#/100mL)

# results:	Geomean	# >	% >	95%:
56	7	0	0	

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

Roanoke River Basin
Basinwide Assessment Report
Whole Effluent Toxicity Program

2000-2004



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

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

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

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

WET Monitoring in the Roanoke River Basin – 2000-2004

Thirty facility permits in the Roanoke River basin currently require whole effluent toxicity (WET) monitoring (Figure 1 and Table 1). Twenty-seven facility permits have a WET limit; the other three facility permits specify monitoring with no limit.

Figure 1. Roanoke River basin facilities required to conduct whole effluent toxicity testing (See Table 1 for key to facility names)

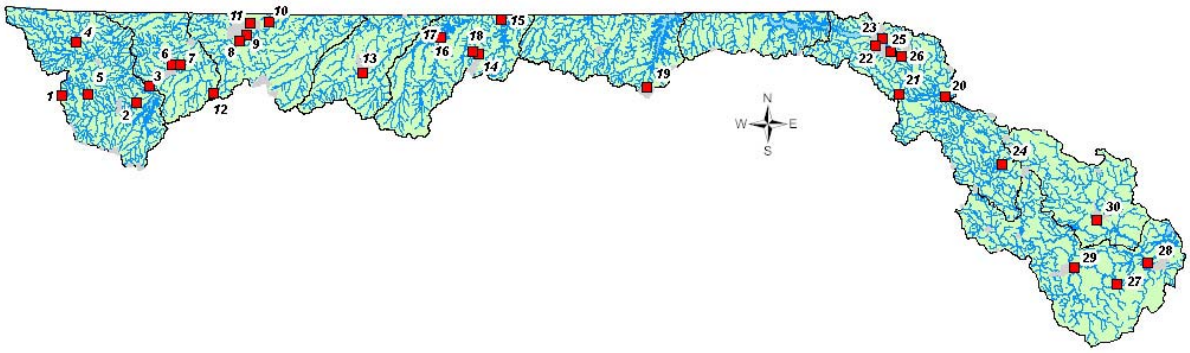


Table 1. Roanoke River basin facilities required to conduct whole effluent toxicity testing

Map Key	Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	7Q10 (cfs)
	03-02-01						
1	AquaSource, Inc.-Briarwood	NC0028746/001	UT Brushy Fork Cr.	Stokes	0.05	49	0.08
2	Duke Power-Belews Creek/003	NC0024406/003	Dan R.	Stokes	NA	NA	80.0
3	Kobe Copper Products, Inc.	NC0035173/001	UT Dan R.	Stokes	0.025	34.0	0.075
4	Stokes Co. Schools-N. Stokes HS	NC0044962/001	UT Dan R.	Stokes	0.0115	23	0.06
5	Stokes Co. Schools-S. Stokes HS	NC0044954/001	Little Neatman Cr.	Stokes	0.0173	9.0	0.27
	03-02-02						
6	Mayodan WWTP	NC0021873/001	Mayo R.	Rockingham	3.0	6	75
7	Stoneville WWTP	NC0028011/001	Mayo R.	Rockingham	0.25	0.66	58.6
	03-02-03						
8	Duke Power-Dan River	NC0003468/002	Dan R.	Rockingham	1.8	1.04	314.0
9	Eden WWTP/Mebane Bridge	NC0025071/001	Dan R.	Rockingham	13.5	5.1	386
10	Eden-Dry Creek WWTP	NC0025151/001	Dan R.	Rockingham	0.5	0.24	313
11	Miller Brewing Co.	NC0029980/001	Dan R.	Rockingham	5.2	2.51	313
12	Rockingham Power LLC	NC0086665/001	UT Jacob's Cr.	Rockingham	NA	100	0
	03-02-04						
13	Yanceyville WWTP	NC0040011/001	Country Line Cr.	Caswell	0.45	37	1.2
	03-02-05						
14	Cogentrix-Roxboro/003	NC0065081/003	UT Mitchell Cr.	Person	VAR	100	0.0
15	CP&L-Mayo Steam Electric Plant	NC0038377/002	Mayo Reservoir	Person	NA	NA	Lake
16	Progress Energy - Roxboro/003	NC0003425/003	Hyco L.	Person	NA	NA	Lake
17	Progress Energy - Roxboro/006	NC0003425/006	Hyco L.	Person	NA	NA	Lake
18	Roxboro WWTP	NC0021024/001	Marlowe Cr.	Person	5.0	100	0.0
	03-02-06						
19	Henderson Nutbush Cr WWTP	NC0020559/001	Nutbush Cr	Vance	4.14	97	0.20
	03-02-08						
20	Correc, Dept Of (Caledonia)	NC0027626/001	Roanoke R.	Halifax	0.8	0.12	1000
21	Halifax WWTP	NC0066192/001	Quankey Cr.	Halifax	0.075	14.0	0.70
22	Int. Paper Roanoke Rapids	NC0000752/001	Roanoke R.	Halifax	28.0	3.7	1120
23	Panda-Rosemary Corp.	NC0079014/001	UT Chockoyotte Cr.	Halifax	0.0538	100	0.0
24	Perdue Inc. Lewiston	NC0028835/001	Roanoke R.	Bertie	3.0	0.42	1102
25	Roanoke Rapids WWTP	NC0024201/001	Chockoyotte Cr.	Halifax	8.34	1.3	1000
26	Weldon WWTP	NC0025721/001	Roanoke R.	Halifax	1.2	0.19	1000
	03-02-09						
27	McMurray Fabrics Jamesville Inc.	NC0023710/001	Roanoke R.	Martin	0.45	0.06	1200
28	Weyerhaeuser-Plymouth	NC0000680/001	Roanoke R.	Martin	55.0	6.8	1160
29	Williamston WWTP	NC0020044/001	Roanoke R.	Martin	2.4	0.26	1170
	03-02-10						
30	Windsor WWTP	NC0026751/001	UT Cashie R.	Bertie	1.15	100	0.0

The number of facilities in this basin monitoring whole effluent toxicity has increased steadily since 1987, the first year that monitoring was required (Figure 2). Whole effluent toxicity limits were written into permits in North Carolina beginning in 1987. The compliance rate of those facilities has generally risen since the inception of the program. Since 1998 the compliance rate has stabilized at approximately 90-95% (Figure 1 and Table 2).

KobieWieland Copper Products, Inc. (Subbasin 01) failed one WET test in 2001 and three in 2004. The facility conducted toxicity identification/reduction activities and concluded that the failures were due to a particularly toxic floor cleaner and a contaminated lubricant. Use of the floor cleaner was discontinued and appropriate clean-up procedures were developed for the lubricant. The facility has not experienced a WET failure since March 2004.

The Town of Eden's Dry Creek WWTP (Subbasin 03) experienced four WET test failures over the period 2001-2003. Two of these appeared to be due to elevated total residual chlorine in the effluent. The facility has passed all of its WET tests since March 2003.

The Cogentrix energy cogeneration facility at Roxboro (Subbasin 05) experienced numerous failures during the period 1997-2001. Various sources have been identified (treatment chemicals, disinfectants, incoming process water) and addressed through operational changes. The facility has experienced no WET failures since December 2001.

The McMurray Fabrics facility in Jamesville (Subbasin 09) failed eight toxicity tests during the period December 2002 through December 2003. Facility personnel speculated that the failures may be related to the use of a polymer compound in the treatment process. The facility has had only one significant month of discharge since January 2004 and may be completely ceasing operations soon.

Figure 2. NPDES facility whole effluent toxicity compliance in the Roanoke River basin, 1987-2004. The compliance values were calculated by determining whether facilities with WET limits were meeting their ultimate permit limits during the given time period, regardless of any SOCs in force.

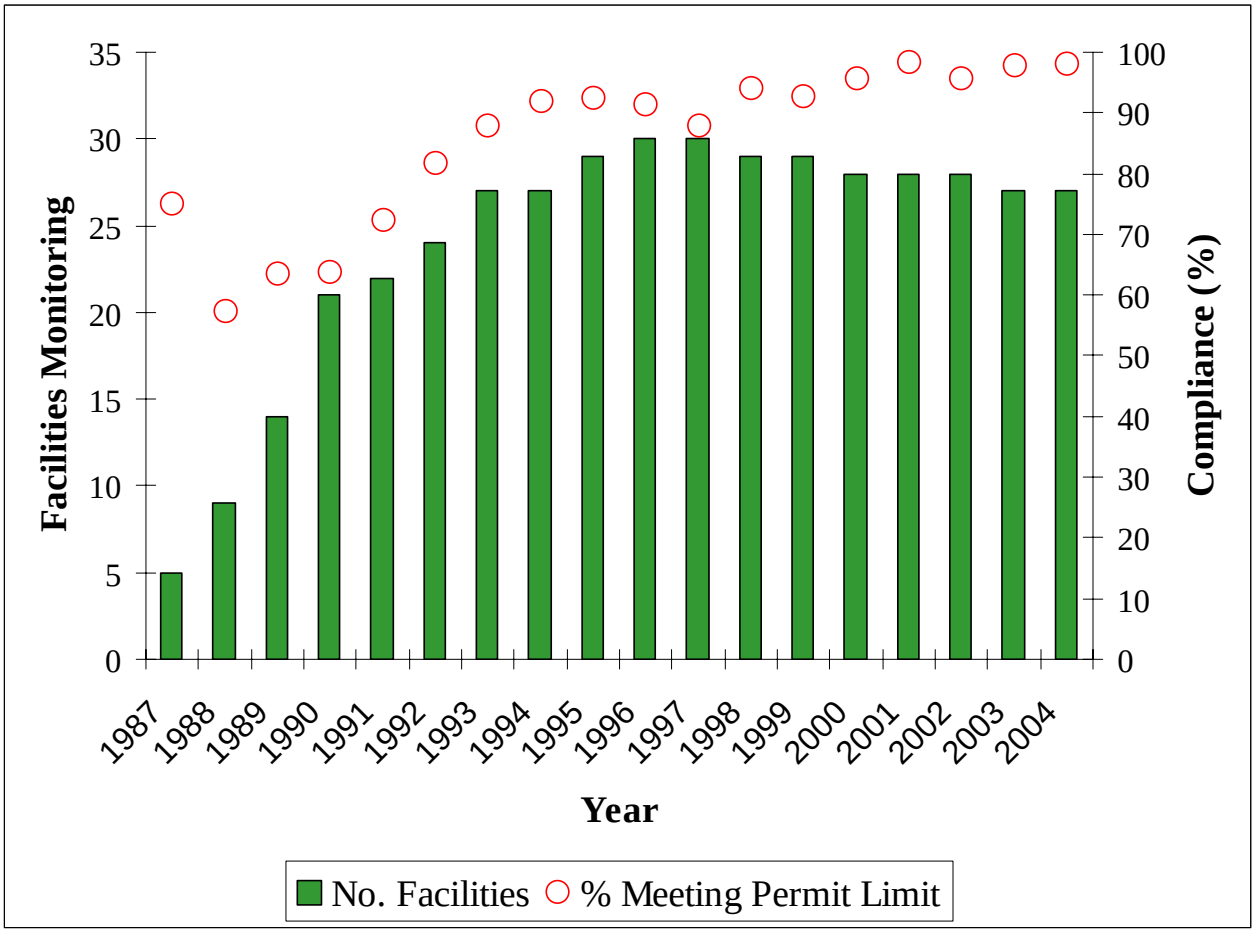


Table 2. Recent compliance record of facilities performing whole effluent toxicity testing in the Roanoke River basin

Subbasin/Facility	NPDES Permit No.	2000- 2003 Passes	2000- 2003 Fails	2004 Passes	2004 Fails
03-02-01					
AquaSource, Inc.-Briarwood	NC0028746/001	18	2	6	1
Duke Power-Belews Creek/003	NC0024406/003	16	0	4	0
KobeWieland Copper Products, Inc.	NC0035173/001	17	1	4	3
Stokes Co. Schools-N. Stokes HS	NC0044962/001	15	3	4	0
Stokes Co. Schools-S. Stokes HS	NC0044954/001	16	0	4	0
03-02-02					
Mayodan WWTP	NC0021873/001	18	3	4	0
Stoneville WWTP	NC0028011/001	16	0	4	0
03-02-03					
Duke Power-Dan River	NC0003468/002	15	0	4	0
Eden WWTP/Mebane Bridge	NC0025071/001	16	0	4	0
Eden-Dry Creek WWTP	NC0025151/001	17	4	4	0
Miller Brewing Co.	NC0029980/001	16	0	4	0
Rockingham Power LLC	NC0086665/001	8	0	2	0
03-02-04					
Yanceyville WWTP	NC0040011/001	16	1	4	0
03-02-05					
Cogentrix-Roxboro/003	NC0065081/003	19	12	5	0
CP&L-Mayo Steam Electric Plant	NC0038377/002	16	0	4	0
Progress Energy-Roxboro/003	NC0003425/003	15	0	4	0
Progress Energy-Roxboro/006	NC0003425/006	4	0	1	0
Roxboro WWTP	NC0021024/001	18	1	4	0
03-02-06					
Henderson Nutbush Cr WWTP	NC0020559/001	23	5	6	1
03-02-08					
Correc, Dept Of (Caledonia)	NC0027626/001	15	1	4	0
Halifax WWTP	NC0066192/001	16	2	6	1
Int. Paper Roanoke Rapids	NC0000752/001	16	0	4	0
Panda-Rosemary Corp.	NC0079014/001	1	3	0	1
Perdue Inc. Lewiston	NC0028835/001	16	0	4	0
Roanoke Rapids WWTP	NC0024201/001	17	1	4	0
Weldon WWTP	NC0025721/001	16	2	4	0
03-02-9					
McMurray Fabrics Jamesville Inc.	NC0023710/001	26	8	1	0
Weyerhaeuser-Plymouth	NC0000680/001	16	0	4	0
Williamston WWTP	NC0020044/001	16	0	4	0
03-02-10					
Windsor WWTP	NC0026751/001	16	2	4	0

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