Environmental Sciences Branch

BASINWIDE ASSESSMENT REPORT

CAPE FEAR RIVER BASIN

June 1999

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

D E N R

Erratum (June 27, 2000): Because benthos swamp and estuarine criteria are not finalized, all previously rated samples are now "Not Rated". The correct ratings listed in Appendix B2 should be followed when the text and the listing in Appendix B2 differ. If you have questions, please contact Trish MacPherson at (919)733-6946 or electronically at: trish.macpherson@ncmail.net.

Appendices L2 and T and the ambient monitoring chemical data sheets are not included in this electronic version of the report. If you desire these pages, please contact Trish MacPherson at (919)733-6946 or electronically at: trish.macpherson@ncmail.net.

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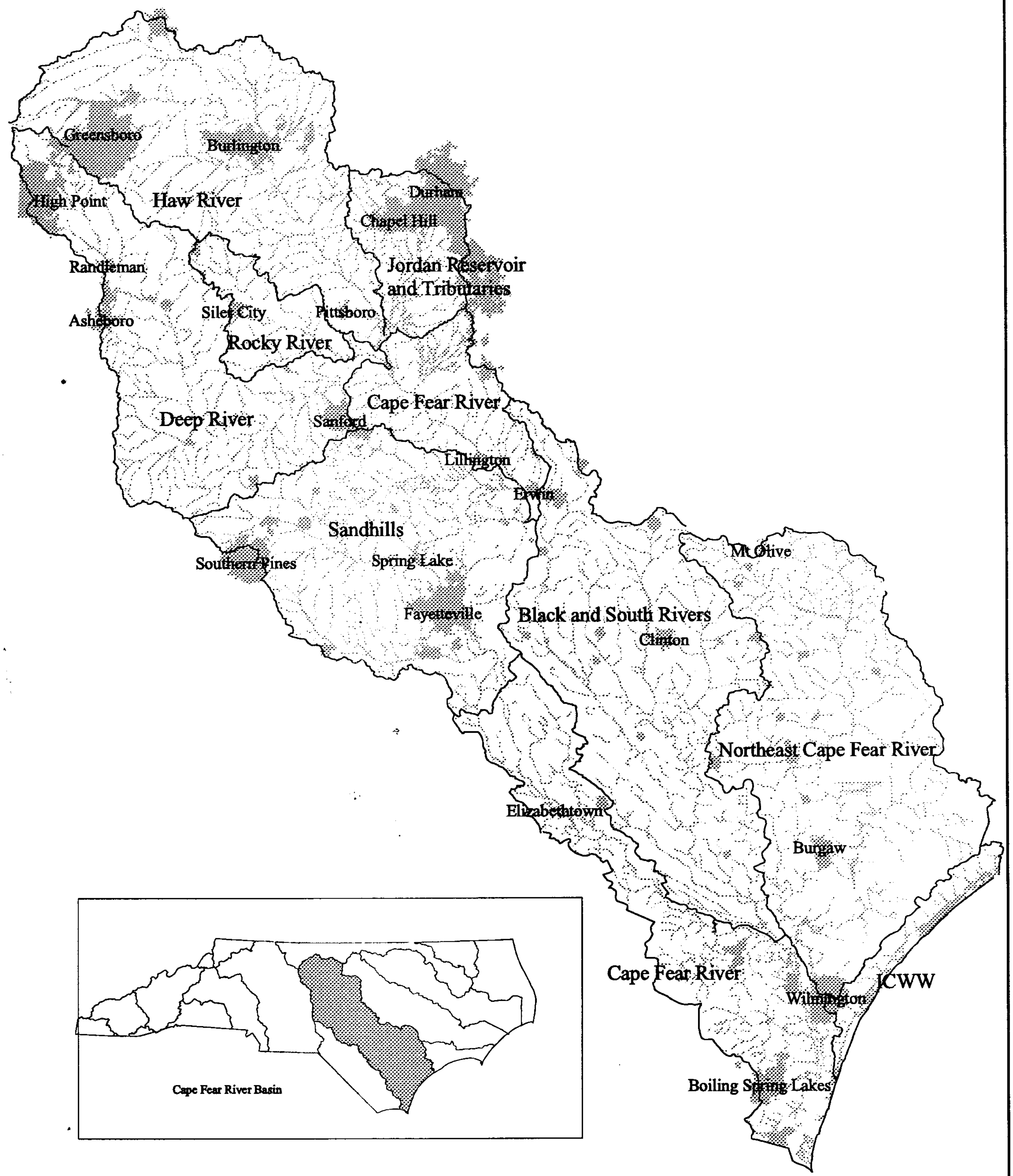

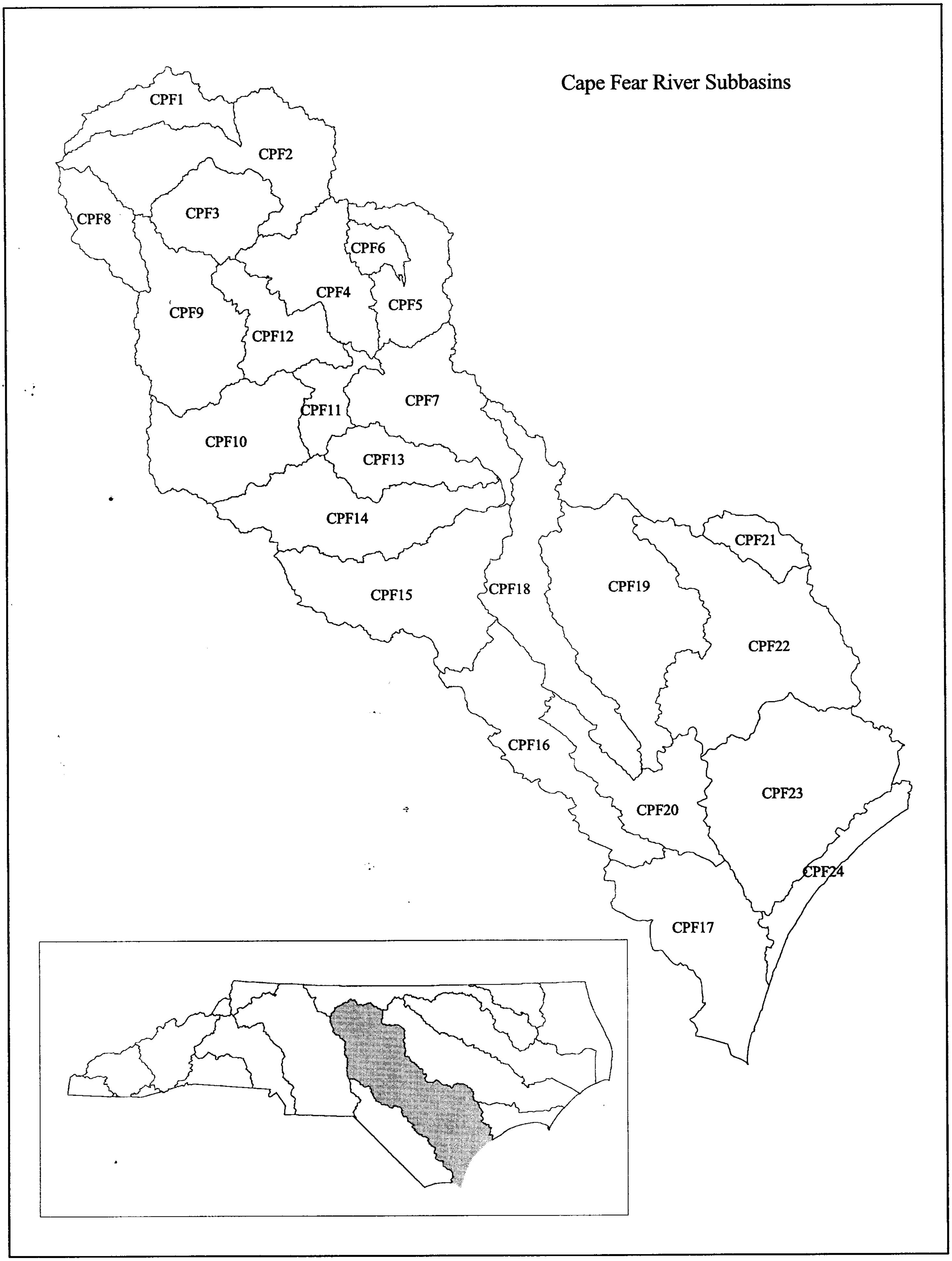
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EXECUTIVE SUMMARY

This document, prepared by the Environmental Sciences Branch, presents a water quality assessment of work conducted by the NC Division of Water Quality, Water Quality Section in the Cape Fear River Basin, and information reported by outside researchers and other agencies. Program areas covered within this report include: benthic macroinvertebrate monitoring, fish population and tissue monitoring, lakes assessment (including phytoplankton monitoring), aquatic toxicity monitoring, and ambient water quality monitoring (covering the period 1993-1997).

In general, the document is structured such that each subbasin is physically described and an overview of water quality is given at the beginning of each subbasin section. This is followed by program area discussions within each subbasin. Specific data and descriptions of information covered by these summaries can be found in the individual subbasin sections and the appendices of this report. General water quality conditions are presented here in an upstream to downstream format. A map showing all 24 Cape Fear River subbasins is presented at the beginning of this report and a map of each subbasin showing basin sampling sites precedes each subbasin section. The Cape Fear River subbasins are described by six digit subbasin codes (030601-030624), but are often referred to by their last two digits (e.g. subbasin 16).

The Cape Fear River Basin is the largest river basin in the state and covers an area of 9,149 square miles in twenty four counties. There are an estimated 6,300 miles of streams and rivers in the basin. None of these are found in the mountains, but are confined to the Piedmont, Sandhills and Coastal Plain ecoregions. The Cape Fear River is formed by the confluence of the Deep and Haw Rivers at the Chatham/Lee County line. B. Everett Jordan Reservoir is the largest impoundment in the basin. Several large tributaries join the river as it flows to the Atlantic Ocean at Cape Fear near Southport: Upper and (Lower) Little Rivers, Rockfish Creek, Black River, South River and the Northeast Cape Fear River.

The basin is characterized by highly urban and industrialized areas around Greensboro, High Point, Burlington, Chapel Hill and Durham in the upper part of the watershed and around Fayetteville and Wilmington in the middle and lower part. Fort Bragg Military Reservation occupies a large area in the middle of the basin. As might be expected in such a populous area, water quality in the basin has been affected by the impacts of numerous dischargers and nonpoint source runoff.

<u>Haw River Drainage</u> (Subbasins 1-4)

The Haw River originates in the piedmont ecoregion near Oak Ridge in Guilford County and drains 1,526 square miles. The river falls from about 1,000 feet above sea level to an elevation of 158 feet at its confluence with the Deep River. The watershed topography is generally rolling hills. The textile industry has historically been a principal industry in the area, but the industrial base has expanded, and agriculture is also important in the watershed.

The most upstream tributaries of the Haw River are Troublesome and Little Troublesome Creeks. The combination of agricultural land use and highly erodable soils produces widespread nonpoint source problems in both the upper Haw River and Troublesome Creek watersheds. Benthic macroinvertebrate surveys in 1998 produced Fair and Good-Fair bioclassifications at three upstream Haw River sites, while a decline from Good-Fair was observed for the Haw River near Altamahaw. These ratings may be influenced by low flows in this part of the river, especially in 1998. Troublesome Creek received a Good-Fair benthos bioclassification, but a fish survey produced a Poor NCIBI, as did a fish sample from the Haw River. Lake Hunt and Reidsville Lake, in the Troublesome Creek watershed were evaluated as eutrophic or mesotrophic in 1998.

Little Troublesome Creek below the Reidsville WWTP has the most severe water quality problems in the upper Haw River area (Poor fish and benthos ratings). This plant has reduced organic loadings, but still consistently fails toxicity tests. Urban runoff has contributed to the problems in Little Troublesome Creek, with Fair benthos ratings found in 1992 and 1994 above the discharge. This discharger will be relocated to the haw River in 1999 to achieve greater dilution.

As the Haw River continues downstream, Reedy Fork and its two major tributaries, North and South Buffalo Creeks join it. There are several major dischargers in the Greensboro area, but the largest of these are the Greensboro T.Z. Osborne South Buffalo Creek WWTP (20 MGD) and the Greensboro North Buffalo Creek WWTP (16 MGD). The Greensboro wastewater plants have been monitored by water chemistry samples at ambient sites, self-monitoring toxicity data, and collections of both benthic macroinvertebrates and fish. The segments of North and South Buffalo Creek in the Greensboro area constitute one of the worst water quality problems in North Carolina. Conductivity continues to increase in these streams (median values are greater than 550 µmhos/cm), nutrient values are high and there are chronically high levels of dissolved copper, zinc and cadmium. Both fish and macroinvertebrate sampling have shown Poor water quality below these discharges. Upstream biological collections have also shown Poor water quality, due to urban stormwater runoff.

Areas of better water quality (Good macroinvertebrate bioclassification) are Stony Creek and Haw Creek, tributaries of the Haw River near Burlington. Jordan Creek, a tributary of Stony Creek was Good-Fair. Reedy Fork had a Good-Fair benthos raing in the headwaters in 1993 and 1998. Lake Higgins, Lake Brandt, and Lake Townsend, are in the upstream section of Reedy Fork and were evaluated as eutrophic or mesotrophic in 1998. Reedy Fork below the lakes was also Good-Fair based on fish and benthos collections. Just above the confluence with the Haw River, but below where North and South Buffalo come in, Reedy Fork declined from Good-Fair in 1993 to Fair in 1998, perhaps a result of a spill at the WWTP prior to collection of the basinwide sample.

The Haw River near Graham was Good-Fair in 1993 and 1998, using benthos data. In the Burlington-Graham area the Haw River collects the Alamance Creek watershed. Erosion from agricultural land may cause large sediment inputs into streams in this watershed, but Big Alamance Creek and Stinking Quarter Creek received Good-Fair or Good macroinvertebrate bioclassifications. Fish NCIBI data also gave a Good rating to Big Alamance Creek. NCIBI ratings of Fair and Poor were given to Stinking Quarter Creek and both Little Alamance Creeks. Burlington Reservoir, Lake Burlington, and Graham-Mebane Reservoir in this area are eutrophic, while Lake Macintosh was mesotrophic in 1998.

The lower reach of the Haw River, above its confluence with B. Everett Jordan Reservoir, is approximately 25 river miles in length and contains many small to medium tributaries. Many of these tributary streams are located within the Carolina Slate Belt ecoregion and are prone to extreme low flow conditions during the summer (see Geology and Soils discussion in Introduction). Good and Good-Fair bioclassifications based on benthic macroinvertebrate samples were assigned to several tributary locations during 1998 surveys: Cane Creek, Collins Creek, Terrells Creek, Dry Creek and Pokeberry Creek. Nonpoint source runoff may account for the water quality deterioration and habitat loss in some tributaries. Fish community structure samples were collected from Collins Creek (Poor), Terrells Creek (Fair) and Ferrells Creek (Good-Fair). Fish assessements may evaluate habitat problems better than benthos data. Cane Creek Reservoir and Pittsboro Lake, on Robeson Creek, were evaluated as eutrophic or mesotropic in 1998.

Water chemistry data from the two lowermost Haw River locations indicate an improvement compared to data collected from upstream locations. The same is true for bioclassifications of the Haw River in this reach (Good-Fair at Saxapahaw and Good at US 64 near Pittsboro) when compared to upstream reaches near Burlington and Graham (Good-Fair and Fair). Biological recovery is noted by consistent Good bioclassifications at the US 64 site prior to flowing into B. Everett Jordan Reservoir.

<u>B. Everett Jordan Reservoir and Tributaries</u> (Subbasins 5-6)
Intensive monitoring and research of the 14,300 acre B. Everett Jordan Reservoir (Jordan Lake) has been performed by State and university personnel since the reservoir was filled in 1981 and DWQ (as DEM) investigations have been conducted since 1983. The reservoir was created for flood control, fish and wildlife habitat, recreation, and water supply. It is now used for water supply by the towns of Cary and Apex. Many complaints about taste and odor in 1995 and 1996 resulted in improving the raw water treatment process. The Haw River makes up 70-90% of the annual flow of Jordan Lake with an average retention time of five days. The New Hope arm of the reservoir has an average retention time of 418 days. Jordan Lake is about five miles in length on the Haw River arm and 17 miles long on the New Hope Creek arm.

A water quality study of the lake in 1996 and 1997 indicated elevated nutrient and chlorophyll *a* levels. Very high NCTSI values have been recorded from Jordan Lake making it one of the most eutrophic lakes in North Carolina. Historic monitoring data indicates that the lake has remained eutrophic since 1982, with little change in trophic index parameters. Actions to improve water quality are continuing.

Tributaries to Jordan Lake, besides the Haw River, include Northeast Creek, New Hope Creek, White Oak Creek and Morgan Creek. Both point and nonpoint sources of pollution have affected streams in this highly urbanized Chapel Hill and Durham area. These streams are also in the Triassic basin and can have very low flows. Such low flows made evaluation by benthos not possible in 1998 for Northeast Creek and White Oak Creek. New Hope Creek was given a Poor NCIBI rating and a Fair benthos rating at downstream sites. A 1993 upstream benthos site showed Good water quality.

Special benthos surveys in 1993 and 1998 in the Chapel Hill area found upstream reaches of Morgan and Bolin Creeks have Good or Excellent ratings. University Lake on Morgan Creek, however, is eutrophic. Water quality conditions degrade as streams flow through the suburban and urban sections of Chapel Hill. No 5-year change in water quality (based on these benthic macroinvertebrate samples) was noted at most of the locations in the special study. Poor NCIBI ratings were given to lower reaches of both Bolin and Morgan Creeks in 1998. A benthos site on Morgan Creek below OWASA remained Fair in 1998.

Deep River Drainage (Subbasins 8-11)
Mainstem
The Deep River originates in eastern Forsyth County and flows about 116 miles, draining about 1,442 square miles, to its confluence with the Haw River. The fall line, separating the Piedmont from the Coastal Plain ecoregions, lies at this confluence. The Deep River flows over 16 small dams between High Point and its confluence with the Haw River, which slow the river's velocity and limit the system's assimilative capacity. The average slope along the entire river from the High Point dam to its mouth is about 5 feet per mile. The fall is rapid down to the mouth of McLendons Creek, where it begins to flatten out. The watershed terrain changes from hilly and rolling in Randloph and Guilford counties to flat or gently rolling in Moore and Lee counties with some swampy areas. The river generally has high banks and few large flood plains.

Its headwaters, the East and West Forks of the Deep River, are both affected by nonpoint source runoff, small dischargers, and by low summer flows, but there is a contrast between the East Fork of the Deep River (urban/residential) and the West Fork of the Deep River (agricultural). Macroinvertebrate data clearly shows more severe water quality in the East Fork (Fair) than in the West Fork (Good-Fair).

Urban areas in the Deep River watershed include High Point, Randleman, Ramseur, Asheboro, and Sanford. Municipal wastewater treatment plants in these cities discharge either directly or indirectly to the Deep River, and their effluents may make up the majority of the flow during low flow periods. The river was intensively sampled in the 1980's. Water quality has improved since 1983. These improvements have been related to upgrades at several wastewater treatment plants. A Deep River site at Randleman was Good-Fair in 1993 and 1998 based on benthos data. Local governments formed the Piedmont Triad Regional Water Authority (PTRWA) in 1986 with plans to construct Randleman Lake for a drinking water supply. Those plans are stilll moving forward.

In the 25 river miles from Randleman to the Randolph/Moore County line there are three ambient locations at Worthville, Ramseur, and Central Falls. Ambient water chemistry shows a general trend of more water quality violations or higher concentrations of nutrient parameters at the upstream location near Worthville and better water quality at downstream locations. This trend indicates that instream assimilative capacity of the Deep River and dilutions are improving water quality at downstream reaches. Benthos samples from the Deep River at Ramseur were Good-Fair in 1993 and 1998.

Benthos data from a Deep River location in Moore County have consistently indicated an Excellent bioclassification, as was true in 1998. Most of the Deep River in Moore County (from

Grassy Creek to NC 42 near Carbonton) is classified as HQW. Ambient water quality samples are collected from the Deep River at High Falls and the Deep River at Carbonton. Slow moving reaches of the river, including the Carbonton impoundment, are severely impacted by nutrient loading from upstream sources. Results from the 1992/93 Deep River/Carbonton water quality investigations indicated a need for the reduction in current point source nutrient inputs, especially from the High Point Eastside WWTP.

The most downstream ambient water chemistry sites on the Deep River are near Sanford and at Moncure. The Moncure site is below the confluence with the Rocky River, and both sites are downstream of the Carbonton dam. These two sites bracket the Sanford WWTP, and both sites declined, based on benthos data, from Good in 1993 to Good-Fair in 1998.

Deep River Tributaries

Major tributary streams in the upper Deep River watershed were either Poor or not rated in 1998. High Point Eastside WWTP is permitted to discharge 16 MGD to Richland Creek, just above its confluence with the Deep River. A fish community site on Richland Creek was Poor above the WWTP, while a benthos site below the WWTP declined from Fair in 1993 to Poor in 1998. Much of this area lies within the Carolina Slate Belt ecoregion and small tributary catchments have a tendency to go dry, or pool up, during summer low flow conditions. Hickory Creek and Muddy Creek were reduced to less than 3 meters width in July 1998, but a fish sample in the spring resulted in a Poor NCIBI for Muddy Creek.

Polecat Creek and Little Polecat are tributaries near Randleman and the winter benthos data from 1993 and 1998 for Polecat Creek indicate Good water quality. Little Polecat Creek has been reclassified as HQW. It was decided in 1998 to not rate the samples collected in the winter of 1993 and 1998 due to the lack of flow noted in the summer of 1998. Hasketts Creek is the next major downstream tributary and receives the discharge from the Asheboro WWTP. Benthos samples from above and below the WWTP in 1998 were both rated Poor.

Benthos surveys conducted in tributary catchments from Ramseur to Moore County noted improvement from Good bioclassifications in 1993 to Excellent in 1998 at Sandy Creek and Richland Creek, while Brush Creek and Fork Creek remained Good. Flat Creek went from Fair in 1993 to Good-Fair in 1998. The improvements may be related to less nonpoint impacts during a low flow period. A fish community structure sample from Sandy Creek gave a Good-Fair NCIBI rating. Sandy Creek Reservoir was eutrophic in 1998.

Water quality in upper Cotton Creek is impacted by the discharge from the Star WWTP (0.6 MGD). In a 1998 special study in September there was no flow above the WWTP, but benthos sample below the discharge were Poor and Fair (further downstream). The bioclassification in Cabin Creek improves to Good at the Mill Creek confluence (fish and benthos). Mill Creek had slightly lower water quality in 1998-Good (winter sample) and Good-Fair (summer sample), but evaluations are complicated by summer low flows. Wet Creek, Bear Creek, and Buffalo Creek also had Good benthos ratings. Falls Creek was rated Fair using benthos data, and Good using fish community data. The federally endangered fish species, the Cape Fear Shiner (Notropis mekistocholas) was collected from Falls Creek. Indian Creek in Chatham County was Good-Fair based on fish data.

The Triassic basin streams, McLendons Creek, Richland Creek, Big Governors Creek, Little Pocket Creek, Cedar Creek and Georges Creek were reduced to pools of water between dry stream bed in the summer of 1998, and it was decided that all Triassic basin streams should not be rated using benthos data until better criteria are derived for such streams. Fish samples collected in the spring, when there was flow, resulted in a Fair NCIBI for McLendons Creek and a Poor rating for Richland Creek and Big Buffalo Creek.

Two impoundments, High Point Lake and Oak Hollow Lake in the upper watershed, have been evaluated as eutrophic or mesotrophic. Algal blooms have been reported from both lakes, principally due to small cyanophytes. Carthage City Lake is spring fed and oligotrophic.

Rocky River (Subbasin 12)
The Rocky River, a major tributary of the Deep River, is approximately 35 river miles in length. It is located mainly within Chatham County. Land use within its watershed is primarily agriculture, dairy production and forest. This watershed is also in the Carolina Slate Belt. Siler City is the only urban area.

Benthos bioclassifications from monitoring locations on the mainstem of the Rocky River in 1998 indicated that upstream reaches were Good-Fair (Rocky River at US 64 and SR 2170), or Good, at US 15-501, near the confluence with the Deep River. The US 64 site suggests an improvement in water quality, perhaps due to the dry weather water releases from Rocky River Reservoir since 1995. A fish sample from above the reservoir had a Fair NCIBI. Several reaches of the lower Rocky River have been designated Critical Habitat for the Cape Fear Shiner by the US Fish and Wildlife Service.

Special surveys on Loves Creek have been conducted to assess the effects of the Siler City WWTP. Poor water quality was assigned to Loves Creek below the discharge in 1989 and again in 1997, but changes in the benthic community suggest some improvement in water quality in 1997. A 1997 benthos sample from Loves Creek above the discharge was Fair, while a 1998 fish community sample was Good-Fair. A Good-Fair benthos bioclassification was given to Harlands Creek and Tick Creek, two other tributaries of the Rocky River in Chatham County. A fish community sample was collected from Bear Creek. This site was given a Good NCIBI rating. Rocky River Reservoir is currently considered as eutrophic.

Cape Fear River Drainage
Mainstem and Minor Tributaries (Subbasins 7, 15, 16, 17)
The mainstem Cape Fear River originates near the fall line and then flows 170 miles through the Coastal Plain to Wilmington. Stream gradient is higher down to Fayetteville, where it begins to flatten out. The flat terrain of the coastal plain results in many swamp systems, but the main river is not a typical swamp stream. The drainage area of the mainstem Cape Fear River is about 6,065 square miles. At its mouth the Cape Fear empties directly into the Atlantic Ocean near Southport and much of this estuarine area has salinities high enough for the waters to be classified as shellfish waters (SA).

Benthos ratings for the Cape Fear River at Lillington have been consistently Good since 1983. Further downstream, near Erwin, Excellent benthos bioclassifications were found in 1993 and 1998 in an area of faster flow than much of that stretch of river. This site is below the Erwin WWTP and Swift Textiles, but above the Dunn WWTP. Benthos data from the Cape Fear River near Fayetteville has been difficult to evaluate because of very different flow regimes during sampling in 1993 and 1998.

Neills Creek improved from Fair in 1993 to Good-Fair in 1998, while Parkers Creek declined from Good to Good-Fair. Parkers Creek, Avents Creek, and Hector Creek, in the Raven Rock State Park area are currently classified as HQW. A fish community sample from Hector Creek as part of the basin assessment, and a sample from Avents Creek as a fish reference site both resulted in Fair NCIBI ratings. Analysis of IBI metrics is ongoing to determine why fish community samples rate reference streams so low. The only Poor water quality indicated by benthos and fish in this area was Kenneth Creek below the Fuquay-Varina WWTP in 1993 and 1998. Harris Lake, a 4,150 acre impoundment of Buckhorn Creek, was mesotrophic in 1998.

Cross Creek and Little Cross Creek are urban streams in Fayetteville that have been sampled for benthos or fish in 1993 and 1998. All data indicate these are impaired streams, but the small size of headwater sites and lack of flow complicate evaluations in the summer. When ratings have been given, they were either Poor or Fair. Four impoundment's on Little Cross Creek, Boonie Doone Lake, Kornbow Lake, Mintz Pond and Glenville Lake, serve as backup water supply for Fayetteville. All were sampled in 1998 and were found to be oligotrophic or mesotrophic, except for Glenville which was eutrophic.

As the Cape Fear River flows into the inner coastal plain it carries a large silt load, and much silt settles out in this portion of the river. The 1993 benthos data indicated a Fair rating for the Cape Fear River near Duarte, below Lock 2 and at SR 1730 in Bladen County, and this improved to Good-Fair in 1998. A benthos site on the Cape Fear River near Elizabethtown was Good-Fair in both 1993 and 1998. Further downstream near Kelly benthos ratings improved from Fair to Good-Fair between 1993 and 1998. Biological data from above and below Federal Paperboard Company on the Cape Fear River found higher EPT taxa richness above the discharge. The site below the discharge may be tidally influenced, which could affect the benthos.

Tributary streams in the coastal plain near Elizabethtown that were sampled include Harrison Creek, that was assigned a Good-Fair rating by both fish and benthic macroinvertebrates in 1998 and Ellis Creek that was Good-Fair, based on benthos data. Other tributaries that were sampled were Turnbull Creek (Good benthos rating, Fair fish rating) and Whites Creek (Good fish rating). The fish community of Browns Creek produced a Poor NCIBI. These streams either improved or did not change since 1993.

Salters Lake, Jones Lake, and White Lake are natural Carolina Bay lakes. Salters Lake and Jones Lake are located within state park or state forest lands and they are dystrophic systems characterized by low pH (<4) and humic water. White Lake is more developed, but has been consistently classified as oligotrophic.

Sandhills (Subbasins 13-15)
The first major watershed in the sandhills is the Upper Little River in Harnett and Lee counties. It has a drainage area of 220 square miles and enters the Cape Fear River below Lillington. Three sites were sampled for benthos on the Upper Little River in the headwaters, the middle section and at the ambient site near its mouth. The headwater and middle sites were barely flowing in the summer of 1998, even though this is a Sandhills stream, while the downstream site had good flow. The benthos ratings indicate a progressive improvement in water quality going downstream in this agricultural watershed: Good-Fair to Good to Excellent. Only the downstream site improved compared to 1993, when it was Good. Barbeque Creek, a slow flowing tributary of the Upper Little River was given a Good-Fair bioclassification in 1998, the same rating it had in 1988.

The (Lower) Little River watershed is much larger (500 square miles) and is largely rural, but lower reaches flow through or near Spring Lake and Fayetteville. The (Lower) Little River from the headwaters to Crane Creek has been designated as High Quality Waters. The (Lower) Little River was sampled for benthos at three sites in 1998. The upper site is in the HQW section of the river and has been Excellent, based on benthos data, since first sampled in 1988. The middle site near Manchester is below the Fort Bragg WWTP and has improved dramatically since 1986 when water quality was Fair. The Fort Bragg WWTP completed an upgrade in 1991 and water quality improved to Good-Fair in 1993 and then to Excellent in 1998. EPT taxa richness increased from 18 in 1993 to 40 in 1998 at this site. This is the highest EPT taxa richness collected at any site in the entire Cape Fear River basin since 1983. The most downstream site had the second highest EPT value in the basin and was Excellent in both 1993 and 1998.

Nicks Creek is a headwater tributary that improved from Good in 1993 to Excellent in 1998 using benthos data. In contrast, a fish sample in 1996 resulted in a Fair NCIBI. Jumping Run Creek in Cumberland County showed a marked improvement from a Good-Fair rating in 1993 to Excellent in 1998, using benthos data. This was despite poor instream habitat, a very developed nearby watershed, and no apparent changes in land use since 1993.

Buffalo Creek and Anderson Creek both had Good-Fair benthos bioclassifications. Even though an NCIBI rating of Fair was given to Anderson Creek, the overall discrepancies between benthos and fish suggest Good-Fair may be a more accurate evaluation of water quality, especially given the small size of the stream.

Old Town Reservoir on Mill Creek was sampled in 1998 and was oligotrophic in June and mesotrophic in July. This stream was given an Excellent benthos bioclassification during an HQW study in 1998.

Rockfish Creek is another large tributary with a drainage area of 310 square miles whose confluence with the Cape Fear River is below Fayetteville. Two benthos sites on Rockfish Creek and one on Little Rockfish Creek were assigned a benthos bioclassification of Excellent and Good respectively in 1998. Puppy Creek is a low pH, low productivity, tributary of Rockfish Creek, that, again, had a Good-Fair NCIBI rating with no apparent source of impact. The stream drains Fort Bragg and had good instream and riparian habitat. Hope Mills Lake on Little Rockfish Creek was also sampled in 1998 and has been primarily eutrophic since 1984.

South and Black Rivers (Subbasins 18-20)
Naming of the Black and South Rivers can cause confusion when discussing sampling sites and water quality information. The South River actually is called the Black River in its headwaters near Dunn, then becomes the South River until its confluence with the Black River, where the combined flow is named the Black River to its confluence with the Cape Fear River. These rivers have been described as among the most beautiful and least disturbed of North Carolina's coastal plain rivers. Both are slow moving, meandering, sandy bottomed, blackwater rivers, with extensive swampy floodplains dominated by bald cypress and gum trees. The South River has a drainage area of about 500 square miles, while the Black River drainage is much larger (1,560 square miles). The South River below Big Swamp was designated ORW in 1994. An ambient site on the South River near Parkersburg has been assigned a Good or Excellent bioclassification, using benthos data, since 1985. Bay Tree Lake, a Carolina bay, was monitored in 1998 and found to be dystrophic.

Great Coharie Creek and Six Runs Creek merge to form the Black River. Land adjacent to the Black River is primarily undisturbed forest and swamp and Clinton is the largest town in the watershed. The Black River from its source to the Cape Fear River, and Six Runs Creek below Quewhiffle Swamp, was reclassified as ORW in 1994. These reclassifications were based on Excellent biological and physical/chemical data, as well as the river's recreational and ecological significance. An ambient site on the Black River (near Tomahawk) has consistently received an Excellent bioclassification, and was Excellent again in 1998. In 1998, Six Runs Creek declined from Excellent to Good, Great Coharie Creek dropped from Good to Good-Fair, while Little Coharie Creek stayed Good-Fair, compared to 1993 data. De-snagging of these streams that occurred after Hurricane Fran came through in 1996 complicates determination of the causes of these changes. These streams were totally de-snagged, removing nearly the entire valuable snag habitat available for macroinvertabrate colonization. This makes it difficult to determine whether any changes that may have occurred in the macroinvertebrate community were due to changes in water quality or lack of suitable habitat.

Though the Black River does continue to flow throughout the year, other large tributaries such as Colly Creek and Moores Creek have periods of no flow. Benthos samples collected in winter when there was flow suggest a Good bioclassification for Moores Creek, and Fair for Lyons Swamp (Canal), mostly as a result of habitat degradation and agricultural land use. Fish community data suggest Good-Fair water quality in Colly Creek and White Oak Branch.

Northeast Cape Fear River (Subbasins 21-23)
The last downstream major tributary of the Cape Fear River is the Northeast Cape Fear River, which originates near Mt. Olive in southern Wayne County and Duplin County. Its drainage area is about 1,750 square miles. Chemical monitoring of the Northeast Cape Fear River below Mt. Olive shows high conductivity values, low dissolved oxygen and high phosphorus values, although recent upgrades at Mt. Olive have significantly reduced both the severity and extent of the impacts. A benthos sample in 1998 at NC 11/903 dropped from Excellent in 1993 to Good-Fair, but this could be attributable to the loss of habitat from de-snagging.

Many of the streams in this watershed stop flowing during parts of the year and in 1998 no benthos samples were taken because of lack of flow. A fish community sample in the spring at Matthew's Creek, a small headwater tributary of the Northeast Cape Fear River, was rated as Good.

Prior benthos data indicate Good to Excellent water quality in the middle portion of the Northeast Cape Fear River with the section of the river between Muddy Creek and Rockfish Creek classified as High Quality Waters. In 1998 a site at NC 41 near Chinquapin was still Good in August, but dropped to a Poor benthos rating in September after Hurricane Bonnie went through the watershed. Very low dissolved oxygen levels were found in the river after the hurricane.

Most of the tributaries, Limestone Creek, Stockinghead Creek, Muddy Creek and Rockfish Creek, are rated Fair or Good-Fair, usually due to nonpoint sources of pollution. Since 1993, Limestone Creek declined from Excellent to Good-Fair (spill of chicken waste in 1995), Stockinghead Creek remained Good-Fair, Muddy Creek was Fair, while the two sites on Rockfish Creek showed opposite trends-upstream of Wallace declined (snagging evident) and downstream of the WWTP and Steveco Knits improved from Fair to Good-Fair. Fish community samples from Grove Creek and Duff Creek resulted in Good-Fair and Good NCIBI ratings, respectively.

Benthos data indicate an improvement from Good-Fair to Good at the most downstream ambient site, the Northeast Cape Fear River at US 117 at Castle Hayne. Many tributaries draining the Holly Shelter Game Refuge appear to be unimpacted, however, most of the streams outside the wildlife refuge are subject to nonpoint sources of pollution. Many of these streams stop flowing during parts of the year. Water quality in Burgaw Creek was evaluated as Fair based on a fish community sample at US 117 below Burgaw's WWTP.

<u>Coastal and Estuarine Area</u> (Subbasins 17, 24)
Large portions of this area have been classified as Outstanding Resource Waters, including Turkey Creek, Howard Channel, Long Point Channel, Green Channel, Cedar Snag Creek, Butler Creek, Nixon Channel and Howe Creek. ORW areas also include portions of Stump Sound, Everett Bay, Middle Sound, Masonboro Sound and the Intracoastal Waterway. Two High Quality Waters's areas have also been designated here based on their use as primary nursery areas: King Creek and Bradley Creek above US 17/74/76. Seven ambient sites are located along the Intracoastal Waterway in this area. It appears that water quality is generally good here. Poor conditions were recorded at heavily urbanized Bradley Creek, while more moderate conditions were found in Hewlett Creek.

Estuarine benthos samples in 1998 indicate water quality has remained stable at Snow's Marsh, while samples were collected for the first time at ten additional sites between Wilmington and Southport. Freshwater benthos sites in Brunswick County ranged from Good-Fair at Town Creek and Barnards Creek, to Good at Hood Creek to Good-Excellent at Lewis Swamp.

Greenfield Lake, near Wilmington, is classified as C SW and is still eutrophic, but water quality is improving. Boiling Springs Lake, near the Town of Boiling Springs, is classified as B SW and is dystrophic.

EXECUTIVE SUMMARIES BY PROGRAM AREA

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates have been collected at over 350 freshwater sites in the Cape Fear River basin since 1983; 121 of these sites were sampled during 1998 basinwide surveys or special studies and could be assigned a rating. For the 1998 collections, the following bioclassifications were found: Excellent - 15 (11%), Good – 34 (26%), Good-Fair – 40 (31%), Fair - 24 (18%) and Poor – 15 (11%). The distribution of water quality ratings is very similar for both the 1998 and 1993 collections, suggesting little overall change in water quality within the Cape Fear River basin. Individual sites, however, often show distinct long-term or short-term changes in water quality (see below).

Listed below are the 1998 ratings (by subbasin) for all ratable benthos sites in the Cape Fear River basin:

Subbasin	Excellent	Good	Good-Fair	Fair	Poor
Piedmont					
01: Upper Haw/Troublesome Cr	-	-	3	2	1
02: Greensboro/Burlington area	-	2	4	4	4
03: Alamance Cr	-	1	1	-	1
04: Lower Haw R	1	2	5	1	-
05: Durham/ Jordan Lake	-	-	-	1	-
06: Chapel Hill area	1	2	1	4	2
07: Upper Cape Fear R	-	1	2	-	1
08: Deep R #1	-	-	2	2	1
09: Deep R #2	3	3	2	-	2
10: Deep R #3	-	4	-	2	1
11: Deep R #4 (Triassic basin)	-	-	2	-	-
12: Rocky R	-	2	4	-	-
Coastal					
13: Upper Little R	2	2	1	-	-
14: (Lower) Little R	6	-	1	-	-
15: Rockfish Cr	2	1	-	1	-
16: Middle Cape Fear R	-	1	5	-	-
17: Lower Cape Fear R	1	3	1	1	-
18: South R	-	1	1	1	-
19: Clinton area	1	1	2	-	-
20: Black R	-	2	-	1	-
21: NE Cape Fear #1	-	-	-	-	-
22: NE Cape Fear #2	1	1	3	2	-
23: NE Cape Fear #3	-	5	-	1	2
24: Coastal	-	-	1	-	-
Total (#)	15	34	40	24	15
Total (%)	11%	26%	31%	18%	11%

Areas of Excellent water quality in the piedmont ecoregion of the Cape Fear River basin are either small streams in protected catchments or large rivers that are far enough downstream to have recovered from point source pollutants. Streams in the first category include Morgan Creek and Cane Creek (near Chapel Hill), while rivers in the second category include the Cape Fear River in Harnett County and the Deep River in Moore County. Two streams between Greensboro and High Point are also worthy of note: the headwaters of Reedy Fork and the West Fork of the Deep River. Although these streams only received a Good-Fair or Good rating, they have unusually diverse communities of intolerant stonefly taxa. Slate Belt tributaries of the Haw and Deep River (Alamance, Chatham and Randolph counties) often receive a Good rating, although these streams may suffer from low-flow effects during droughts.

Areas of highest water quality in the coastal area of the Cape Fear River basin are concentrated in subbasins 13-15: Upper Little River, Little River, Rockfish Creek and their tributaries. This area comprises most of the sandhills area within the Cape Fear River basin, and contained 10 Excellent sites and 3 Good sites. Portions of the Black and South River (subbasins 18-19) have high benthic diversity, although few tributary streams have the diversity observed at mainstem sites. A similar community also occurs in the middle section of the Northeast Cape Fear River near Chinquapin (Subbasin 22).

The Division is developing criteria for swamp streams, and many swamp streams in the lower Cape Fear basin were sampled for the first time. Areas of highest water quality ("natural" conditions) included Town Creek, Hood Creek, Shelter Swamp and Merricks Creek.

Samples taken in 1998 were often collected during a period of very low flow. These may have a variety of effects on streams, depending on both catchment size and relative contribution of point source dischargers vs. nonpoint source runoff. The smallest streams may suffer from very flow or entirely cease flowing. This causes a lower bioclassification (sometimes evaluated as "not rated") or makes it impossible to collect samples. This was true for streams in subbasins 04 (Dry Creek), 08 (Muddy Creek/Hickory Creek), Triassic basin sites in subbasins 05 and 10-11, and coastal plain sites in subbasins 14, 15, 16, 17.

Streams affected by point source runoff may have a lower bioclassification during low flow periods, due to lower dilution of the effluent (Reedy Fork, subbasin 02). More common, however, are those streams that improve due to a reduction in nonpoint source runoff during a low flow year: Haw Creek, Pokeberry Creek, and Stinking Quarter Creek.

The most acute problems in the piedmont section of the Cape Fear River basin (Poor bioclassifications) are usually associated with point source discharges and/or urban runoff. Poor water quality was found for Little Troublesome Creek (Reidsville, subbasin 01), North and South Buffalo Creeks (Greensboro, subbasin 02), Northeast Creek (Durham, urban runoff, subbasin 05), Little Alamance Creek (Burlington, urban runoff, subbasin 03), Richland Creek (High Point, subbasin 08), Cotton Creek (Star, subbasin 10), Kenneth Creek (subbasin 07), Loves Creek (Subbasin 12) and Burgaw Creek (subbasin 22). The segments of North and South Buffalo Creeks below Greensboro constitute one of the worst water quality problems in North Carolina.

Long term changes in water quality were evaluated at 117 sites in the Cape Fear River basin, with the majority of sites showing no changes in water quality other than flow-related changes in bioclassification. The benthos sampling since 1983 may slightly overestimate the proportion of

Fair and Poor sites, as DWQ special study sampling often has the greatest sampling intensity (number of sites/stream) in areas with severe water quality problems.

The table below does not tabulate flow-related changes as a between-year change in water quality. For long-term changes in water quality, positive changes outnumber negative changes, usually reflecting improvements at wastewater treatment plants. Over the last five years, however, there were more negative changes, but this compares 117 sites, while there were only 69 sites with long-term data. The latter trend reflects changes in the coastal plain area associated with a combination of desnagging (after Hurricane Fran) and possible runoff from hog farms. It is usually not possible to differentiate between the effects of these two problems.

	# Trend sites	5-year trend			Long-term (>5 years)		
Subbasin	5 yr & >5 yr	None	+	-	None	+	-
01: Upper Haw/Troublesome Cr	5	4	0	1	2	0	0
02: Greensboro/Burlington area	11	9	1	1	5	1	1
03: Alamance Cr	3	2	0	0	3	0	0
04: Lower Haw R	5	5	0	0	3	2	0
05: Durham/ Jordan Lake*	5	3	0	0	3	1	0
06: Chapel Hill area	10	8	1	1	3	1	1
07: Upper Cape Fear R	4	3	0	1	1	0	0
08: Deep R #1	6	5	0	1	3	3	0
09: Deep R #2	9	8	1	0	3	3	0
10: Deep R #3*	10	10	0	0	2	0	0
11: Deep R #4 (Triassic)*	4	2	0	2	1	0	1
12: Rocky R	5	2	1	0	3	2	0
Coastal							
13: Upper Little R	5	5	0	0	4	0	0
14: (Lower) Little R	6	4	2	0	2	1	0
15: Rockfish Cr	3	3	0	0	1	1	0
16: Middle Cape Fear R	5	4	1	1	1	1	1
17: Lower Cape Fear R**	3	2	1	0	0	0	0
18: South R*	1	1	0	0	0	1	1
19: Clinton area	4	2	0	2	1	0	2
20: Black River	1	1	0	0	1	0	0
21: NE Cape Fear #1*	0	0	0	0	0	0	0
22: NE Cape Fear #2	6	3	0	3	0	1	1
23: NE Cape Fear #3	4	3	1	0	0	1	0
24: Coastal	2	2	0	0	0	0	0
Total	117	91	10	13	42	19	8

*Sampling difficulties due to inability to rate streams (Triassic basin) or lack of flow in many streams during 1998 collections.
**Many estuarine sites that are not included in this tabulation.

Positive changes (either over 5 years or over longer time periods) were primarily related to improvements in wastewater treatment, including collections from the Haw River (3 sites), Deep River (6 sites), New Hope Creek (slight improvement), Morgan Creek (slight improvement), Little River below Ft. Bragg, Rockfish Creek, and the Northeast Cape Fear River at Castle Hayne. The most striking recent change in water quality was the improvement seen in the Little River below the Ft. Bragg WWTP.

Two sites on the Rocky River improved due to a combination of better flow management (upstream site) and upgrades at the Siler City WWTP. The lower Cape Fear River in Bladen and Columbus County improved in 1998, but some of this change may be due to low nonpoint source inputs in 1998.

Declines in water quality were sometimes related to expanding urban areas. This was observed for Horsepen Creek (Greensboro), and Bolin Creek (Chapel Hill). Road construction in Greensboro caused a decline (possibly temporary) for the upper portion of South Buffalo Creek. The lower portion of the Deep River (near Sanford) has declined from Good to Good-Fair, and this change is apparently unrelated to dischargers in the Sanford area.

Hurricane Bonnie swept through much of the lower Cape Fear River after our sampling in the summer of 1998. Selected sites in subbasins 17, 19, and 22 were resampled, and declines (usually one bioclass) were observed at Hood Creek, the estuarine portion of the Cape Fear River near Southport, Six Runs Creek, the Black River, and Rockfish Creek (Duplin County). The greatest impact was observed for the Northeast Cape Fear River near Chinquapin, which declined from Good in August 1998 to Poor in September 1998. The most undeveloped catchment (Town Creek) showed no impact from Hurricane Bonnie. Since DWQ could only monitor a few streams, we must assume that damage was widespread across this region.

Some sites may still being showing impacts from Hurricane Fran (September 1996), especially the effect of de-snagging following this storm. The Emergency Watershed Protection Program, administered by the USDA's Natural Resources Conservation Service (NRCS), provided technical and financial assistance "to preserve life and property threatened by excessive erosion and flooding". The federal government granted monetary assistance to those counties in North Carolina that were most affected by Hurricane Fran in 1996 and this money was used to clear hurricane debris (blow-down) from clogged waterways. Zealous pursuit of this goal often totally cleared all woody material from the stream, material that is a critical habitat for both fish and invertebrates. For some streams, heavy machinery was used along the banks, with a resulting increase in sediment inputs from (and through) the riparian zone.

It is difficult to separate out the effects of de-snagging in these streams from the potential impact of increased numbers of hog farms within the same area. Streams that showed a five-year decline in water quality in this area included the South River near Parkersburg, Six Runs Creek, Great Coharie Creek, the upper Northeast Cape Fear River, Limestone Creek, and upper Rockfish Creek (Duplin County).

Several rare or unusual invertebrate species were collected in the Cape Fear River basin during 1998 basinwide surveys. Triaenodes melaca (a caddisfly) was collected from two streams in subbasins 01-02: Haw River near Reidville and Jordan Creek. Villosa constricta (a mussel) also was collected from this Haw River site, while Ephoron leukon (a mayfly) was collected from Jordan Creek. A new crayfish species (being described by John Cooper, NC Museum of Natural History) was collected from Beartree Creek, a small tributary of Jordan Reservoir.

The Rocky River is also an area with many unusual species, including a very rare dragonfly (Gomphus septima), various mussel species, and a new crayfish species (John Cooper, personal communication). Another new crayfish species was collected from Puppy Creek and is apparently limited to the Rockfish Creek drainage (John Cooper, personal communication).

The Black River and tributaries contains a variety of rare freshwater mussels (Elliptio folliculata, Elliptio marsupiobsea, Fusconaia masoni, Lampsilis cariosa, Lampsilis radiata), plus the four-toed black salamander. E. marsupiobesa (a North Carolina endemic) also is found in nearby portions of the Cape Fear River. A rare mayfly (Amercaenis sp.) has been collected in North Carolina only from the ORW segment of the Black River, as has the mayfly, Dolania americana.

Two rare snails were originally described from Greenfield Lake (near Wilmington) and are endemic to North Carolina: Helisoma eucosmium and Planorbella magnifica. Although extirpated from Greenfield Lake, they still occur in the Wilmington area.

FISHERIES

FISH COMMUNITY STRUCTURE

Previous studies of the stream fish communities of the Cape Fear River Basin have been conducted primarily by state resource agencies. For example, during 1962-1963, the North Carolina Wildlife Resources Commission (NCWRC) intensively sampled the fishery resources at 255 sites (Bayless 1963; Louder 1964; Carnes, *et al*. 1964). These three studies concluded that soil erosion and the resulting stream turbidity coupled with municipal and industrial pollution were the two major man-induced factors limiting the productivity and recreational potential of the waters in the Piedmont portion of the watershed (especially the Haw River and Deep River watersheds). Waters in the Northeast Cape Fear River basin were generally in better shape because much of the watershed was still forested and the human population density was low.

During the early 1990s, stream fish community data were collected and analyzed from 37 wadeable sites by the NCDWQ (NCDEHNR 1995). These data coupled with water chemistry and biological (benthic macroinvertebrate and toxicity testing) data concluded that the major pollutants in the entire river basin were biochemical oxygen demand, sediment, nutrients, toxicants (such as heavy metals, chlorine, pH, and ammonia) and fecal coliform bacteria (NCDEHNR 1996). The most recent investigation on the fishery of the lower mainstem Cape Fear and Northeast Cape Fear River were conducted by Mallin, et al. (1997).

In 1998, 52 sites, representing 19 of the 24 subbasins, were sampled and evaluated by the NCDWQ using the North Carolina Index of Biotic Integrity (NCDEHNR 1997 and Appendices FC-1a and 1b). Subbasins 030620, 21, and 23 were sampled for the first time in 1998. These 52 sites were chosen based upon the Use Support Ratings which the streams had received during the first round of basinwide monitoring during 1994 (Figures 4.19a-4.19c in NCDEHNR 1996) (Appendix FC-3). Streams that were specifically targeted in each subbasin and which had the greatest sampling priority were those which were rated as either Partially Supporting (25 sites) or Not Supporting (eight sites). As resources permitted, streams, which were rated Fully Supporting but Threatened (eight sites) or Supporting (11 sites), were then sampled.

The 52 sites were distributed across the three ecoregions constituting the Cape Fear River Basin: the Piedmont (35 sites), Sandhills (seven sites), and Coastal Plain (10 sites) (Appendix FC-3). The watershed sizes for the 52 monitored streams ranged across one order of magnitude from 7.4

(Rocky River in Chatham County) to 125 mi^2 (Reedy Fork in Guilford County); the median watershed size was 21.4 mi^2. The NCIBI classifications at these 52 sites ranged from Good (seven sites) to Poor (20 sites) (Figure F-1). The distribution of these ratings were: Good--7, Good-Fair--13, Fair--12, and Poor--20 (Appendix FC-4). The fish community with the greatest biological integrity score was Whites Creek (Bladen County); the fish community with the lowest biological integrity score was South Buffalo Creek (Guilford County) (Figure F-2).

Of the 52 sites sampled in 1998, 17 of the sites (of which 16 were at the exact site) were previously sampled in 1992-1994 (Figure F-3 and Appendix FC-5). In 1998, the distribution of the ratings of these 17 sites were: Good-Fair-4, Fair--3, and Poor--10. The 1998 average NCIBI score was 35 with an NCIBI classification of Poor. In 1992-1994, the distribution of these ratings were: Good--1, Good-Fair--3, and Fair -- 6, and Poor--7. The 1992-1994 average NCIBI score was 38 with a NCIBI classification of Fair.

According to Menhinick (1991), 99 species of predominantly freshwater fish have been collected from the Cape Fear River Basin in North Carolina. NCDWQ and the North Carolina State Museum of Natural Science collections have documented an additional four species: Cyprinella lutrensis, Phoxinus oreas, Pimephales promelas, and an undescribed species of redhorse sucker (Moxostoma n. sp.) tentatively called the Carolina redhorse. Thus, 103 species of freshwater fish have been collected from this river basin (Appendix FC-2). At least 17 of these species (16% of the total fauna) are exotics that were introduced either as sportfish, baitfish, or for reasons unknown, into waters of the Cape Fear Basin. The known species assemblage includes 30 species of minnows, 10 species of suckers, 18 species of sunfish and bass, and 6 species of darters.

In 1998, 13,984 fish, representing 70 of the 103 possible species, were collected during the basinwide monitoring program. In the Piedmont, the most commonly collected species was the redbreast sunfish (collected at all 35 sites); the most abundant species was the bluehead chub

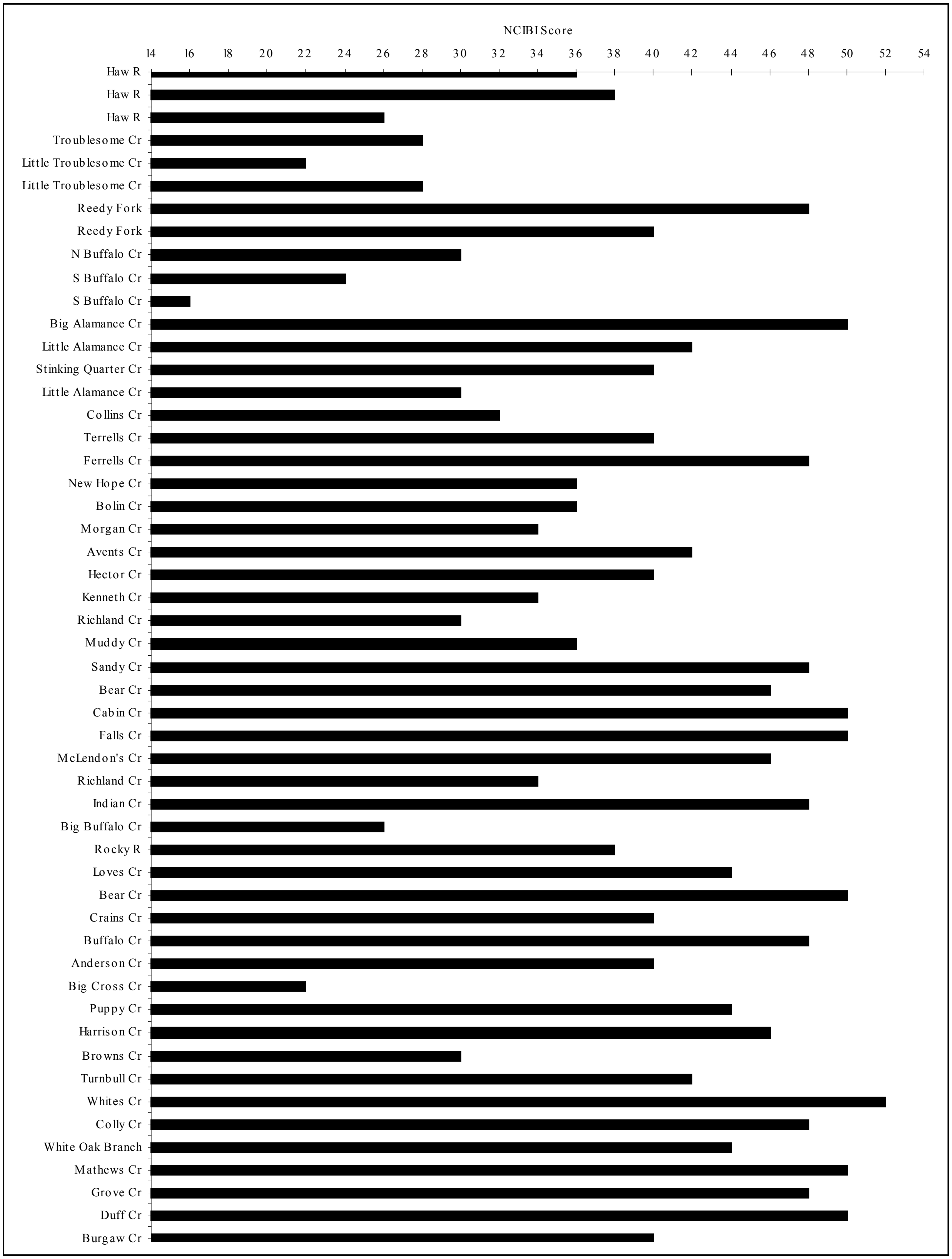


Figure F-1. The North Carolina Index of Biotic Integrity for the Cape Fear River Basin, 1998.

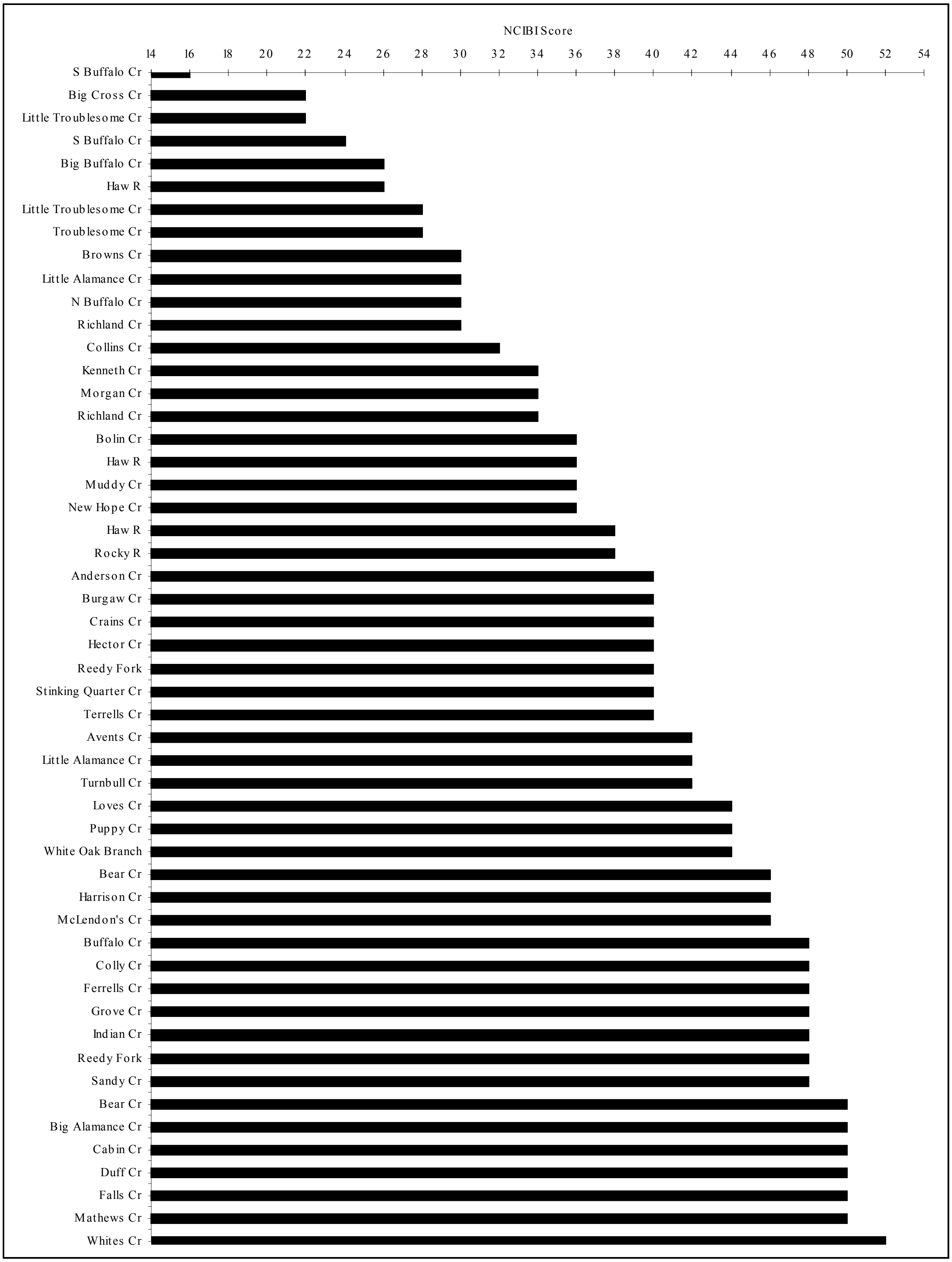


Figure F-2. The North Carolina Index of Biotic Integrity for the Cape Fear River Basin, 1998.

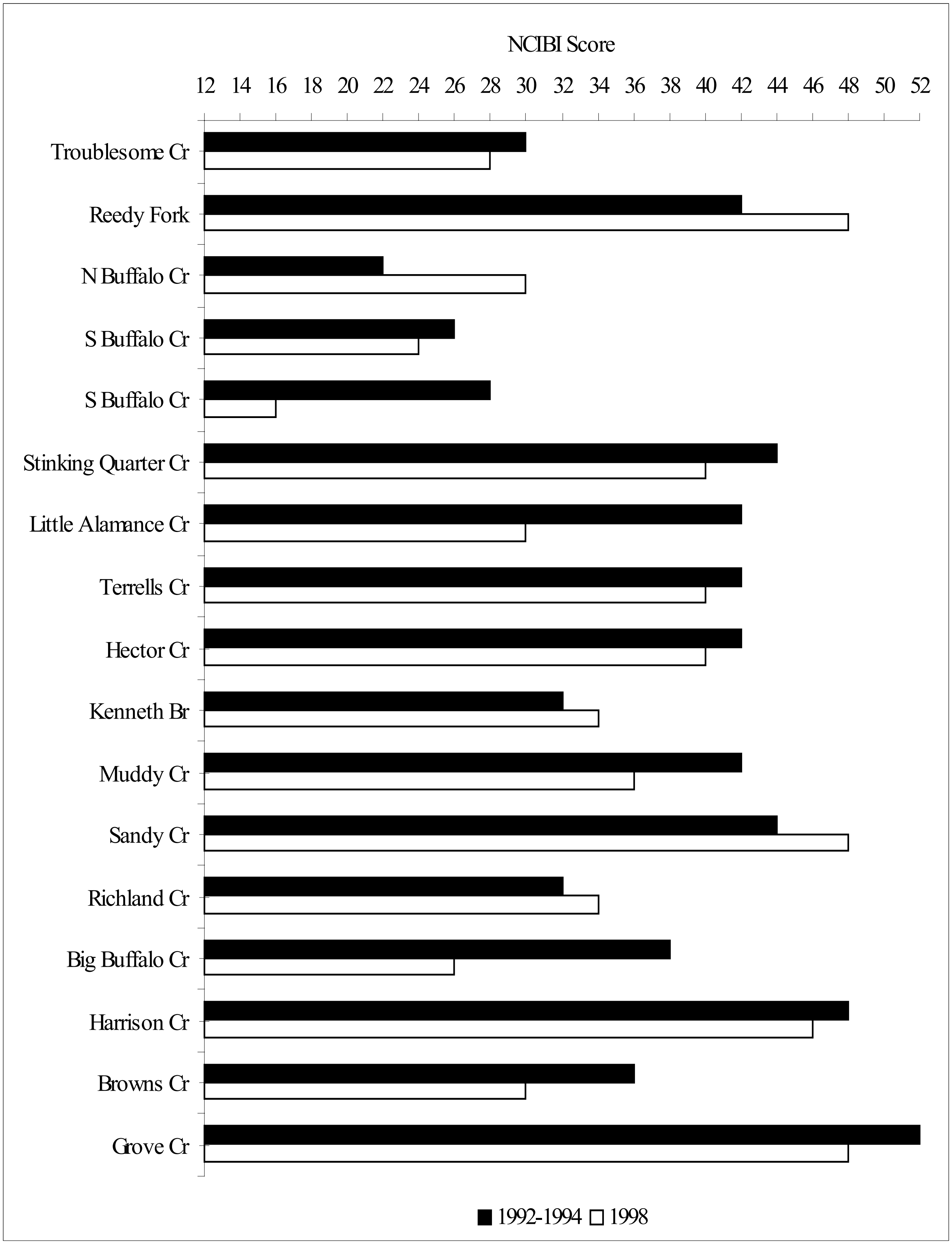


Figure F-3. The North Carolina Index of Biotic Integrity for the Cape Fear River Basin, 1992-1994 and 1998.

(2,017 or 21% of all the fish collected were of this species). In the Sandhills, the most commonly collected species were the pirate perch, redbreast sunfish, and tessellated darter (each collected from 10 of the 12 sites); the most abundant species was the redbreast sunfish (284 or 22% of all the fish collected were of this species). In the Coastal Plain the most commonly collected species was the redfin pickerel (collected at 14 of the 15 sites); the most abundant species was the eastern mosquitofish (579 or 20% of all the fish collected were of this species).

For 10 species reported from the Cape Fear River basin, special status has been granted 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 1130337 (LeGrand and Hall 1997; Menhinick and Braswell 1997) (Table F-1).

Table F-1. Species of fish listed as endangered, rare, threatened, special concern, or significantly rare in the Cape Fear River Basin in North Carolina.

Species	Common Name	State or Federal Status	State Rank[1]
Notropis mekistocholas	Cape Fear Shiner	Federal-Endangered	S1
Acipenser brevirostrum	Shortnose Sturgeon	Federal-Endangered	S1
Acipenser oxyrhynchus	Atlantic Sturgeon	State-Special Concern	S3
Carpiodes velifer	Highfin Carpsucker	State-Special Concern	S2
Cyprinella zanema form	Thinlip Chub	State-Special Concern	S2
Etheostoma collis	Carolina Darter	State-Special Concern	S3
Heterandria formosa	Least Killifish	State-Special Concern	S1
Lucania goodei	Bluefin Killifish	State-Special Concern	S1
Noturus sp.	Broadtail Madtom	State-Special Concern	S2
Semotilus lumbee	Sandhills Chub	State-Special Concern	S3

[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 and Hall 1997).

During the 1998 basinwide survey, three special status species were collected in the Cape Fear River basin. The Carolina darter, Etheostoma collis, was collected from two locations. A single specimen was collected from the Haw River in Guilford County, while four individuals were collected from Bear Creek in Chatham County. The Chatham County collection represented a slight range extension. The Cape Fear shiner was recorded from Falls Creek in Moore County. Eleven specimens were collected from this location. This record indicated a slight range extension for the species also. The sandhills chub, Semotilus lumbee, was also found at a single location. One specimen was collected in Anderson Creek in Harnett County. Additional zoogeographical and biological information on all species listed in Table F-1 may be found in Menhinick and Braswell (1997).

FISH TISSUE

Fish tissue was sampled at 23 stations within the Cape Fear River basin from 1994 to 1998. Fish tissue surveys were conducted in the basin as part of mercury assessments of fish in the eastern part of the state and during routine basinwide assessments. Most fish samples collected during the period contained metal and organic contaminants at undetectable levels or at levels below FDA and EPA criteria. Elevations in mercury were, however, measured in largemouth bass and bowfin samples from numerous stations, and in multiple species collected from the Black and South rivers. Nearly two thirds of the total samples collected from the Black and South stations contained mercury above FDA/NC and/or EPA criteria. Mercury contamination of fish in the Cape Fear basin was not associated with point sources and is consistent with levels measured in fish species throughout the North Carolina coastal plain.

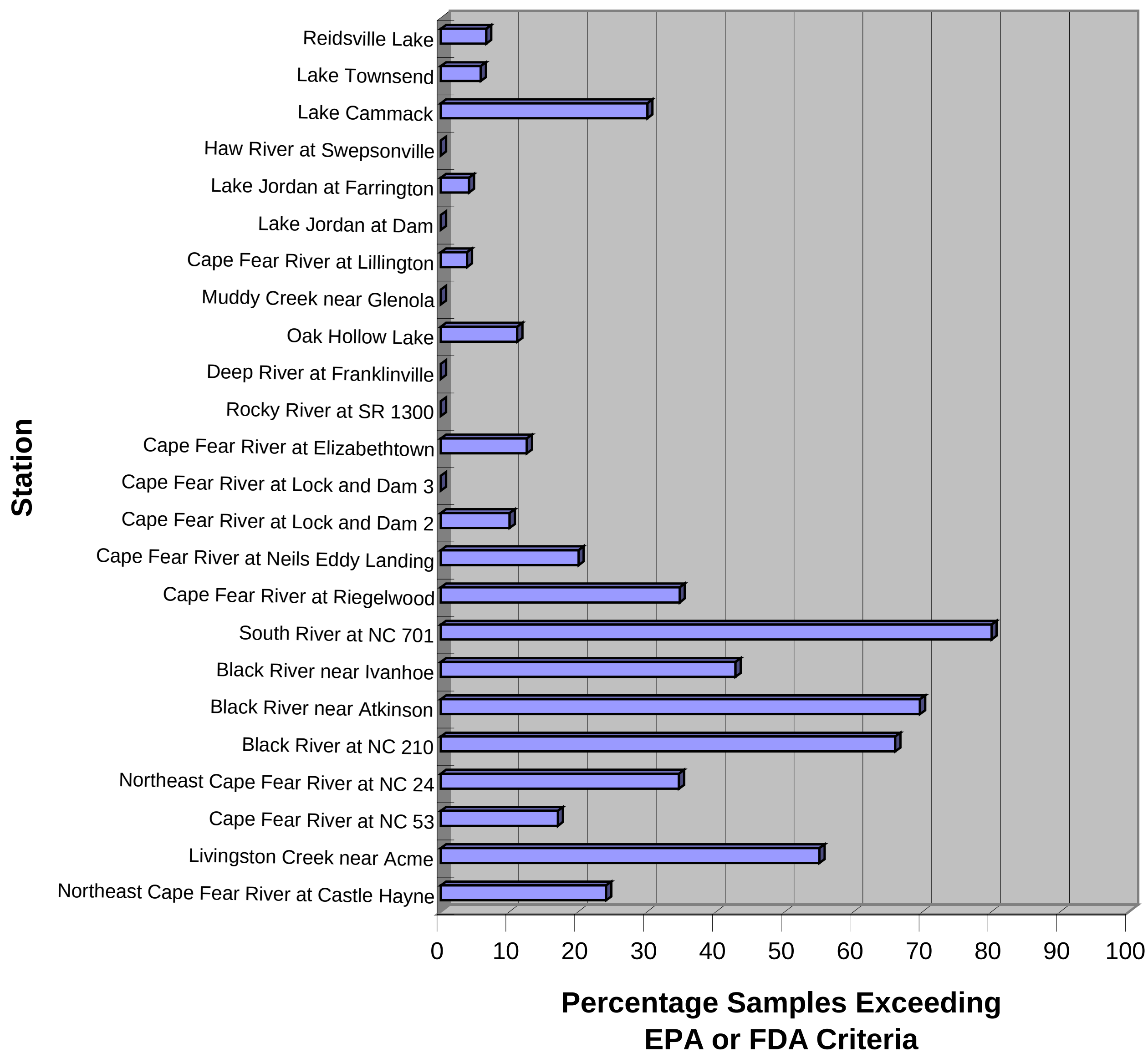
A small number of fish samples collected from the Cape Fear River, the Deep River, and the Haw River were analyzed for chlorinated pesticides and PCB arochlors during the 1998 assessment. Results showed undetectable levels of organic contaminants in fish tissue from these stations.

International Paper Company performs yearly monitoring of fish tissue for dioxins and furans along the Cape Fear River near the company mill in Reigelwood. Monitoring is performed as part of NPDES permit number NC0003298. Results from 1994 to 1998 show dioxin and furan levels in gamefish and bottom species at undetectable levels or at concentrations well below the NC limit of 3 parts per trillion (CZR Incorporated, 1998).

Carolina Power and Light (CP&L) conducts annual environmental monitoring of Lake Sutton near Wilmington. CP&L has measured levels of arsenic, copper, mercury , and selenium in the liver and muscle tissue of two fish species since 1992. Results of a 1996 survey showed a significant increase in levels of copper and selenium in bluegill and largemouth bass over levels seen in prior years. Tissue burdens measured in bass and bluegill during 1996 were considered to be at levels capable of causing ecological effects. (CP&L, 1996).

At present there are no specific fish tissue consumption advisories posted in the Cape Fear basin. The entire basin is posted for bowfin, however, as part of a statewide mercury advisory on the species. Consumption of bowfin is limited to no more than 2 meals per month for the general population. Children and women of childbearing age are advised not to consume bowfin.

Figure FT-1: Cape Fear River Basin Fish Tissue



LAKES ASSESSMENT

There were 32 lakes in the Cape Fear River Basin sampled as part of the Lakes Assessment Program. These lakes, by river subbasin, are presented below.

SUBBASIN 030601 Lake Hunt, Reidsville Lake

SUBBASIN 030602 Lake Higgins, Lake Brandt, Lake Townsend, Burlington Reservoir, Lake Burlington, Graham-Mebane Reservoir

SUBBASIN 030603 Lake Macintosh

SUBBASIN 030604 Cane Creek Reservoir, Pittsboro Lake

SUBBASIN 030605 B. Everett Jordan Reservoir

SUBBASIN 030606 University Lake

SUBBASIN 030607 Harris Lake

SUBBASIN 030608 Oak Hollow Lake, High Point Lake

SUBBASIN 030609 Sandy Creek Reservoir

SUBBASIN 030610 Carthage City Lake

SUBBASIN 030612 Rocky River Reservoir

SUBBASIN 030614 Old Town Reservoir

SUBBASIN 030615 Hope Mills Lake, Kornbow Lake, Bonnie Doone Lake, Mintz , Glenville Lake

SUBBASIN 030616 Salters Lake, Jones Lake, White Lake

SUBBASIN 030617 Greenfield Lake, Boiling Springs Lake

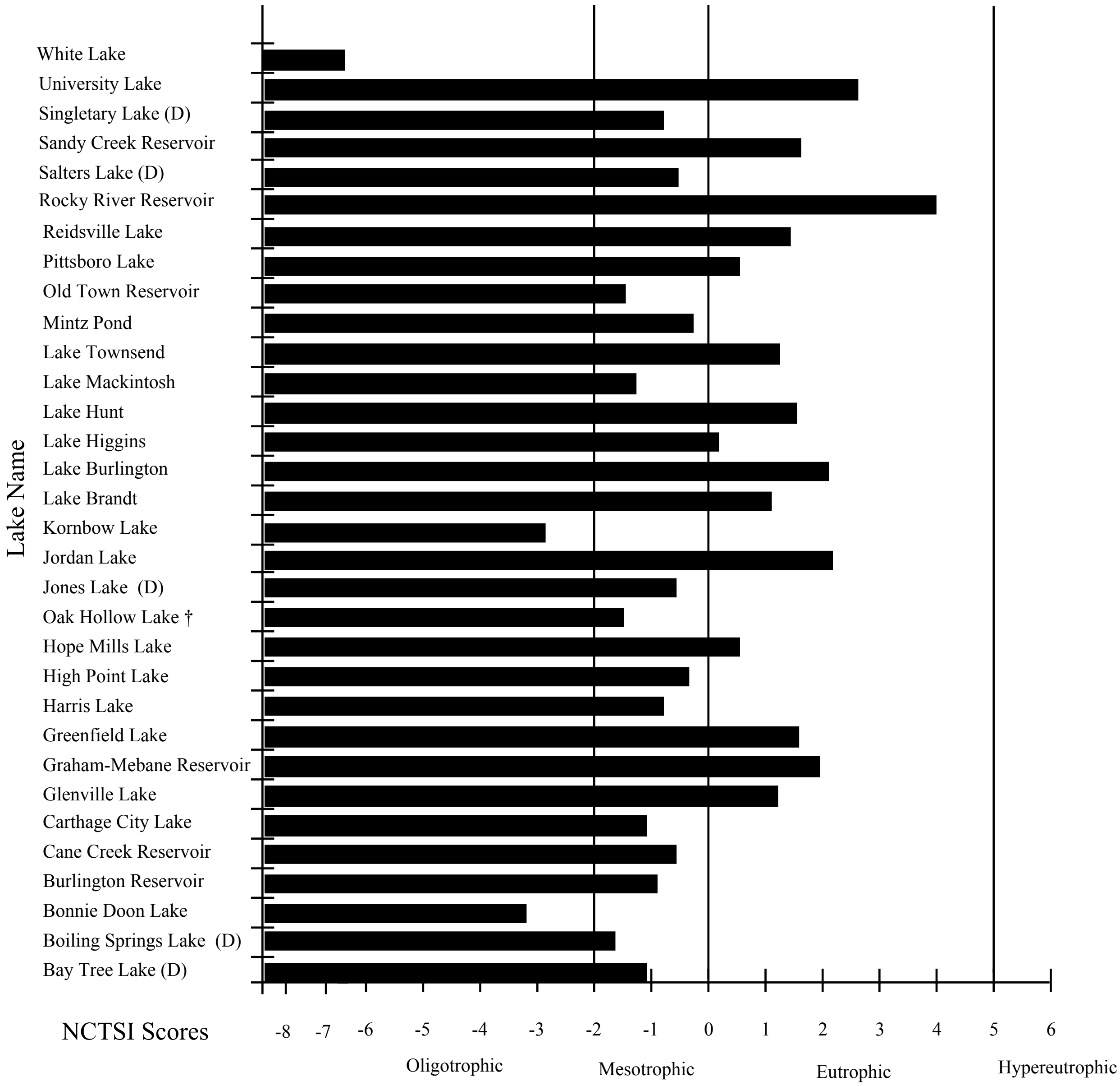
SUBBASIN 030618 Bay Tree Lake

SUBBASIN 030620 Singletary Lake

Each lake is individually discussed in the appropriate subbasin section with a focus on the most recent available data. Figure L1 shows the most recent NCTSI scores for the thirty-two lakes of the Cape Fear River basin. Thirty-one of these lakes were sampled by DWQ in 1998. Harris Lake was most recently sampled by DWQ in 1996.

The August NCTSI scores were not calculated for the lakes monitored by DWQ in 1998 due to unacceptable laboratory results for chlorophyll *a*.

Figure L1. Cape Fear River Basin NCTSI Score (All NCTSI Scores Reflect July 1998 except for Oak Hollow Lake)



(D) Dystrophic Lake

AQUATIC TOXICITY MONITORING
Whole Effluent Toxicity Compliance: 1985-1998

Year	Facilities	Tests	% Meeting Permit Limit*
1985	9	91	45.0
1986	15	145	49.6
1987	27	233	42.1
1988	42	383	53.0
1989	49	538	69.7
1990	57	625	71.8
1991	63	685	83.1
1992	67	799	80.2
1993	71	845	85.7
1994	79	908	83.7
1995	80	964	85.3
1996	82	963	87.5
1997	85	994	89.3
1998	87	1018	90.9

*This number was calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.

"Tests" is not the actual number of tests performed, but the number of opportunities for limit compliance evaluation. Assumptions were made about compliance for months where no monitoring took place based on data previous to that month. Facilities compliant in a given month were assumed to be in compliance during months following until the next actual monitoring event. This same policy was applied to facilities in noncompliance.

The City of Reidsville WWTP (subbasin 01) has experienced problems with whole effluent toxicity for quite some time. The facility's Special Order by Consent (SOC) expired on 11/30/98; the City has submitted an application for extension of the SOC. Toxicity reduction activities performed include refractory toxicity testing that has targeted at least one industrial contributor as the source of toxicity. The facility has also relocated its discharge from Little Troublesome Creek to the Haw River, reducing the WET compliance limit from 90% to 61%.

Cone Mills Corporation (subbasin 02) has failed to consistently meet its WET limit since 1993. Toxicity identification activities have indicated total dissolved solids (salts) as a primary source of toxicity. The facility is currently under an EPA administrative order which directs the facility to be in compliance with its WET limit by December 31, 2000. Cone officials plan for the facility to be connected to the City of Greensboro's TZ Osborne WWTP by that time.

The Town of Star (subbasin 10) has had ongoing effluent toxicity problems since it began monitoring in 1987. The facility's effluent is dominated by textile waste and thus the source of toxicity is total dissolved solids (salts). The facility has worked with consultants and its industries over the period with varying results, at times meeting its limit for as long as three consecutive months. Town officials have requested a Special Order by Consent. The Town's industries have scheduled site visits with Division of Pollution Prevention and Environmental Assistance personnel.

The Environmental Management Commission has granted Mt. Olive Pickle Co. (subbasin 21) and Charles F. Cates & Sons (subbasin 22) variances from the State's action level standard for chloride and water quality standard for WET. These variances were granted effective 1996 based on material presented by the facility describing the technical and economic impracticability of treating the waste and the subsequent adverse economic impact on the region should these two facilities relocate.

The Town of Rose Hill (subbasin 22) has experienced recent problems meeting its WET limit. The Town has applied for a Special Order by Consent (SOC) in order to complete toxicity reduction activities.

Stevcoknit Fabrics (subbasin 22) had failed to meet its WET limit consistently since monitoring began in 1991. As of July 1998, the facility has closed and ceased discharge.

The Town of Holly Ridge has experienced ongoing problems with effluent toxicity since 1991. The Town is in the process of developing a land application system in order to ultimately cease discharge.

BASINWIDE ASSESSMENT DOCUMENT
CAPE FEAR RIVER BASIN

INTRODUCTION

The Cape Fear River Basin is the largest river basin in the state and covers an area of 9,149 square miles in twenty seven counties. There are an estimated 6,300 miles of streams and rivers in the basin and 39,200 acres of estuarine waters. The waters in the basin are confined to the Piedmont, Sandhills and Coastal Plain ecoregions. The Cape Fear River is formed by the confluence of the Deep and Haw Rivers at the Chatham/Lee County line. B. Everett Jordan Reservoir is the largest impoundment in the basin. Several large tributaries join the river as it flows to the Atlantic Ocean at Cape Fear near Southport: Upper and (Lower) Little Rivers, Rockfish Creek, Black River, South River and the Northeast Cape Fear River.

There are three coastal Outstanding Resource Waters (ORW)-Stump Sound, Middle and Topsail Sounds, and Masonboro Sound, and one freshwater ORW-a portion of the Black River and watershed. A portion of the Black River is also High Quality Waters.

The basin is characterized by highly urban and industrialized areas around Greensboro, High Point, Burlington, Chapel Hill and Durham in the upper part of the watershed and around Fayetteville and Wilmington in the middle and lower part. There are 114 municipalities located in whole or in part in the basin. Fort Bragg Military Reservation occupies a large area in the middle of the basin. Over half of the land in the river basin is forested. The lower Cape Fear basin has the most concentrated animal producing areas in the state in Sampson and Duplin counties.

The Water Quality Section of DWQ uses a whole basin approach to water quality management. Activities within the Section, including permitting, monitoring, modeling, nonpoint source assessments, and planning, are coordinated and integrated by basin, for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Cape Fear River basin was sampled by the Environmental Sciences Branch in 1993 and 1998.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning concept. 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 Cape Fear River Basin include benthic macroinvertebrates, fisheries, lakes assessment, phytoplankton, aquatic toxicity monitoring, and ambient monitoring system. A brief introduction to each program follows:

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S). Likewise, ratings can be assigned with a North Carolina Biotic Index (BI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies. Separate draft criteria have been developed for slow flowing swamp streams, for deep coastal rivers, and for estuarine areas. Appendix B-1 gives much more detail on benthic sampling methods and criteria.

Appendix B-2 lists all the benthic macroinvertebrate collections in the Cape Fear River basin between 1983 and 1998, giving site location, DWQ Classification Schedule Index Number, collection date, taxa richness and biotic index values, and bioclassifications. Bioclassifications listed in this report may differ from older reports because evaluation criteria have changed since 1983. Originally, Total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

FISH

FISH COMMUNITY STRUCTURE ASSESSMENT

The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr, et al. (1986). The Index has been subsequently modified and is continually being refined for applicability to wadeable streams in North Carolina (Appendix FC-1). 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, a stream which rated excellent on the NCIBI should be expected to have excellent water quality. Currently, in the Cape Fear River Basin, the NCIBI is applicable only streams that are wadeable from one shoreline across to the other and for a distance of 600 feet. Nonwadeable streams and larger rivers that must be sampled with a boat are not currently evaluated with the NCIBI.

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 indicates additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

FISH TISSUE

Since fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources have been documented for heavy metals, pesticides, and other complex organic compounds. Once these contaminants reach surface waters, they may be available for bioaccumulation, either directly or through aquatic food webs, and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water. Fish tissue analysis results are used as indicators for human health concerns, fish and wildlife health concerns, and the presence and concentrations of various chemicals in the ecosystem. Criteria used to evaluate fish tissue data are given in Appendix FT-1.

LAKE ASSESSMENT PROGRAM

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. The North Carolina Lake Assessment Program seeks to protect these waters through monitoring, and pollution prevention and control. Assessments have been made at publicly accessible lakes, at lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed. Data are used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity.

Tables presented in each subbasin summarize data used to determine the trophic state of each lake. These determinations are based on information from the most recent summertime sampling (date listed). The most recent North Carolina Trophic State Index (NCTSI) value is shown, followed by the descriptive trophic state classification (O=oligotrophic, M=mesotrophic, E=eutrophic, H=hypereutrophic, D=dystrophic). Appendix L gives details of the NCTSI calculation and other details of the lakes data, such as the Algal Growth Potential Test (AGPT).

PHYTOPLANKTON

Phytoplankton are microscopic algae found in the water column of lakes, rivers, streams, and estuaries. Phytoplankton populations respond to nutrient availability and other environmental factors such as light, temperature, pH, salinity, water velocity, and grazing by organisms in higher trophic levels. Phytoplankton may be useful as indicators of eutrophication and are often collected with ambient water quality samples from lakes. Prolific growths of phytoplankton, often due to high concentrations of nutrients, sometimes result in "blooms" in which one or more species of algae may discolor the water or form visible mats on top of the water. Blooms may be unsightly and deleterious to water quality, causing fish kills, anoxia, or taste and odor problems. The Algal Bloom Program was initiated in 1984 to document suspected algal blooms with species identification, quantitative biovolume, and density estimates. Usually, an algal sample with a biovolume larger than 5000 mm^3/m^3, density greater than 10,000 units/ml, or chlorophyll *a* concentration approaching or exceeding 40 µg/L (the North Carolina state standard) constitutes a bloom. Bloom samples may be collected as a result of complaint investigations, fish kills, or during routine monitoring if a bloom is suspected.

AQUATIC TOXICITY MONITORING

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 several researchers to be predictive of discharge effects on receiving stream populations. Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Other facilities may be tested by DWQ's Aquatic Toxicology Laboratory. The 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 DWQ administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

AMBIENT MONITORING SYSTEM

The Ambient Monitoring System (AMS) is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered 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 appended when justified.

Water quality data collected at all sites in a basin were evaluated for the previous five year period. These data were downloaded from STORET to a desktop computer for analysis. Some stations have little or no data for several parameters. However, for the purpose of standardization it was felt that data summaries for each station should include all parameters. These chemistry data summaries are found at the end of the ambient monitoring section.

Ambient Monitoring System Freshwater Parametric Coverage.

CLASS C WATERS (minimum monthly coverage for all stream stations)

Field Parameters: dissolved oxygen, pH, conductivity, temperature,
Nutrients: total phosphorus, ammonia, total Kjeldahl nitrogen, nitrate+nitrite
Physical Measurements: total suspended solids, turbidity, hardness
Bacteria: fecal coliforms (Millipore Filter method)
Metals: aluminum (no present water quality standard), arsenic, cadmium, chromium, copper*, iron*, lead, mercury, nickel, silver*, zinc*

TROUT WATERS and SWAMP WATERS

No changes or additions

WATER SUPPLY

Chloride*, total coliforms, manganese, total dissolved solids

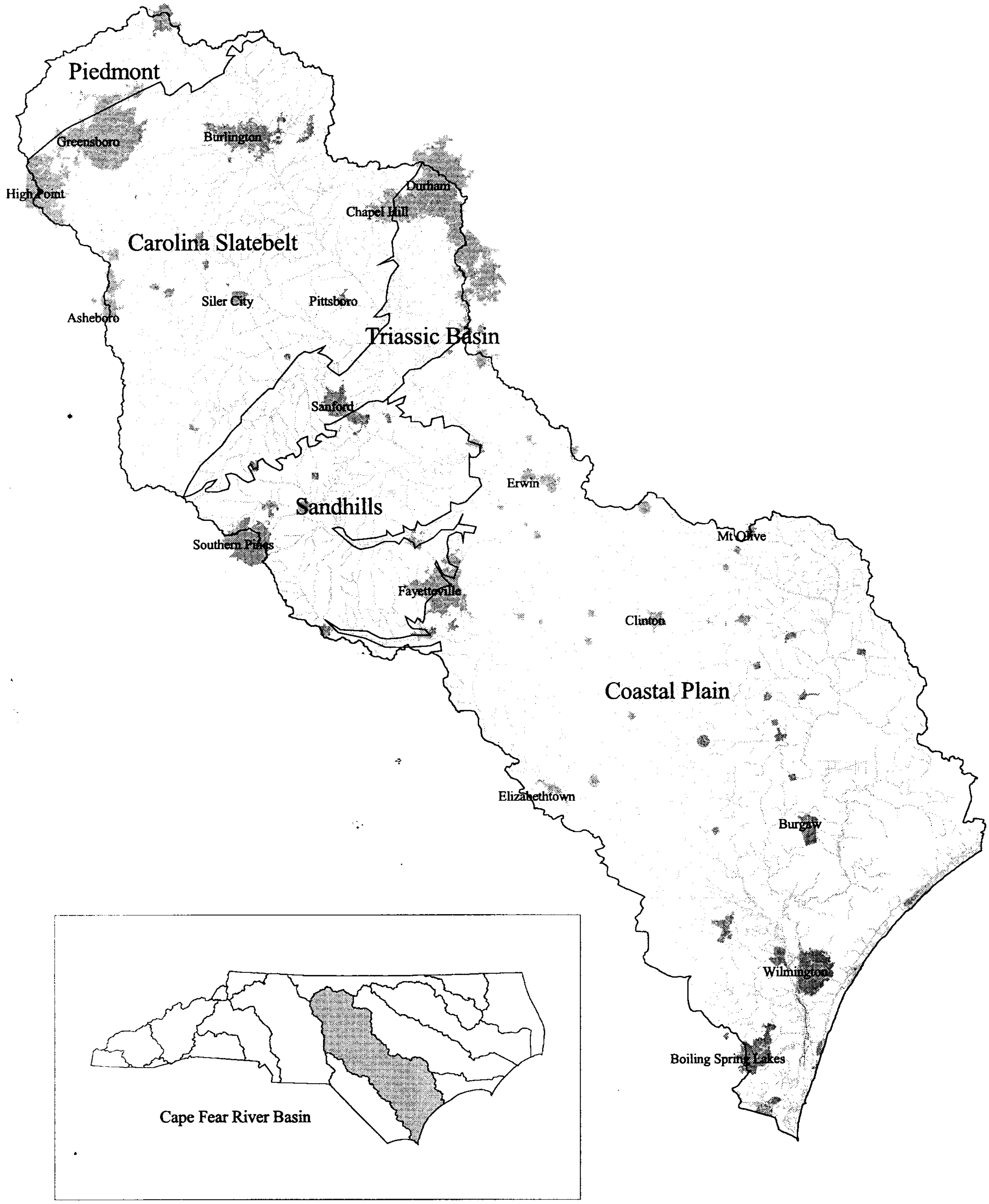
NUTRIENT SENSITIVE WATERS

Chlorophyll *a* (where appropriate)

PLUS any additional parameters of concern for individual station locations.

*Action level water quality standard.

Physiography of the Cape Fear River Basin



GEOLOGY AND SOILS

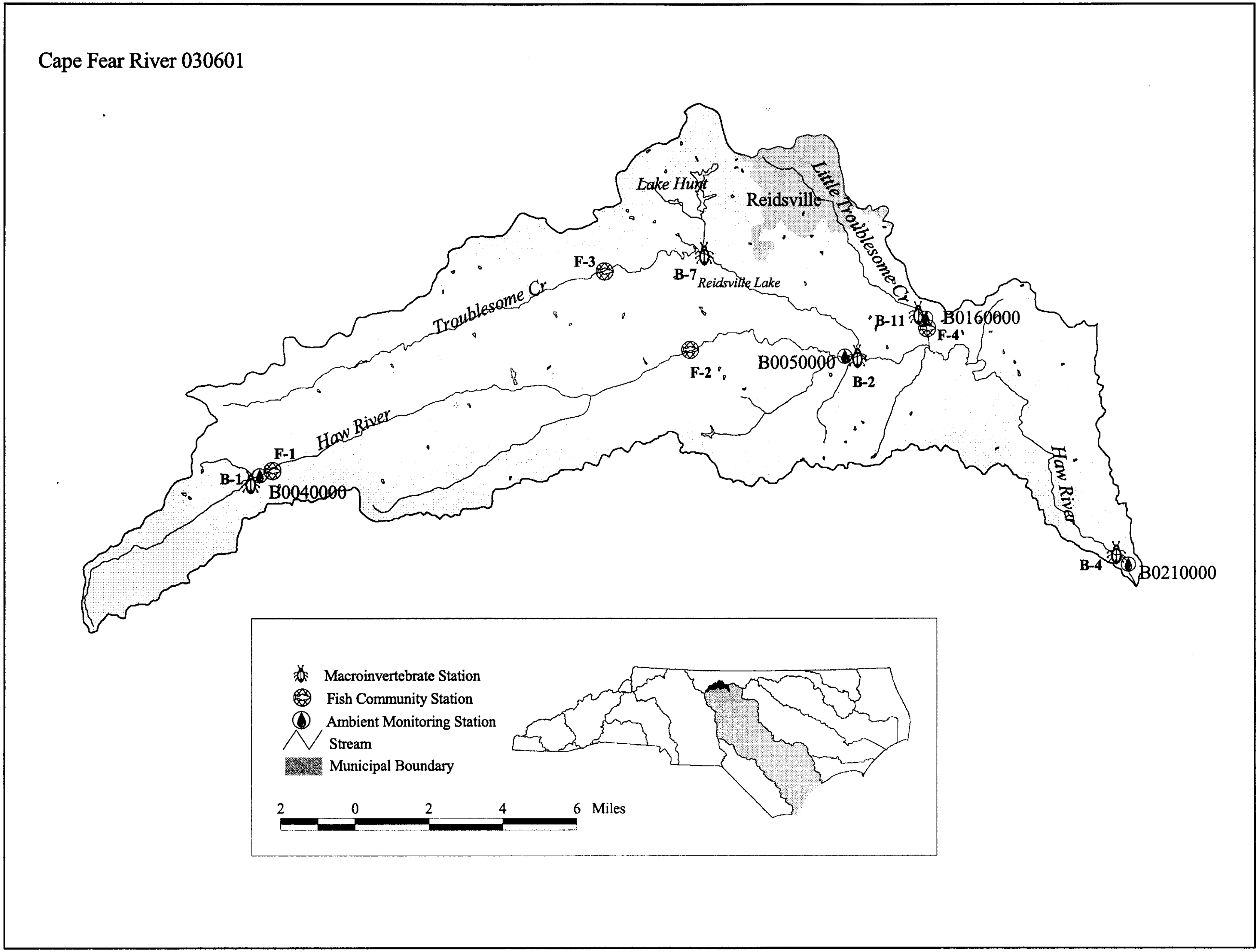
The geology and soils of a watershed can have a large effect on stream habitat, water chemistry and the potential for sustained base flows in streams. Low flow, also referred to as base flow or sustained fair-weather flow, is composed largely of groundwater discharge from aquifers into streams. During high rainfall periods the aquifers are recharged. Low flows in North Carolina typically occur at the conclusion of the growing season in late summer and early autumn. The geology (underlying rock units which weather to form the overlying soils) indirectly affects the potential for sustained base flow. The extent of fractures in underlying rocks is also an important factor (USGS 1998). Soil type and soil permeability plays an important role in the ability of a stream to sustain base flow. They determine whether rainfall can infiltrate and reach the groundwater or mainly flows overland to reach a stream. Though biological communities are affected by both high and low flows, the ability of a stream to maintain some base flow is critical to many aquatic organisms.

The Cape Fear River basin has several distinct geological regions. Most of the Piedmont is underlain by belts of metamorphic and metavolcanic rocks. An exception is the Triassic Basin, which extends from Moore County, up through Chatham County into Wake, Durham and Granville counties in the Neuse River basin. The broad, flat terrain of the Triassic Basin is one of the most anomalous features of the Piedmont. With its meandering streams, wide floodplains, old oxbow ponds and extensive swamps, it is more similar to the coastal plain than the more usual Piedmont topography. This flat terrain was created by freshwater deposits rather than marine, reflecting its origin as an interior rift valley. During the Triassic period (250 million years ago) crustal plate tectonic movement created large faults where blocks of the crust slipped downward to create basins. These basins, or valleys, formed inland seas which eventually became filled with sediments. (Hall and Boyer 1992) The Triassic Basin is underlain by basalt and fine-grained sedimentary rocks, which include sandstone, siltstone, and shale. These rocks have low porosity and permeabilities, and support a lower potential for sustained base flows. Many sites in the Triassic Basin have 7Q10 discharges equal to zero flow (USGS 1998).

The Sandhills is a distinct physiographic province found in the Cape Fear and Lumber River basins between the piedmont and coastal plain. Located mainly in southern Moore and Lee counties, southwestern Harnett and northwestern Cumberland counties and northeastern Hoke County, the Sandhills are named for the rolling topography featuring sandy soils, with pines and scrub oaks being very characteristic features of the landscape (Carter and LeGrande 1989). The dividing line between the sandhills and the coastal plain is located along a subtle escarpment called the Coats Scarp which extends through central Hoke and northern Cumberland counties. The sandhills are underlain by the Tuscaloosa geologic formation which is composed of light colored sands and clays. It is overlain by well-drained sandy soils. These soils have a high percolation rate which allows for ample recharge of natural groundwater reserves. This benefits the streams which receive substantial flow from the high quality groundwater during low rainfall periods. Thus, swiftly-flowing sandy streams characterize this area. These streams are generally of high water quality, which reflects both soil characteristics and undisturbed watersheds.

Another distinct geological region within the piedmont ecoregion is the Carolina Slate Belt. This is an extensive formation in North Carolina, ranging from just east of Charlotte northeastward across the state through Moore and Chatham counties in the Cape Fear River basin to Henderson in the Roanoke River basin. This geologic formation consists mainly of metamorphosed sedimentary and igneous rocks, with most of the igneous rocks being volcanic (extrusive). It represents an ancient arc of island volcanoes and adjoining marine sediments that were crushed and uplifted during the Paleozoic, approximately 300 million years ago. Rocks making up this belt are all crystalline in structure, but highly diverse. (Hall and Boyer 1992). Most are lightly metamorphosed sedimentary rocks such as argillite, graywacke (muddy sandstone), sandstone, and siltstone that weather into acidic soils. Slate, a blackish, flaky rock, is a more highly metamorphosed rock, that produces a more circumneutral soil. Slate belt streams with small watersheds can have periods of very low flows, similar to the Triassic Basin streams.

The lower portion of the Cape Fear River basin is located in the inner coastal plain region. This area is characterized by relatively flat low-lying terrain, sluggish blackwater streams that are bordered by swamps and bottomland forests, and poorly drained soils. The blackwater streams are so named because of their natural tea color from the tannic acid released from decomposing plant material.


Cape Fear River 030601
Lake Hunt
Reidsville
Little Troublesome Cr
F-3
B-7
Reidsville Lake
Troublesome Cr
B-11
B0160000
F-4
F-2
B0050000
B-2
Haw River
F-1
B-1
B0040000
Haw River
B-4
B0210000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2
0
2
4
6
Miles

CAPE FEAR SUBBASIN 030601

DESCRIPTION

Cape Fear subbasin 01 is located in the piedmont ecoregion and contains the city of Reidsville. This area comprises the headwaters of the Haw River, including Troublesome Creek. The characteristics of streams in this subbasin are strongly affected by geology and soil type. Streams in the northern and western portion (upper Haw River, upper Troublesome Creek, Little Troublesome Creek) are within the Milton Belt and tend to be very sandy. Portions of the Carolina Slate belt, however, occur in the southeast portion of subbasin 01, producing some rockier streams (lower Troublesome Creek, lower Haw River). Agriculture is widespread. There are 12 permitted dischargers in subbasin 01, mostly near Reidsville. Most of these are very small, with the largest dischargers being the Reidsville WWTP (5 MGD, Little Troublesome Creek) and Glen Raven Mills (0.15 MGD, Haw River).

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1*	Haw R	Guilford	SR 2109	Fair	Fair
B-2	Haw R	Rockingham	US 29 Bus	Good-Fair	Good-Fair
B-3	Haw R	Rockingham	NC 150	no sample	Good-Fair
B-4*	Haw R	Alamance	NC 87	Good-Fair	Fair
B-7	Troublesome Cr	Rockingham	SR 2422	Good-Fair	Good-Fair
B-11	L Troublesome Cr	Guilford	SR 2600	Poor	Poor
FISH					
F-1	Haw R	Guilford	SR 2109	no sample	Poor
F-2	Haw R	Rockingham	SR 2426	no sample	Poor/Fair
F-3	Troublesome Cr	Rockingham	SR 1001	Poor	Poor
F-4	L Troublesome Cr	Rockingham	SR 2600	no sample	Poor

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Lake Hunt, Reidsville Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Reidsville Lake	1998	15	1	0	EPA mercury limit exceeded in 1 bass sample

The combination of widespread agriculture and highly erodable soils produces widespread nonpoint source problems in both the Haw River and Troublesome Creek catchments. Many sites since 1983 received a Good-Fair rating using macroinvertebrate data, but Fair conditions were recorded often, and at the upper site on the Haw River. Low flow in this segment of the river may influence its benthos rating. Fish sampling produced Poor or Fair ratings at three sites in this area that were primarily affected by nonpoint source runoff, reflecting the influence of sedimentation on habitat quality.

A point source discharger (Reidsville WWTP, Little Troublesome Creek) has caused the most severe water quality problems in this subbasin (Poor benthos and fish rating in 1998). This facility greatly reduced organic loading during the prior five-year cycle, but still consistently fails self-monitoring toxicity tests. Special studies of this discharger (1992 and 1994) demonstrated a reduction in organic loading in 1992 only, but self-monitoring data, fish, and benthic macroinvertebrates still indicated toxic conditions in Little Troublesome Creek during 1998. Urban runoff also may contribute to this problem, as a Fair benthos rating was assigned in 1992 and 1994 for Little Troublesome Creek above the discharge. This discharger will be relocated to the Haw River in 1999 to achieve greater dilution.

Benthos of the five sites sampled for benthic macroinvertebrates in both 1993 and 1998, four showed no between-year change in bioclassification. The Haw River near Altamahaw, however, declined from a Good-Fair rating in 1993 to Fair in 1998. This site also had been assigned a Fair benthos rating in 1990.

The Division of Water Quality collects information from two lakes in the subbasin: Lake Hunt and Reidsville Lake. Both lakes usually receive a mesotrophic or eutrophic designation based on the NC Trophic State Index (NCTSI). Data from both lakes in July 1998 produced the highest NCTSI on record, and data from Lake Hunt suggests increasing eutrophication since 1988, although there is a large amount of between-year variation for these ratings. Both lakes were evaluated by the Division of Inland Fisheries and found to have good largemouth bass fishing. Tissue samples from Reidsville Lake did not indicate any water quality problems, although one of 15 samples had a mercury concentration above the EPA screening level.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Haw River, SR 2109 (headwaters)

This Haw River site is an ambient monitoring site located within the headwater segment; it is only 4-5 meters in width. The substrate is largely sand and gravel, with no riffles, eroding banks, and infrequent pools. It is affected by agricultural runoff, but its consistent Fair benthos rating (3 samples) also may be influenced by very low flow during summer periods. Although the benthic community lacks diversity, a few intolerant taxa have been present in each sample.

A Poor classification was assigned to the fish community at this headwater location. The low number of fish collected, lack of any intolerant species, and a low percentage of species with multiple age classes were the major contributors to the low classification. Two mud sunfish (Acantharchus pomotis) individuals were collected from this site. This collection represented a western range extension for the species. The Haw River at SR 2109 had some coastal plain characteristics similar to those mud sunfish habitats found much further east.

Haw River, SR 2426

The Haw River at this location is roughly 10 meters wide and has a sand substrate with abundant snags and undercut banks in the stream. The fish community at this site received a Poor classification in April 1998. The NCIBI score was significantly (10 points) less than the score upstream at the SR 2109 Haw River location. The low classification for the SR 2426 site was due to a variety of reasons including low numbers of species and individuals, and a high percentage of tolerant fish. Only two metrics, percent piscivores and percent of diseased fish, received the top scores at this site for the April collection. An additional fish community sample was collected from this location in October 1998, as part of a seasonality study. The fish community classification improved to Fair for the fall sampling event.

Haw River, US 29 Business (near Reidsville, above Troublesome Creek)
This ambient monitoring location is about 8 meters in width, and has a substrate largely composed of sand, gravel and silt. Severe bank erosion was noted at this site and a riffle was observed only near the bridge. Most of the benthic fauna is associated with snag habitat (logs), but abundant filamentous algae growths in 1998 may have interfered with the invertebrate fauna of this microhabitat. The low flow in 1998 (relative to 1993) may have promoted periphyton growth, and caused a shift towards more slow-water species. However, there was little between-year change in the number of taxa or the abundance of intolerant species. A Good-Fair rating was assigned to this site in both 1993 and 1998. Rare taxa collected at this site in 1998 included Triaenodes melaca (3 NC records) and Villosa constricta (NC Special Concern list**)**.

Haw River, NC 150 (below Little Troublesome Creek)
This site was sampled for the first time in 1998, producing a Good-Fair rating. This segment of the river is just downstream of the new discharge point of the ReidsvilleWWTP, although this change had not gone into effect at the time of our collection. It is also downstream of Little Troublesome Creek, suggesting that the existing Reidsville discharge (via Little Troublesome Creek) has little affect on the Haw River. The Haw River is about 17 meters wide at this site, with a substrate largely composed of sand and gravel. Most taxa were associated with snag habitats.

Haw River, NC 87 near Altamahaw
The site (near the ambient monitoring location at SR 1561) is located a short distance below a run-of-the-river dam. This segment of the Haw River is about 20 meters wide with a rocky substrate. The NC 87 site has fluctuated between a Good-Fair benthos bioclassification (1985, 1987, 1993) and Fair (1990, 1998). While the drop from Good-Fair in 1993 to Fair in 1998 indicates a decline in water quallity, part of this change may be due to the lower flow in 1998.

Year	EPT S	EPT N	NCBI	Flow	Bioclass
1998	17	56	6.7	Low	Fair
1993	22	117	5.9	Normal	Good-Fair
1990	12	65	7.1	Low	Fair
1987	14	74	6.4	Low	Good-Fair

Taxa that declined sharply in abundance from 1993 to 1998 included Acroneuria abnormis, Polycentropus, Triaenodes ignitus, and several elmid beetles. The chironomid assemblage indicated toxic stress (many individuals having mentum deformities), and nutrient enrichment.

Troublesome Creek, SR 1001
The stream in this area is approximately eight meters wide with a mixed substrate composed of sand, silt, and clay. Instream habitat included abundant snags and leaf packs, with undercut banks and root mats also present. The fish community at this site was classified as Poor in both 1993 and 1998 with low numbers of species and individuals being collected both years.

Troublesome Creek, SR 2422 (near Reidsville)
This portion of Troublesome Creek is about seven meters in width, with a fairly rocky substrate. The substrate composition reflects local geology (Slate Belt), rather than any reduction in nonpoint source runoff. EPT taxa richness was fairly low in 1998 (14), but several intolerant taxa were abundant: Isonychia, Acroneuria abnormis, and Chimarra. This site received a Good-Fair benthos rating in both 1993 and 1998.

Little Troublesome Creek, SR 2600 (below Reidsville WWTP)
This ambient monitoring location is about three miles downstream of the Reidsville WWTP. The stream is about seven meters wide with a very uniform substrate of unstable sand. Both pools and riffles are largely absent, although a single riffle is present at the bridge. Summer benthos sampling has consistently produced a Poor rating for this site (1993, 1998), although fall and winter samples (12/87, 11/94) just below the discharge have produced Fair ratings. It is likely that cooler temperatures and higher flow for the latter samples contribute to a slightly higher bioclassification. A Poor rating is most appropriate for all of Little Troublesome Creek below the discharge. Taxa collected in 1998 still suggest toxic impact, but an increase in organic indicator species (vs. 1993) also suggested low dissolved oxygen and high organic enrichment: Chironomus, Natarsia, Limnodrilus hofmeisteri, and Physella.

A fish community assessment was conducted for the first time at this site in April 1998 and resulted in a Poor classification. The percent piscivores and percent omnivores were the only two metrics to have high scores at this location. Pools were more common in the area where the fish were collected than where the macroinvertebrate sampling took place. An additional fish community sample was collected in October 1998, as part of a seasonality study. The Poor classification for the fall matched that assigned to this site in the spring.

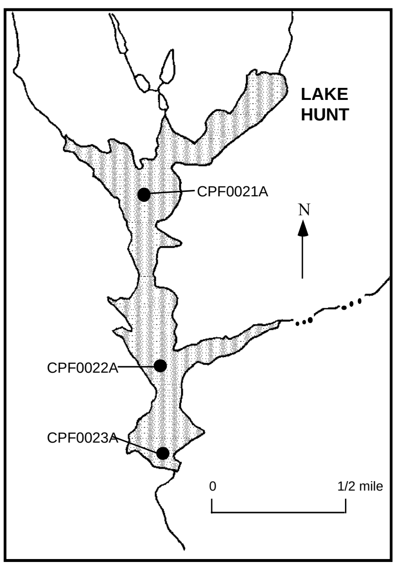
SPECIAL STUDIES
Benthic macroinvertebrates were collected above and below the Reidsville WWTP in November 1994 (B-960105). Both sites received a Fair bioclassification, but changes in community structure clearly showed an impact from the Reidsville discharge on stream fauna. Large numbers of Chironomus larvae indicated high organic loading. In comparing to a prior survey in 1987, very little improvement was observed.

OTHER DATA
The Haw River Assembly collects data from several sites, including temperature, pH, and benthic macroinvertebrates. Macroinvertebrates are usually identified to order and evaluated using the Izak Walton League's analysis method. Sampling sites include three sites on Little Troublesome Creek, Troublesome Creek, and two sites on the Haw River. For further information, contact The Haw River Assembly, PO Box 25, Saxapahaw NC 27340, 919-542-5790, hawriverwatch@mindspring.com.

LAKE ASSESSMENT PROGRAM
Lake Hunt

COUNTY:	Rockingham	**CLASSIFICATION:**	WS-III B NSW
SURFACE AREA:	180 acres (73 hectares)	**MEAN DEPTH :**	33 feet (10 meters)
VOLUME:	2.8 $\times 10^6 m^3$	**WATERSHED**:	5 mi^2 (13 km^2)

Lake Hunt is a recreational lake located in Reidsville, North Carolina. The City of Reidsville owns the lake which was built in 1956. The boat launch area is privately owned and access by the public is restricted. Maximum depth at the spillway is 33 feet (10 meters). Lake Hunt was the City of Reidsville's primary water supply until Reidsville Lake was built in 1979. Residential development upstream is now replacing farmland. Lake Hunt is fed by an unnamed tributary to Troublesome Creek.



Lake Hunt was most recently sampled in June, July and August, 1998. Physical and chemical lake data are presented in Appendix L2. Notable observations include a surface pH value of 5.8 s.u. which was observed at upper lake sampling site (CPF0021A) in July. This value was less than the state water quality lower limit of 6.0 s.u. for pH. The greatest total phosphorus values were also observed in July at all three lake sampling sites while the greatest ammonia values were observed in July and August at the most upstream lake sampling site (CPF0023A). In June, copper (42 µg/L) was greater than the state water quality action level of 7.0 µg/L. All other observations were within normal ranges. Lake Hunt was determined to be mesotrophic in June and eutrophic in July based upon calculated NCTSI scores (Table L1).

According to Mr. Gary Moore, Water Plant Supervisor for the City of Reidsville, there have been no reports of fish kills or algal blooms in Lake Hunt. Generally, the water treatment facility receives one or two complaints per year regarding taste or odor problems in the processed drinking water, (raw water is drawn from Reidsville Lake and Lake Hunt is used for water storage). Rockingham County has limited activities in the lake watershed with strict zoning laws; the reservoirs have a 100 foot buffer with a 50 foot buffer on all flowing streams (Gary Moore, Supervisor, City of Reidsville Water Treatment Facility, pers. com).

A stock assessment of largemouth bass (*Micropterus salmoides*) in Lake Hunt was conducted by the North Carolina Division of Boating and Inland Fisheries on April 7, 1997. Lake Hunt was found to have a fair largemouth bass population that appeared to be shifting towards older, larger fish. A recommendation was made to retain the statewide largemouth bass regulation of a 14 inch minimum size limit and five fish creel, with two of the five fish allowed to be less than 14 inches (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com; Bryant and Besler, August 1997).

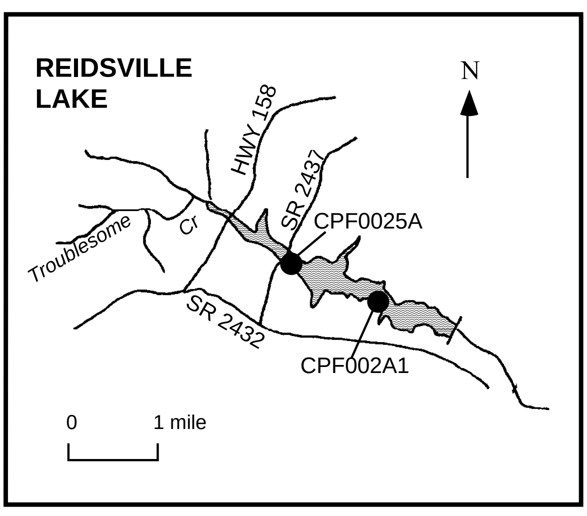
Table L1. Lake Hunt Historical NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Hunt	980803	no score	0.01	0.23	n/a	1.0
Lake Hunt	980701	1.6[E]	0.06	0.45	11	1.0
Lake Hunt	980602	-1.5[M]	0.01	0.20	11	0.8
Lake Hunt	930819	-2.3[O]	0.01	0.19	10	1.4
Lake Hunt	930722	-1.6[M]	0.02	0.18	6	1.2
Lake Hunt	930616	0.9[E]	0.04	0.31	18	1.2
Lake Hunt	920806	-1.2[M]	0.01	0.27	11	1.3
Lake Hunt	920717	0.6[E]	0.04	0.33	7	0.7
Lake Hunt	920602	-0.3[M]	0.02	0.31	10	1.2
Lake Hunt	910821	-1.3[M]	0.04	0.21	5	1.6
Lake Hunt	910723	-2.0[O]	0.01	0.27	8	2.1
Lake Hunt	910624	0.0[M]	0.07	0.24	8	1.8
Lake Hunt	880816	-2.1[O]	0.02	0.24	5	2.3
Lake Hunt	810714	-1.9[M]	0.02	0.32	10	3.8

Reidsville Lake

COUNTY:	Rockingham	**CLASSIFICATION:**	WS-III NSW CA
SURFACE AREA:	750 acres (304 hectares)	**MEAN DEPTH :**	20 feet (6 meters)
VOLUME:	4.3 x$10^6$$m^3$	**WATERSHED**:	53 mi^2 (136 km^2)

Reidsville Lake is a water supply reservoir located on Troublesome Creek just outside of the City of Reidsville in Rockingham County. The lake is owned by the City of Reidsville. The topography of the watershed is characterized by rolling hills and land use is mainly agricultural (row crop and pastures) along with light residential and commercial development. A public park with boat launch area is located off of SR 2435 and is operated by the City of Reidsville Department of Parks and Recreation.



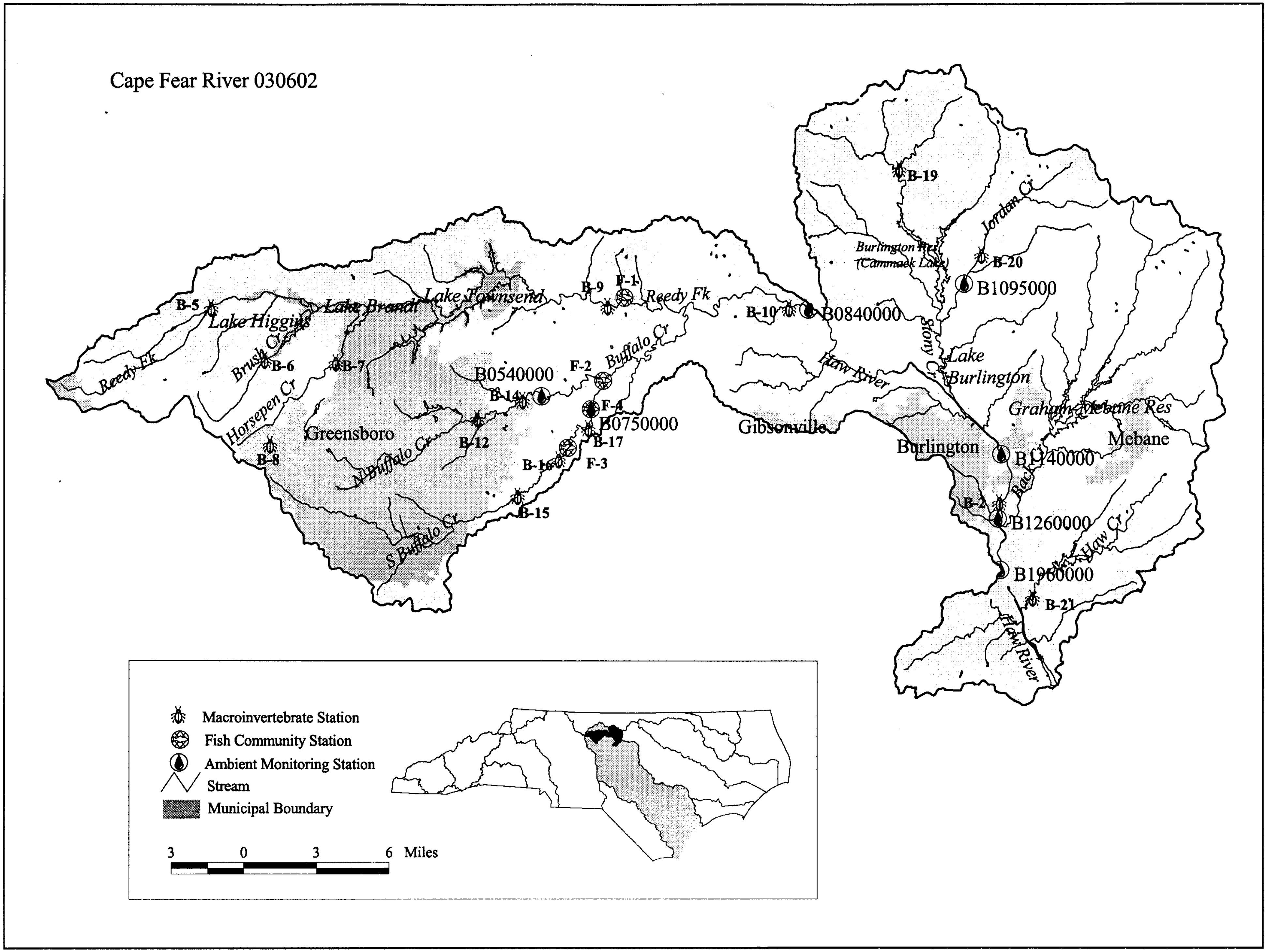
Reidsville Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical lake data are presented in Appendix L2. The greatest chlorophyll *a* value for 1998, as well as for the historical period that this lake has been sampled by DWQ, was found at the upper lake sampling site in July (30 µg/L). In June July and August, copper were greater than the state water quality action level of 7.0 µg/L, with the maximum observation being 12.0 µg/L. The NCTSI scores for Reidsville Lake indicated that the lake was mesotrophic in June and eutrophic in July(Table L2).

Table L2. Reidsville Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Reidsville Lake	980803	no score	0.02	0.25	n/a	1.0
Reidsville Lake	980701	1.5[E]	0.05	0.42	19	1.2
Reidsville Lake	980602	-1.8[M]	0.01	0.20	10	1.0
Reidsville Lake	930819	-0.9[M]	0.02	0.24	12	1.4
Reidsville Lake	880816	-1.7[M]	0.02	0.23	7	1.6
Reidsville Lake	870818	0.1[E]	0.03	0.38	12	1.3
Reidsville Lake	810715	-1.9[M]	0.02	0.28	8	3.7

TISSUE DATA

Fish tissue samples were collected from the Reidsville Lake during April 1998. Of the 15 samples analyzed for metals contaminants, only one largemouth bass sample contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results from Reidsville Lake were below levels of concern.


Cape Fear River 030602
B-5
Lake Higgins
Lake Brandt
Lake Townsend
Reedy Fk
Brush Cr
B-6
B-7
Horsepen Cr
B-8
Greensboro
N Buffalo Cr
B-12
S Buffalo Cr
B-15
B0540000
B-14
F-2
Buffalo Cr
F-4
B0750000
B-17
B-16
F-3
B-9
F-1
Reedy Fk
B-10
B0840000
Haw River
Gibsonville
B-19
Burlington Res
(Cammack Lake)
Jordan Cr
B-20
B1095000
Stony Cr
Lake Burlington
Graham-Mebane Res
Mebane
Burlington
B1140000
Back
B-2
B1260000
Haw Cr
B1960000
B-21
Haw River
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
3
0
3
6
Miles

CAPE FEAR SUBBASIN 030602

DESCRIPTION

Cape Fear subbasin 02 is located in the piedmont ecoregion, and contains the cities of Greensboro, Burlington, Graham and Mebane. Major tributaries of the Haw River in this subbasin include Stony Creek, Reedy Fork, North Buffalo Creek and South Buffalo Creek. Although there is a large amount of agricultural land use in this subbasin, urban land use is more likely to affect stream water quality near the cities of Greensboro and Burlington.

The characteristics of streams in this subbasin are strongly influenced by geology. Reedy Fork and tributaries above Lake Townsend are sandy streams located within the Charlotte Belt. All rocky streams are located within the Carolina Slate Belt, although some very sandy streams (example: South Buffalo Creek) are also found on the western edge of this geologic region.

There are 32 permitted dischargers in subbasin 02 with a total permitted flow of 67 MGD, including seven dischargers with a permitted flow greater than 1.0 MGD. The largest of these are:

> Greensboro: 16 MGD into North Buffalo Creek and 20 MGD into South Buffalo Creek
> Burlington: 12 MGD into the Haw River and 12 MGD into Big Alamance Creek near the confluence with the Haw River.

Cone Mills also discharges 1.3 MGD into the headwaters of North Buffalo Creek. North Buffalo Creek, South Buffalo Creek, and the lower segment of Reedy Fork are effluent-dominated streams, often strongly colored by wastewater discharges.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-2*	Haw R	Alamance	NC 54	Good-Fair	Good-Fair
B-5*	Reedy Fk	Guilford	SR 2128	Good-Fair	Good-Fair
B-6	Brush Cr	Guilford	SR 2136	no sample	Fair
B-7*	Horsepen Cr	Guilford	US 220	Fair	Fair
B-9	Reedy Fk	Guilford	SR 2728	Good-Fair	Good-Fair
B-10*	Reedy Fk	Alamance	NC 87	Good-Fair	Fair
B-14*	N Buffalo Cr	Guilford	SR 2832	Poor	Poor
B-16*	S Buffalo Cr	Guilford	US 70	Fair	Poor
B-17*	S Buffalo Cr	Guilford	SR 2821	Poor	Poor
B-19	Stony Cr	Caswell	SR 1100	Good	Good
B-20	Jordan Cr	Alamance	SR 1002	Good-Fair	Good-Fair
B-21	Haw Cr	Alamance	SR 2158	Good-Fair	Good
FISH				1994	
F-1	Reedy Fk	Guilford	SR 2728	Fair	Fair/Good-Fair
F-2	N Buffalo Cr	Guilford	SR 2770	Poor	Poor
F-3	S Buffalo Cr	Guilford	US 70	Poor	Poor
F-4	S Buffalo Cr	Guilford	SR 2821	Poor	Poor
LAKES					

Lake Higgins, Lake Brandt, Lake Townsend, Burlington Reservoir, Lake Burlington, Graham-Mebane Reservoir

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Lake Townsend	1998	17	1	0	EPA mercury limit exceeded in 1 bass sample
FT-2	Lake Burlington	1998	20	6	0	EPA mercury limit exceeded in 5 bass and 1 catfish samples
FT-3	Haw R at Swepsonville	1998	20	0	0	No samples excceeded criteria

Both point source dischargers and nonpoint source runoff (agriculture, urban) contribute to the Fair to Poor water quality found in many streams in subbasin 02. Areas immediately downstream of the Greensboro WWTPs had Poor water quality based on both fish and benthos samples, with a slight improvement to a Fair benthos rating further downstream on Reedy Fork, but the benthos sample was taken one week after a spill at the WWTP on South Buffalo Creek. The segments of North and South Buffalo Creek below the Greensboro dischargers constitute one of the worst water quality problems in North Carolina. Conductivity continues to increase in these streams (median values are now greater than 550 µmhos/cm), nutrient values are high and there are chronically high levels of dissolved copper, zinc and cadmium.

Urban runoff also has a severe impact (Poor or Fair ratings) on the water quality of headwater streams in Greensboro and Burlington, including portions of North and South Buffalo Creeks, Horsepen Creek and Brush Creek. Areas affected by agricultural runoff, however, usually have Good or Good-Fair benthos ratings. Stream segments with the best water quality (in spite of substantial habitat degradation) include the headwaters of Reedy Fork, Stony Creek, Haw Creek, and Jordan Creek.

Benthic macroinvertebrate data indicated stable water quality at most sites in subbasin 02. Of the 11 sites sampled for benthic macroinvertebrates in both 1993 and 1998, eight showed no change in bioclassification. Between-year differences in flow appear to be the cause of a decline in bioclassification at one site on Reedy Fork and an improvement in bioclassification at Haw Creek. South Buffalo Creek showed a decline in water quality, probably associated with a spill at the wastewater treatment plant in the week before the sample was collected. Examination of long term trends in water quality (>5 years) have shown improvements in bioclassification for the Haw River at NC 54, but a decline for Horsepen Creek. The improvement for the Haw River is associated with changes at wastewater treatment plants, while the decline at Horsepen Creek is associated with residential development. Recent fish tissue samples from the Haw River (Swepsonville) did not indicate any problems with either metals or pesticides.

Six lakes have been sampled in subbasin 02: three in the Reedy Creek area (Lake Higgins, Lake Brandt, Lake Townsend), two near Burlington (Burlington Reservoir, Lake Burlington) and one near Mebane (Graham-Mebane Reservoir). The Reedy Creek lakes are usually either eutrophic or mesotrophic, Burlington Reservoir is consistently mesotrophic, while Lake Burlington and the Graham-Mebane Reservoir are consistently eutrophic. Algal blooms have been reported on all lakes except Lake Higgins and Burlington Reservoir, but these have not caused taste or odor problems. Tissue samples from Lake Townsend showed few metals problems, although one of 17 samples had a mercury concentration above the EPA screening level.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

The 1998 basinwide benthic macroinvertebrate sampling in subbasin 02 occurred during the first week of July. Streams were very low, and this flow regime may have affected streams in several ways:

-Effluent-dominated streams had less dilution of wastewater discharges. Relative to prior collections, these streams might show a decline in taxa richness and a shift to more tolerant species

-Nonpoint source-affected streams had less runoff entering the stream. These streams might show an increase in taxa richness and/or a shift to less tolerant species.

Haw River, NC 54 near Graham

The Haw River at this site is about 40 meters wide with a rocky substrate. This portion of the river is downstream of all Greensboro and Burlington dischargers. This accounts for consistently high conductivity values (613 μmhos/cm at the time of the macroinvertebrate collection). There were few major habitat problems, although the field crew noted infrequent riffles and many breaks in the riparian zone. Dissolved oxygen was only 5 mg/l at the time of sampling, and the rarity of EPT taxa in slower water and shore habitats suggested that low dissolved oxygen might have affected the fauna in areas with low aeration. An abundant benthic fauna, however, was observed in areas of higher current velocity.

The Haw River near Graham has been sampled for benthos seven times since 1983 and this site improved from a Fair bioclassification (1983-1985) to a Good-Fair rating in 1989 and 1993. Intolerant species were rare during all years; increased EPT taxa richness values were usually due to the increased abundance of facultative Trichoptera. Few changes were observed between 1993 and 1998, with a Good-Fair rating assigned in both years.

Haw River at Swepsonville

Fish tissue samples were collected from the Haw River near Swepsonville during November 1998. Twenty samples were analyzed for metals contaminants and all results were lower than EPA and FDA/NC limits. Two largemouth bass samples were also analyzed for chlorinated pesticides and PCB arochlors. Results showed undetectable levels of these contaminants in the bass tissue.

Reedy Fork near Oak Ridge, SR 2128

The headwater segment of Reedy Fork is located in an agricultural area, although the proportion of residential land use is increasing as Greensboro expands. This portion of the creek is about 6-7 meters wide, and the stream bottom is almost entirely coarse sand. Erosion within this catchment produces a relatively uniform sandy-run habitat, with few riffles or pools and eroding banks. Most benthic macroinvertebrates were associated with snag and leaf pack habitats. In spite of the poor habitat, the benthic macroinvertebrates suggested Good water quality. Over four collections (1988-1998) this site has rated either Good-Fair or Good. Intolerant taxa have been abundant at this site, including four stonefly taxa: Pteronarcys, Perlesta, Neoperla, and Eccoptura xanthenes.

Brush Creek, SR 2136 (Fleming Rd)
Brush Creek is a small stream (4 meters in width) that drains a developed catchment. It was sampled for benthos for the first time in 1998 and was given a Fair rating. Upstream land use included an airport, a golf course and many residential areas. Habitat at this site was similar to that of upper Reedy Fork: 90% sand with no riffles or pools. Unlike Reedy Fork, however, this site also had water quality problems. The intolerant stonefly species that were abundant in the headwaters of Reedy Fork were entirely absent at this site, in spite of the presence of favorable leafpack habitat. Instead, the dominant EPT taxa were grazing baetid mayflies, especially those species which favor algae growing over a coarse sand substrate. Uncommon baetid species at this site included Barbaetis, Paracloeodes, and Baetis cinctutus. These taxa were abundant under the low flow condition observed during July of 1998, but might be scoured out during periods of higher flow.

Horsepen Creek, US 220
Horsepen Creek is a small sandy stream (5 meters wide) draining a residential area of Greensboro. This site declined from Good-Fair to Fair between 1986 and 1993, coincident with upstream residential development. No change, however, was observed between 1993 and 1998.

Reedy Fork, SR 2728, below Lake Townsend
This portion of Reedy Fork is still upstream of all major dischargers, but it may be influenced by release of water from Lake Townsend. Very little water is released from this lake during drought periods, with a resultant decrease in flow in this portion of Reedy Fork. Reedy Fork at this site has a channel width of 17 meters. Areas with high current velocity, however, occurred during July1998 only in those parts of the stream where it narrowed to a width of about 4 meters.

This site has a very rocky substrate due to a combination of slate belt geology and sediment trapping in Lake Townsend. Good habitat was present, although field notes indicate some bank erosion and many breaks in the riparian zone. A Good-Fair benthos rating has been assigned to this site in both 1993 and 1998. This is the only site in Cape Fear subbasins 1-3 where pleurocerid snails (Leptoxis) were abundant. This intolerant group should be abundant at all rocky streams in the Haw River drainage, but their distribution has been restricted by water quality problems.

The fish community at this site has been given a Fair rating for November 1993 and April 1998. The number of sucker species collected was significantly lower than expected for both sampling years. Reedy Fork at SR 2728 was sampled again in October 1998, as part of a fish community seasonality study. The community rating for the site improved to Good-Fair during the fall.

In 1963, the NCWRC conducted a fish population survey slightly less than two miles upstream from the DWQ site. The 15 species of fish collected by the NCWRC at their Reedy Fork location is comparable to the 16 and 22 species collected by DWQ in the spring and fall of 1998.

Reedy Fork near Ossippee, NC 87
This ambient monitoring location is downstream of both Greensboro WWTPs. This portion of Reedy Fork is about 25 meters wide with a rocky substrate. Although there are some breaks in the riparian zone and some bank erosion, overall habitat quality is good. Water quality is

strongly influenced by upstream dischargers, with colored water and high conductivity. Benthos bioclassification for this site improved from Fair in 1983-1989 to Good-Fair in 1993, coincident with both higher flows and some discharger upgrades. The Fair rating in 1998 is probably related to both low flow and an upstream spill at the Greensboro South Buffalo WWTP a week before sampling. The dominant chironomids in 1998 indicated both organic loading (Chironomus, Dicrotendipes neomodestus, Rheotanytarsus) and toxicity (Cricotopus bicinctus). Many specimens were observed with deformities, and further analysis of mentum deformities for Chironomus larvae clearly indicated some instream toxicity.

North Buffalo Creek, SR 2770

North Buffalo Creek at the sampling location is approximately 12 meters wide and has a substrate that varies from mostly cobble and boulders in some areas to mostly sand in other areas. Although the NCIBI score increased from 1994 to 1998, the fish community in both years was classified as Poor. The number of species and number of individuals collected were well below what would be expected for a stream this size. The tolerant redbreast sunfish (Lepomis auritus) and green sunfish (Lepomis cyanellus) composed a major portion (71% in 1998 and 53% in 1994), of the fish community at this site.

North Buffalo Creek below Greensboro WWTP, SR 2832

This ambient monitoring location was about 10 meters wide, with a boulder/rubble substrate. Dissolved oxygen at the time of macroinvertebrate sampling was 5.1 mg/l and specific conductivity was 480 µmhos/cm. There were good riffle areas near the bridge, with profuse growths of an attached algae.

Macroinvertebrates have been sampled four times at this site since 1985, with a Poor rating each time. There was some slight improvement between 1988 and 1993, but the benthic macroinvertebrate community showed no change between 1993 and 1998, with indicator species indicating both organic loading and instream toxicity. Not enough Chironomus larvae were present to calculate the percentage of deformities, but two mounted specimens both had mentum deformities.

South Buffalo Creek, US 70

Overall habitat was largely unchanged in relation to prior collections (1988, 1993) and in relation to an upstream special study site at McConnell Road. The stream is a uniform sandy run with evidence of massive sediment inputs. During 1998, however, the stream was very turbid, with an unusual milky color. Duckweed was observed throughout the stream, suggesting the draining of a pond upstream of this site. A new road was being constructed in an area parallel to the stream, and this is the most likely source of the turbidity. Conductivity is still high at this site (239 µmhos/cm), about the same as the McConnell Road site. High dissolved oxygen (9.2 mg/l) and high pH (9.0) both suggested high primary production, which also might have been associated with drainage of an upstream pond. This site was rated as Fair in 1993 using macroinvertebrate data, but declined to Poor in 1998. Most of the taxa were associated with root mats near the banks. In July 1998 there was a decline in the abundance of grazing mayflies, especially Paracloeodes.

In April 1998, when the fish community sample was collected, the stream was clear with a conductivity measurement of 212 µmhos/cm. The community was rated as Poor in 1998 and 1994. The same three tolerant species, redbreast sunfish (Lepomis auritus), eastern mosquito fish (Gambusia holbrooki), and red shiner (Cyprinella lutrensis), that accounted for 63% of the individuals collected in 1994, dominated the population in 1998, comprising 98% of the sample.

South Buffalo Creek below Greensboro WWTP, SR 2821

This ambient monitoring location on South Buffalo Creek has much better habitat than the two upstream sites, with rocky riffle areas. It is downstream of a Greensboro WWTP, however, and this portion of the stream had a fish kill associated with a spill at the plant just prior to our sampling in July 1998. Specific conductivity was 552 µmhos/cm with a dissolved oxygen of 5.6 mg/l. EPT taxa were largely absent in 1998, with only a single specimen of Hydropsyche betteni collected at this site. Taxa richness was very low (26), and only two midges were abundant. All specimens were small, suggesting a recent recolonization of this site. Although Chironomus was one of the abundant chironomids, mentum deformities could not be assessed with these small specimens (1st and 2nd instars). Based on benthos monitoring, this portion of South Buffalo Creek had the worst water quality of any site in the Cape Fear River basin.

The fish community was rated Poor at this location in 1994 and in 1998. Similar to the SR 2770 site, the tolerant redbreast sunfish (Lepomis auritus) was by far the most commonly collected fish at this location. As was the case with the macroinvertebrate data, the NCIBI data indicated this site to be the most degraded site in the Cape Fear River basin. In addition to numerous other deficiences in the fish community, the highest percentage of diseased fish (43%) for the Cape Fear basin was recorded from this site.

The 1963 WRC sampling location for the Buffalo Creek catchment was at SR 2795, roughly 1.5 miles below the confluence of North and South Buffalo Creeks. WRC personnel reported “This is a thoroughly offensive stream; the odor and color of the water resembled those of sewage.” No fish were collected from the site.

Stony Creek, SR 1100

Stony Creek drains an agricultural catchment. It is a deeply entrenched stream, about 6 meters wide. Habitat problems include infrequent riffles, severe bank erosion and embedded substrate. Areas with rocky substrate and higher flow velocities had a diverse EPT fauna. This site received a Good benthos rating in both 1993 and 1998.

Jordan Creek, SR 1002

Very low flow was observed at Jordan Creek during July 1998, and this may have limited the diversity of the macroinvertebrate fauna. This small stream is an ambient monitoring location, but was only about 4 meters wide. Jordan Creek had many habitat problems: infrequent riffles, infrequent pools, sandy substrate, and severely eroding banks. A Good-Fair benthos rating was assigned to this stream in both 1993 and 1998. Two unusual taxa, however, were collected at this site: Triaenodes melaca (one of 3 DWQ records in North Carolina), and Ephoron leukon (only DWQ record in Cape Fear subbasins 1-8). The 1993 sample was collected during the winter to avoid low flow problems. The same benthos rating was reached with both summer and winter samples, although there were only 4 taxa in common between the February and July samples.

Haw Creek, SR 2158
Haw Creek is about 6 meters wide, with a good riffle area downstream of the bridge. Most of the stream was very sandy, with eroding banks, an entrenched channel, and infrequent pools. This site was assigned a Good-Fair benthos rating in 1993, but improved to Good in 1998. The slightly higher rating does not suggest a long-term change in water quality, because low flow in July 1998 may have reduced the effect of nonpoint source runoff.

SPECIAL STUDIES
Benthic macroinvertebrates were collected at three sites in the headwaters of North Buffalo Creek during July 1997 (B-970804). Sites were located above and below Cone Mills, plus a site was established above the Greensboro WWTP. All sites received a Poor rating, indicating that the effects of urban runoff make it difficult to evaluate impact from the Cone Mills discharge.

The North Buffalo Creek site below Cone Mills (at Summit Avenue) also was sampled during the basinwide collections in July 1998. This site had some boulder/rubble substrate, but the stream bottom had a black color caused by the Cone Mills discharge. This portion of North Buffalo Creek was about 10 meters wide. Habitat degradation was evident from the rarity of pools and riffles, eroding banks, some channelization, and embedded substrate. Dissolved oxygen was 4.8 mg/l at the time of macroinvertebrate sampling, with a conductivity of 920 μmhos/cm. This site was again rated as Poor.

As part of an investigation of streams on the 303d list, samples were collected from UT Horsepen Creek (B-981207). This stream could not be rated due to its small size.

During basinwide sampling in July 1998, an additional site was sampled on South Buffalo Creek at McConnell Road, upstream of the road construction near the ambient site at NC 70. This portion of South Buffalo Creek is about 7 meters wide with a very sandy substrate. It drains a highly developed catchment, as reflected in the elevated specific conductivity (264 μmhos/cm). Except for a riffle area near the bridge, this stream was largely a uniform sandy run, with few pools or riffles. Abundant periphyton grew over the sand under the low flow conditions observed during July 1998. A Fair benthos rating was assigned to this site in 1998 based on EPT taxa richness.

OTHER DATA
The City of Greensboro collects water chemistry, habitat information, and benthic macroinvertebrates from many streams within the Greensboro city limits. Their macroinvertebrate sampling is limited to 100-count sampling, making it difficult to compare their results with the more intensive DWQ samples. Most sites were also too small for DWQ monitoring.

North Buffalo Creek and tributaries (8 sites, all upstream of Greensboro WWTP). This area was characterized by high conductivity and poor habitat. Low EPT taxa richness suggested Fair or Poor water quality at most sites. The best site was Jordan Branch at McKnight Mill Road, although this stream was only two meters wide.

South Buffalo Creek and tributaries (7 sites, all in headwaters). Conductivity increased at mainstem sites from 120 µmhos/cm at Big Tree Park to 264 at McConnell Avenue. Macroinvertebrate data suggested a Fair water quality for most sites.

Mile Run and tributaries (4 sites). All sites had elevated conductivity (330-500 µmhos/cm) with a sand/gravel substrate. Macroinvertebrate data suggested Fair or Poor water quality.

Reedy Fork and tributaries (11 sites). The very sandy substrate in the headwater areas made it difficult to rate these streams, although this catchment had much lower conductivity values than the North Buffalo/South Buffalo area. The best streams (possibly Good-Fair water quality) included UT Lake Jeanette, UT Reedy Fork in Bryan Park, Bull Run at Mackay Rd, and Squirrel Creek at Church Street.

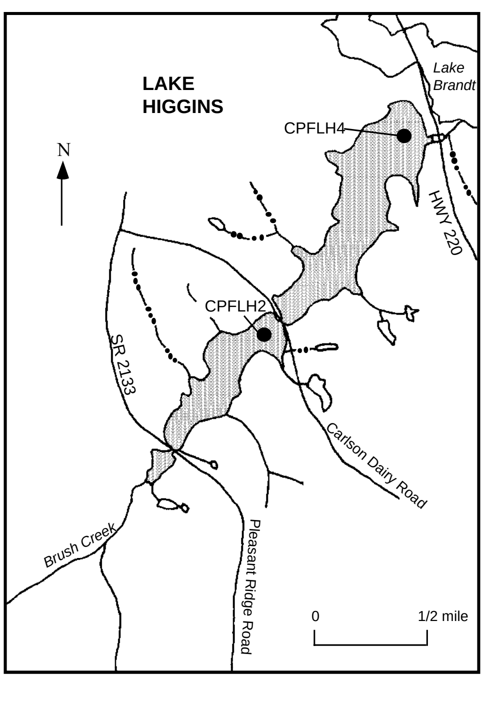
The Haw River Assembly collects data from several sites, including temperature, pH, and benthic macroinvertebrates. Macroinvertebrates are usually identified to order and evaluated using the Izak Walton League's analysis method. Sampling sites include Little Buffalo Creek, North Bufallo Creek, South Buffalo Creek, Reedy Fork, Squirrel Creek, Peabody Creek, Pauls's Creek, Motes Creek and Meares Fork. For further information, contact The Haw River Assembly, PO Box 25, Saxapahaw, NC 27340, 919-542-5790, hawriverwatch@mindspring.com.

LAKE ASSESSMENT PROGRAM

Lake Higgins

COUNTY:	Guilford	**CLASSIFICATION:**	WS-III NSW CA
SURFACE AREA:	287 acres (116 hectares)	**MEAN DEPTH :**	4 feet (12 meters)
VOLUME:	3.0 x10^6m^3	**WATERSHED**:	11 mi^2 (29 km^2)

Lake Higgins is one of three lakes used by the City of Greensboro as a water supply. This lake, which is an impoundment of Brush Creek, drains into Lake Brandt which, in turn, discharges into Lake Townsend. Built in 1957, Lake Higgins has a maximum depth of 20 feet (six meters). The watershed is mostly forested land with a few private homes set back from the lakeshore.



The watershed is a mix of agriculture and residential development. A public park operated by the City of Greensboro Parks & Recreation Department is located at Lake Higgins off of Hamburg Mill Road. Recreational activities include fishing, sailing and canoeing.

Lake Higgins was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical lake data collected in 1998 are presented in Appendix L2. Concentrations of metals were less than the applicable state water quality standards in June, July and August. Based on calculated NCTSI scores, Lake Higgins was determined to be mesotrophic in June and eutrophic in July (Table L3).

This region experienced a drought during the summer of 1998 and the water levels of the lower two lakes (Lake Brandt and Townsend Lake) dropped noticeably by August. The water level of Lake Higgins did not drop as much. This may partly be due to the fact that the City of Greensboro draws water from both Brandt and Townsend, but not from Higgins.

According to Mr. Mark Slade, Lake Warden for Lake Higgins, there have been no reports of algal blooms or other water quality problems at this lake. The watershed for this lake has not experienced substantial development which might influence water quality. Mr. Slade also stated that a program to monitor the water quality of Lake Brandt was under development (Mark Slade, Lake Warden, Lakes Townsend, Brandt and Higgins, pers. com.).

The North Carolina Division of Inland Fisheries stocks a small pond (the Taylor Turner Hatchery Pond) adjacent to the lake with channel catfish (*Ictalurus punctatus*). The catfish are allowed to grow larger so that their survival is improved when they are later released into the lake for sports fishing. Other sports fish present in Lake Higgins include largemouth bass (*Micropterus salmoides*) and hybrid striped bass. Recreational fishing is one of the activities supported by Lake Higgins, and there have been no recent reports of problems related to the quality of fishing at this lake (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

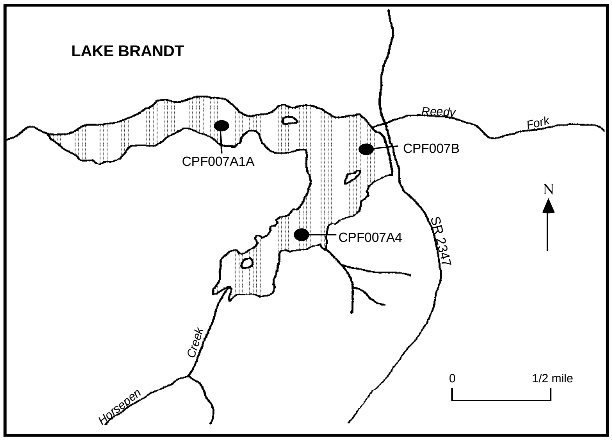
Table L3. Lake Higgins NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Higgins	980806	no score	0.04	0.31	n/a	0.9
Lake Higgins	980709	0.1[E]	0.04	0.21	18	1.0
Lake Higgins	980625	-1.0[M]	0.02	0.24	11	1.0
Lake Higgins	930812	-0.6[M]	<0.01	0.35	28	0.8
Lake Higgins	900806	1.1[E]	0.03	0.33	18	0.8

Lake Brandt

COUNTY:	Guilford	**CLASSIFICATION:**	WS-III NSW CA
SURFACE AREA:	710 acres (287 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	$84.0 \times 10^6 m^3$	**WATERSHED**:	40 mi^2 (104 km^2)

Lake Brandt is one of two primary water supplies for the City of Greensboro. The original surface area of Lake Brandt was 420 acres (170 hectares) when it was impounded in 1925. The lake was enlarged to 710 acres (287 hectares) in 1959. Reedy Fork Creek and Horsepen Creek are the main tributaries to the lake. The shoreline of Lake Brandt is forested and the watershed consists of a mix of residential developments, pastures, row crop fields and scattered small businesses. A public park operated by the City of Greensboro Parks & Recreation Department is located at this lake off of Lake Brandt Road. Recreational activities allowed at Lake Brandt include fishing and canoeing.



Lake Brandt was most recently sampled by DWQ in June, July and August, 1998 and physical and chemical data are presented in Appendix L2. This region experienced a drought in the summer of 1998. The water level in Lake Brandt during the August sampling trip was down 2.5 feet and boaters were warned that the low water level in the lake had exposed tree stumps and rocks in the upper end of the lake. An ammonia value of 0.11 mg/L was observed at the sampling site in the Horsepen Creek arm of the lake (CPF007A4) in July. The greatest concentrations of chlorophyll *a* were observed at all three sampling sites in July (range = 20 to 23 µg/L). In June, July and August, algal blooms were observed in Lake Brandt based on phytoplankton analysis. Algal biovolumes ranged from 6,547 to 13,896 mm^3/m^3 and algal densities ranged from 52,774 to 282,045 units/ml. Filamentous blue-green alga and green algas dominated these samples. Concentrations of metals in June July and August were less than the applicable state water quality standards. Lake Brandt was determined to be mesotrophic in June and eutrophic in July based on its NCTSI scores for those months (Table L4).

According to Mr. Mark Slade, Lake Warden for Lake Brandt, there have been no reports of algal blooms and the water treatment facility has not had any problems related to treating the raw water take from this lake. The watershed for this lake has not experienced any substantial development which might influence water quality. Mr. Slade also stated that a program to monitor the water quality of Lake Brandt was under development (Mark Slade, Lake Warden, Lakes Townsend, Brandt and Higgins, pers. com.). Lake Brandt has been stocked with largemouth bass (*Micropterus salmoides*) by the North Carolina Wildlife Commission, Division of Inland Fisheries to provide recreational sports fishing in the lake (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

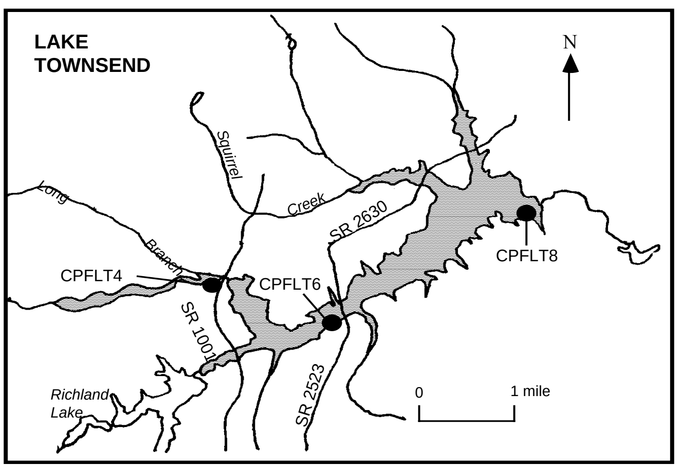
Table L4. Lake Brandt NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Brandt	980806	no score	0.05	0.39	n/a	0.5
Lake Brandt	980709	0.9[E]	0.04	0.24	22	0.8
Lake Brandt	980625	-0.4[M]	0.04	0.20	11	1.2
Lake Brandt	930812	-0.4[M]	0.02	0.19	20	0.9
Lake Brandt	880823	2.3[E]	0.04	0.37	45	0.8
Lake Brandt	820721	2.9[E]	0.05	0.48	52	0.9
Lake Brandt	810715	2.3[E]	0.04	0.52	23	0.9

Lake Townsend

COUNTY:	Guilford	**CLASSIFICATION:**	WS-III NSW CA
SURFACE AREA:	1610 acres (652 hectares)	**MEAN DEPTH :**	10 feet (3 meters)
VOLUME:	$1.6 \times 10^6 m^3$	**WATERSHED**:	105 mi^2 (272 km^2)

Lake Townsend was built in 1969 by the City of Greensboro to provide drinking water for the area. Although mean retention time of this reservoir is not known, it takes an estimated seven to eight months for water to travel from Lake Higgins to the dam at Lake Townsend (NCDEM, 1992). The reservoir drains a watershed which includes Lake Higgins and Lake Brandt located upstream on Reedy Fork Creek. Land in the drainage area is forested and urbanized. A public park operated by the City of Greensboro Parks & Recreation Department is located within the Bryan Park Complex off of Bryan Park Road. Recreational activities permitted at Lake Townsend include sailing, canoeing and fishing. The immediate shoreline of Lake Townsend consists of forested areas and a golf course. The watershed is a mix of urban development, residential development and agriculture (pastures and row crop fields).



Lake Townsend was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data collected for Lake Townsend are presented in Appendix L2. Secchi depths of less than one meter were observed in June, July and August at the most upstream lake sampling site (CPFLT4) and in June and July at the mid-lake sampling site (CPFLT6). An algal bloom sample was collected near the dam (CPFLT8) in July. Analysis of this sample confirmed algal bloom based on a biovolume of 2,041 mm^3/m^3 and algal density of 42,115 units/ml. Approximately 70% of this sample was dominated by blue-green algas. In August, an algal bloom sample was collected at CPFLT4. Algal biovolume was 14,273 mm^3/m^3 and algal density was 148,187 units/ml. The August sample was dominated by the filamentous blue-green algas , *Anabaenopsis raciborskii and Lyngbya lagerheimii*. Concentrations of metals in Lake Townsend were less than the applicable state water quality standards. Based on calculated NCTSI scores, Lake Townsend was determined to be mesotrophic in June and eutrophic in July (Table L5).

Very little rain fell within the watershed of Lake Townsend during the summer of 1998. By August, the water level in this lake had dropped 34 inches and boaters were warned of tree stumps and rocks that had been exposed and presented a threat to navigation in the upper end of the lake. According to Mr. Mark Slade, Lake Warden for Lake Townsend, there have been no reports of algal blooms and the water treatment facility has not had any problems related to treating the raw water take from this lake. The watershed for this lake has not experienced any substantial development which might influence water quality. Mr. Slade also stated that a program to monitor the water quality of Lake Townsend was under development (Mark Slade, Lake Warden, Lakes Townsend, Brandt and Higgins, pers. com.).

Lake Townsend is annually stocked with hybrid striped bass along with a supplemental stocking of threadfin shad (*Dorosoma petenense*) by the North Carolina Division of Inland Fisheries. Recreational fishing is one of the activities supported by Lake Townsend, and there have been no recent reports of problems related to the quality of fishing at this lake (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

Seventeen fish tissue samples, analyzed for metals contaminants, collected from Lake Townsend in April 1998, had one largemouth bass sample that contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.

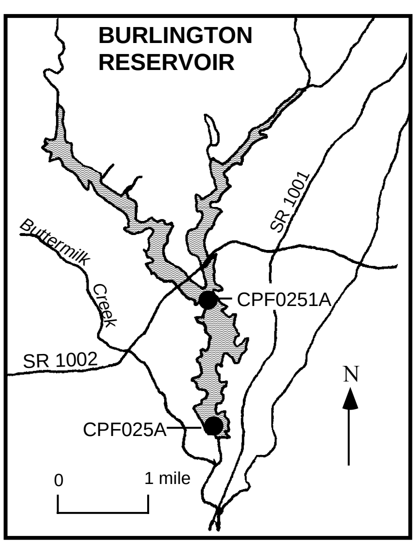
Table L5. Lake Townsend NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Townsend	980806	no score	0.03	0.30	n/a	0.7
Lake Townsend	980709	1.1[E]	0.04	0.35	15	0.9
Lake Townsend	980625	-1.6[M]	0.02	0.16	9	1.1
Lake Townsend	930812	1.4[E]	0.04	0.30	20	0.7
Lake Townsend	900806	1.1[E]	0.04	0.32	17	0.9

Burlington Reservoir

COUNTY:	Alamance	**CLASSIFICATION:**	WS-III NSW CA
SURFACE AREA:	750 acres (304 hectares)	**MEAN DEPTH :**	12 feet (4 meters)
VOLUME:	12.2 x$10^6$$m^3$	**WATERSHED**:	28 mi^2 (74 km^2)

Burlington Reservoir (also called Lake Cammack) is an auxiliary water supply formed at the confluence of Stony Creek and Toms Creek in Alamance County and is owned by the City of Burlington. The lake watershed area consists primarily of forested and agricultural land.



Burlington Reservoir was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The greatest ammonia value was observed at the dam sampling site in July (0.12 mg/L). Metals in June, July and August were less than the applicable state water quality standards. Burlington Reservoir was found to be mesotrophic in June and July based on the NCTSI scores (Table L6).

According to Mr. Hal Hayes, Assistant Lake Warden, there have been no reports of fish kills or algal blooms at this lake. In 1998, the dam at Burlington Reservoir underwent some refortification and repair (Hal Hayes, Assistant Lake Warden, City of Burlington, pers. com).

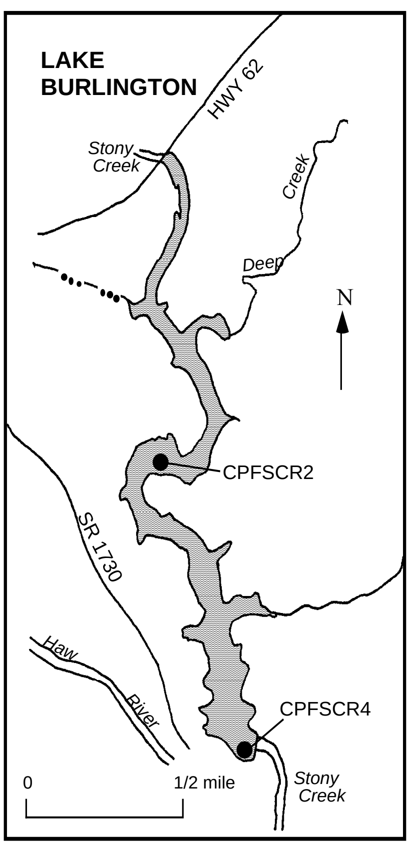
Table L6. Burlington Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Burlington Res.	980821	no score	0.03	0.24	n/a	1.0
Burlington Res.	980709	-0.9[M]	0.03	0.15	15	1.0
Burlington Res.	980609	-0.3[M]	0.02	0.29	11	0.9
Burlington Res.	930720	1.6[E]	0.04	0.74	6	0.8
Burlington Res.	880816	0.0[E]	0.03	0.30	12	1.3
Burlington Res.	870818	0.0[E]	0.03	0.38	8	1.3
Burlington Res.	810813	0.3[E]	0.03	0.46	13	1.5

Lake Burlington

COUNTY:	Alamance	**CLASSIFICATION:**	WS-II NSW CA
SURFACE AREA:	137 acres (55 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	1.5 x$10^6$$m^3$	**WATERSHED**:	110 mi^2 (285 km^2)

Lake Burlington (also called Stony Creek Reservoir) was built between 1927 and 1928 by the City of Burlington as a water supply. Stony Creek and Toms Creek drain the watershed which is characterized by rolling hills. Agriculture is the most common land use upstream of the lake.



Lake Burlington was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data for this lake are presented in Appendix L2. Surface dissolved oxygen ranged from 5.8 mg/L at the sampling site near the dam (CPFSCR4) in August to 8.9 mg/L at the same sampling site in July. Secchi depth in this lake in 1998 were less than one meter. In July, an algal bloom sample was collected near the dam. Although it was not quantified, the sample contained several species of blue-green algas and appeared to represent a large bloom. Metals were less than the applicable state water quality standards except for copper in June (18 µg/L) which was greater than the state water quality action level of 7 µg/L and manganese in August (260 µg/L) which was greater than the state water quality standard of 200 µg/L for a lake classified as a water supply (WS). Lake Burlington was determined to be eutrophic in June and July based on the calculated NCTSI scores for those months (Table L7). According to Mr. Hal

Hayes, Assistant Lake Warden, there have been no reports of fish kills or algal blooms at this lake (Hal Hayes, Assistant Lake Warden, City of Burlington, pers. com).

Table L7. Lake Burlington NCTSI Data.

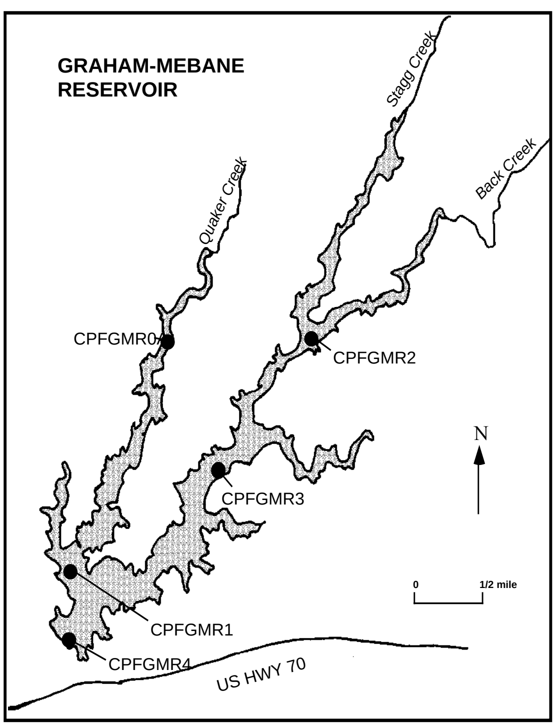
Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Burlington	980821	no score	0.06	0.45	n/a	0.6
Lake Burlington	980709	2.0[E]	0.05	0.32	23	0.6
Lake Burlington	980609	0.5[E]	0.03	0.20	20	0.6
Lake Burlington	930720	3.4[E]	0.07	0.54	16	0.4
Lake Burlington	900719	1.7[E]	0.04	0.24	45	0.7

Fish tissue samples were collected from Lake Burlington during April 1998.
Of the 20 samples analyzed for metals contaminants, five largemouth bass and one white catfish sample contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.

Graham-Mebane Reservoir

COUNTY:	Alamance	**CLASSIFICATION:**	WS-II NSW CA
SURFACE AREA:	650 acres (263 hectares)	**MEAN DEPTH :**	10 feet (3 meters)
VOLUME:	8.7 x$10^6$$m^3$	**WATERSHED**:	66 mi^2 (171 km^2)

Graham-Mebane Reservoir is a water supply lake for the Towns of Graham and Mebane. The lake also serves as a drinking water source for the Towns of Green Level and Haw River. Construction of the dam was started in May of 1989 and full pool elevation was reached in the fall of 1992. The lake is located on Quaker and Back Creeks and encompasses the old Quaker Creek Reservoir which has been historically monitored by DWQ. The immediate shoreline is primarily forested except for a few houses, a public school with an athletic field, and some farmland. A public marina is located off of Bason Road on the Quaker Creek arm of the lake.



Graham-Mebane Reservoir was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical lake data are presented in Appendix L2. The highest dissolved oxygen values were observed in August (range = 8.7 to 10.0 mg/L. The highest total phosphorus values for each month was observed at the sampling site in the Quaker Creek arm (CPFGMROA). Cattle have direct access to the lake near this sampling site and

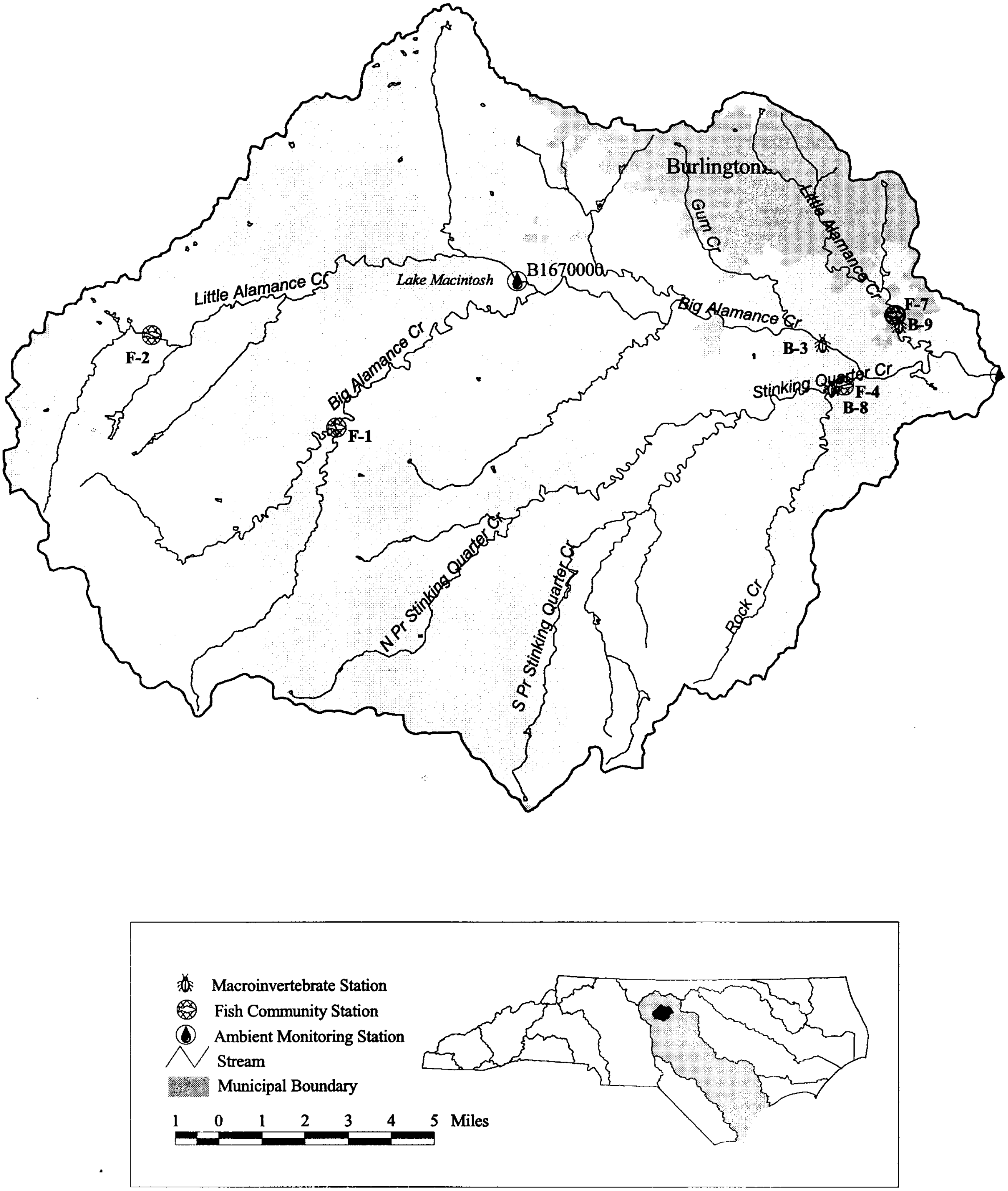
were observed standing in the water in June and August. A review of DWQ historic lake sampling data indicated that the Quaker Creek arm (CPFGMROA) consistently had a higher concentration of total phosphorus as compared with the other lake sampling sites. The greatest chlorophyll *a* concentration (45 µg/L) was observed at CPFGMR2, the most upstream sampling site near the confluence of Stagg Creek and Back Creek. This value was greater than the state water quality standard of 40 µg/L. Graham-Mebane Reservoir was eutrophic in June and July based on its NCTSI scores for those months (Table L8).
The water at the Quaker Creek arm sampling site had elevated dissolved oxygen, appeared brownish-green, and an algal bloom sample was taken in July. Immediately downstream of the site, cattle were observed along the shoreline with one or two animals in the water. Analysis of this sample confirmed the presence of an algal bloom with algal biovolume at 3,660 mm^3/m^3 and algal density at 40,367 units/ml. This bloom consisted primarily of filamentous blue-greens, *Lyngbya* sp. (56%) and *Anabaenopsis raciborskii* (25%). Concentrations of metals in Graham-Mebane Reservoir in 1998 were not greater than the applicable state water quality standards. Based on calculated NCTSI scores, this reservoir was determined to be eutrophic in June and July (Table L8).

According to Mr. Mike Carson, Assistant Water Plant Operator, Town of Graham, there have been no recent public complaints of taste and odor problems in water processed from Graham-Mebane Reservoir or reports of fish kills or algal blooms. In 1997, complaints regarding taste and odor problems with the processed drinking water was a result of lowering the lake level for repair work on the spillway. The lowered lake level had increased manganese levels which required chemical treatment of the raw water (Mike Carson, Assistant Water Plant Operator, Graham-Mebane Water Treatment Facility, pers. com).

Table L8. Graham-Mebane Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Graham-Mebane	980813	no score	0.05	0.44	n/a	0.5
Graham-Mebane	980715	1.9[E]	0.06	0.27	22	0.7
Graham-Mebane	980603	0.6[E]	0.03	0.18	23	0.6
Graham-Mebane	930817	1.4[E]	0.04	0.49	11	0.9

Cape Fear River 030603



CAPE FEAR SUBBASIN 030603

DESCRIPTION

Cape Fear subbasin 03 is located in the piedmont ecoregion. It contains few urban areas except along the I-40/85 corridor between Burlington and Greensboro. Most streams are deeply entrenched with sandy substrate. The primary land use is a mixture of agriculture and forest. The subbasin is comprised of Big Alamance Creek, Little Alamance Creek, and Stinking Quarter Creek. The "Little Alamance Creek" in the headwaters of this subbasin should not be confused with "Little Alamance Creek" that drains the Burlington area. There are no dischargers in this subbasin with a permitted flow > 0.05 MGD, therefore, most problems are associated with nonpoint source runoff.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3*	Big Alamance Cr	Alamance	NC 49	Good-Fair	Good-Fair
B-8*	Stinking Quarter Cr	Alamance	SR 1136	Good-Fair	Good
B-9*	L Alamance Cr	Alamance	SR 2309	Not Sampled	Poor
FISH				1993/1994	
F-1	Big Alamance Cr	Guilford	SR 3088	no sample	Good
F-2	L Alamance Cr	Guilford	SR 3039	no sample	Fair
F-4	Stinking Quarter Cr	Alamance	SR 1136	Good-Fair	Fair
F-7	L Alamance Cr	Alamance	SR 2309	Fair	Poor

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Lake Macintosh

Erosion from agricultural land may cause large sediment inputs into streams within this subbasin, but Big Alamance Creek, and Stinking Quarter Creek received a Good-Fair and Good macroinvertebrate bioclassification. Big Alamance Creek at SR 3088 (upstream of the benthos site) also received a Good fish rating. A Fair fish rating, however, was assigned to Little Alamance Creek (west) and Stinking Quarter Creek, reflecting the greater sensitivity of the fish community to sediment problems. The worst water quality was observed in Little Alamance Creek (Burlington), which was rated as Poor based on both macroinvertebrates and fish. Urban runoff is the most likely cause of this low rating.

Most sites in this subbasin have received a Good-Fair benthos rating since 1983, although occasional Good ratings have been recorded during periods of cooler temperatures or lower flow. For example, the Good benthos rating at Stinking Quarter Creek in 1998 occurred during a period of lower flow in 1998, suggesting that nonpoint source runoff is the primary problem.

Lake Macintosh was usally evaluated as either mesotrophic or eutrophic since 1993. Algal blooms (Amphanizomenon flos-aquae or Anabaena) may occur during summer months, causing taste and odor problems.

RIVER AND STREAM DATA, 1993-1998
BASIN MONITORING
Big Alamance Creek, SR 3088
A fish community sample was collected at this location for the first time in 1998 and resulted in a Good rating. Big Alamance Creek in the collection area is roughly eight meters wide and had slightly mixed substrate with sand being the largest component. Abundant instream habitat included sticks and leafpacks, snags and logs, undercut banks, and root mats. A 1963 WRC survey site was the next bridge crossing below the 1998 DWQ site. The WRC collected 10 species of fish but reported very little instream cover.

Little Alamance Creek, SR 3039
Little Alamance Creek at the collection site is around eight meters wide with mixed substrate. Pockets of good instream habitat (snags and logs, undercut banks, root mats) were found primarily along the sides of the stream with sand dominating the center of the stream. The fish community was rated as Fair at this location. A lower number of fish and the absence of suckers contributed to the community rating.

Big Alamance Creek, SR 2309
The 1998 benthos collections occurred during a period of very low flow, and prolific periphyton growths (including some floating mats of algae) occurred on the stream bottom. The stream channel was over 25 meters wide, but the stream narrowed to about 10 meters under these low flow conditions. Nonpoint source problems were indicated in this catchment by the entrenched channel, lack of riffles and pools, severe bank erosion, and the uniform sand substrate. Most taxa were found on snag habitats. A Good-Fair rating was assigned to this site in 1993 and 1998.

Stinking Quarter Creek, SR 1136
This stream is similar in size and habitat to Big Alamance Creek, but the area downstream of SR 1136 contained one good riffle area at the site of an old mill dam. Away from this riffle area, the stream has a shifting sand substrate and deeply entrenched channel. This site has varied between a Good-Fair rating and a Good rating, depending on flow. More detailed analysis of the data does not support any long term change in water quality. The slightly higher EPT taxa richness in 1998 compared to 1993 (23 vs.16) was associated with lower flow and, therefore, lower amounts of nonpoint source runoff. The same dominant species were found in both years, with the most intolerant taxa (Chimarra, Isonychia) abundant in both collections. The 1998 sample had some additional rare taxa, but the greatest change was the increased abundance of Baetis intercalaris. This surface-feeding grazer may have responded positively to lower amounts of scour in 1998.

The fish community rating decreased by one class from 1994 to 1998. The NCIBI metric that accounted the most for this decrease was a drop in the percentage of piscivores. In 1963 the WRC sampled Stinking Quarter Creek at NC 49, just upstream of SR 1136. Information from the NC 49 area indicated that the stream supported a redbreast fishery and had a “large population of suckers and catfish.”

Little Alamance Creek, SR 2309
Little Alamance Creek drains the Burlington area, and water quality problems were suggested by high conductivity (211 µmhos/cm). Although we observed severely eroding banks, this stream

had rocky substrate with good riffle areas. Little Alamance Creek was about 7 meters wide. EPT taxa richness was low at this site in 1998, resulting in a Poor rating. A Fair rating was assigned to this site in July 1985, but comparison of these samples in more detail does not suggest any long term decline in water quality. Organic or toxic benthic indicator species were not abundant at this site, suggesting that problems are associated with urban runoff.

The fish community rating decreased from Fair in 1993 to Poor in 1998. Although a number of metrics influenced the classification change, the most notable was the 50% decrease in the number of fish collected in 1998.

SPECIAL STUDIES
Benthic macroinvertebrates were collected above and below Triangle Paving (UT Back Creek) in April 1995 (B-950526). Runoff from this facility was shown to change the stream rating from Excellent at an upstream site to Good at a downstream site. This facility was asked to cease discharge of waste concrete into the stream and to develop a buffer zone between their operation and the stream.

OTHER DATA

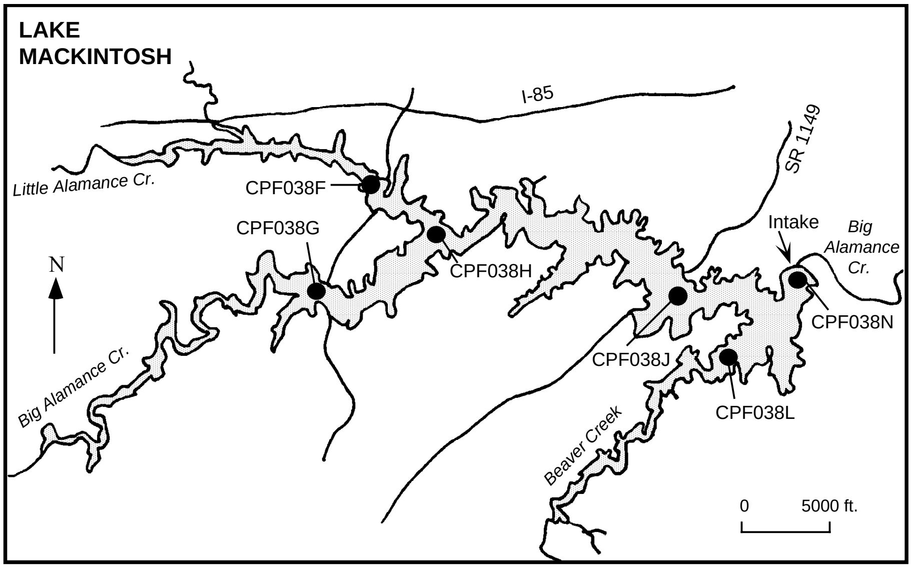
The Haw River Assembly collects data from several sites, including temperature, pH, and benthic macroinvertebrates. Macroinvertebrates are usually identified to order and evaluated using the Izak Walton League's analysis method. Sampling sites include Little Alamance Creek (Burlington), Alamance Creek, and Stinking Quarter Creek. For further information, contact The Haw River Assembly, PO Box 25, Saxapahaw, NC 27340, 919-542-5790, hawriverwatch@mindspring.com.

LAKE ASSESSMENT PROGRAM

Lake Mackintosh

COUNTY:	Alamance/Guilford	**CLASSIFICATION:**	WS-IV NSW CA
SURFACE AREA:	1150 acres (465 hectares)	**MEAN DEPTH :**	33 feet (10 meters)
VOLUME:	29 $x10^6 m^3$	**WATERSHED**:	129 mi^2 (334 km^2)

Lake Mackintosh is a water supply reservoir for the City of Burlington. The lake is used for recreational purposes (fishing and boating but not activities involving full body contact with the water such as swimming). Located on Big Alamance Creek, Lake Mackintosh was filled in 1993. The surrounding land is comprised of pastures and farmland with a few houses. A public park and marina operated by Alamance County is located off of SR 1149 (Huffman Mill Road) and Guilford County operates a small marina located on the Little Alamance Creek arm of Mackintosh Lake. A 'No Wake Zone' has been established by Guilford County for the Little Alamance arm and boats entering this arm are restricted to electric motors.



Lake Mackintosh was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data collected for Lake Mackintosh in 1998 are presented in Appendix L2. June surface dissolved oxygen values in Little Alamance Creek (CPF038F), Big Alamance Creek (CPF038G) and at the upper end of the mainstem of the lake (CPF038H) were 10.4, 11.0 and 10.6 mg/L, respectively. The highest surface pH values for 1998 in Lake Mackintosh were also observed at these three sites in June (8.8 to 8.9 s.u.). In June, chlorophyll *a* values in the upper end of Lake Mackintosh ranged from 16 to 29 µg/L. An algal bloom sample collected in the Little Alamance Creek Arm (CPF038F) in June indicated the presence of an algal bloom based on the algal density (19,339 units/ml) and algal biovolume (8,761 mm^3/m^3). The algal assemblage was dominated by filamentous blue-green algae (*Anabaena* sp.). A sample of plant material collected near the boat ramp in August was identified as *Chara sp*., a macroalga which is an indicator of clear water. Metals concentrations in June, July and August were less than applicable state water quality standards. Lake Mackintosh was determined to be mesotrophic in June and July based on the calculated NCTSI scores for the water quality data collected during these months.

According to Mr. Larry Glenn, Assistant Superintendent of the J. D. Macintosh Water Treatment Plant, the lake continues to have problems during the summer months with algal blooms and related taste and odor problems. A private contractor has been hired to perform chlorophyll, nutrient, turbidity and other water quality parameter testing of the lake (Larry Glenn, Assistant Superintendent, J. D. Mackintosh Water Treatment Plant, pers. com.).

Lake Mackintosh was previously sampled by DWQ in 1997, 1996, and 1994. Physical and chemical data collected by DWQ for each of these sampling trips is presented in Appendix L2. Surface dissolved oxygen in June, 1997 ranged from 9.5 to 11.1 mg/L. Secchi depths were less than one meter at each of the six sampling sites (range = 0.6 to 0.8 meter). Total phosphorus ranged from 0.02 mg/L in the Big Alamance Creek arm to 0.09 mg/L in the Little Alamance Creek arm. Chlorophyll *a* ranged from 9 µg/L in the Little Alamance Creek arm to 21 µg/L near the dam.

In 1996, Lake Mackintosh was sampled by DWQ in June, July and August. In June, metals were below the Division of Water Quality (DWQ) laboratory detection levels except for zinc (15 µg/L) and copper (18 µg/L). The value for copper was greater than the state water quality action level of 7.0 µg/L. Chlorophyll *a* ranged from 9 to 25 µg/L near the dam (CPF038N). The highest nutrient concentrations were found at station CPF038F in the Little Alamance Creek arm of the lake. Elevated dissolved oxygen and pH values were observed at a depth of two meters at three lake sampling stations, indicating algal activity at this depth. The highest dissolved oxygen (14.4 mg/L) and pH values (9.0 s.u.) were at the sampling site CPF038N, located near the dam and water intake area. During the June sampling visit, it was observed that the water in Lake Mackintosh had a greenish tint at several areas. Phytoplankton analyses from the lake indicated the presence of an algal bloom dominated by the blue-green alga, *Aphanizomenon flos-aquae*. This alga is planktonic and forms small feathery floating colonies composed of parallel filaments. Taste and odor problems in processed drinking water may arise when bloom die-off occurs.

On July 18, 1996 metals were below DWQ laboratory detection levels. Chlorophyll *a* values ranged from 9 to 13 µg/L. Lake Mackintosh had a NCTSI score of -1.0, indicating that the lake was mesotrophic on the day it was sampled. Sampling of Lake Mackintosh was again performed on August 15, 1996. Chlorophyll *a* values ranged from 12 to 20 µg/L Physical measurements indicated stratified conditions at each of the sampling stations with hypoxic conditions at a depth of five meters near the dam. The NCTSI score was –0.9.

Lake Mackintosh was sampled on January 4, 1994 following a request by the City of Burlington due to an observed algal bloom and a change in the taste of the treated drinking water taken from the lake. Physical data collected at the six lake sampling sites indicated that the lake was well mixed with adequate oxygen present throughout the water column. Surface dissolved oxygen and pH values were typical for a piedmont reservoir monitored in winter. Secchi depths were less than one meter throughout the lake (range = 0.6 to 0.8 meter). The lake had a green tint and appeared turbid. Chlorophyll *a* values, however, were low (range = 5 to 10 µg/L). Windy conditions at the time of sampling created wave turbulence which broke up and dispersed algal mats reported on the upper portion of the lake the day before. Bloom levels of the blue-green alga, *Aphanizomenon flos-aquae,* were detected in water samples collected near the confluence of Little and Big Alamance Creeks (CPF038H).

An algal bloom was reported in May 1994 after the City of Burlington noticed problems with taste and odor of drinking water taken from this water supply reservoir. The lake was sampled on May 16, 1994 in response to this reported bloom. Elevated photic zone ammonia and nitrite plus nitrate were measured at the sampling site on the Little Alamance Creek arm. Heavy rains had occurred in the region prior to sampling and this was reflected in the elevated turbidity (16 NTU as compared with 4 NTU in 1993) and decreased Secchi depth. The lake water appeared brown with suspended particles. Hypoxic conditions occurred below the thermocline, which was located at a depth of approximately four meters. Elevated surface pH (8.1 s.u.) was observed at the sampling sites near the dam and on the Beaver Creek arm. Despite the heavy rains which occurred prior to sampling, water samples collected from stations near the dam still contained high densities of the blue-green alga, *Aphanizomenon flos-aquae*. This species is often implicated in taste and odor complaints. Two types of common green, filamentous algae, *Oedogonium* and *Spirogyra*, were also found in the lake. These green algae are seasonal and usually cause little problems. Because of this lake's eutrophic status and reports of algal blooms, continued monitoring may be necessary in the future.

Historical data collected at Mackintosh Lake from 1993 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L6.

Figure L6. Lake Mackintosh Data Analysis, 1993 - 1998.

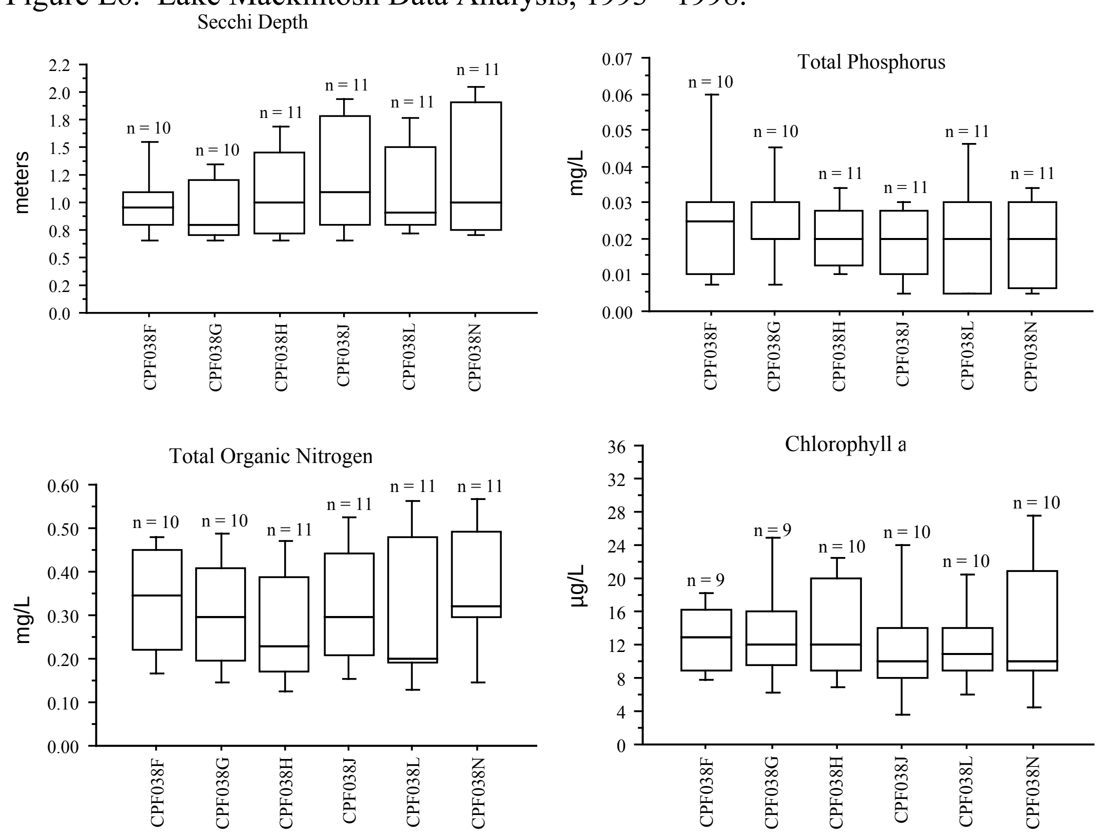
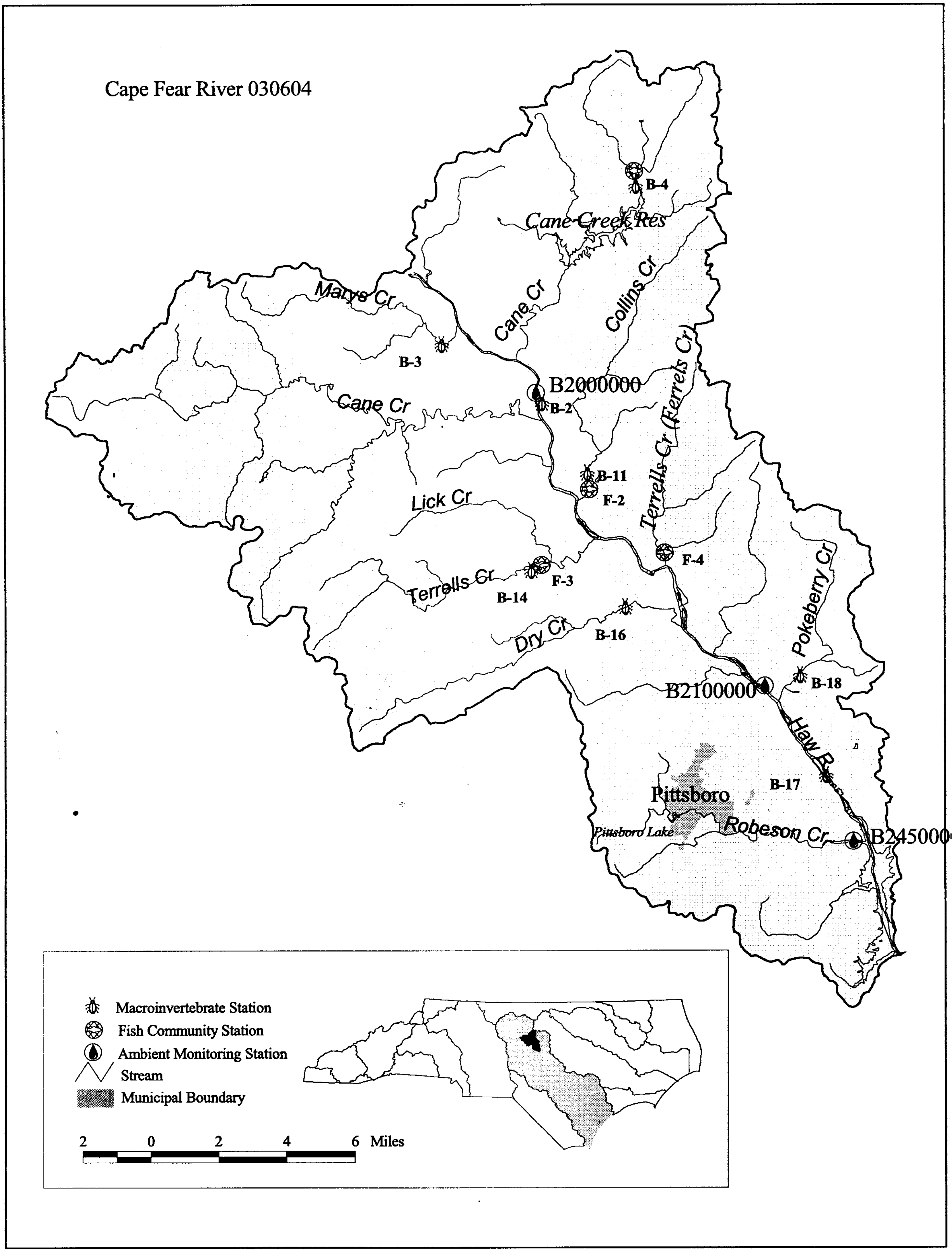


Table L10. Lake Mackintosh NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Lake Mackintosh	980813	no score	0.03	0.40	n/a	1.6
Lake Mackintosh	980715	-1.3[M]	0.02	0.18	10	1.4
Lake Mackintosh	980603	-1.0[M]	0.01	0.19	17	0.9
Lake Mackintosh	970807	-2.4[O]	0.01	0.24	6	1.6
Lake Mackintosh	970611	1.4[E]	0.04	0.40	14	0.8
Lake Mackintosh	960815	-0.9[M]	0.01	0.32	16	1.3
Lake Mackintosh	960718	-1.0[M]	0.01	0.27	11	0.8
Lake Mackintosh	960619	1.4[E]	0.03	0.48	17	0.9
Lake Mackintosh	960104	-0.3[M]	0.03	0.23	8	0.7
Lake Mackintosh	940516	0.6[E]	0.02	0.49	10	0.7
Lake Mackintosh	930817	0.2[E]	0.02	0.49	24	1.9


Cape Fear River 030604
B-4
Cane Creek Res
Marys Cr
Cane Cr
Collins Cr
B-3
Terrells Cr (Ferrels Cr)
B2000000
Cane Cr
B-2
B-11
F-2
Lick Cr
F-4
Terrells Cr
F-3
B-14
Pokeberry Cr
Dry Cr
B-16
B2100000
B-18
Haw R
B-17
Pittsboro
Pittsboro Lake
Robeson Cr
B245000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 6 Miles

CAPE FEAR SUBBASIN 030604

DESCRIPTION

This subbasin contains the lower reaches of the Haw River in Alamance, Orange and Chatham counties. This reach extends from the confluence of Marys Creek in Alamance County to the Haw River arm of Jordan Lake (near Pittsboro). This section of the Haw River is approximately 25 river miles in length and is completely within the Carolina Slate Belt. Tributary streams within this subbasin are strongly influenced by geology and characteristically have large boulder and/or rubble riffle areas. However, many of the tributary streams in this subbasin are prone to extremely low flow conditions during summer months.

Much of the land use within this subbasin is forest, although pasture, cultivated crops and urban and built-up land uses also account for significant portions of the subbasin. All three counties within this subbasin have large numbers of registered livestock and animal operations, particularly cattle and poultry operations in Chatham County. There are 7 permitted dischargers in this subbasin and only the Pittsboro WWTP (Robeson Creek) has a permitted flow of more than 0.5 MGD.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-2*	Haw R	Alamance	SR 1005	Good-Fair (s)	Good-Fair (s)
B-3	Marys Cr	Alamance	SR 2174	Not Sampled	Fair (w)
B-4*	Cane Cr	Orange	SR 1114	Good (w)	Good&Excell(w)
				Good-Fair (s)	Good (s)
B-11	Collins Cr	Chatham	SR 1539	no sample	Good-Fair (w)
B-14	Terrells Cr	Chatham	NC 87	Good (w)	Good-Fair (s)
B-16*	Dry Cr	Chatham	SR 1520	Good (w)	Good-Fair (w)
B-17*	Haw R	Chatham	US 64	Good (s)	Good (s)
B-18*	Pokeberry Cr	Chatham	SR 1711	Good-Fair (w)	Good (w)
FISH				1994	
F-2	Collins Cr	Chatham	SR 1539	no sample	Poor
F-3	Terrells Cr	Chatham	NC 87	Fair	Fair
F-4	Ferrells Cr	Chatham	SR 1525	no sample	Good-Fair

(w) winter collection, (s) summer collection
*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES DATA
Cane Creek Reservoir, Pittsboro Lake

Ambient water quality data are being collected from three locations in this subbasin: two mainstem locations on the Haw River (US 15-501 near Bynum and below B. Everett Jordan Dam near Moncure) and Robeson Creek at SR 1939 near Seaforth. These data have indicated good water quality, with few violations in water quality criteria. Additionally, data from the two Haw River locations in this subbasin indicate an improvement in water quality compared to conditions recorded from ambient monitoring sites at the Haw River at Haw River and Saxapahaw.

Benthic macroinvertebrate samples have been collected from two Haw River locations since 1984, including two basinwide surveys in 1993 and 1998. These data indicate that water quality conditions improve downstream near the Haw River arm of Jordan Lake (Good bioclassifications, US 64) compared to upstream reaches at Saxapahaw (Good-Fair bioclassifications, SR 1005). A benthos sample also was collected from the Saxapahaw location in November 1998 during extremely low flow conditions. Although the bioclassification did not change from summer data, taxa richness values were much lower. These data may reflect the effects of greater instream waste concentrations from upstream sources during extremely low flow conditions.

DWQ investigations have indicated that water quality conditions of small Slate Belt streams are more effectively assessed using benthic macroinvertebrates during winter months rather than summer low-flow conditions. Benthic macroinvertebrate data from Terrells Creek illustrate these seasonal differences (Good-Fair summer rating, Good winter rating). Good or Good-Fair ratings based on benthic macroinvertebrate data were given to most of the tributary streams in this subbasin, although a Fair bioclassification was given to Marys Creek. A 5-year decline in rating was recorded from Dry Creek and 5-year improvements were found at Pokeberry and Collins Creeks. Fish community analyses of tributary streams in this subbasin resulted in NCIBI ratings of Poor, Fair and Good-Fair at Collins, Terrells and Ferrells Creek, respectively.

Data collected by DWQ from Cane Creek Reservoir during three summer surveys in 1998 resulted in mesotrophic and eutrophic NCTSI scores. Algal bloom conditions were noted during the July and August investigations. Data from summer surveys in 1998 from Pittsboro Lake also resulted in mesotrophic and eutrophic NCTSI scores. Field observations in 1998 continued to identify a problem with excessive macrophyte growth in the lake.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Haw River near Saxapahaw, SR 1005

This site is the most upstream site on the Haw River in this subbasin, but it is below the urban areas of Burlington and Graham in subbasin 030602. Ambient water quality data from this location, particularly during low flow conditions, have historically recorded elevated conductivity values (700+ µmhos/cm). The Haw River at this location is very wide (40-50 meters) and has a substrate dominated by large bedrock runs and rubble riffles. Some sedimentation is evident in pool and backwater areas, but high gradient riffles are generally free of sediment. The Asiatic clam (Corbicula fluminea) is extremely abundant at this location and numerous empty shells were seen along the banks.

Good-Fair benthos bioclassifications have been consistently assigned to this site, including basinwide surveys in 1993 and 1998. A Good-Fair rating also was given to this site during an investigation in November 1998. This survey, which was conducted to assess the effects of extremely low flow conditions, resulted in lower EPT taxa richness and abundance values, and an increase in some tolerant taxa (especially Cricotopus bicinctus) compared to the July basinwide survey. Lower flow may have promoted periphyton growth and caused a shift to slower water species.

Marys Creek, SR 2174

This site was sampled for the first time in February 1998 and resulted in a Fair benthos bioclassification. Marys Creek catchment (approximately 12 square miles) was mostly forest with some pastureland. The stream at this location was approximately 8 meters wide and had numerous higher gradient, boulder/rubble riffle areas. However, pools were filled with unstable, coarse sand and sediment deposition also had occurred in the riparian area as well. This latter observation suggests the effects of nonpoint source runoff.

Cane Creek, SR 1114

The Cane Creek catchment at this point is approximately 8 square miles and is primarily forested, but with large tracts of land in pasture and cultivated crops. This site is above the Cane Creek Reservoir and is a water supply for the Town of Chapel Hill. The substrate is very rocky but, due to the lack of groundwater recharge, stream flow and habitat diversity is reduced during summer drought conditions. Many flow-dependant species are reduced in abundance or eliminated during these low-flow periods. For this reason, winter surveys are conducted at this location. Winter data from Cane Creek have consistently resulted in Good or Excellent water quality ratings.

Collins Creek, SR 1539

This site was sampled as part of the basinwide program for the first time in February 1998 and given a Good-Fair bioclassification. Benthic macroinvertebrates also had been collected from this site as part of the Jordan Lake Watershed benthic investigation in 1986. At that time, this site received a Poor bioclassification. Collins Creek is approximately 7 meters wide with a substrate composed of bedrock and large boulders, with only a slight amount of sediment deposition. This site also had prolific growths of algae, suggesting enrichment.

The fish community was sampled for the first time in this stream in 1998 and was rated as Poor. NCIBI metrics receiving low scores included those for numbers of sunfish, sucker, and intolerant species, and for the percentage of piscivores.

Terrells Creek, NC 87

Terrells Creek is about 6 meters wide at this site, with a substrate largely composed of boulders and rubble. Benthic macroinvertebrate samples have been collected from this site during basinwide surveys in 1993 and 1998, although a summer survey was conducted in 1998 (EPT=15, Good-Fair) and a winter survey in 1993 (EPT=30, Good). Very low flow conditions were recorded during the summer survey. These data suggest that seasonal differences in flow and habitat characteristics may have accounted for differences in the community structure and resulted in a lower bioclassification during the summer survey.

At the time of the fish community assessment in April 1998, the stream width was estimated to be between nine and ten meters. The community rating was Fair in 1994 and 1998. The omnivorous bluehead chub (Nocomis leptocephalus) was the most commonly collected fish during both years, and accounted for almost half of the fish collected in 1998.

Ferrells Creek, SR 1525

Ferrells Creek in the sampling area was approximately seven meters wide with a mixed substrate. Evaluated for the first time in 1998, the fish community at this site was rated Good-Fair. The absence of any intolerant fish species was the most apparent reason for the rating not being higher. The WRC sampled a couple of miles upstream of the DWQ site during the 1963 survey. The WRC found a moderately diverse fish population (14 species) at the site.

Dry Creek, SR 1520
Benthic macroinvertebrates have been collected from this site during winter basinwide surveys in 1993 and 1998. Data also were collected from this site during the 1986 Lake Jordan Watershed investigation. Dry Creek is about 8 meters wide and has a substrate composed of boulder/rubble riffle areas and very sandy runs. Many of the pools have been filled in with sediment. Bioclassification has varied considerably at this site (Poor in 1986, Good in 1993 and Good-Fair in 1998), which may reflect flow conditions prior to collection including the effects of scour in this sandy stream. EPT abundance values were much lower in 1998 (62) than during the 1993 survey (177).

Haw River near Pittsboro, US 64
Data from this location represents water quality conditions in the Haw River prior to flowing into the Haw River arm of B. Everett Jordan Reservoir. Good bioclassifications have been recorded from this site during most benthic surveys and EPT taxa richness values have consistently ranged from 24-28 taxa since 1985. This information suggested that water quality conditions of the Haw River at this location are stable and that water quality improves at this site compared to upstream monitoring sites at Saxapahaw and Graham.

Pokeberry Creek, SR 1711
This is a small Slate Belt stream with a drainage area of 12.9 square miles at its confluence with the Haw River. Pokeberry Creek, which is 7 meters wide at the collection site, is unlike most Slate Belt streams because it has a very sandy substrate. The catchment appears mostly forested, although severe bank erosion was noted at the collection site. Winter basinwide surveys have been conducted at this site in 1993 and 1998 and resulted in a 5-year improvement in bioclassification (Good-Fair to Good). Many more intolerant taxa (i.e. Chimarra) were collected during the 1998 investigation.

SPECIAL STUDIES
Three special studies have been conducted in this subbasin since 1993. Two samples were collected from Cane Creek west (Alamance County) to assess the potential impacts of recreational dredging (B-981202). Samples were collected from sites above and below the Major Hill Gold Campground. Data suggested that there were no major impacts to the stream fauna because of this activity.

Benthic macroinvertebrates were collected from 4 sites near Pittsboro to assess the instream impacts from a fuel oil spill (B-970318). Collections were made from 2 very small, temporary tributaries of Robeson Creek. These data were used only to look for the presence of aquatic life and to compare one UT, which received the fuel oil spill to an unstressed UT. Samples also were collected from two sites on Robeson Creek, above and below the UT receiving the fuel oil spill. Both of these sites were above the Pittsboro WWTP. No aquatic taxa were collected from the UT receiving the fuel oil spill, while 24 taxa were collected from the unstressed UT. Many dead invertebrates were observed in Robeson Creek below the UT receiving the spill and many fewer intolerant taxa were collected compared to an upstream location.

Benthic macroinvertebrates also were collected from Cane Creek (Orange County) as part of a study to assess the effects of habitat on stream benthos from consecutive reaches (from one bridge to another). Data from these two Cane Creek locations illustrated how changes in habitat characteristics (mainly the amount of silt instream) can influence the bioclassification. Higher taxa richness values were found at the location with less silt and more riffles, while biotic index values were similar. This study suggested that changes in habitat are more likely to affect taxa richness than biotic index values (B-941026).

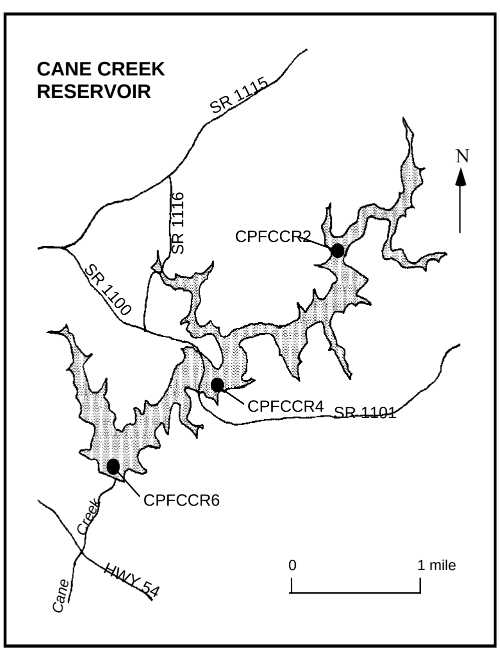
OTHER DATA

Haw River Assembly. The Haw River Assembly coordinates a volunteer monitoring network, which consists of 82 sites within the Haw River catchment. Volunteers note physical conditions and detailed stream descriptions during each stream visit. In addition, benthic macroinvertebrates are collected using methods that are similar to those developed by the Isaac Walton League of America. Samples are collected from several habitat types and then specimens are field identified, counted and sorted into three pollution sensitivity categories. Water quality ratings are then assigned to each site based on the number of organisms in each category. In some instances data have been collected for four years and trends in water quality ratings have been conducted. The Haw River Assembly has 25 monitoring locations in this subbasin, 10 sites that are within similar reaches sampled by DWQ. Direct comparison of benthic macroinvertebrate data is not possible due to differences in level of identification.

LAKE ASSESSMENT PROGRAM

Cane Creek Reservoir

COUNTY:	Orange	**CLASSIFICATION:**	WS-II NSW CA
SURFACE AREA:	500 acres (202 hectares)	**MEAN DEPTH :**	8 feet (3 meters)
VOLUME:	11 x$10^6 m^3$	**WATERSHED:**	32 mi^2 (82 km^2)



Cane Creek Reservoir was built in 1989 by Orange Water and Sewer Authority (OWASA) as a water supply for the City of Chapel Hill. The maximum depth is approximately 54 feet (17 meters). The majority of the watershed is forested with some agriculture. Two main tributaries entering the lake are Cane Creek and Turkey Hill Creek. A public park is located off of HWY 54 West and provides a boat rental facility and boat launch area.

Cane Creek Reservoir was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical lake data are presented in Appendix L2. In July, an algal bloom sample was collected at

CPFCCR2. Algal biovolume was 22,271 mm^3/m^3 and algal density was 29,707 units/ml. The bloom was determined to consist primarily of filamentous blue-green *Anabaena subcylindrica* (58%). Another algal bloom sample was collected in August at CPFCCR2 based on the elevated surface dissolved oxygen (9.2 mg/L) and surface pH (8.1 s.u.). Algal biovolume was 18,664 mm^3/m^3 and algal density was 66,405 units/ml indicating the presence of a bloom The green alga, *Westella botryoides,* comprised 26% of the sample. Metal concentrations were less than the applicable state water quality standards in 1998. Cane Creek Reservoir was mesotrophic in June and eutrophic in July based on the calculated NCTSI scores.

According to Mr. Doug Terry, Water Supply and Treatment Manager, Orange Water and Sewer Authority (OWASA), there are usually an average of ten complaints regarding taste and odor but most of these are related to the amount of chlorine in the processed drinking water. During the spring and summer months, OWASA has experienced elevated chemical treatment costs associated with controlling constituents in the raw water that contribute to taste and odor problems. The water intake is kept above the thermocline (approximately two meters from the surface) to avoid problems with anoxic or hypoxic water. This lake is sampled by OWASA laboratory personnel during the summer and fall months and lake profile sampling at one meter depth increments is performed at least once a week. Recently an automatic monitoring station was purchased and installed in the lake. The station samples the lake at preset depths and stores the data until it is retrieved via telephone. All data are available to the public upon request. The water in Cane Creek Reservoir has a dirty brownish color (not muddy) and also sometimes takes on a greenish tinge; algal activity is evident. Laboratory staff collects water samples and performs algae counts weekly or more often if required during the spring and summer months. Also during the spring and summer months, an increase in aquatic macrophytes, predominantly alligator weed (*Alternanthera philoxeroides*), occurs in the upper reaches of the lake. There have been no reports of fish kills or observations of distressed or malformed fish in the lake. To protect the water quality of Cane Creek Reservoir, OWASA is purchasing critical acreage around the lake as it becomes available to created a protective buffer zone (Doug Terry, Water Supply and Treatment Manager, OWASA, pers. com.).

On June 26, 1997 the Orange Water and Sewer Authority (OWASA) adopted the "Provisional Recommendations for Protecting the Cane Creek Water Supply". These recommendations were based upon the conclusions made by a 22-member Watershed Advisory Committee for the protection of the Cane Creek Reservoir water supply. Suggestions included the acquisition of approximately 1300 acres of critical land in the Cane Creek Reservoir watershed by OWASA to reduce future contamination of the lake along with discussions with Alamance County officials regarding re-zoning of the Alamance portion of the watershed (OWASA, 1997). In October, 1997, the Board of Directors adopted the final recommendations for protecting the water quality of Cane Creek Reservoir (OWASA, September 1, 1998).

The North Carolina Clean Water Management Trust Fund awarded OWASA a one million dollar grant to help acquire land and conservation easements in the Cane Creek watershed. This award would complement more than five million dollars of OWASA funds previously budgeted for this purpose over the next five years. To identify the most important land, OWASA developed a special computer model and began working with the Conservation Trust Fund of North Carolina, which will provide much of the legal and technical expertise in negotiating with potential sellers of land and conservation easements (OWASA September 1, 1998).

Cane Creek Reservoir appears to have a good crappie (*Pomoxis sp.*) and largemouth bass (*Micropterus salmoides*) population according to Ms. Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries. The largemouth bass population, however, appeared to be stunted. Ms. Bryant also noted that the lake seemed to have a lot of filamentous algae (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com.).

Cane Creek Reservoir was previously sampled by DWQ in 1996 . Surface dissolved oxygen ranged from 8.0 to 10.8 mg/L with the highest values observed in June when all three lake sampling sites had surface dissolved oxygen values greater than 10.0 mg/L (Appendix L2). A chlorophyll *a* value of 47 µg/L was observed at the sampling site near the dam in June and a value of 42 µg/L was observed in the upper end of the lake in August. These values were greater than the state water quality standard of 40 µg/L for chlorophyll *a*. Analysis of phytoplankton in June determined the presence of the blue-green alga, *Aphanizomenon flos-aquae* (this sample was not quantified). Concentrations of metals were not greater than the applicable state water quality standards.

Historical data collected at Cane Creek Reservoir from 1990 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L7.

Figure L7 . Cane Creek Data Analysis, 1990 – 1998.

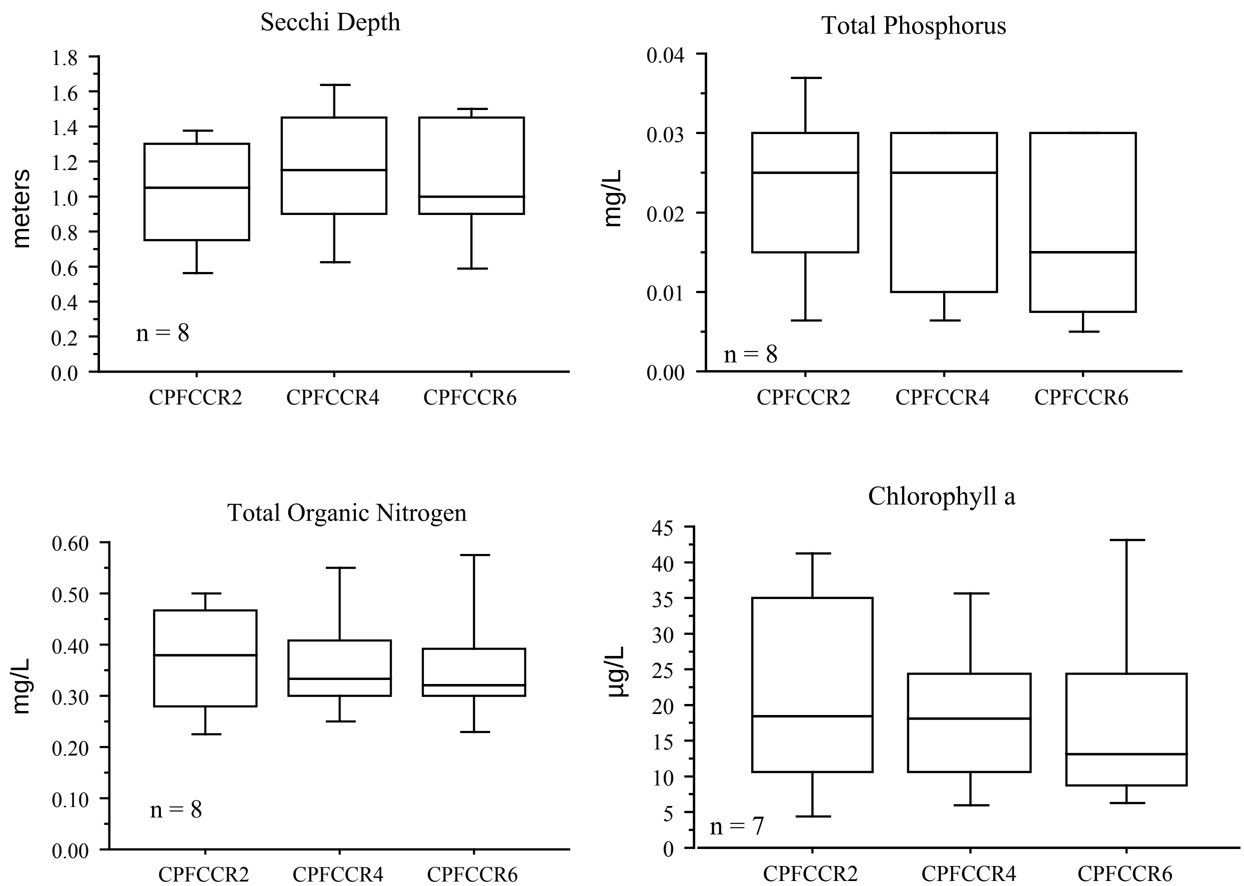


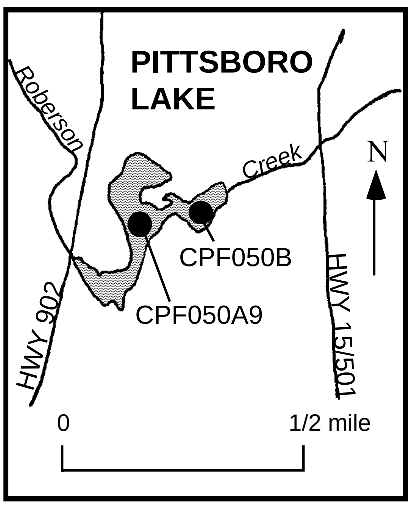
Table L10. Cane Creek Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Cane Creek Res.	980813	no score	0.02	0.26	n/a	1.4
Cane Creek Res.	980716	0.7[E]	0.03	0.33	17	0.9
Cane Creek Res.	980618	-1.4[M]	0.01	0.26	10	1.5
Cane Creek Res.	960815	-0.3[M]	<0.01	0.46	32	1.0
Cane Creek Res.	960718	-0.4[M]	0.01	0.30	19	0.8
Cane Creek Res.	960620	2.6[E]	0.03	0.35	41	0.5
Cane Creek Res.	930708	0.3[E]	0.03	0.40	7	1.1
Cane Creek Res.	900803	0.7[E]	0.03	0.30	24	1.1

Pittsboro Lake

COUNTY:	Chatham	**CLASSIFICATION:**	WS-IV NSW
SURFACE AREA:	38 acres (151 hectares)	**MEAN DEPTH :**	3 feet (1 meters)
VOLUME:	0.02 x10^6m^3	**WATERSHED**:	8 mi^2 (21 km^2)

Pittsboro Lake is a small impoundment located just outside of and owned by the Town of Pittsboro in Chatham County. The lake, which is a retired water supply, is actually a system of two separate ponds connected by a canal that becomes dry during periods of low precipitation. The impoundment is shallow with a depth of only seven feet (two meters) at the lower dam (CPF050B). The drainage area for Pittsboro Lake is composed of forested, urban, and agricultural area. Pittsboro Lake is currently part of a town park.

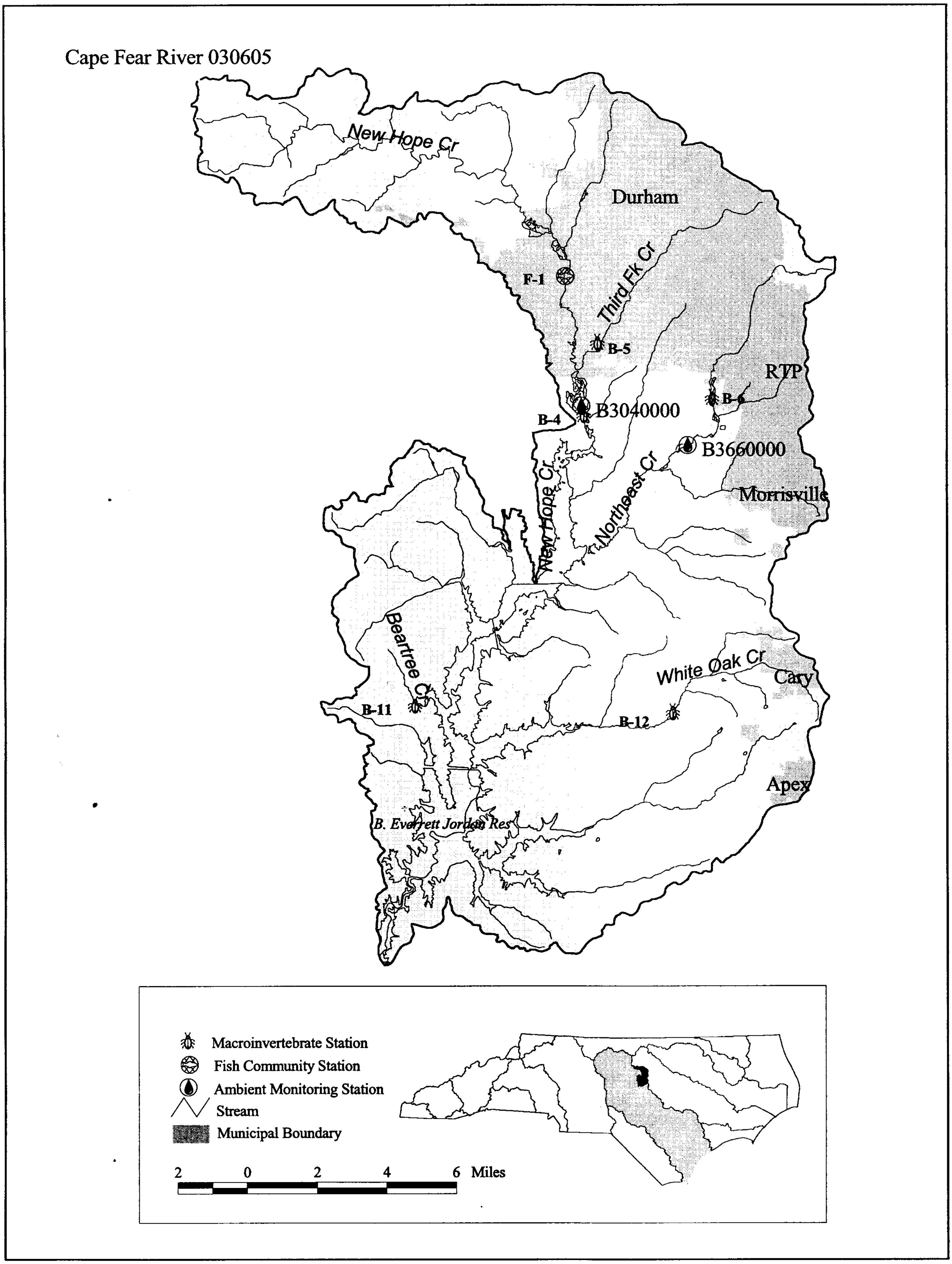


Pittsboro Lake was most recently sampled by DWQ in June, July and August, 1998. When sampled by DWQ in 1993, this lake had a significant macrophyte infestation problem. Field observations in 1998 continued to identify a problem with excessive macrophyte growth in the lake. Chemical and physical data for Pittsboro Lake are presented in Appendix L2. Secchi depths in Pittsboro Lake were consistently less than one meter, ranging from 0.4 to 0.7 meter. The greatest total phosphorus concentration (0.16 mg/L) was observed at CPF050B in August. Despite the abundance of nutrients in this lake, chlorophyll *a* values in 1998 ranged from 3 to 8 µg/L. Pittsboro Lake was mesotrophic in June and eutrophic in July based upon the calculated NCTSI scores (Table L11).

According to Mr. Walter Harris, Town Manager for the Town of Pittsboro, there has been no dredging or macrophyte control actions (either mechanical or chemical) to reduce the plant growth in the lake. Hurricane Fran (1996) did remove a great deal of the plant material and algae which had been previously observed in the lake in 1993 by DWQ (Walter Harris, Town Manager, Town of Pittsboro, pers. com.).

Table L11. Pittsboro Lake NCTSI Data

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Pittsboro Lake	980806	no score	0.12	0.37	n/a	0.4
Pittsboro Lake	980708	0.6[E]	0.03	0.29	8	0.5
Pittsboro Lake	980603	-1.3[M]	0.02	0.15	8	0.7
Pittsboro Lake	930729	0.4[E]	0.02	0.34	6	0.4
Pittsboro Lake	870804	2.7[E]	0.06	0.48	27	0.7
Pittsboro Lake	810819	3.9[E]	0.06	0.95	38	0.9



Cape Fear River 030605
New Hope Cr
Durham
F-1
Third Fk Cr
B-5
RTP
B-6
B3040000
B-4
B3660000
Morrisville
New Hope Cr
Northeast Cr
Beartree Cr
White Oak Cr
Cary
B-11
B-12
Apex
B. Everett Jordan Res
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 6 Miles

CAPE FEAR SUBBASIN 030605

DESCRIPTION

Cape Fear River subbasin 05 contains the entire New Hope Creek catchment, plus other, smaller, tributaries of B. Everett Jordan Reservoir. This catchment includes large sections of Durham and Research Triangle Park. New Hope Creek and many of its tributaries are within the Triassic Basin, an area that covers about 1,100 square miles. The 7Q10 values are zero for all but the largest catchments.

A large percentage of land use within this subbasin is urban and built-up which includes commercial sites, construction sites, residences, and parking lots. There are 8 permitted dischargers in the subbasin and 2 of these facilities have permitted flow of greater than 1 MGD. Durham County Triangle WWTP has a permitted flow of 6 MDG and discharges to Northeast Creek and Durham South Water Reclamation Facility has a permitted flow of 20 MGD and discharges to New Hope Creek.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-4	New Hope Cr	Durham	SR 1107	Not sampled	Fair (s)
B-6*	Northeast Cr	Durham	SR 1102	Not Rated (w)	Not rated (w)
B-11*	Beartree Cr	Chatham	SR 1716	Not Rated (w)	Not rated (w)
B-12	White Oak Cr	Chatham	SR 1603	Not sampled	Not rated (w)
FISH					
F-1	New Hope Cr	Durham	SR 2220	no sample	Poor

(w) winter collection, (s) summer collection

*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES DATA

B. Everett Jordan Reservoir

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Lake Jordan near Farrington	1998	24	1	0	EPA mercury limit exceeded in 1 bass sample
FT-2	Lake Jordan near Dam	1998	22	0	0	No samples excceeded criteria

Ambient water quality samples are collected from two locations in this subbasin: New Hope Creek at SR 1107 near Blands and Northeast Creek at SR 1100 near Nelson. These two ambient monitoring locations assess water quality below two of Durham's WWTPs. These facilities discharge to Northeast Creek (Durham County Triangle WWTP) and New Hope Creek (Durham, South Water Reclamation Facility) and have instream waste concentrations of 100% and 99.5%, respectively under 7Q10 flow conditions. Elevated nutrient concentrations and depressed dissolved oxygen values have been recorded at both of these locations during this reporting period (Figure A-4) when compared to most other Haw River tributary locations. Median fecal coliform counts are above the 200/100ml water quality criteria from both of these locations during this reporting period.

Both point and nonpoint sources have impacted stream systems in this highly urbanized subbasin. However, geology and ecoregion complicate analysis of these data. Streams in this subbasin are typical of the Triassic Basin: 7Q10 values are zero, and streams have poor instream habitat. For these reasons most stream in this subbasin were not sampled because of low flow conditions or were not rated using benthic macroinvertebrate criteria. A Poor NCIBI rating was given to New Hope Creek at SR 2220 using fish community criteria.

Fish tissue samples were collected from two locations on Jordan Lake during the 1998 basinwide program: Farrington arm and near the dam. Only one sample (a largemouth bass from the Farrington arm location) had a mercury concentration exceeding EPA criteria.

DWQ has conducted water quality assessments of B. Everett Jordan Reservoir since 1984. NCTSI values have consistently indicated eutrophic conditions. An intensive water quality investigation of B. Everett Jordan Reservoir was conducted in 1996 and 1997. Results of this investigation indicated elevated nutrient levels, primarily from the Haw River and New Hope Creek arms of the reservoir. Seventeen percent of the chlorophyll *a* values were greater than the state water quality standard of 40µg/l, and 89 percent of the phytoplankton samples collected contained algal concentrations at bloom levels. Actions to improve water quality in the reservoir are continuing, but conditions observed during this intensive investigation still indicate nutrient-enriched conditions.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

New Hope Creek, SR 2220

This stream was roughly nine meters wide with a sand substrate at the sampling location. While good pool habitat was documented, no riffles were present in the stream segment that was sampled. The Poor classification for the fish community in New Hope Creek was due to the low number of fish and species of darters, the absence of any sucker or intolerant species, and the high percent of tolerant fish collected. The 1963 WRC site was at US 15-501, approximately one mile upstream of the DWQ site. The collecting personnel reported a good gamefish population with 16 total species collected.

New Hope Creek, SR 1107

Most sites in this subbasin were not sampled in 1998 because of the lack of stream flow. However, data were collected from this ambient monitoring location because stream flow was augmented by the Durham South Water Reclamation Facility (20 MGD). New Hope Creek at this site is about 4 meters wide and has a substrate composed almost entirely of silt and FPOM (Fine Particulate Organic Matter). A Fair bioclassification, based on benthic macroinvertebrate data, was given to this site during the 1998 basinwide survey. EPT abundance values were very low, only Stenonema modestum and Cheumatopsyche were abundant. The only other benthic macroinvertebrate data collected from this site was during a 1985 investigation of the Durham-Farrington Road WWTP (now Durham South Water Reclamation Facility). These data resulted in a Poor bioclassification.

During the 1993 basinwide surveys, benthic macroinvertebrates were collected from an upstream site on New Hope Creek at SR 1734 in Orange County. These data resulted in a Good bioclassification suggesting that water quality conditions degrade in the catchment.

Third Fork Creek, NC 751
Data were not collected from this basinwide site during the 1998 monitoring program due to the lack of stream flow. However, Poor bioclassifications were given to this site during the 1993 basinwide program and during a 1985 special investigation. Recent DQW information has suggested that bioclassification of Triassic Basin streams using Piedmont classification criteria is inappropriate. Third Fork Creek, which drains urban sections of Durham, is about 4 meters wide at NC 751 and has a substrate composed of sand and silt.

Wildlife Resources Commission biologists have collected a relatively rare crayfish from this location. The southern most range of Fallicambarus (Creaserinus) fodiens, along the Atlantic coast extends into the Cape Fear River basin. In 1993, specimens of this crayfish were collected from burrows along the stream at this location (Cooper et. al, 1998).

Northeast Creek, SR 1102
Northeast Creek is contained completely within the Triassic Basin and has flow and habitat characteristics that are typical for streams in this ecoregion. This site is located above the Durham County Triangle WWTP, but drains urban and suburban sections of Durham. Because of the urban nature of this catchment, flow may be flashier than other Triassic Basin streams. Northeast Creek is 5-6 meters wide and has a substrate composed of silt, FPOM and hard-packed clay. Most benthic organisms were collected from snag habitats. Data have been collected from this location during winter basinwide surveys in 1993 and 1998, but no ratings can be assigned.

Beartree Creek (UT New Hope Creek), SR 1716
Benthic macroinvertebrates have been collected four times from this very small tributary (2-3 meters wide) of B. Everett Jordan Reservoir. This site was initially selected as part of a DWQ/USGS cooperative pristine streams study. This site is atypical for Triassic Basin streams, in that it has higher gradient, and has a diverse substrate composed mostly of boulders and rubble. Seasonal changes in EPT taxa richness values have been recorded from this site. No bioclassifications are now being assigned to Beartree Creek. An undescribed species of crayfish (Cambarus, subgenus Cambarus), known only from intermittent streams, has been collected from this location.

White Oak Creek, SR 1603
Data were collected from this location only during the 1998 basinwide monitoring program. This site was selected to replace the White Oak Creek location at NC 751 near Jordan Lake. White Oak Creek at this site is about 5 meters wide and has a substrate composed of coarse, shifting sand. Recently deposited sand has created new bars within the channel and overbank deposition of sand is severe in many places within the riparian zone. Sedimentation within this reach of White Oak Creek may be a result of construction activities along NC. EPT taxa richness and abundance is very low, perhaps reflecting flow patterns typical of Triassic Basin streams or poor instream habitat. No bioclassification was given to this site.

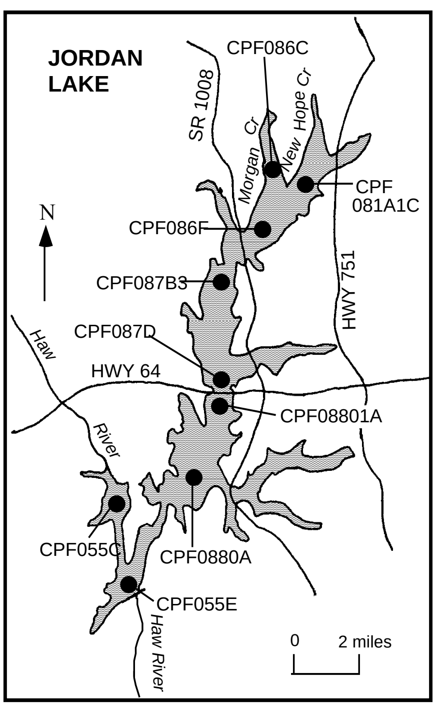
OTHER DATA
Haw River Assembly. The Haw River Assembly has 3 monitoring locations in this subbasin, 2 sites that are within similar reaches sampled by DWQ. Unfortunately, direct comparison of benthic macroinvertebrate data is not possible due to differences in level of identification.

LAKE ASSESSMENT PROGRAM

B. Everett Jordan Reservoir

COUNTY:	Chatham	**CLASSIFICATION:**	WS-III IV B NSW CA
SURFACE AREA:	14300 acres (5787 hectares)	**MEAN DEPTH :**	16 feet (5 meters)
VOLUME:	265 $x10^6m^3$	**WATERSHED**:	1700 mi^2 (4403 km^2)

B. Everett Jordan Reservoir (Jordan Lake) was created by the United States Army Corps of Engineers for various uses including flood control, fish and wildlife habitat, recreation, and water supply. Initial filling of the lake did not occur until late 1981. Jordan Lake is used extensively for boating, swimming, fishing and other types of recreation. Several municipalities have approval to use water from the lake. Major inflows into Jordan Lake are the Haw River and New Hope and Morgan Creeks. The Haw River accounts for 70-90% of the annual flow of Jordan Lake with an average hydraulic retention time of five days. The New Hope arm of the lake has an average hydraulic retention time of 418 days. Maximum depth of Jordan Lake is approximately 66 feet (20 meters). Land uses in the watershed include forest, agriculture, and urban centers with much of the area undergoing development for industrial and residential purposes. Many point and nonpoint sources discharge into the tributaries of the lake.



Jordan Lake was sampled in June, July and August, 1998 by DWQ. Physical and chemical lake data for Jordan Lake are presented in Appendix L2. Secchi depths were generally ≤1 meter in June and July and >1 meter in August. The highest total phosphorus value (0.11 mg/L) was observed at the sampling site downstream of the HWY 64 bridge (CPF081A1C). Chlorophyll *a* values for Jordan lake ranged from <1 to 33 µg/L. Fecal coliform bacteria concentrations were <10 colonies per 100 ml at the four swimming areas (Vista Point, Ebenezer, Seaforth and Poplar Point) as well as at each of the lake sampling sites. Metals were below DWQ laboratory detection levels except for zinc (range = 14 to 42 µg/L), copper (range = 2.2 to 3.9 µg/L), manganese (range = 33 to 430 µg/L) and aluminum (range = 100 to 2300 µg/L). The values for manganese were greater than the state water quality standard of 200 µg/L in the Morgan Creek and New Hope Creek arms as well as at the sampling site upstream of the SR 1008 bridge (CPF086F) in June, July and August. Jordan Lake was eutrophic in June and July according to the calculated NCTSI scores (Table L12).

According to Mr. Kelvin Kreech, Superintendent of the Cary/Apex Water Treatment Plant, in 1995 and 1996 there were several hundred complaints filed with the Town of Cary regarding taste problems associated with the drinking water supply and algal blooms. The town has since corrected this problem by improving the raw water treatment process and less than ten complaints are currently filed per year. Jordan Lake is sampled twice a week by the Town of Cary from late April to late September, and once per month the remainder of the year. This sampling data is available to the public upon request. There have been no major changes in water clarity observed in Lake Jordan. Turbidity values usually measure 5 to 15 NTUs, however, following the major rainfall events related to El Nino in the Winter of 1997 - 1998, turbidity values ran from 25 to 30 NTUs. No major problems have been encountered in processing raw water from Jordan Lake by the water treatment plant. During March through June, the plant treats for algal blooms and treats for filter clogging algae in mid to late summer. Treatment for manganese is conducted from late May to September. Water is drawn from the lake from two depths, nine feet and 19 feet. From May through September, water cannot be drawn from the lower intake due to hypoxic or anoxic conditions at that level. No aeration system is utilized in the lake. There have been no reports of fish kills in Jordan Lake and no observations of floating algal mats or scums. Development is increasing in the lake's watershed on the Chatham County side. The Cary city limits extend to the shore of the lake on the Wake county side and development is increasing there, as well. Cary is working on implementing watershed protection within its jurisdiction to protect its water supply (Kelvin Kreech, Plant Superintendent, Cary/Apex Water Treatment Plant. pers. com.).

There has been an increase in aquatic macrophytes in some areas of the lake, The Crosswinds boat launch area (21 miles southwest of Raleigh off US 64 in Chatham county) has experienced an increase in aquatic plants according to Mr. Mike Seigh, North Carolina Parks and Recreation. In 1998 at the Vista Point swimming area, an outbreak of shigella occurred during the summer of 1998. This area was closed to the public for one month following the outbreak (Mike Seigh, Park Superintendent, Jordan Lake State Park, pers. com.). According to Shari Bryant, District 5 Fisheries Biologist, no problems have been reported fish malformation diseases or parasites in the mainstem of Jordan Lake. Some samples taken above the SR 1008 bridge have shown some malformed fish, however (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com)

Jordan Lake was previously sampled by DWQ in 1994, 1995, 1996 and 1997. Physical and chemical water data for this lake are presented in Appendix L2. Water quality data collected in May, June, July, August and September, 1997 indicated the presence of eutrophic conditions. Surface dissolved oxygen measurements were elevated, particularly in the Haw River Arm (CPF055C) and near the dam (CPF055E) in August and September. The greatest chlorophyll *a* value was 44 µg/l at the sampling site located in the upper end of the lake upstream of the SR 1008 bridge (CPF086F) in September. The greatest total phosphorus value (0.12 mg/L) was observed at CPF086C in the Morgan Creek arm in May and at CPF086F in June.

In 1996, Jordan Lake was sampled from June through September. NCTSI scores indicated that the lake was eutrophic each time it was sampled (Table L12). The greatest total phosphorus value for Jordan Lake in 1996 was observed in the New Hope Creek arm of the lake

(CPF081A1C) in September (0.22 mg/L). The greatest chlorophyll *a* values were observed in the New Hope Creek arm and Morgan Creek arm (CPF086C) in August (110 µg/L).

A water quality study of Jordan Lake was conducted in 1996 and 1997 for the purpose of characterizing current water quality conditions in the lake. Sampling results indicated elevated nutrient levels in both 1996 and 1997. The greatest nutrient concentrations were observed in the Haw River and New Hope River arms of the lake. Seventeen percent of the chlorophyll *a* values were greater than the state water quality standard of 40 µg/L, and 89% of the phytoplankton samples collected contained algal concentrations at bloom levels. Eutrophic conditions were found at all sampling sites during both years of this study based on NCTSI scores. Conditions observed in 1996 and 1997 continued to indicate nutrient-enriched conditions. Increasing population and development in the watershed along with increased discharges from wastewater treatment plants within the drainage area of the lake will likely contribute to continuing eutrophic conditions in Jordan Lake (NCDWQ, December 1998).

Jordan Lake was monitored by DWQ in July, 1995. Surface dissolved oxygen was greatest in the Haw River arm (CPF055C) where the concentration was 13.2 mg/L. Surface pH at this site was also elevated (9.4 s.u.). Secchi depths were less than one meter at all of the sampling sites. The greatest total phosphorus values (0.11 mg/L) were observed in the Haw River arm and in the New Hope Creek arm.

On August 2, 1994, no chlorophyll *a* levels were present above the state standard of 40 ug/L. Algal blooms were observed in the Haw River arm near station CPF055C with greenish water present and elevated surface dissolved oxygen and pH values of 11.4 mg/L and 9.3 s.u. respectively. The pH value of 9.3 s.u. was greater than the state standard of 9.0 s.u. Surface scum was present at the stations on New Hope and Morgan Creeks as well as low Secchi measurements. Physical measurements indicated stratified conditions at the deeper stations with anoxic conditions found below five meters.

Historical data collected at Jordan Lake from 1982 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L8. Secchi depths were lower at the sampling sites located in the upper end of the lake in the vicinity of the Morgan Creek and New Hope Creek arms. Total phosphorus, total organic nitrogen and chlorophyll *a* concentrations were also greater in the upper end of the lake as compared with areas of the lake.

Figure L8 . Jordan Lake Data Analysis, 1982 – 1998.

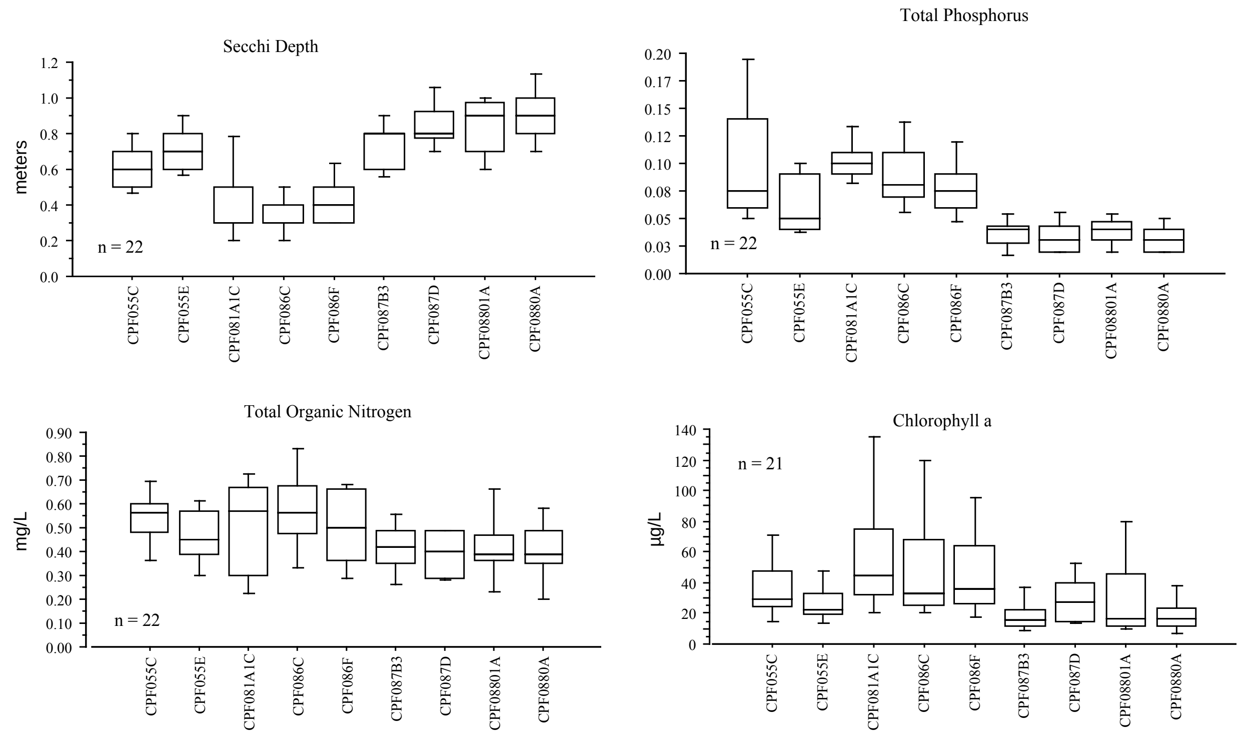


Table L12. Jordan Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Jordan Lake	980805	no score	0.04	0.40	n/a	0.5
Jordan Lake	980707	2.1[E]	0.06	0.30	22	0.6
Jordan Lake	980617	1.9[E]	0.05	0.33	22	0.7
Jordan Lake	970804	2.7[E]	0.06	0.44	23	0.7
Jordan Lake	970701	2.0[E]	0.04	0.42	19	0.7
Jordan Lake	970609	2.0[E]	0.07	0.30	16	0.6
Jordan Lake	960822	3.2[E]	0.05	0.47	61	0.7
Jordan Lake	960702	2.9[E]	0.05	0.43	44	0.7
Jordan Lake	960603	2.3[E]	0.05	0.35	32	0.8
Jordan Lake	950720	3.0[E]	0.07	0.53	11	0.7
Jordan Lake	940802	2.6[E]	0.05	0.53	21	0.8
Jordan Lake	930907	3.7[E]	0.07	0.49	31	0.4
Jordan Lake	920812	4.6[E]	0.07	0.72	42	0.4
Jordan Lake	910807	3.5[E]	0.06	0.57	26	0.5
Jordan Lake	900802	4.5[E]	0.09	0.56	40	0.
Jordan Lake	890801	4.0[E]	0.08	0.48	45	0.5
Jordan Lake	870825	3.9[E]	0.08	0.60	26	0.5
Jordan Lake	860807	5.7[E]	0.15	0.63	1	0.5
Jordan Lake	850814	3.8[E]	0.08	0.56	33	0.6
Jordan Lake	840816	3.3[E]	0.07	0.43	56	0.8
Jordan Lake	830803	4.4[E]	0.11	0.58	40	0.6
Jordan Lake	820810	4.5[E]	0.08	0.56	80	0.6

FISH TISSUE

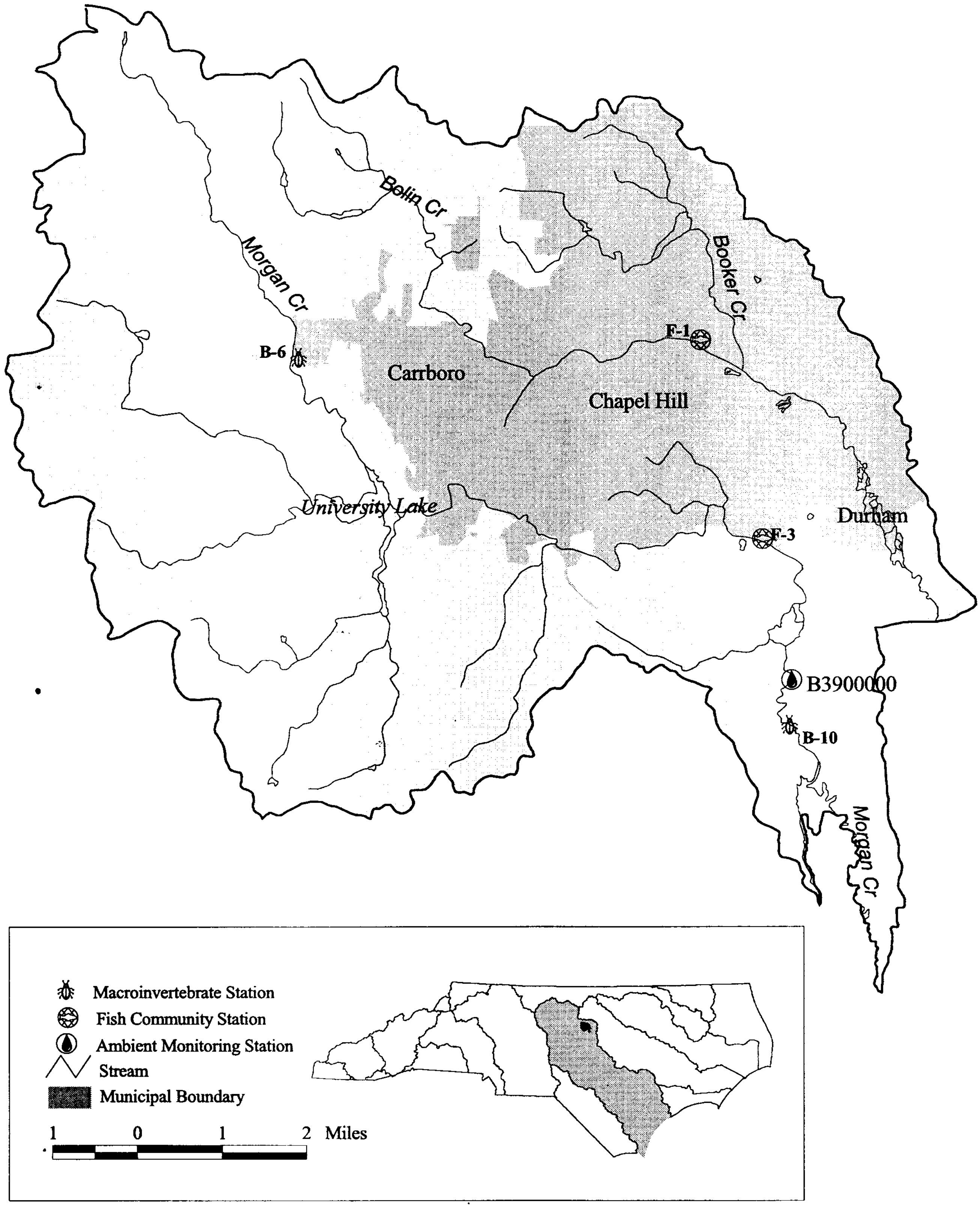
Lake Jordan near Farrington

Fish tissue samples were collected from the Lake Jordan near Farrington during July 1998. Of the 24 samples analyzed for metals contaminants, one largemouth bass sample contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.

Lake Jordan near Dam

Fish tissue samples were collected from the Lake Jordan near the dam during July 1998. Twenty two samples were analyzed for metals contaminants. All metals results were lower than EPA and FDA/NC limits.

Cape Fear River 030606



CAPE FEAR SUBBASIN 030606

DESCRIPTION
Cape Fear River subbasin 06 contains the entire Morgan Creek catchment, from its headwaters to the Morgan Creek Arm of B. Everett Jordan Reservoir. This very small subbasin contains the urban and large suburban sections of Chapel Hill in Orange County. Relative to other subbasins in the Cape Fear River Basin, subbasin 06 contains a large proportion of urban and built-up land use. This type of land use includes residential areas, institutional sites, construction sites and golf courses. Forest and agriculture, including pasture and cultivated cropland, also make up portions of the subbasin. Streams in the western portion of this subbasin (headwater reaches of Morgan and Bolin Creeks) are within the Slate Belt and typically have rocky substrates. These streams change parent geology and become much sandier as they flow through the Triassic Basin before reaching Jordan Lake. Small streams in this subbasin typically stop flowing during low-flow periods due to the lack of groundwater recharge. USGS has estimated streams with catchment areas of 18 square miles or less within the Slate Belt will have zero 7Q10 flows during summer low-flow periods (USGS 1993).

There are 7 permitted dischargers in this subbasin. Most of these are very small, with the largest being the OWASA/Mason Farm WWTP. This facility has a permitted flow of 8.0 MGD into Morgan Creek.

OVERVIEW OF WATER QUALITY
The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-6	Morgan Cr*	Orange	NC 54	Excellent (w)	Excellent (w)
				Good (s)	-
B-10	Morgan Cr*	Orange	SR 1726	Fair (s)	Fair (s)
FISH					
F-1	Bolin Cr	Orange	off SR 1750	no sample	Poor
F-3	Morgan Cr	Orange	SR 1900	no sample	Poor

(w) winter collection, (s) summer collection
*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES DATA
University Lake

Ambient water quality data are being collected from one location in this subbasin: Morgan Creek at SR 1726 near Farrington. This collection location is below the OWASA/Mason Farm WWTP. This facility has an instream waste concentration of 93% during 7Q10 flow conditions. Water quality conditions at this location are similar to those recorded during the 1988-1993 collection period and suggest that upgrades at the OWASA facility prior to 1988 have improved water quality in this reach of Morgan Creek.

Benthic macroinvertebrate samples have been collected from three sites on Bolin Creek and four sites on Morgan Creek during basinwide and special surveys in 1993 and 1998. In both catchments, data illustrate a downstream decline in water quality. Good or Excellent water quality results are recorded from upstream sites in both catchments and water quality degrades as these two streams flow through urban and suburban sections of Chapel Hill. Poor NCIBI ratings were given to lower reaches of both Bolin and Morgan Creeks. No 5-year change in water quality (based on these benthic macroinvertebrate samples) was noted at most of these locations. The one exception to this are data from Bolin Creek at Village Road. Benthic macroinvertebrate data from this location resulted in a 5-year improvement in water quality (Good-Fair to Good). Fair and Poor bioclassifications using benthic macroinvertebrates were recorded from Little Creek and Meeting of the Waters Creek during both basinwide surveys in 1993 and 1998. Eutrophic water quality conditions and algal densities suggesting bloom conditions were recorded from University Lake during surveys conducted there in 1998.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

<u>Bolin Creek, off SR 1750</u>

Bolin Creek in the sampling area was estimated to be six meters wide with a sand and gravel substrate. Pools were small and infrequent in the segment. The fish community was assigned a Poor rating. The absence of sucker and intolerant species contributed significantly to the low rating, as did the high percentage (47%) of omnivores. In 1963 the WRC attempted to collect fish in roughly the same area, but their efforts yielded no fish. Bolin Creek was noted as "a very polluted stream" with grey water and foam.

<u>Morgan Creek, NC 54</u>

Benthic macroinvertebrates have been collected from this location six times and data have resulted in Good or Excellent bioclassifications. Morgan Creek at this location is about 7 meters wide and has a diverse substrate composed mostly of boulder and rubble. This site, which has a drainage area of approximately 8 square miles, is characteristic of the Slate Belt. Substantially lower EPT taxa richness and abundance values were recorded at this site during the July 1993 survey than either winter basinwide surveys. The lower EPT values are a response to very low flow conditions at this site in July and the rating should be considered as flow-affected.

<u>Morgan Creek, SR 1900 (below OWASA WWTP)</u>

Morgan Creek at this site was eight meters wide and had a sand substrate. There were no well developed riffles in the sample area. The tolerant redbreast sunfish (<u>Lepomis</u> <u>auritus</u>) and satinfin shiner (<u>Cyprinella</u> <u>analostana</u>) were the two most commonly collected fish in Morgan Creek. The high percentage of tolerant fish along with a low number of sucker species and a low percentage of species with multiple age classes were the main reasons for the Poor classification for the fish community at this site.

<u>Morgan Creek, SR 1726</u>

This is the ambient monitoring location on Morgan Creek above Jordan Lake. Fair benthos ratings have been given to this site on five occasions, including basinwide surveys in 1993 and 1998. The lower reach of Morgan Creek is within the Triassic Basin. However, flow is augmented by the OWASA WWTP creating a stream with more stable flow. Morgan Creek at this location is about 7 meters wide and has a substrate composed of sand and silt. Most of the benthic macroinvertebrates were collected from snag habitats in the current.

SPECIAL STUDIES

Benthic macroinvertebrates were collected from 10 locations in Orange County as part of a cooperative water quality monitoring program with the Town of Chapel Hill (B-980723). Nine of these locations also were sampled in 1993 (B-930930). These sites were selected to assess the effects of urban and/or stormwater runoff within this subbasin. These data found that water quality conditions deteriorate as Morgan Creek and Bolin Creek flow through urban sections of Chapel Hill. These data were similar to results of the 1993 investigation.

A Good bioclassification was found at Morgan Creek at NC 54 following extremely high flows due to Hurricane Fran. This site was part of a statewide assessment of Hurricane Fran impacts (B-970117). In 1994, Fair and Poor bioclassifications were given to sites on Morgan Creek above and below the OWASA facility. Data were collected from these locations as part of an investigation to assess the effects of dischargers.

OTHER DATA

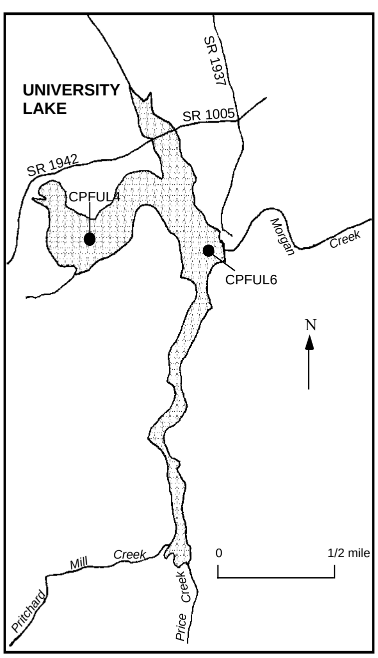
Town of Chapel Hill. The Town of Chapel Hill has initiated a water quality monitoring program that addresses stormwater management and growth. Water quality data have been collected monthly from nine locations since November, 1993. In addition, a Geographic Information System (GIS) has been developed and includes a land use/land cover layer. Water quality data from these Chapel Hill streams can be compared to level of development and percent of impervious surfaces (D. Wise, Draft Report Only).

Haw River Assembly. The Haw River Assembly coordinates a volunteer monitoring network within the Haw River catchment. The Haw River Assembly has 9 monitoring locations in this subbasin, 7 sites that are within similar reaches sampled by DWQ. Unfortunately, direct comparison of benthic macroinvertebrate data is not possible due to differences in level of identification.

LAKE ASSESSMENT PROGRAM

University Lake

COUNTY:	Orange	**CLASSIFICATION:**	WS-II NSW CA
SURFACE AREA:	205 acres (85 hectares)	**MEAN DEPTH :**	5 feet (2 meters)
VOLUME:	2.6 x$10^6$$m^3$	**WATERSHED**:	29 mi^2 (75 km^2)



University Lake was originally impounded in 1932. The lake was raised three feet (0.9 meter) in 1970 to increase its volume. Orange County Water and Sewer Authority leases the lake from the University of North Carolina to provide drinking water for the City of Chapel Hill. Recreational fishing and boating are allowed at this lake. Nearly three quarters of the watershed is forested with some agriculture and some low density residential development. Major tributaries to the lake include Morgan Creek, Phils Creek, Prices Creek, and Prichards Mill Creek. A public park with boat rental facility and launch area is located at this lake.

University Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data for University Lake are presented in Appendix L2. The highest dissolved oxygen concentrations each month were observed at the sampling site near the dam (CPFUL6). The highest value for chlorophyll *a* (45 µg/L) was observed at the upstream lake sampling site in July. A bloom sample collected near the dam in July had an algal biovolume of 34,472 mm^3/m^3 and an algal density of 231,368 units/ml, confirming the presence of a bloom Approximately 89% of the sample density was dominated by blue-green algas. In August, another algal bloom sample was collected at CPFUL6 due to elevated surface dissolved oxygen (10.1 mg/L) and surface pH (8.4 s.u.) observed at this site. Analysis of this sample determined that the algal biovolume was 97,860 mm^3/m^3 and algal density was 304,413 units/ml, which confirmed the presence of an algal bloom. Filamentous blue-green algas were dominant in this sample. Concentrations of metals were less than the applicable state water quality standards in June, July and August. University Lake was eutrophic in June and July (Table L13).

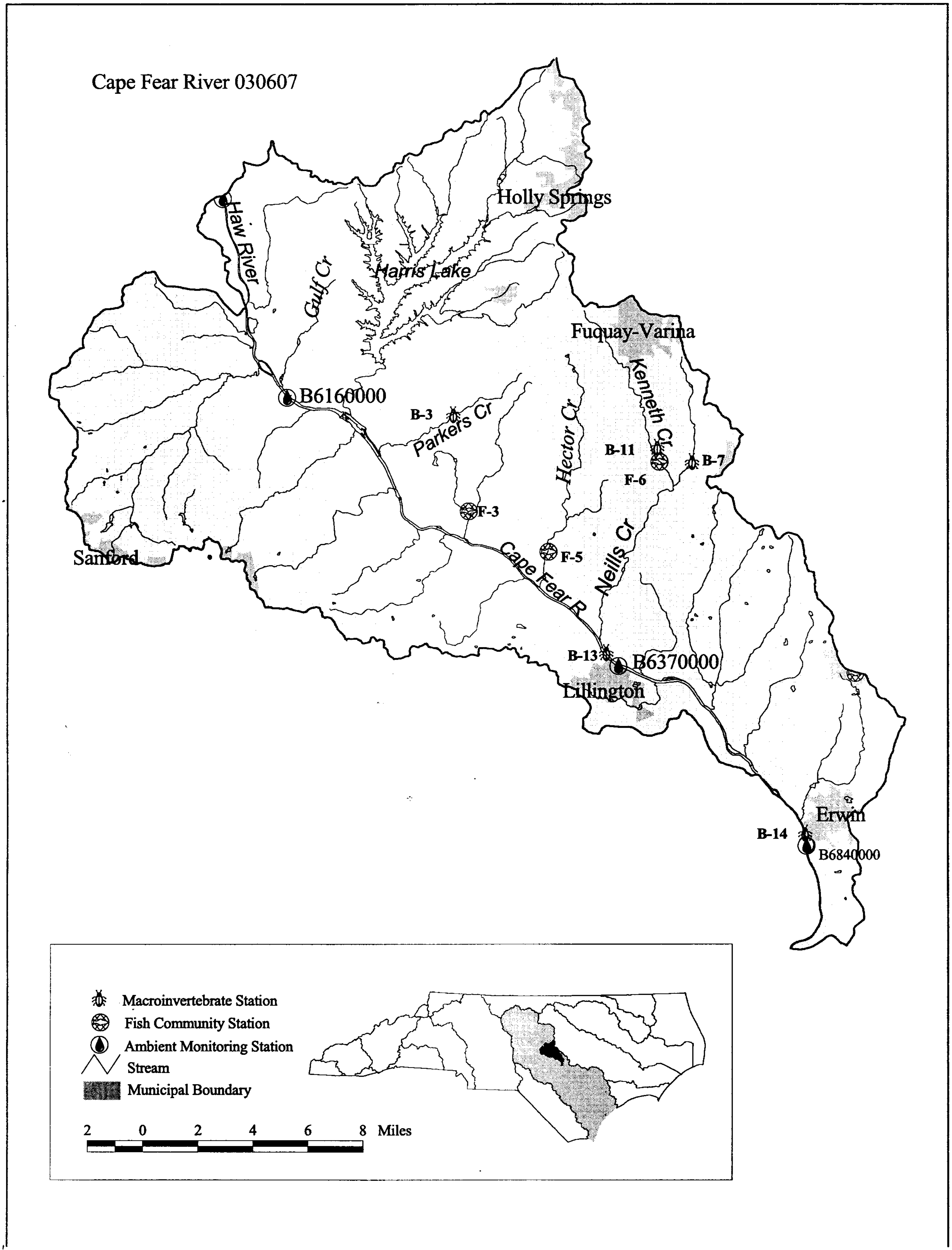
According to Mr. Doug Terry, Water Supply and Treatment Manager, Orange Water and Sewer Authority (OWASA), there are usually an average of ten complaints regarding taste and odor but most of these are related to the amount of chlorine in the water. During the spring and summer months, OWASA has experienced elevated chemical treatment costs associated with controlling constituents in the raw water that contribute to taste and odor problems. The water intake is kept above the thermocline (approximately two meters from the surface) to avoid problems with anoxic or hypoxic water. University Lake is sampled by OWASA laboratory personnel during the summer and fall months and lake profile sampling at one meter depth increments is performed at least once a week. Recently an automatic monitoring station was purchased and installed in the lake. The station samples the lake at preset depths and stores the data until it is retrieved via telephone. All data are available to the public upon request. The water in University Lake has a dirty brownish color (not muddy) and sometimes takes on a greenish tinge. Algal activity is also evident in this lake. Laboratory staff collect water samples and perform algae counts weekly or more often if required during the spring and summer months. During the spring and summer months, an increase in aquatic macrophytes, predominantly alligator weed (*Alternanthera philoxeroides*), occurs in the upper reaches of the lake. There have been no reports of fish kills or observations of distressed or malformed fish in the lake. University Lake's watershed is considered prime real estate and increased urbanization of the watershed has altered the water quality of the lake (Doug Terry, Water Supply and Treatment Manager, OWASA, pers. com.).

A fisheries survey was conducted at University Lake in 1996, according to Ms. Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries. The largemouth bass population was found to be in good condition as were the populations of other fish species in the lake (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com.).

Table L13. University Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
University Lake	980813	no score	0.07	0.50	n/a	0.6
University Lake	980720	2.5[E]	0.07	0.25	36	0.5
University Lake	980603	1.2[E]	0.04	0.34	20	0.9

University Lake	930708	2.7[E]	0.07	0.58	10	0.5
University Lake	900830	2.8[E]	0.07	0.40	26	0.7


Cape Fear River 030607
Holly Springs
Haw River
Gulf Cr
Harris Lake
Fuquay-Varina
Kenneth Cr
B6160000
B-3
Parkers Cr
Hector Cr
B-11
B-7
F-6
F-3
Neills Cr
Sanford
Cape Fear R
F-5
B-13
B6370000
Lillington
Erwin
B-14
B6840000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 6 8 Miles

CAPE FEAR SUBBASIN 030607

DESCRIPTION

Subbasin 07 contains approximately 25 river miles of the Cape Fear River from near the confluence of Lick Creek in Lee County (approximately 2 miles below where the Cape Fear River begins in subbasin 11 at the confluence of the Haw and Deep Rivers) to near Buies Creek in Harnett County. This subbasin contains many tributary streams that are completely contained within the Sandhills, although other streams within this subbasin have piedmont or coastal plain characteristics as well. The sandy soils and high permeability rates of Sandhill soils allow for greater groundwater recharge than Slate Belt or Triassic Basin streams. Many streams within this ecoregion typically have 7Q10 flow rates greater than zero.

The subbasin is primarily forested, although agriculture (including pasture and cultivated cropland) accounts for a significant amount of land use. The towns of Sanford, Fuquay-Varina and Lillington are the largest urban areas in the subbasin. Parkers Creek, Avents Creek and Hector Creek in Raven Rock State Park are HQW. There are 16 permitted dischargers in subbasin 07 and six of these facilities have permitted flows of 0.5 MGD or greater. These facilities include six municipal WWTPs (Fuquay-Varina, Angier, Holly Springs, Buies Creek and Lillington, Erwin) and the CP&L Cape Fear Steam Electric Plant and Swift Textiles.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
Benthos				**Bioclassification**	
B-3	Parkers Cr	Harnett	SR 1450	Good (w)	Good-Fair (w)
				Good (s)	Good-Fair (s)
B-7	Neils Cr	Harnett	SR 1441	Fair (w)	Good-Fair (w)
B-11	Kenneth Cr	Harnett	SR 1441	Poor (w)	Poor (w)
B-13*	Cape Fear R	Harnett	US 401	Good (s)	Good (s)
B-14	Cape Fear R	Harnett	NC 217	Excellent	Excellent
FISH				1994	
F-5	Hector Cr	Harnett	SR 1412	no sample	Fair
F-6	Kenneth Cr	Harnett	SR 1441	Poor	Poor

(w) winter collection, (s) summer collection
*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES DATA

Harris Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Cape Fear R at Lillington	1998	22	1	0	EPA mercury limit exceeded in 1 bowfin sample

Ambient water quality is currently be monitored at three mainstem Cape Fear River locations in this subbasin: NC 42 near Corinth, US 401 near Lillington, and at NC 217 near Erwin.. These locations are the most upstream ambient monitoring locations in the Cape Fear River below the confluence of the Haw and Deep Rivers. There does not appear to be any long-term changes in water quality at these two locations compared to data collected from the 1993 basinwide program. Sediment oxygen demand (SOD) tests conducted in a 3.6 mile stretch of the Haw

River and Cape Fear River in Chatham County in November, 1998 indicated significant SOD in the reach with average rates ranging from –1.3 to 11.8 gr/m^2/day at 20^{o}C.

Bioclassifications based on benthic macroinvertebrate data for the Cape Fear River at Lillington have been Good, with only one exception, since the first survey in 1983. This includes basinwide surveys in 1993 and 1998. Fish tissue samples also were collected from the Cape Fear River at Lillington during 1998. Twenty-six specimens were analyzed for metal contaminants. Only one bowfin had mercury exceed the EPA screening value. In addition, undetectable levels of chlorinated pesticides and PCB arochlors were found from a single catfish sample from this location. The Cape Fear River near Erwin had an Excellent benthos bioclassification in 1998 and in 1993.

A 5-year decline in water quality was found at Parkers Creek based on basinwide benthos surveys conducted in 1993 and 1998. This decline was evident during surveys conducted during both winter and summer surveys at this location. Changes in land use activities and/or nonpoint source runoff in the catchment above the collection location may have accounted for the decline in water quality. There are no permitted point source facilities in the catchment. A 5-year improvement in bioclassification is noted at Neils Creek (Fair in 1993 to Good-Fair in 1998), although only one additional EPT taxa was collected during the 1998 survey to account for the change in bioclassification. A fish community sample was collected from Hector Creek and the NCIBI score resulted in a Fair rating. The only Poor water quality indicated by macroinvertebrates in this subbasin was for Kenneth Creek at a location below the Fuquay-Varina WWTP (1.2 MGD). This site also received a Poor NCIBI score.

Harris Lake was most recently monitored by DWQ in 1996. NCTSI data resulted in mesotrophic conditions, although dense growths of Hydrilla were observed in the White Oak Creek portion of the reservoir.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Parkers Creek, SR 1450

Parkers Creek, which is classified as High Quality Waters, is a tributary of the Cape Fear River near Lillington. The Parkers Creek catchment is approximately 8.8 square miles and appears to be mostly forested. However, the land use at SR 1450 is primarily pasture and the riparian zone has been reduced to 1-3 meters in width. These conditions have allowed animals direct access to the stream. In addition, field teams have noted severe bank erosion. This small stream is about 4-5 meters wide and had a substrate composed mostly of gravel and sand. Benthos samples were collected from this site during winter and summer surveys during basinwide surveys in both 1993 and 1998. Bioclassifications were lower during both surveys in 1998 (Good-Fair) compared to data collected in 1993 (Good). It appears that land use activities in this catchment have resulted in nonpoint source impacts to the benthic fauna at this location.

Hector Creek, SR 1412

Hector Creek at SR 1412 was a seven meter wide stream with a predominantly bedrock substrate. The large areas of bedrock prevented significant pool formation and provided minimal cover for fish. NCIBI metrics that indicated the largest shortfalls in the fish community were the number of intolerant species, the percent of tolerant fish, and the percent of insectivores. A 1962 sample here by the WRC resulted in 10 species being collected from this shallow stream.

Neils Creek, SR 1441
Neils Creek at this location is about 5 meters wide and has a substrate composed mostly of coarse sand and gravel. The current is very swift at this site resulting in little accumulation of FPOM in riffles, typical of the Sand Hills. This site is located above the confluence with Kenneth Creek. Basinwide surveys have been conducted at this location in 1993 and 1998. Benthic macroinvertebrate data from this site in 1998 resulted in a Good-Fair bioclassification and a 5-year improvement in water quality (Fair in 1993). However, this marginal change is primarily due to a better biotic index value in 1998 as the EPT taxa richness values were very similar.

Kenneth Creek, SR 1441
Kenneth Creek has a catchment area of 16.5 square miles at the confluence with Neils Creek. The Kenneth Creek catchment is mostly forested, although the headwater sections drain urban and suburban sections of Fuquay-Varina. In addition, the Fuquay-Varina WWTP (1.2 MGD) discharges to this stream. Kenneth Creek at SR 1441 is about 8 meters wide and has a substrate composed mostly of coarse sand. Prolific growths of Aufwuchs were found at this site during both surveys. Poor benthos bioclassifications were given to this location in 1993 and 1998.

The fish community at this site was rated Poor in 1994 and 1998. No sucker or intolerant species were collected during either of the sampling events. The 1962 WRC sampling crew collected 13 total species, including two species of suckers, from this site and described Kenneth Creek as primarily a minnow stream.

Cape Fear River, US 401 near Lillington
Benthic macroinvertebrates have been collected from this ambient monitoring location eight times, including basinwide surveys in 1993 and 1998. These surveys have resulted in Good bioclassifications seven times with EPT values ranging from 28 to 36 taxa during these surveys. The river at this location is very wide and wadable under normal flow conditions. The substrate is dominated by rubble and boulders, although some sedimentation is evident along the banks. EPT abundance values are very high at this location and overwhelmingly dominated by filter-feeding caddisfly taxa (esp. Macrostemum). This particular caddisfly is found in large rivers throughout North American and is a very effective filter-feeder of very small particles because of the fine size of their nets.

Fish tissue samples were collected from here during September 1998. Of the 22 samples analyzed for metals contaminants, one bowfin sample contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits. One channel catfish sample was also analyzed for chlorinated pesticides and PCB arochlors. Results showed undetectable levels of these contaminants in the catfish tissue.

Cape Fear River, NC 217 near Erwin
The Cape Fear River at NC 217 near Erwin is fairly shallow where a series of rapids are present on one side of a river island, allowing easy collection of benthos samples. Most of the river in

this section is deeper and inaccessible when wading. The drainage area for the river above the confluence with the Upper Little River is 3524 square miles. Currents here are swift and this is reflected in the diverse benthic fauna found in both 1993 and 1998. The macroinvertebrate data indicated Excellent water quality both years. The collection site is below the Erwin WWTP (1.2 MGD) discharge and Swift Textiles (2.5 MGD), but above the Dunn WWTP (3.75 MGD). It is below the Upper Little River, which also had an Excellent benthos bioclassification in 1998.

SPECIAL STUDIES

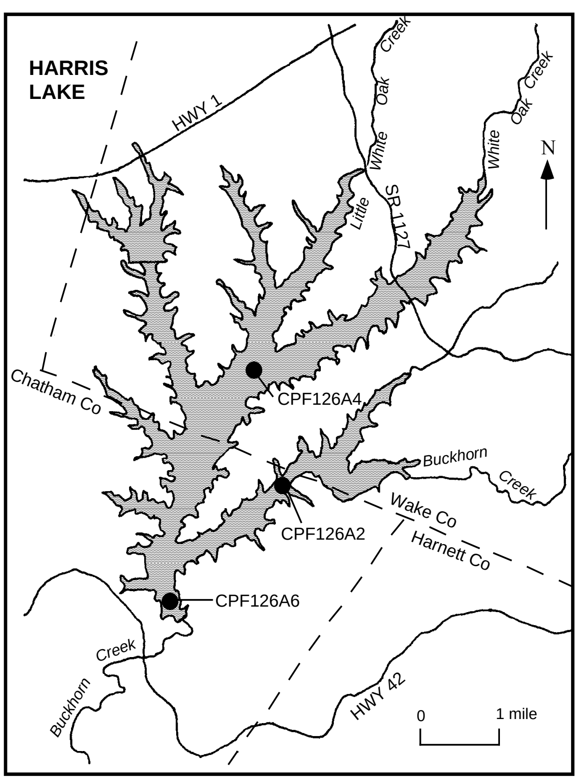
Benthic macroinvertebrate samples were collected from two sites on Kenneth Creek, above and below the Fuquay-Varina WWTP, in 1998. Each site is less than 3 meters wide. Taxa richness values were similar at each, and similar to data from 1990. However, data from these two locations could not be used to assign a rating.

A fish community sample was collected from Avents Creek in September 1998 as part of a statewide reference stream study. The stream received only a Fair rating.

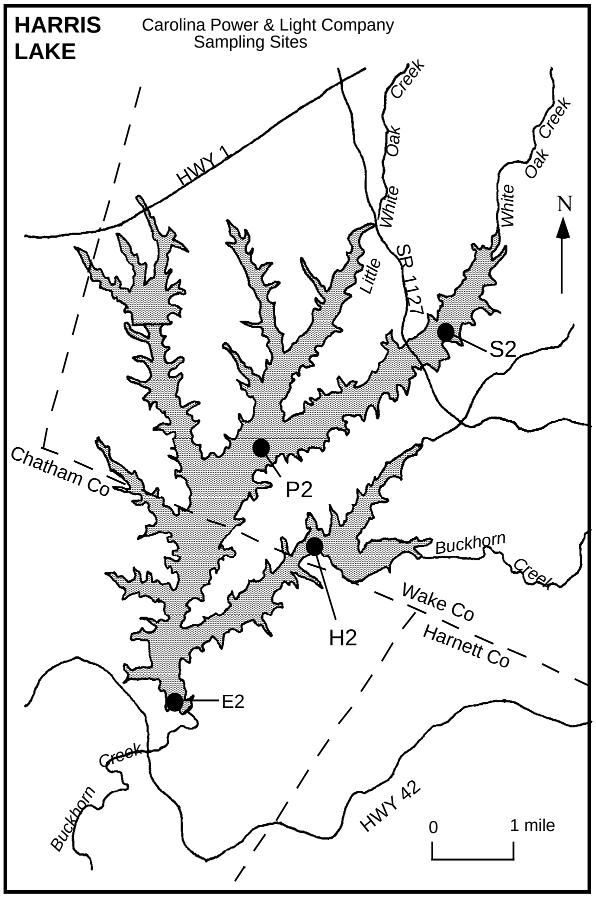
<u>Harris Lake</u>

COUNTY:	Chatham	**CLASSIFICATION:**	WS V
SURFACE AREA:	4150 acres (1680 hectares)	**MEAN DEPTH :**	20 feet (6 meters)
VOLUME:	$10.1 \times 10^6 m^3$	**WATERSHED**:	70 mi^2 (181 km^2)

Harris Lake is an impoundment constructed in 1983 to provide cooling water for the Shearon Harris Nuclear Power Plant as well as to provide public recreation. The lake is owned by Carolina Power and Light (CP&L), which conducts monitoring of the chemical, physical, and biological parameters. Harris Lake is located on Buckhorn Creek. Other significant tributaries to the lake include White Oak Creek, Little White Oak Creek, Thomas Creek, and Tom Jack Creek. Maximum depth is 20 feet (six meters) and the shoreline length is 40 miles (64 kilometers). The average residence time is 28 months. The watershed, characterized by rolling hills, consists primarily of forest and agriculture.



Harris Lake was most recently monitored by DWQ on July 25, 1996. Physical and chemical data collected in 1996 are presented in Appendix L2. Chlorophyll *a* values ranged from 19 µg/L in the upper end of the lake (CPF126A4) to 31 µg/L in the Buckhorn Creek arm (CPF126A2). Fecal coliform bacteria concentrations were all below the laboratory reporting level of 10 colonies per 100 ml. A dense growth of aquatic macrophytes, including *Hydrilla sp.*, was observed in the White Oak Creek portion of the lake making boat travel into the most upstream portion of this arm exceptionally difficult. Harris Lake had an NCTSI score of -0.9, indicating that this lake was mesotrophic on the day it was sampled (Table L14).



Harris Lake is also routinely monitored by CP&L's Environmental Services Section. In 1996, CP&L monitored this lake in January, March, May, July, September and November for water quality parameters (physical measurements and water chemistry) and chlorophyll *a* concentrations. Also during these months, Harris Lake was surveyed for the presence of Zebra mussels (*Dreissena polymorpha*). In May and November, surveys were conducted for Asiatic clams (*Corbicula* sp.) and an aquatic vegetation survey was conducted in November. Based on CP&L data analysis, chlorophyll *a* concentrations during 1996 were not greater than 40 µg/L and no nuisance algal blooms were observed in the reservoir. In 1996, the annual mean total phosphorus concentrations were greater at Station E2 as compared with concentrations at Stations H2 and P2. The annual mean total nitrogen concentrations were greater in Harris Lake during 1996 as compared with 1992, 1993 and 1995 annual mean concentrations (CP&L, 1997).

According to Mr. Ronald Hobbs, Senior Analyst, Environmental Services Section, Carolina Power & Light Company, there have been no problems with fish kills, nuisance growth of aquatic macrophytes or algal blooms in Harris Lake. Construction activities off of US 1 in the vicinity of the lake by the North Carolina Department of Transportation has not resulted in any noticeable changes to the water quality of the lake (Ronald Hobbs, Senior Analyst, Environmental Services Section, Carolina Power & Light Company, pers. com.).

Historical data collected at Harris Lake from 1987 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L9. Secchi depth was similar at the three sampling sites from 1987 through 1998. Total phosphorus values were greatest at the sampling site near the dam (CPF126A6) while total organic nitrogen values were greatest at the sampling site located in the upper end of the lake (CPF126A4). Chlorophyll *a* values were similar at the upper lake sampling site and the site located in the Buckhorn Creek arm (CPF126A2) and slightly greater at the sampling site located near the dam.

Figure L9. Harris Lake Data Analysis, 1987 - 1998.

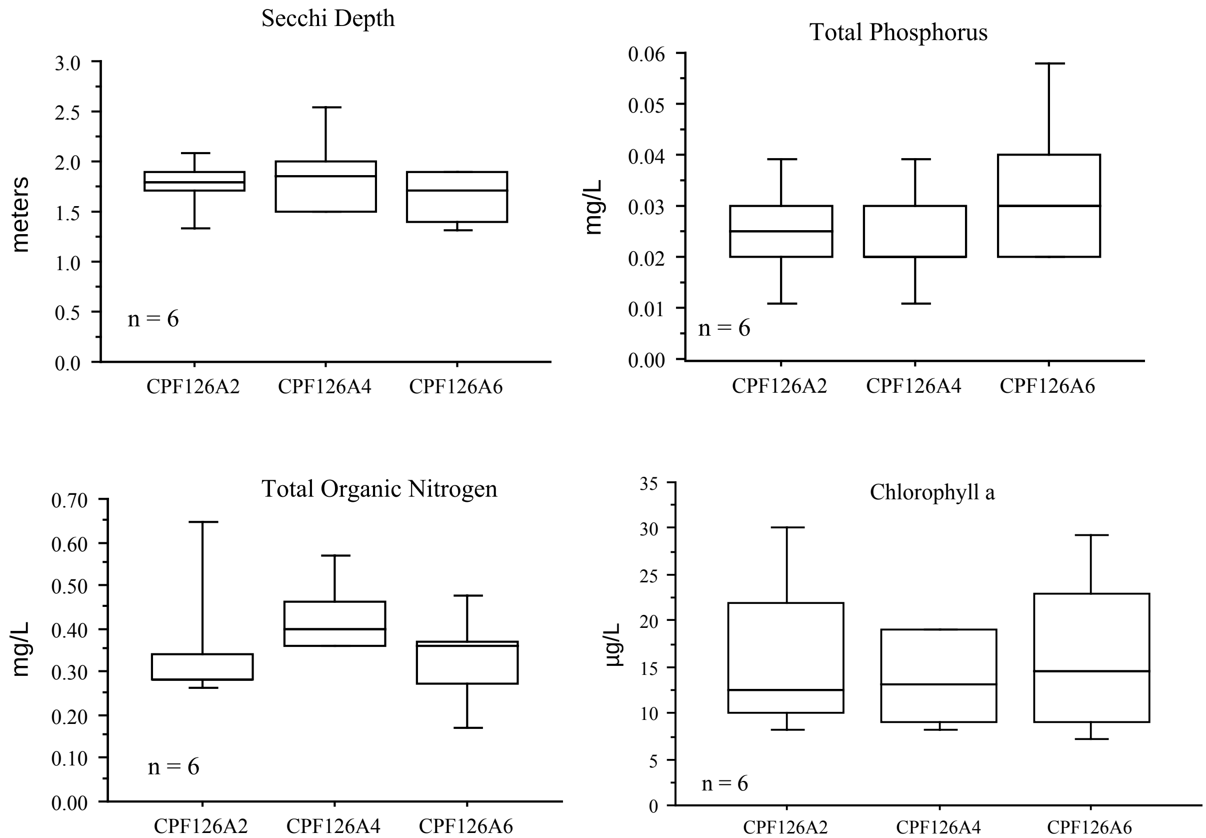
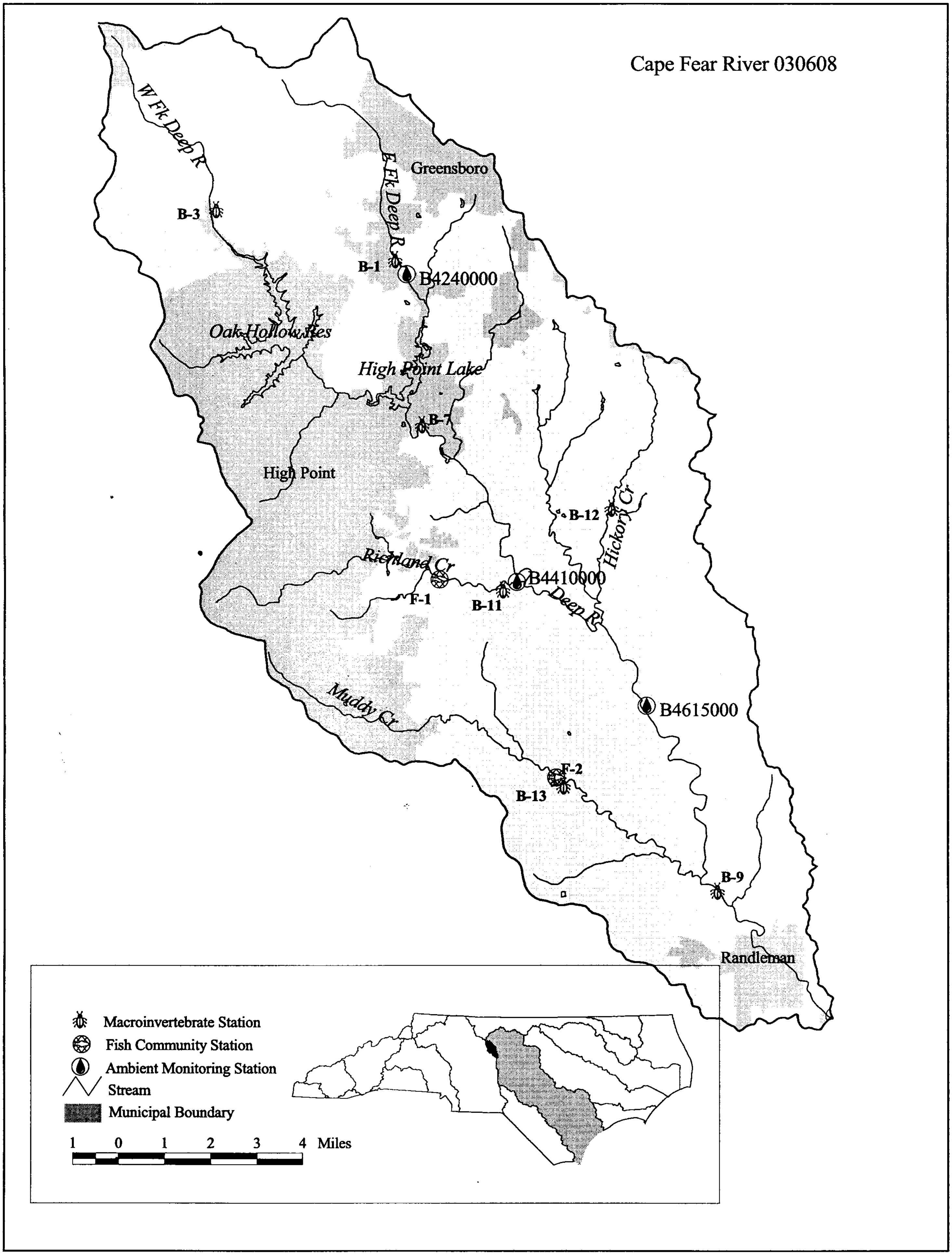


Table L14. Harris Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Harris Lake	960725	-0.9[M]	0.01	0.27	24	1.4
Harris Lake	930826	-0.2[M]	0.02	0.58	9	2.1
Harris Lake	910723	-0.5[M]	0.02	0.34	11	1.7
Harris Lake	900829	-0.3[M]	0.03	0.38	9	2.0
Harris Lake	890807	0.9[E]	0.05	0.35	15	1.5
Harris Lake	870805	0.3[E]	0.03	0.31	24	1.8



Cape Fear River 030608
W Fk Deep R
E Fk Deep R
Greensboro
B-3
B-1
B4240000
Oak Hollow Res
High Point Lake
B-7
High Point
B-12
Hickory Cr
Richland Cr
F-1
B-11
B4410000
Deep R
Muddy Cr
B4615000
F-2
B-13
B-9
Randleman
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
1 0 1 2 3 4 Miles

CAPE FEAR SUBBASIN 030608

DESCRIPTION

Cape Fear subbasin 08 is located in the piedmont ecoregion, and contains the cities of High Point, parts of Greensboro and Randleman. This subbasin comprises the headwaters of the Deep River. Most of subbasin 08 is located within the Carolina Slate Belt, and most of the Deep River has a rocky substrate. Tributary sites, however, are usually deeply entrenched with a substrate dominated by sand and gravel. Subbasin 08 contains a mixture of urban, residential and agriculture land use. Urban residential land use is increasing due to growth in both High Point (Richland Creek, Muddy Creek) and Greensboro (West Fork Deep River, Hickory Creek).

There are many small dischargers in this subbasin (21), but only two facilities with permitted flows greater than 1 MGD. Highpoint Eastside WWTP is permitted to discharge 16 MGD to Richland Creek, (just above its confluence with the Deep River) and the Randleman WWTP is permitted to discharge 1.7 MGD directly to the Deep River.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1	E Fk Deep R	Guilford	SR 1541	Fair	Fair
B-3	W Fk Deep R	Guilford	SR 1850	Good-Fair	Good-Fair
B-9*	Deep R	Randolph	US 220 Bus	Good-Fair	Good-Fair
B-11*	Richland Cr	Guilford	SR 1145	Fair	Poor
B-12	Hickory Cr	Guilford	SR 1131	Fair	Not Rated
B-13	Muddy Cr	Randolph	SR 1929	Fair	Not Rated
				1994	
F-1	Richland Cr	Guilford	SR 1154	no sample	Poor
F-2	Muddy Cr	Randolph	SR 1929	Fair	Poor

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

High Point Lake, Oak Hollow Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Muddy Creek nr Glenola	1994	4	0	0	No samples excceeded criteria
FT-2	Oak Hollow Lake	1998	18	2	0	EPA mercury limit exceeded in 2 bass samples

The High Point WWTP affects water quality in both Richland Creek (Poor) and portions of the Deep River. Both of these streams, however, are also affected by urban runoff with Fair benthos ratings upstream of the discharge. Fish data assigned a Poor rating to Richland Creek above the High Point discharge. The Deep River at Randleman has a consistently Good-Fair rating over the last 5 years.

Urban runoff also affects many other small streams in this area. It is interesting to contrast the East Fork of the Deep River (urban/residential) with the West Fork of the Deep River (agricultural). Macroinvertebrate data clearly shows worse water quality in the East Fork (Fair) than in the West Fork (Good-Fair). Increased development in both High Point and Greensboro can be expected to have negative effects on the water quality of small streams in this subbasin.

Benthic macroinvertebrate data indicated stable water quality at most sites in subbasin 08 since 1993, although Richland Creek declined from Fair in 1993 to Poor in 1998. Low flow in Hickory Creek and Muddy Creek prevented any assessment of water quality changes at these sites during 1998, although a fish tissue sample from Muddy Creek did not record any metals above criteria levels. Long-term analysis of data has shown improvements at 3 sites on the Deep River, associated with upgrades of wastewater treatment plants. The most substantial change occurred for the Deep River at Randleman: Poor in 1985, Fair in 1986 and 1987, Good-Fair in 1993 and 1998.

Two lakes have been evaluated in subbasin 08: High Point Lake and Oak Hollow Lake. Since 1993, High Point Lake has usually been evaluated as either eutrophic or mesotrophic, while Oak Hollow Lake has usually been evaluated as mesotrophic. Algal blooms have been reported from both lakes (principally due to small cyanophytes), causing taste or odor problems at water treatment facilities. The higher levels of algal problems in High Point Lake may reflect the more developed catchment, paralleling differences seen in the benthos for the East Fork vs. the West Fork Deep River. Both lakes also had increased turbidity associated with upstream road construction activities. Fish populations (especially bass and crappie) are healthy in High Point Lake, but an apparent decline has been reported for game fish in Oak Hollow Lake. This decline may be associated with increased competition (with white perch) or loss of aquatic macrophytes. Fish tissue samples (metals) from Oak Hollow Lake indicated few problems, although two out of 18 samples were above the EPA Hg screening level.

RIVER AND STREAM DATA, 1993-1998
BASIN MONITORING

East Fork Deep River, SR 1541
This site is about 9 meters wide with a sandy substrate. The July 1998 samples, however, included a rocky upstream riffle that had not been sampled in 1993. Habitat problems include some channelization, limited fish cover, infrequent pools and riffles, and bank erosion. The East Fork of the Deep River drains a more urban catchment than the West Fork, and this is reflected in both water chemistry and aquatic biota. Conductivity at the time of the invertebrate sampling was 136 µmhos/cm for the East Fork, but only 82 µomhos/cm for the West Fork. Likewise, the East Fork has consistently received a Fair benthos rating (1993 and 1998), while the West Fork is rated as Good-Fair. Stoneflies (an intolerant group) are absent in the East Fork, while several species are abundant in the West Fork.

West Fork Deep River, SR 1850
This site is about 4 meters wide with a sandy substrate. Most benthic macroinvertebrates were associated with leaf packs. This site has poor habitat with no riffles, infrequent pools, eroding banks and little fish cover. The composition of the invertebrate fauna, however, suggests Good-Fair water quality with 2-3 abundant stonefly taxa. The abundance of this intolerant group usually indicates better water quality. Only the headwaters of Reedy Fork (subbasin 02) had a similar fauna within the upper Cape Fear River subbasins. Note that these two streams are geographically close, although they drain to different subbasins.

Deep River, US 220 Business, Randleman

This section of the Deep River is very rocky, with a mean width of 30 meters. There are no significant habitat problems. This site has been sampled seven times since 1983, improving from a bioclassification of Poor in 1985 to Good-Fair in 1993 and 1998. No change was observed between macroinvertebrate samples collected in 1993 and 1998. The earlier changes were associated with upgrades of 2 wastewater treatment plants.

Richland Creek, SR 1154, above WWTP
Richland Creek in this area is eight meters wide with a predominantly sand substrate. Instream habitat is patchy and numerous tires and other urban debris were observed at the site. The fish community at this location was assigned a Poor rating largely due to the absence of darter and intolerant species and a high percentage of tolerant fish.

Richland Creek, SR 1145, below WWTP
This part of Richland Creek (near its confluence with the Deep River) is about 9 meters wide and located just below the High Point Eastside WWTP. Rocky riffle areas are present only near the road crossing, and most of the stream is a uniform sandy run. Other habitat problems include absence of pools, severe bank erosion, and little cover for fish. This station had consistently been rated as Poor using benthos data between 1985 and 1988, but improved to Fair in 1993. The amount of the recovery at this site is limited by Fair conditions upstream of the discharge (August 1988 data). Under the low flow conditions of 1998, Richland Creek again declined to Poor, equivalent to conditions last observed in 1985. The very low invertebrate taxa richness observed in 1998 (28) suggested toxic conditions.

Year	Total S	EPT S	EPT N	NCBI	Flow	Bioclass
1998	28	5	11	7.9	Low	Poor
1993	53	13	73	7.1	Normal	Fair
1988	62	9	28	7.6	Low	Poor
1987	61	9	51	7.6	Low	Poor
1986	40	2	13	8.2	Low	Poor
1985	30	5	13	8.4	Normal	Poor
1983	47	9	49	7.5	Low	Fair

Hickory Creek, SR 1131
The low flow conditions during July 1998 reduced this stream to about two meters in width – too small to assign a bioclassification. Elevated conductivity (265 µmhos/cm) reflected some urban runoff and 5 small permitted dischargers within the catchment. Hickory Creek had poor habitat, with a substrate composed largely of unstable coarse sand. Other habitat problems included severe bank erosion, no riffles, and few pools. This site was assigned a Fair rating based on benthos collections in February 1993.

Muddy Creek, SR 1929
Muddy Creek drains a catchment with large amounts of both urban and agricultural land uses. The low flow conditions during July 1998 reduced this stream to about three meters in width – too small to assign a bioclassification. The substrate was largely unstable sand, with few riffles, infrequent pools, severe bank erosion, and a narrow riparian zone. Muddy Creek was assigned a Good-Fair rating in 1993, based on benthos samples collected in February. The overall composition of the fauna in July 1998 did not suggest any between-year change in water quality, with two stonefly species present and one abundant intolerant taxon (Isonychia).

During April 1998, when the fish community assessment was conducted, Muddy Creek at this site was estimated to be over eight meters wide with a number of pools of various sizes. The absence of any intolerant species and absence of piscivores contributed the most to the Poor bioclassification for the fish community. The 1963 WRC sampling location was slightly over one mile above the 1998 DWQ site. In 1963 Muddy Creek was described as a small headwater stream with little cover for fish and only five species were collected.

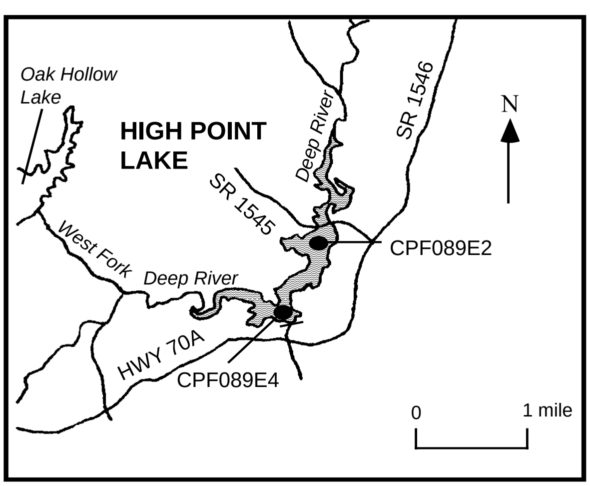
Four largemouth bass samples were collected from Muddy Creek near Glenola during March 1994 and analyzed for metals contaminants. All metals results were lower than EPA and FDA/NC limits.

SPECIAL STUDIES
As part of an investigation of stream on the 303d list, samples were collected from the Deep River at SR 1113 in 1998. This site was about 16 meters in width, with good rocky riffles. This site was originally selected to monitor a discharge from the Jamestown WWTP, which ceased discharge in 1984. The bioclassification improved from Poor in 1983 to Fair in 1985, and was still Fair in 1998. Urban runoff is the most likely cause of water quality problems here.

LAKE ASSESSMENT PROGRAM
<u>High Point Lake</u>

COUNTY:	Guilford	**CLASSIFICATION:**	WS-IV CA
SURFACE AREA:	300 acres (121 hectares)	**MEAN DEPTH :**	16 feet (5 meters)
VOLUME:	4.8 x10^6m^3	**WATERSHED**:	60 mi^2 (155 km^2)

High Point Lake (also known as City Lake), built in 1928 by the City of High Point, is used as a water supply and for recreation. Maximum depth of the lake is 33 feet (10 meters). Urban/residential areas and pasture/row crop farms dominate the watershed. The two arms of the lake are fed by the East Fork Deep River and the West Fork Deep River.



High Point Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data for this lake are presented in Appendix L2. Secchi depths at both lake sampling sites in High Point Lake were less than one meter in June, July and August. High Point Lake was determined to be eutrophic in June and mesotrophic in July based upon the calculated NCTSI scores (Table L15).

According to Mr. Bill Frazier, Laboratory Supervisor for the High Point Water Plant, there have been frequent public complaints of taste and odor problems from processed drinking water taken from this lake related to algal blooms. To reduce this problem, the water treatment plant currently treats the raw water to reduce algae related taste and odor problems. Typical diurnal affects (dissolved oxygen and pH) related to algal activity are observed in High Point Lake and a winter bloom with a temperature of 6°C has been observed. This winter boom was investigated and was believed to have been caused by the use of fertilizer in the watershed as a deicer during a winter ice storm. Low dissolved oxygen levels have been recored at the water intake and a destratification system (forced air) is in place in the mainstem of the lake to help improve the dissolved oxygen levels. The High Point Water Treatment Plant samples this lake every two weeks at three major inflow points (tributaries) and one outlet point. Parameters include nutrients, fecal coliform bacteria, water temperature, pH and phytoplankton identification. Summer depth profiles are also performed. A database containing 20 years of water quality data for High Point Lake is available upon request and will soon be available via the Internet. Water clarity has decreased since 1984 and is associated with increasing construction activities (two major highway construction projects, one for I-40 and the other the HWY 73/74 Bypass, are currently underway) in the watershed along with algal blooms. There have been no reports of stressed or dead fish in the lake and no problems with nuisance levels of aquatic macrophytes (Bill Frazier, Laboratory Supervisor, High Point Water Treatment Facility. pers. com.).

The High Point Lake game fish communities are in very good condition, according to Ms. Shari Bryant, Division 5 Fisheries Biologist for the Division of Inland Fisheries. This is particularly true for largemouth bass (*Micropterus salmoides*) and crappie (*Pomoxis sp*.). Aquatic weeds in the upper end of the lake along the shoreline provide good habitat and shelter for these fish (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

Two research projects for High Point Lake are currently underway according to Mr. Robert Holman with the Water Resources Research Institute (pers. com.). The first project, which is being conducted by the Water Resource Research Institute, involves an evaluation of pesticide inputs into High Point Lake via the watershed tributaries. The second project, which is being conducted by the Civil Engineering Department at North Carolina State University involves input and output of nutrients in four retention ponds in the High Point Lake watershed.

High Point Lake was previously sampled in 1997, 1996, and 1994. Physical and chemical data collected by DWQ for High Point Lake are presented in Appendix L2. In 1997, High Point Lake was sampled in July and August. In July, the greatest surface dissolved oxygen and pH values were observed at the upstream sampling site. Chlorophyll *a* ranged from 20 µg/L at the upstream sampling site to 46 µg/L near the dam. An algal bloom was verified at the upstream sampling site with an algal density of 17,300 units/ml.

In 1996, metals were below DWQ laboratory detection levels except for zinc (15 µg/L) and copper (2.3 µg/L). Chlorophyll *a* at CPF089E2 (120 µg/L) was greater than the state water quality standard of 40 µg/L. The chlorophyll *a* value at CPF89E4 was 31 µg/L. Physical parameters indicated stratification at both stations with hypoxic conditions observed at depths below three meters. In July, 1994, an algal bloom was verified in High Point Lake at the sampling site near the dam (algal biovolume = 11, 943 mm^3/m^3, density = 52,949 units/ml). The phytoplankton community in 1994 was dominated by blue green algae, particularly *Anabaenopsis raciborskii*.

Historical data collected at High Point Lake from 1981 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L10.

Figure L10. High Point Lake Data Analysis, 1981 - 1998.

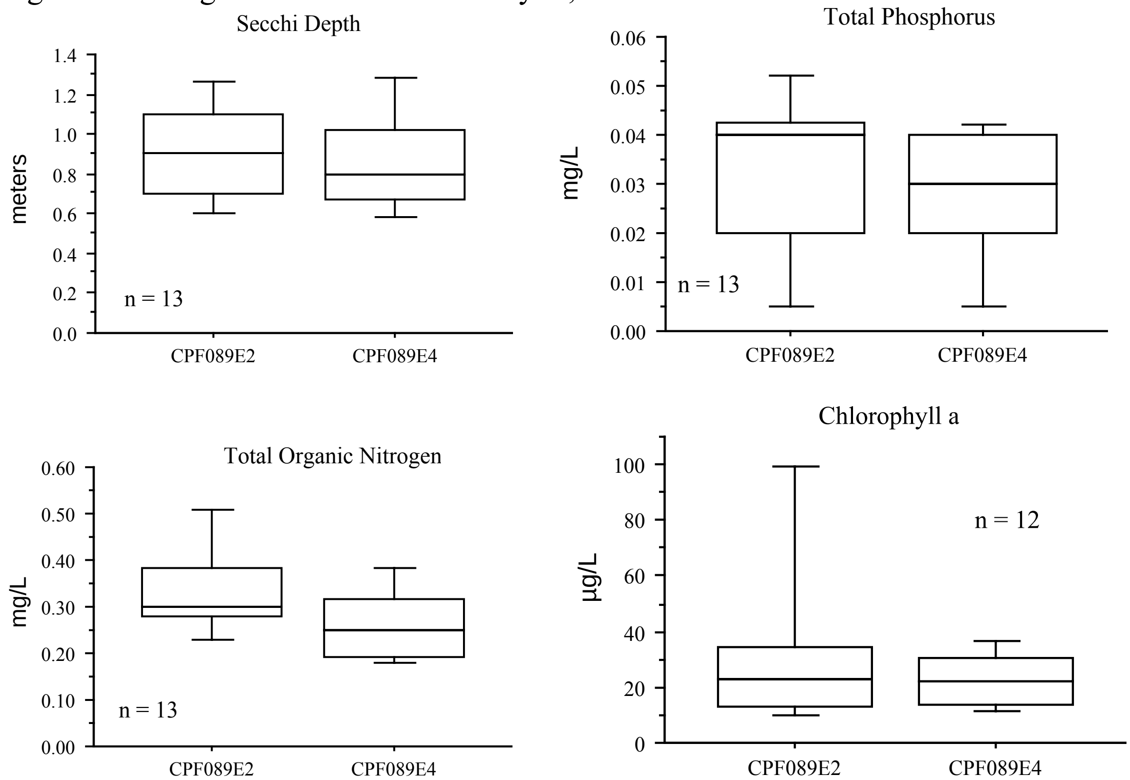


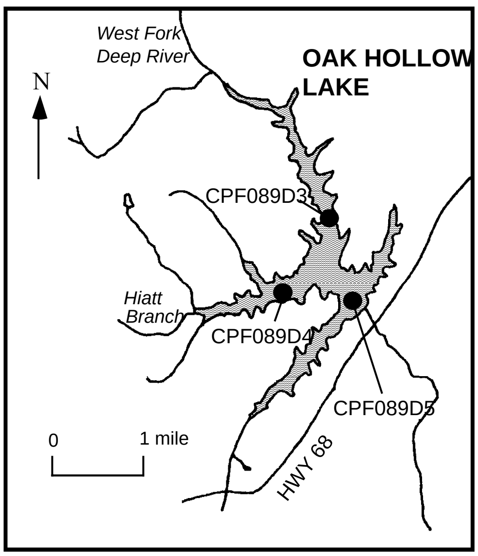
Table L15. High Point Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
High Point Lake	980820	no score	0.04	0.32	n/a	0.6
High Point Lake	980709	-0.3[M]	0.04	0.14	16	0.8
High Point Lake	980609	1.6[E]	0.04	0.25	33	0.6
High Point Lake	970819	0.2[E]	0.03	0.25	10	0.7
High Point Lake	970716	-1.1[M]	<0.01	0.25	33	0.9
High Point Lake	960718	no score	0.02	0.24	n/a	1.0
High Point Lake	960627	1.6[E]	0.03	0.24	76	0.9
High Point Lake	940712	0.1[E]	<0.01	0.48	14	0.8
High Point Lake	930811	-0.1[M]	0.02	0.34	12	1.1
High Point Lake	880817	1.2[E]	0.04	0.27	30	1.0
High Point Lake	870819	1.7[E]	0.04	0.34	23	0.7
High Point Lake	820722	2.6[E]	0.06	0.44	50	0.6
High Point Lake	810716	1.4[E]	0.05	0.39	28	1.6

Oak Hollow Lake

COUNTY:	Guilford	**CLASSIFICATION:**	WS-IV CA
SURFACE AREA:	720 acres (291 hectares)	**MEAN DEPTH :**	23 feet (7 meters)
VOLUME:	17 x$10^6$$m^3$	**WATERSHED**:	55 mi^2 (142 km^2)

Oak Hollow Lake (also known as High Point Reservoir was constructed by the City of High Point. Boating, fishing and swimming are common activities on the lake. The lake has a maximum depth of 36 feet (11 meters). The rolling watershed is characterized by urban, residential and some agricultural land uses. Two 18-hole golf courses adjoin the lake.



Oak Hollow Lake was most recently sampled by DWQ on August, 1998. Physical and chemical data are presented in Appendix L2. Secchi depths were less than one meter at all three lake sampling sites. Total phosphorus, ammonia and nitrite plus nitrate concentrations were the same at all three lake sampling sites. Chlorophyll *a* ranged from 5 to 6 µg/L. Metals were less than the applicable state water quality standards in August. Oak Hollow Lake was mesotrophic in June and July based on the calculated NCTSI scores (Table L16).

Conditions in Oak Hollow lake are similar to those in High Point Lake. According to Mr. Bill Frazier, Laboratory Supervisor for the High Point Water Plant, there have been frequent public complaints of taste and odor problems from processed drinking water taken from this lake related to algal blooms. To reduce this problem, the water treatment plant currently treats the raw water to reduce algae related taste and odor problems and a destratification system (forced air) is in place in the mainstem of the lake to help improve the dissolved oxygen levels in the lake. Water clarity has decreased since 1984 and is associated with increasing urban development and construction in the watershed along with algal blooms (the HWY 73/74 Bypass which is under construction, will cross over Oak Hollow Lake). In 1998 a fish kill was reported at this lake. American shad (*Alosa sapidissima*) were trapped in the spillway area and this had led to their death; the kill was not associated with a water quality problem (Bill Frazier, Laboratory Supervisor, High Point Water Treatment Facility. pers. com.).

According to Ms. Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, there have been complaints made by individuals fishing at Oak Hollow Lake regarding the quality of the fisheries. Specifically, fishermen have noticed the presence of white perch (*Morone americana*) in the lake. These fish have the capability of out competing largemouth bass and crappie, which are favored sports fish. There have also been complaints regarding the loss of aquatic macrophytes (specifically water lilies) in the upper end of the lake. These plants provide refuge areas for bass and their absence is believed to impact the number of bass in the lake. The reasons for the loss of these plants is unclear, although increased sedimentation or the new diffusion system in the lake are thought to be contributors to the problem (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

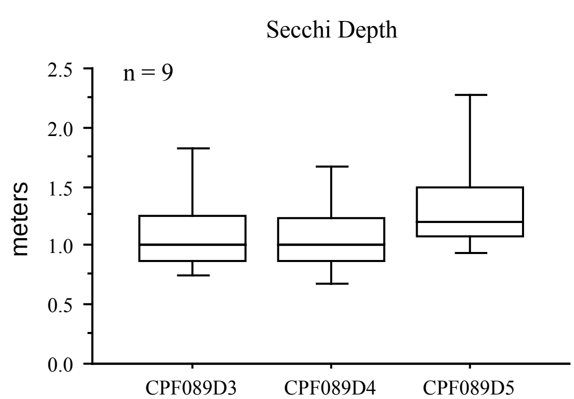
Oak Hollow Lake was previously sampled by DWQ in 1997, 1996, and 1994. Physical and chemical data collected by DWQ for this lake are presented in Appendix L2. In 1997, Oak Hollow Lake was sampled in July and August. Metals were below applicable state water quality standards except for zinc (100 µg/L) which was greater than the state action level of 50 µg/L Phytoplankton analysis determined the presence of an algal bloom in the West Fork Deep River arm (density = 15,867 units/ml, biovolume = 8,633 mm^3/m^3. Phytoplankton samples were dominated by the blue-green alga, *Anabaena wisconsinense*.

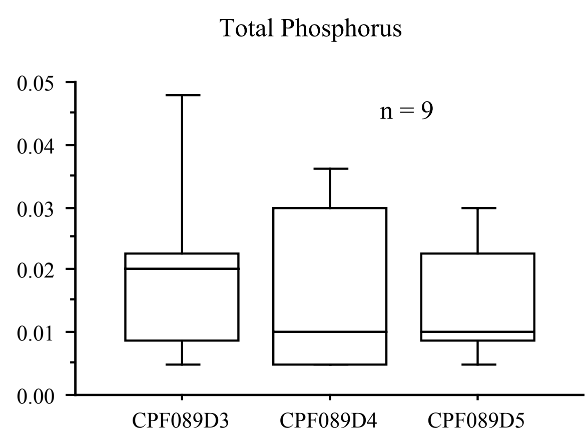
Oak Hollow Lake was sampled in June and July, 1996. Metals were not greater than the applicable state water quality standards. Stratified conditions were found at all lake sampling sites, with hypoxic conditions found at depths greater than four meters.

In July, 1994, Oak Hollow Lake had a distinctive green color, however, no floating algal mats or clumps were observed. The three lake sampling sites were stratified with the thermocline occurring at a depth of approximately three meters. This included the site near the dam, despite the operation of three destratifiers

Historical data collected from 1981 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L11.

Figure L11. Oak Hollow Lake Data Analysis, 1981 - 1998





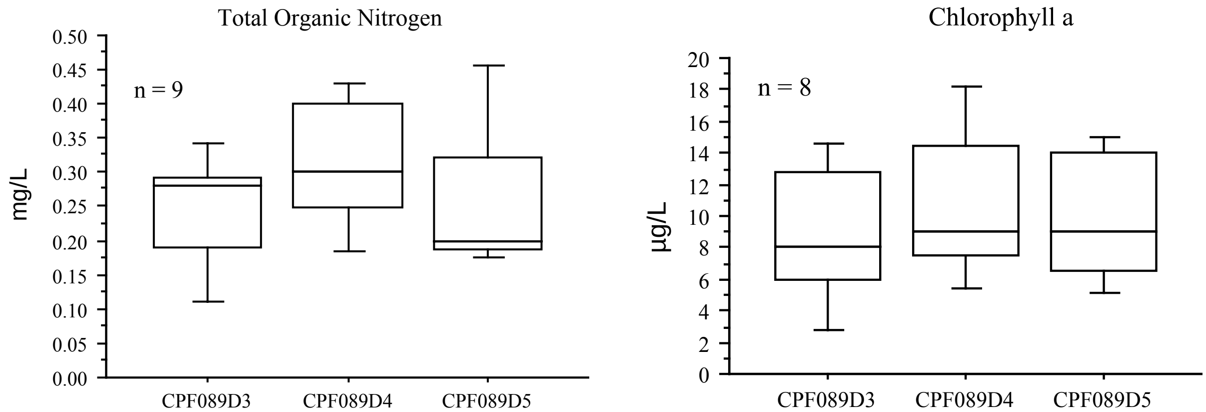
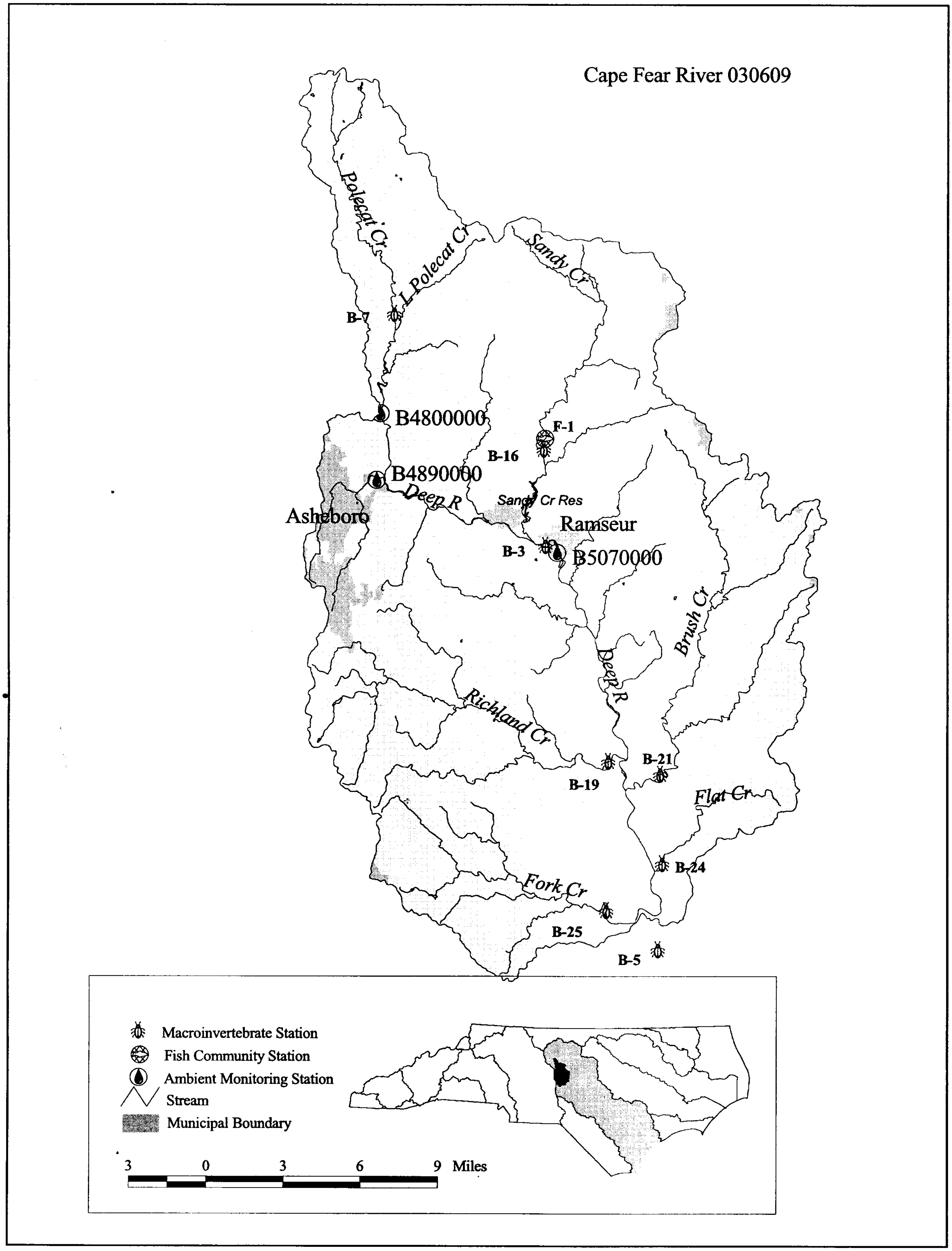


Table L16. Oak Hollow Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Oak Hollow Lake	980820	no score	0.03	0.22	n/a	0.9
Oak Hollow Lake	970819	-1.5[M]	0.01	0.30	8	1.1
Oak Hollow Lake	970716	-0.8[M]	<0.01	0.37	14	0.9
Oak Hollow Lake	960718	no score	0.03	0.22	—	1.1
Oak Hollow Lake	960627	-2.0[M]	0.01	0.24	10	1.6
Oak Hollow Lake	940712	-2.5[O]	<0.01	0.27	5	1.3
Oak Hollow Lake	930811	-0.3[M]	0.02	0.29	11	0.9
Oak Hollow Lake	880817	-0.3[M]	0.02	0.30	14	1.2
Oak Hollow Lake	810716	-1.2[M]	0.03	0.25	7	1.8

TISSUE DATA

Fish tissue samples were collected from Oak Hollow Lake during April 1998. Of the 18 samples analyzed for metals contaminants, two largemouth bass samples contained mercury exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.



Cape Fear River 030609
Polecat Cr
L Polecat Cr
Sandy Cr
B-7
B4800000
F-1
B-16
B4890000
Deep R
Sandy Cr Res
Asheboro
Ramseur
B-3
B5070000
Brush Cr
Deep R
Richland Cr
B-21
B-19
Flat Cr
B-24
Fork Cr
B-25
B-5
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
3 0 3 6 9 Miles

CAPE FEAR SUBBASIN 030609

DESCRIPTION

Cape Fear River subbasin 09 contains approximately 25 river miles of the Deep River from Randleman to the Randolph/Moore County line. This reach is completely contained within the Slate Belt. Streams within this area are typically very rocky but, due to poor soils permeability rates, have very low flows during summer months.

Much of the land use within this subbasin is forest, although pasture, cultivated crops and urban and built-up land uses also account for significant portions of the subbasin. Randolph County has large numbers of registered livestock and animal operations, particularly cattle and poultry operations. There are 14 permitted discharge facilities in the subbasin; all but one facility have permitted flow of less than 1 MGD. This facility, Asheboro WWTP, discharges 9.0 MGD into Hasketts Creek.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3*	Deep R	Randolph	SR 2615	Good-Fair (s)	Good-Fair (s)
B-5*	Deep R	Moore	SR 1461	Excellent (s)	Excellent (s)
B-7	Polecat Cr	Randolph	SR 2113	Good (w)	Good (w)
B-10	L. Polecat Cr	Randolph	SR 2108	Not Rated	Not Rated
B-16*	Sandy Cr	Randolph	SR 2481	Good (w & s)	Excellent (s)
B-19	Richland Cr	Randolph	SR 2873	Good (s)	Excellent (s)
B-21	Brush Cr	Randolph	NC 22	Good (w)	Good (s)
B-24	Flat Cr	Randolph	SR 2886	Fair (w)	Good-Fair (w)
B-25	Fork Cr	Randolph	SR 2873	Good (w)	Good (w)
FISH				1994	
F-1	Sandy Cr	Randolph	SR 2481	Good-Fair	Good-Fair

(w) winter collection, (s) summer collection
*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES
Sandy Creek Reservoir

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Deep R at Franklinville	1998	15	0	0	EPA mercury limit exceeded in 1 bass sample

Ambient water quality data are being collected from four locations in this subbasin. These include three mainstem Deep River locations at Worthville, Ramseur, and Central Falls, and one tributary location at Hasketts Creek. The Hasketts Creek location is below the Asheboro WWTP which discharges 9.0 MGD directly into Hasketts Creek. Water quality data from the Deep River locations generally suggest water quality problems. For example, median conductivity concentrations are in excess of 200 µmhos/cm at each location in this subbasin. Higher median nutrient concentrations and fecal coliform numbers are typically found at the Worthville location. These values decline progressively downstream, suggesting recovery at downstream locations.

Benthic macroinvertebrate data from the Deep River near Ramseur has found long-term improvements in water quality (since 1985 and 1986 surveys), although no 5-year change in bioclassification was seen during basinwide surveys in 1993 and 1998. Four other Deep River locations have been sampled in this subbasin as part of intensive investigations of this river. The results of these investigations have generally indicated long-term improvements in water quality. Benthic macroinvertebrate data from the most downstream location in Moore County have consistently indicated an Excellent bioclassification, suggesting that the Deep River at this point has recovered from upstream perturbations.

Benthic macroinvertebrate data from tributary streams in this subbasin found improvements at 3 of the 6 sites sampled during the 1998. Two of these locations improved from Good to Excellent (Sandy and Richland Creek). EPT taxa richness at Sandy Creek (above the Sandy Creek Reservoir) improved from 22 taxa in 1993 to 35 taxa in 1998. A Good-Fair NCIBI rating was assigned to this location. Good bioclassifications, based on benthic macroinvertebrate data, were given to the three other tributary locations in this subbasin and no change in bioclassifications were found compared to surveys conducted in 1993 at these locations.

Fish tissue samples were collected from the Deep River at Franklinville in 1998 as part of the basinwide program in this subbasin. Franklinville is located above the Ramseur ambient monitoring location. Fifteen specimens were analyzed for metal contamination and, in addition, two largemouth bass were analyzed for chlorinated pesticides and PCB arochlors. These data found that no FDA or EPA criteria were exceeded.

A lake assessment investigation was conducted at the Sandy Creek Reservoir in June, July, and August 1998. NCTSI scores for June and July resulted in a eutrophic classification assigned to this reservoir. In addition, algal bloom conditions were evident during the July survey.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Deep River at Franklinville

Fish tissue samples were collected from the Deep River at Franklinville during August 1998. Fifteen samples were analyzed for metals contaminants. All metals results were below EPA and FDA/NC limits. Two largemouth bass samples were also analyzed for chlorinated pesticides and PCB arochlors. Results showed undetectable levels of these contaminants in the bass tissue

Deep River at Ramseur, SR 2615

The Deep River at Ramseur is approximately 28-30 meters wide and has large riffle areas composed mostly of boulder and rubble, although pools are filled in with sand and FPOM. Prolific Aufwuchs material cover most of the substrate and Podostemum (or river weed) is common in high current areas. Benthic macroinvertebrates have been collected from this ambient monitoring location seven times, including basinwide surveys in 1993 and 1998. These data have indicated long-term improvements in the river at this site since initial surveys in 1983 and 1985 (Fair). These improvements were attributed to facility upgrades at several WWTPs. Bioclassifications have remained Good-Fair since 1985. Many of the dominant taxa have remained similar between collections, although Biotic Index values were lower during the 1998 survey than all previous surveys.

Deep River near Jugtown, SR 1461

This location was selected to assess assimilative capacity and recovery of the Deep River as it flows into Moore County. The river at this location is about 40 meters wide, shallow and has a diverse substrate. Large riffle areas are composed of boulders and rubble, although sedimentation is more evident at this site than at the upstream location at Ramseur. Water chemistry data recorded during the benthic macroinvertebrate survey in July indicated algal bloom conditions (water temperature=30 ^{o}C, dissolved oxygen=11.8 mg/l, conductivity=285 µmhos/cm, pH=8.7 units). Benthic macroinvertebrate data, however, resulted in an Excellent bioclassification. Summer surveys have been conducted at this location seven times and Excellent bioclassifications have been assigned to all collections since 1985.

Polecat Creek, SR 2113

Polecat Creek is a large headwater tributary of the Deep River with a drainage area of 56.3 square miles at its confluence with the Deep River. Most of the catchment appears to be forested, although pasture also is a major land use. Polecat Creek at SR 2113 is about 9 meters wide and has a very sandy substrate. The field team noted severe bank erosion and animal access to the stream. Winter basinwide surveys have been conducted at this location in 1993 and 1998. Even with land use perturbations and severe bank erosion, both surveys have resulted in Good bioclassifications. A Fair bioclassification was given to Polecat Creek at SR 2116 during a summer survey in 1993. This site is located downstream of the SR 2113 location and these data may reflect the effects of summer low flow conditions and/or nonpoint source runoff.

Little Polecat Creek, SR 2108

Little Polecat Creek has a drainage area of 14 square miles at the confluence with Polecat Creek. This tributary stream is about 3 meters wide at the collection location and has a diverse substrate of rubble, gravel and sand. Much of the land use near the collection location is pasture with forest and residential areas. The field team noted severe bank erosion and animal access to the stream during the February 1998 survey. This stream is too small to rate and flow permanence, particularly during summer months, may affect the benthic macroinvertebrate population. However, several intolerant taxa were collected during the 1998 survey including Chimarra and Neophylax oligius, suggesting that water quality is not seriously stressed.

Sandy Creek, SR 2481

Sandy Creek is a large tributary catchment of the Deep River and is the water supply for the City of Ramseur. This catchment has a drainage area of 60 square miles at its confluence with the Deep River. The monitoring location at SR 2481 is located above the water supply reservoir. The stream at this location is about 14 meters wide and has a diverse substrate composed of boulder/rubble riffles and sandy runs. Benthic macroinvertebrates have been collected from this location during basinwide surveys in 1998 and 1993, and during a 319 monitoring program with the Soil Conservation Service. All data collected from this site prior to 1998 resulted in Good bioclassifications. An increase in taxa richness in 1998 resulted in an Excellent bioclassification at this location. Many taxa increased in abundance (Isonychia, several Baetidae) or were collected during the 1998 survey and not the 1993 survey (Heptagenia marginalis, Perlesta, Neophylax oligius, Triaenodes injusta).

Although the NCIBI score was slightly higher in 1998, the fish community was classified as Good-Fair in 1994 and 1998. The difference in the score between the two years was due to the lack of piscivores in 1994.

Richland Creek, SR 2873
Richland Creek is a large tributary to the Deep River in Randolph County (approximately 65 square miles). Much of this catchment is forested, although pasture and cultivated crops also are important land uses. Richland Creek at SR 2873 is about 16 meters wide and has infrequent boulder/rubble riffle areas and very sandy, low-gradient reaches. During the summer surveys prolific aquatic macrophytes, Aufwuchs and Podostemum growths are found at this site. Benthic macroinvertebrate samples have been collected from this site in 1998 and 1993 during basinwide surveys and in 1988 as part of a 319 cooperative monitoring program with the Soil Conservation Service. An Excellent bioclassification was given to this site in 1998 and Good ratings were found from all previous investigations. This improvement parallels trends from Sandy Creek, although the Excellent bioclassification is borderline Good.

Brush Creek, NC 22
Brush Creek is another large tributary of the Deep River in Randolph County and has a catchment area of approximately 70 square miles at the confluence. Forest appears to be the major land use in the catchment. Brush Creek at NC 22 is about 13 meters wide and has a diverse substrate of boulder, rubble and gravel. Many of the pools at this location have been filled in with sediment, suggesting the impacts from nonpoint source runoff. Benthic macroinvertebrate samples have been collected from this site four times, including basinwide surveys in 1998 and 1993. No change in ratings was seen between the two basinwide surveys (Good), although samples were collected in different seasons. Taxa richness values from the 1998 and 1993 surveys were slightly lower than data collected from this site in 1990 (Excellent).

Flat Creek, SR 2886
Benthic macroinvertebrate samples were collected from Flat Creek during February basinwide surveys in 1998 and 1993. Flat Creek at this location is about 7 meters wide and has a catchment area of 14 square miles. This site has substrate characteristics that are typical for streams in the Slate Belt and may dry up or stop flowing during summer periods. The substrate is dominated by rubble and coarse gravel riffles, although sandy reaches and bedrock outcrops are common. Field teams have noted severe bank erosion and prolific Aufwuchs growths. An increase in EPT taxa richness was seen in 1998 (Good-Fair), although dominant taxa remained similar between surveys. This site was given a Fair bioclassification in 1993.

Fork Creek, SR 2873
Fork Creek is a large tributary stream of the Deep River that, at its confluence in southeastern Randolph County, has a catchment of 48 square miles. Land use is primarily forest near the collection location, however pasture and built-up residential sections are common in the catchment. Fork Creek at this location is about 12 meters wide and very sandy relative to other Deep River tributaries in Randolph County. Short boulder/gravel riffles are common, although embeddedness is high, suggesting the input of sediment from nonpoint source runoff in the catchment. Benthic macroinvertebrates have been collected from this location during February

basinwide surveys in 1998 and 1993. Good bioclassifications were given to this site during both of these surveys implying no change in water quality.

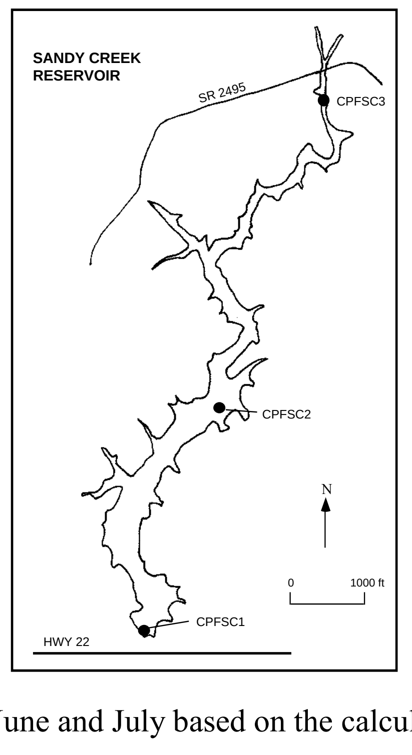
SPECIAL STUDIES
Benthic macroinvertebrate samples were collected from two sites on Hasketts Creek above and below the Asheboro WWTP (9.0 MGD) as part of the 303(d) monitoring program in 1998. Poor bioclassifications were given to both locations.

LAKE ASSESSMENT PROGRAM

Sandy Creek Reservoir

COUNTY:	Randolph	**CLASSIFICATION:**	WS-III CA
SURFACE AREA:	125 acres (51 hectares)	**MEAN DEPTH :**	19 feet (6 meters)
VOLUME:	1.5 x10^6m^3	**WATERSHED**:	55 mi^2 (142 km^2)

Sandy Creek Reservoir is the water supply for the Town of Ramseur. Impounded in 1978, it is fed by Big Sandy Creek and Little Sandy. The maximum depth is 48 feet (15 meters). The watershed is moderately developed and land use is mostly characterized by forested and agricultural areas as well as urban development.



Sandy Creek Reservoir was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The greatest range of surface dissolved oxygen observed in June with values ranging from 6.5 mg/L at the upstream lake sampling site to 11.1 mg/L at the mid-lake sampling. Chlorophyll *a* values ranged from <1 to 30 µg/L. An algal bloom sample was collected in July at CPFSC3. The percent saturation of dissolved oxygen at the surface of the lake at this site was 150.8% and surface pH was 9.0 s.u. Analysis of this sample determined the presence of an algal bloom with algal biovolume at 46,435 mm^3/m^3 and algal density was 8,679 units/ml. The bloom consisted primarily of the blue-green alga *Anacystis cyanea* (68%). A surface algal sample collected at the upstream sampling site in August was found to consist of green and blue-green algas (this sample was not quantified). Values for metals in June, July and August were less than the applicable state water quality standards. Sandy Creek Reservoir was determined to be eutrophic in June and July based on the calculated NCTSI scores for those months.

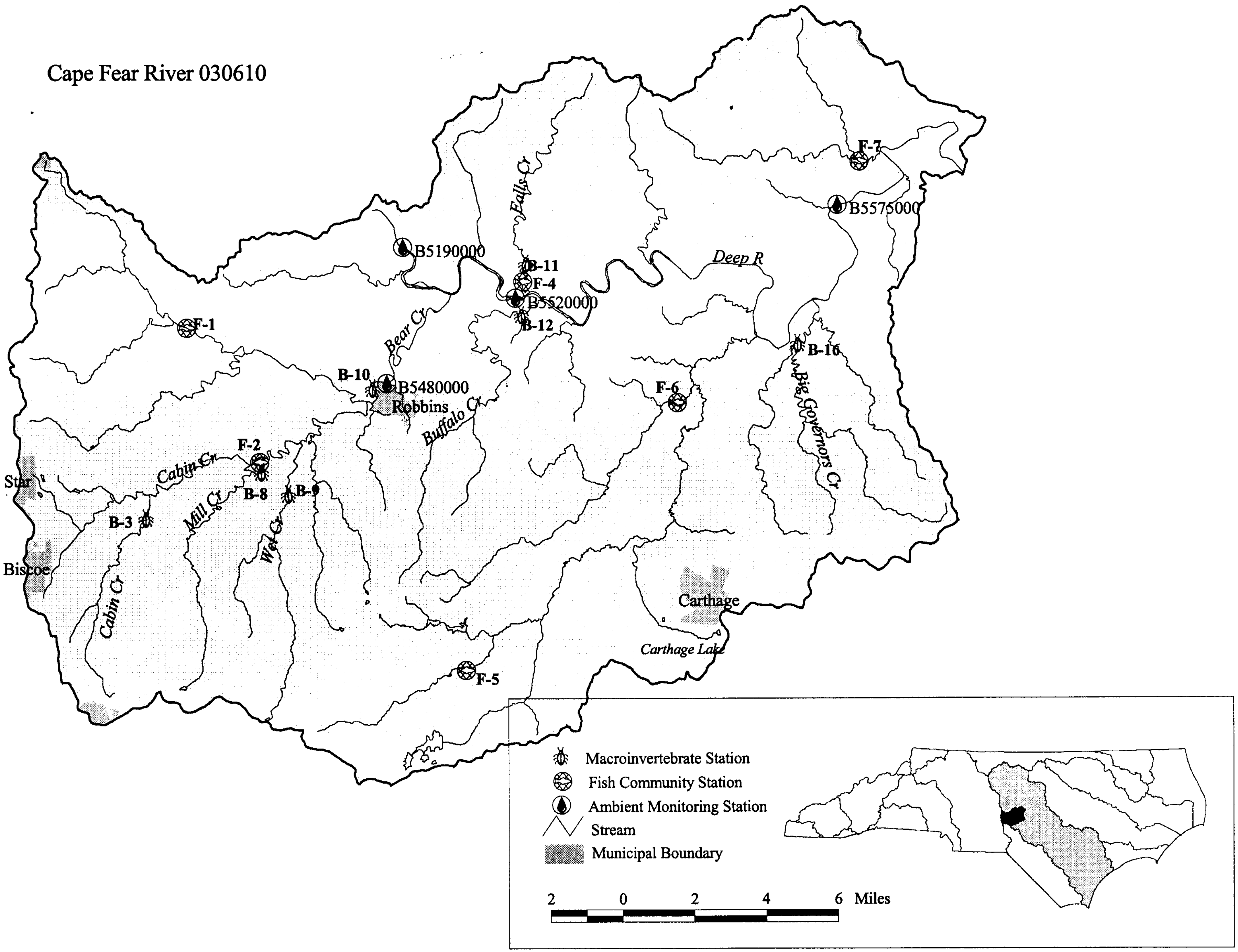
According to Mr. Scott Underwood, Supervisor for the Town of Ramseur Water Treatment Plant, there is frequently a problem with taste and odor associated with water drawn from Sandy

Creek Reservoir. Algae and manganese are believed to be the source of these problems. The water treatment plant samples the reservoir daily at the water intake for iron, manganese, color, turbidity, alkalinity, pH, chlorine and odor. Mr. Underwood stated that there were no problems related to excessive aquatic macrophytes or fish kills. The town is currently purchasing land adjacent to the lake to provide a shoreline butter zone (Scott Underwood, Supervisor, Town of Ramseur Water Treatment Plant, pers. com.). Mr. Jim Macintosh, Public Works Director for the Town of Ramseur, agreed with Mr. Underwood's observations regarding the water quality of Sandy Creek Reservoir (Jim Macintosh, Director of Public Works, Town of Ramseur, pers. com.). Fisheries data is collected by the North Carolina Wildlife Commission, Division of Inland Fisheries for Sandy Creek Reservoir. Based on a survey of crappie (*Pomoxis sp.*) in 1994 to 1995, the very poor community counts resulted in a size limit imposed on crappie catches at this lake (Shari Bryant, District 5 Fisheries Biologist, Division of Inland Fisheries, pers. com).

Table L17. Sandy Creek Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Sandy Creek Res.	980804	no score	0.05	0.33	n/a	0.8
Sandy Creek Res.	980716	1.6[E]	0.07	0.26	21	0.8
Sandy Creek Res.	980602	0.2[E]	0.07	0.19	12	1.1
Sandy Creek Res.	930706	1.8[E]	0.07	0.57	9	1.2
Sandy Creek Res.	920827	2.2[E]	0.06	0.57	15	1.1

Cape Fear River 030610



CAPE FEAR SUBBASIN 030610

DESCRIPTION

Subbasin 10 includes the middle section of the Deep River in Moore County. The House in the Horseshoe historic site is named for its location in a bend in this section of the Deep River. The Deep River here is classified as HQW from Grassy Creek to NC 42, where Moore, Chatham and Lee counties meet near Carbonton. Cedar Creek, Scotchman Creek and Lick Creek are also HQW. Bear Creek and McLendons Creek are the two largest tributaries, with nearly all of their watersheds in Moore County, with small portions in Chatham and Montgomery counties. This area contains portions of both the Carolina Slate Belt and Triassic Basin geologic regions. Many streams in this area can experience a complete lack of flow during the summer months. The towns of Robbins and Carthage are in this subbasin. Most of the land is forested, but there is some agriculture.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3	Cabin Cr	Moore	SR 1400	Good	Good
B-8	Mill Cr	Moore	nr SR 1275	Exc/Good	Good/G-F
B-9	Wet Cr	Moore	NC 24	Good	Good
B-10	Bear Cr	Moore	NC 705	Good-Fair	Good
B-11	Falls Cr	Moore	SR 1606	Fair	Fair
B-12	Buffalo Cr	Moore	NC 22	Good-Fair	Good
B-16	Big Governors Cr	Moore	SR 1625	Poor	Not Rated
FISH				1994	
F-2	Cabin Cr	Moore	SR 1275	no sample	Good
F-4	Falls Cr	Moore	SR 1606	no sample	Good
F-5	McLendons Cr	Moore	SR 1210	no sample	Fair
F-6	Richland Cr	Moore	SR 1640	Poor	Poor
F-7	Indian Cr	Chatham	SR 2306	no sample	Good-Fair
LAKES					
Carthage City Lake					

Ambient water quality samples are currently being collected from three locations in this subbasin: Bear Creek at NC 705 at Robbins, Deep River at NC 22 at High Falls, and Deep River at NC 42 at Carbonton. Much lower dissolved oxygen values have been found at the Carbonton site than at any of the upstream Deep River sites.

Good bioclassifications were found using benthos data at Cabin Creek, Mill Creek, Wet Creek, Bear Creek and Buffalo Creek in 1998. Compared to 1993 data, this indicated a slight decline in water quality for Mill Creek, an increase in bioclassification for Bear Creek and Buffalo Creek, and no change for Cabin Creek and Mill Creek. Very low flows occurred here during the summer of 1998, with McLendons Creek, Richland Creek, and Big Governors Creek reduced to pools of water between dry stream bed. These Triassic Basin streams could not be rated. Good bioclassifications were also found at Falls Creek and Cabin Creek using fish community assessments. The federally endangered Cape Fear shiner was collected in Falls Creek along with 25 other species of fish, the most for any Cape Fear basin fish samples. Indian Creek was given a Good-Fair NCIBI rating. Carthage Lake in 1998 was oligotrophic in June and mesotrophic in July.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Cabin Creek, SR 1400

Cabin Creek is a large slate belt tributary of Bear Creek. However, it was sampled in a headwaters area that was 6 meters wide (drainage area = 12 square miles) with a substrate consisting of a good mix of boulder, rubble, gravel and sand. There was moderate bank erosion, and some of the pools were very sandy. The sample site was in a forested area above the confluence with Cotton Creek, which is on the impaired streams list. Benthos samples collected in the winter of 1993 and 1998 both resulted in Good bioclassifications. EPT taxa richness was similar in both years: 27 in 1993 and 29 in 1998. In 1998, few (4) of these taxa were abundant and many were winter species. This is an indication of the low flows likely in summer.

Cabin Creek, SR 1275

Cabin Creek at SR 1275 was 13 meters wide and had a substrate with a good mix of gravel, cobble, and boulders. The sampling segment was mostly runs with a few shallow pools and scattered riffle areas. The fish community assessment resulted in a Good classification.   Few notes were made of the 1963 WRC sample at this location other than the rocky stream substrate and the collection of 10 species.

Mill Creek, near SR 1275

Mill Creek is a small (9 meters wide, drainage area =16 square miles) shallow, stream with some boulder and rubble, but primarily gravel and sand substrate. The sample site was about 50-100 meters upstream from where Mill Creek flows into Cabin Creek.   The surrounding watershed was all forested, resulting in good shading for the stream.

The site was sampled for benthos in both March and July 1998. Water levels were very low in July, but there were still riffle/run areas with some flow.   Benthic bioclassifications are complicated by the ratings changing with season and flow. Excellent and Good ratings were given in 1993, changing to Good and Good-Fair in 1998. The 1998 summer sample had 20 EPT taxa, and 21 taxa would have resulted in a Good bioclassification, so overall the water quality is still Good. The winter samples had the biggest changes in EPT taxa. EPT taxa decreased by 8, and EPT abundance dropped from 199 in 1993 to 93 in 1998. These changes do indicate a change in water quality. Few winter stoneflies were found in 1998, and caddisfly abundance was much lower. However, the differences in the fauna between summer samples was slight.

Wet Creek, NC 24

This tributary of Cabin Creek is another slate belt stream (7 meters wide, drainage area = 17 square miles at sample site) with good riffles and forested land around the sampling site. There was plenty of flow when sampled in March 1998, and no evidence of bank erosion. Benthos samples gave this stream Good bioclassifications during both winter basin assessments, but EPT taxa richness did decrease by 10 in 1998 (there were many more winter stoneflies in 1993). No hydropsychids were abundant, again suggesting that flows can get very low during summer and fall.

Bear Creek, NC 705
Bear Creek is a large tributary of the Deep River in Moore County, with a drainage area of 139 square miles at NC 705. Cabin Creek, Wet Creek and Dry Creek are upstream tributaries of Bear Creek. This site is on the outskirts of Robbins with forest, commercial and residential development in the immediate watershed. This is a slate belt stream with a good mix of boulder, rubble, gravel and sand and a width of about 20 meters. Flow was very low in 1998.

Benthos samples indicate a slight improvement in water quality with bioclassifications of Good in 1998 and Good-Fair in 1993. EPT taxa richness increased slightly (22 to 25), but the Biotic Index dropped from 6.27 to 5.70. Ten of the 25 EPT taxa were abundant despite the low flows. The dry summer in 1998 may have resulted in less nonpoint source impacts.

Falls Creek, SR 1606
This is a slate belt stream about 6 meters wide (drainage area = 15 square miles) with a predominantly boulder and rubble substrate, good riffles and a variety of pool sizes. The land at the sampling site was completely forested. Instream and riparian zone habitats were good, though there were heavy aufwuchs growths on the rocks. Fair bioclassifications were given during both basin assessments from winter benthos samples. The abundance of the mayfly, Stenonema femoratum indicates that this is a stream with very low summer flows that are inhibiting the development of a normal stream community. This is reinforced by a lack for filter feeding caddisflies, and few taxa that are not winter species. The Fair ratings by the benthos are probably not a good measurement of water quality or habitat. It may be more appropriate to not rate this stream. More flow data should be gathered to make this decision.

The fish community was rated Good at this site with the only major weakness is the community structure being the lack of piscivores. More species of fish (26) were collected from Falls Creek than any other stream in the Cape Fear River basin and this was the only site where the federally endangered Cape Fear shiner (Notropis mekistocholas) was found.

Buffalo Creek, NC 22
Buffalo Creek, a slate belt stream, has a drainage area of 22 square miles at NC 22 just above its confluence with the Deep River. It was 10 meters wide, and had a predominantly boulder and rubble substrate. Riffles were infrequent, pools were large, and some erosion was evident along the stream bank. Land use was mainly forest, with some pasture and residential areas. It has been sampled for benthos in February of 1993 and 1998. These data indicate an improvement from Good-Fair to Good. The increase of 7 EPT taxa from 20 to 27 is substantial for an EPT sample, though, again as was found for the other slate belt streams, few taxa were abundant.

McLendons Creek, SR 1210
The McLendons Creek watershed is a 67,100 acre (100 square miles) tributary of the Deep River. Agricultural land uses include about 3,000 acres of cropland, and 3,200 acres of pasture for beef cattle grazing, with 12 poultry, 2 swine and 20 beef pasture operations. DWQ has provided a Clean Water Act, Section 319 grant for a 3 year (1996-1999) effort to install and evaluate agricultural and urban best management practices in the watershed. The goal is to reduce nutrient and sediment runoff to McLendons Creek (Moore Clean Water, Vol. 1, March 1998).

Benthos samples were collected from a site in the lower watershed at SR 1628 in the winter and summer of 1993, resulting in Fair bioclassifications. In March 1998, an attempt was made to resample this site but the water was too deep. The stream at that time was about 10 meters wide with water depth greater than 1.5 meters. In July 1998, there was water in a deep pool at the bridge with areas of dry stream bed above and below the pool. Bottom substrate was mainly gravel, sand and silt, and erosion was evident along the banks. All upstream bridge crossings were looked at, but no sites were found with flowing water, even though there was water in the stream at these upstream sites. The drastic change in the nature of this stream between seasons with low flow summers is characteristic of Triassic Basin streams. After the 1998 sampling attempts it was clear to DWQ biologists that the present benthos criteria for flowing water streams should not be applied to this stream, or any others in the Triassic Basin. See Geology and Soils section in the Introduction for more details about the Triassic Basin.

This headwater McLendons Creek site was evaluated using NCIBI sandhills criteria instead of the piedmont criteria used for most other fish sites in this subbasin. The stream was estimated to be six meters wide with primarily a sand and gravel substrate. The fish community was assigned a Good-Fair rating with the most notable low metric score being for the low percentage of piscivores collected. This site overlapped with the upper area being monitored as part of the multi-agency McLendons Creek Watershed Project.

Richland Creek, SR 1640

Richland Creek was also evaluated using NCIBI sandhills criteria. The stream was approximately six meters wide at the sampling site with a sand substrate. Richland Creek received a Poor fish community rating in 1994 and 1998 with few fish collected either time.

Big Governors Creek, SR 1625

This is another Triassic Basin stream that was sampled for benthos in February 1998 and 1993 near its confluence with the Deep River. It has a drainage area of 41 square miles at its mouth. Both samples had a comparable, sparse fauna and a Fair rating was assigned in 1993. In February 1998 the stream was 10 meters wide with swift flow and a slippery clay bottom substrate. All but one narrow area with snags were too deep to sample. The stream was deeply entrenched with steep and severely eroding banks. The sampling site is in a completely forested area. When the site was revisited in July 1998, portions of the stream were completely dry and water level was down more than one meter from the February level. It was apparent then that this stream should not be rated using present benthos criteria for flowing water streams.

Indian Creek, SR 2306

A fish community sample was collected from Indian Creek for the first time in 1998. A low number of sucker species was the only major departure from what was expected at the site and the fish community was assigned Good-Fair classification. Indian Creek was 10 meters wide with a gravel substrate in the area where the sample was collected.

The WRC collected eleven species of fish from this site in 1962. As was the case with the 1998 DWQ field notes, the WRC indicated that Indian Creek has slightly tannin water but recorded the stream's substrate to have a much higher percentage of silt and clay than did the DWQ field team.

SPECIAL STUDIES

Cotton Creek was sampled for benthos in September 1998 to determine whether it should remain on the 303(d) list. Two samples were collected below the Star WWTP at SR 1372 and SR 1370. The stream was Poor and Fair at these two sites, respectively. This small stream (4 meters wide) is in the slate belt with boulder and rubble instream, but deeply incised clay banks. Conductivity below the WWTP at the time of sampling was 1200 µmhos/cm. There was no discernable flow above the WWTP, so a sample could not be collected that could be rated.

Crawley Creek is a tributary of Big Governors Creek that is in a forested watershed of 14 square miles in the Triassic Basin. In February 1998 it was 7 meters wide, and deeply incised with a completely clay bottom substrate. The site was chosen as a reference site for the Triassic Basin because it appeared to have little or no disturbance to its watershed. A benthos sample was collected and found to have only 10 EPT taxa, with most of those winter taxa. This data reinforced the decision to not rate any Triassic Basin streams using benthos data.

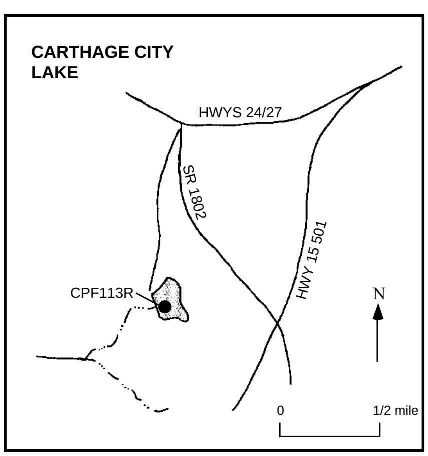
A fish community sample was collected from Bear Creek at SR 1405 in September 1998, as part of a statewide reference stream study. The stream received a Good-Fair fish community bioclassification.

LAKE ASSESSMENT PROGRAM

<u>Carthage City Lake</u>

COUNTY:	Moore	**CLASSIFICATION:**	WS-III CA
SURFACE AREA:	8 acres (3 hectares)	**MEAN DEPTH :**	3 feet (0.9 meters)
VOLUME:	0.08 $x10^6 m^3$	**WATERSHED**:	27 mi^2 (69 km^2)

Carthage City Lake is a small water supply lake for the City of Carthage in Moore County. The deepest part of the lake, approximately eight to ten feet (three meters), is located at the intake structure. The lake was impounded around 1950 and is spring fed. In dry weather conditions, water is pumped a distance of six miles (four kilometers) from Nicks Creek to maintain an adequate water level. The watershed is moderately developed and land use is mostly characterized by wooded areas and agriculture.

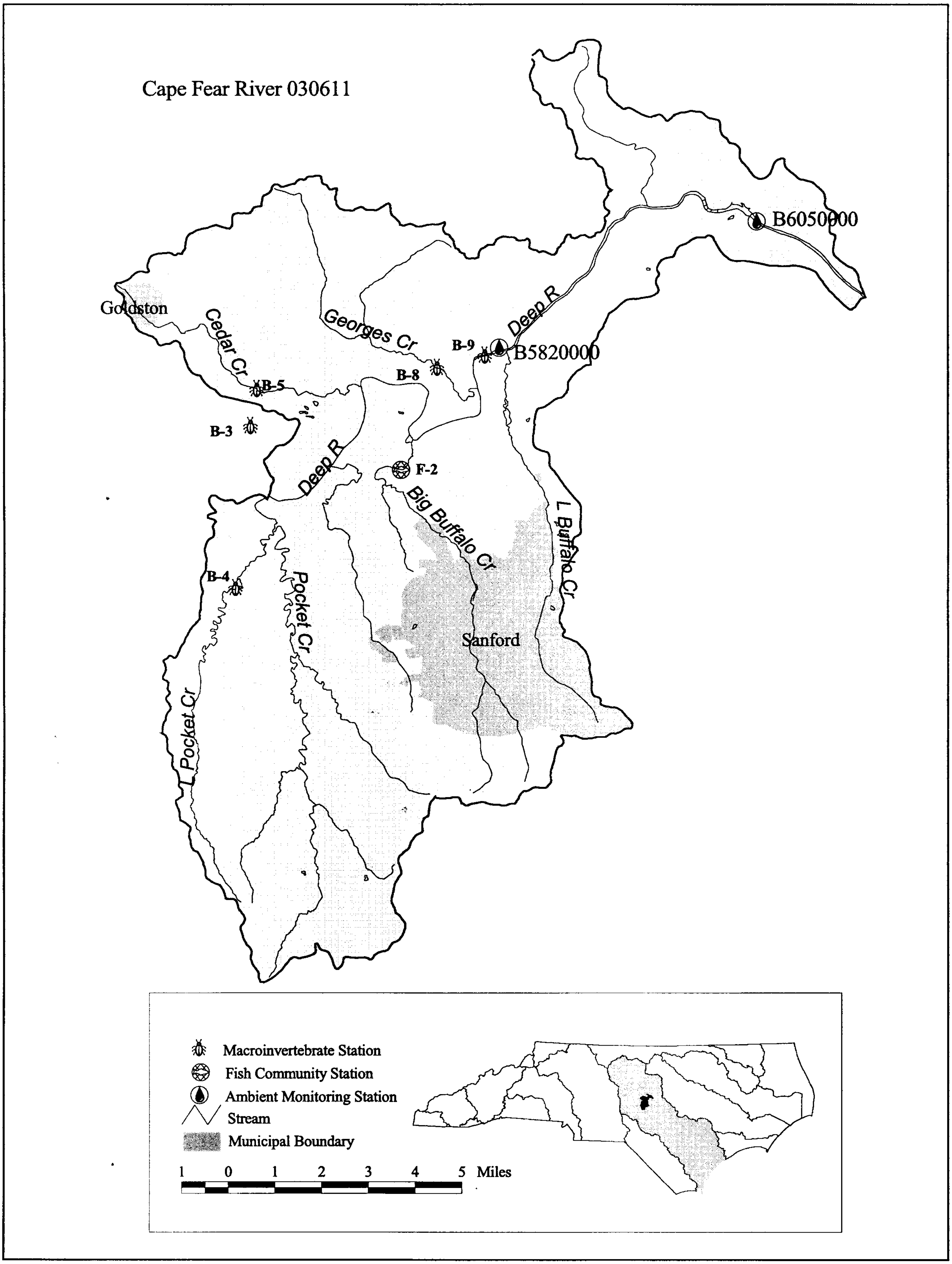


Carthage City Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The highest concentration of chlorophyll *a* (23 µg/L) was observed in July. The concentration of metals were less than the applicable state water quality standards except for iron in June (1100 µg/L) which was greater than the state water quality action level of 1.0 mg/L. Carthage City Lake was oligotrophic in June and mesotrophic in July based on the calculated NCTSI scores (Table L18).

According to Mr. Sam Taylor, Director of Public Works for Carthage, Carthage City Lake is primarily spring-fed (90%) and has a protected water shed. There have been no complaints of taste or odor from processed drinking water taken from this lake, nor are there any current problems with algal blooms or aquatic macrophytes. The last known fish kill occurred 15 years ago and was due to an accidental alum spill into a drainage ditch on the facility property. The lake is sampled daily by the water plant at the intake. Water quality parameters include turbidity, chlorine, hardness, pH, alkalinity and temperature (dissolved oxygen is not measured) (Sam Taylor, Director of Public Works, Carthage City. pers. com.). Mr. Johnny Whitlock, Operator In Charge for the Carthage City Water Treatment Plant also stated that Carthage City Lake no know water quality problems. Very few problems are encountered in treating the raw water (Johnny Whitlock, Operator In Charge, Carthage City Water Treatment Plant. Pers. com.). According to Wayne Chapman, District 6 Fisheries Biologist, there are no reports regarding fisheries data for Carthage City Lake (Wayne Chapman, District 6 Fisheries Biologist, Division of Inland Fisheries, pers. com.).

Table L18. Carthage City Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Carthage City Lake	980804	no score	0.01	0.10	n/a	2.2
Carthage City Lake	980715	-1.1[M]	0.03	0.17	23	2.5
Carthage City Lake	980602	-6.4[O]	<0.01	0.20	<1	3.3
Carthage City Lake	930727	-3.3[O]	0.02	0.15	3	2.2
Carthage City Lake	910821	-2.2[O]	0.06	0.17	2	2.3


Cape Fear River 030611
Goldston
Cedar Cr
Georges Cr
Deep R
B-9
B5820000
B6050000
B-8
B-5
B-3
Deep R
F-2
Big Buffalo Cr
L Buffalo Cr
B-4
Pocket Cr
Sanford
L Pocket Cr
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
1 0 1 2 3 4 5 Miles

CAPE FEAR SUBBASIN 030611

DESCRIPTION

Subbasin 11 contains the lowermost reach of the Deep River (approximately 15 river miles) prior to its confluence with the Haw River. This subbasin also contains short reaches of the Haw River prior to the confluence with the Deep River. The Cape Fear River originates in the northeast corner of this subbasin by the joining of the Deep River and the Haw River. Tributary streams of the Deep River within this subbasin (Little Pocket, Cedar, Georges and Big Buffalo Creeks) are typical of the Triassic Basin. The sedimentary geology and poor groundwater recharge capacity of these streams result in 7Q10 values of zero for all but the largest catchments.

Much of the land use within this subbasin is forest, although pasture, cultivated crops and urban and built-up land uses also account for significant portions of the subbasin. Chatham County streams in this subbasin have high numbers of certified animal operations, primarily cattle and poultry. There are 7 permitted discharge facilities in this subbasin and only two facilities have permitted flow greater than 1 MGD. These facilities, both of which discharge to the Deep River, are the Sanford WWTP (5.0 MGD) and Golden Poultry (1.0 MGD).

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3*	Deep R	Lee	SR 1007	Good (s)	Good-Fair (s)
B-4	Little Pocket Cr	Lee	NC 42	Not Rated (w)	Not Rated (w)
B-5	Cedar Cr	Chatham	SR 2142	Not Rated (w)	Not Rated (w)
B-8	Georges Cr	Chatham	SR 2150	Not sampled	Not Rated (w)
B-9*	Deep R	Lee	US 15/501	Good (s)	Good-Fair (s)
FISH				1994	
F-1	Cedar Cr	Chatham	SR 2145	Fair	no sample
F-2	Big Buffalo Cr	Lee	SR 1403	Fair	Poor

(w) winter collection, (s) summer collection
*data available prior to 1993, see discussion below or data in Appendix 1.

Ambient water quality samples are currently being collected from two Deep River locations in this subbasin: US 15-501 near Sanford and at Moncure. These two locations are the most downstream monitoring sites on the Deep River prior to its confluence with the Haw River. The Deep River at Moncure is below the confluence with the Rocky River. Both of these locations are downstream of the Carbonton Dam, which impounds approximately 6.5 river miles and is approximately 10 river miles above the Sanford monitoring location. Anoxic conditions are common within this impoundment. These anoxic conditions may be partially responsible for lower median dissolved oxygen values, particularly at the Sanford site.

Two Deep River locations have been sampled for benthic macroinvertebrates during basinwide surveys in 1993 and 1998 in this subbasin. These two sites were selected to bracket the Sanford WWTP, although both sites are below the Carbonton Dam. Declines in water quality were found at both locations (Good in 1993 to Good-Fair in 1998) suggesting impacts other than the Sanford WWTP. This 5-year decline in water quality was not evident at the next most upstream Deep

River location in Moore County. The Moore County location near Jugtown has been consistently rated Excellent.

Tributary streams within this subbasin have physical characteristics that are typical for the Triassic Basin. These characteristics, which include zero 7Q10 values and poor instream habitat, produce streams that are difficult to rate using current DWQ classification criteria for benthic macroinvertebrates. Data were collected during winter surveys from three tributary streams in this subbasin in 1998. However, these streams were not given bioclassifications. A Poor NCIBI rating was assigned to Big Buffalo Creek below the Sanford WWTP.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Deep River, SR 1007

The Deep River at SR 1007 was selected as an upstream site above both the Sanford WWTP and numerous small tributaries that drain urban and suburban sections of Sanford. The river at this point is approximately 40 meters wide and has a diverse substrate. The substrate is composed of short rubble/boulder riffles (primarily bridge rubble) and long sandy reaches between riffles. The field team noted prolific Aufwuchs growths and severe bank erosion. Much of the land use immediately adjacent to the Deep River at this point is active tobacco farming.

Benthic macroinvertebrate samples have been collected from this site three times. These samples include basinwide surveys in 1998 and 1993, plus part of an intensive investigation of the Deep River in 1987. Lower taxa richness and EPT abundance values have been found each year, resulting in a decline from Good in 1987 and 1993 to Good-Fair in 1998. All data were collected during low-flow summer surveys. Many more tolerant taxa were collected during the 1998 survey (esp. Cricotopus bicinctus and Conchapelopia), while fewer intolerant taxa were found (most notably Chimarra).

Year	Total S	EPT S	EPT N	NCBI	Flow	Bioclass
1998	61	23	80	5.93	Low	Good-Fair
1993	74	25	131	5.78	Low	Good
1987	99	32	183	5.76	Low	Good

Little Pocket Creek, NC 42

Benthic macroinvertebrates have been collected from this site during February surveys in 1998 and 1993. Taxa richness values were similar, suggesting that water quality conditions have not changed between surveys. Little Pocket Creek is about 5 meters wide and has substrate and flow characteristics that are typical for Triassic Basin streams. These streams are deeply entrenched systems with sand/clay substrates. Winter surveys are conducted in these streams because, in most cases, Triassic Basin streams have zero 7Q10 values during summer months. Most benthic taxa were collected from snag and leaf pack habitats. Bioclassifications were not assigned to this location.

Cedar Creek, SR 2142

Habitat and biological observations from Cedar Creek mimic those from Little Pocket Creek. Cedar Creek, which is about 4 meters wide, is a deeply entrenched stream with very poor instream habitat, although the catchment appears to be completely forested. Most benthic macroinvertebrates are collected from snag or leafpack habitats. Samples have been collected from this site during February surveys in 1998 and 1993. Data are similar suggesting that there has not been a change in water quality, although these streams are not given ratings.

Big Buffalo Creek, SR 1403

In 1994, the fish community was rated as Fair but by 1998, the community had declined to Poor. The greatest declines between the two sampling periods were in the trophic metrics and the absence of the intolerant species of darter. Overall, the community was lacking in fish abundance and species diversity metrics (also including an absence of suckers), and the trophic composition was highly skewed towards insectivores. The instream pool habitat however was good as indicative of five species of sunfish which were collected. The most abundant species collected was the bluegill. In 1963, Big Buffalo Creek was described by WRC as being a “very polluted stream” because of the effluent from Sanford’s WWTP (Carnes, et al. 1964). The stream was devoid of oxygen and only seven mosquitofish were collected from a 150 ft. reach of the stream.

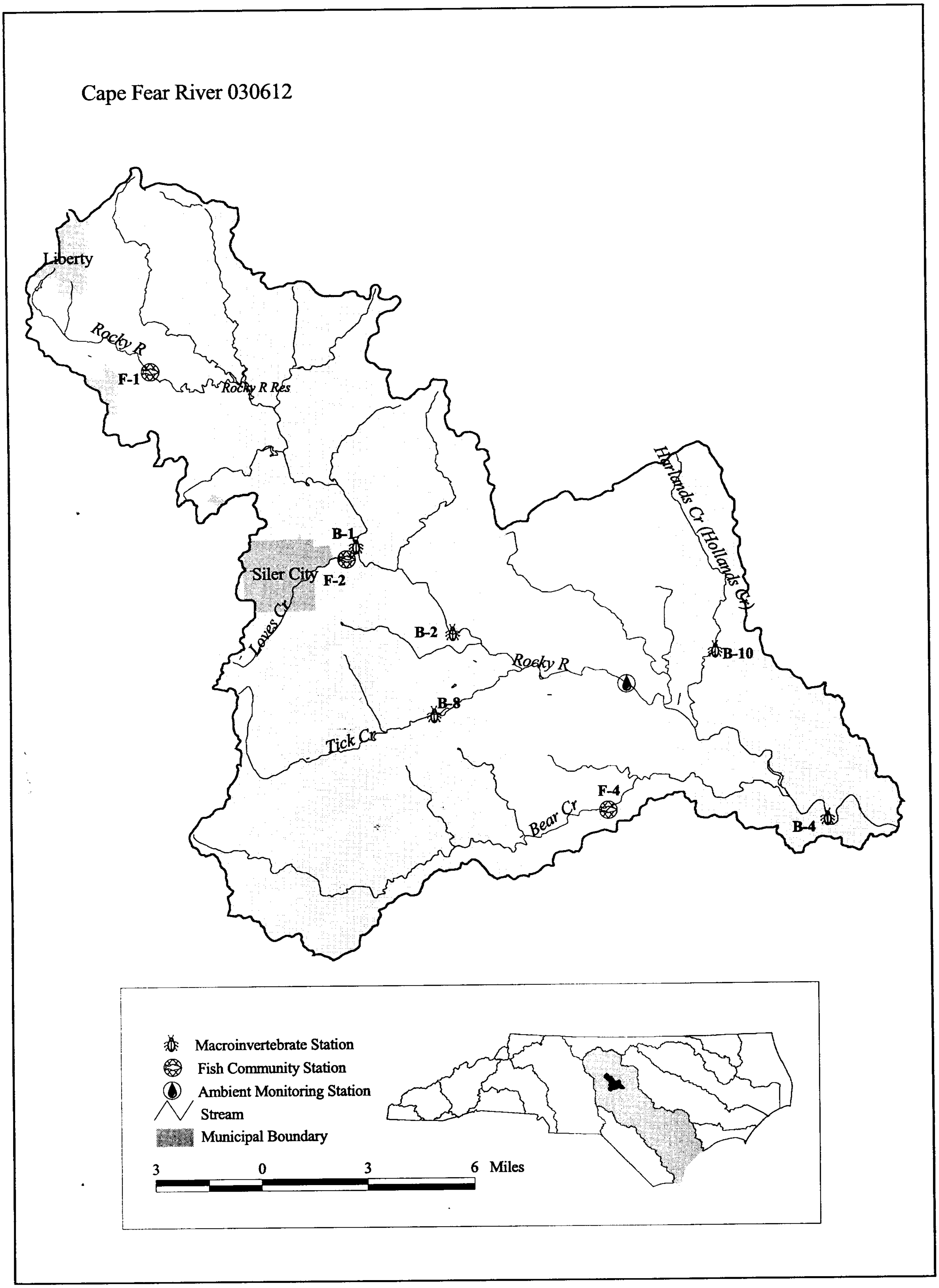
Georges Creek, SR 2150

Benthic macroinvertebrates have only been collected from this site during the 1998 basinwide program. Data were collected from an upstream location in 1993. The collection site was moved downstream to incorporate more of the catchment. Georges Creek, which is very similar to Little Pocket and Cedar Creeks, is about 5 meters wide, deeply entrenched and has a substrate composed of sand and hard-packed clay. The Georges Creek catchment also appears to be completely forested. Very few EPT taxa were collected from this location (4), significantly less than the upstream site at SR 2142 in 1993 (15), and only Leptophlebia and Allocapnia were abundant. This Triassic basin stream was not rated.

Deep River, US 15/501

Benthic macroinvertebrates have been collected from this location during basinwide surveys in 1998 and 1993. In addition, data also were collected from this site as part of a special study of the Deep River in 1987. This site is below the Sanford WWTP, which has a permitted flow of 5.0 MGD to the Deep River, and many small tributaries that drain the urban and suburban sections of Sanford. The river at this point is very wide (approximately 60 meters), with a diverse habitat. The substrate contains infrequent boulder/rubble riffle areas, long sandy runs and numerous snags and undercut banks. Aufwuchs are very prolific.

A 5-year decline in bioclassification was seen at this location: Good-Fair in 1998, Good in 1993. Lower EPT S (21 vs 27) and N (84 vs 111) values and a higher NCBI value (6.39 vs 5.97) were found in 1998 than 1993. Declines in bioclassification were seen at this site and the Deep River at SR 1007, above the Sanford WWTP, suggesting that factors other than the WWTP are responsible. Conductivities were similar above (141 µmhos/cm) and below (154 µmhos/cm) the facility. A Good-Fair bioclassification also was given to this location in 1987, although a much lower EPT N value was found in 1998.



Cape Fear River 030612
Liberty
Rocky R
F-1
Rocky R Res
Harlands Cr (Hollands Cr)
B-1
Siler City
F-2
Loves Cr
B-2
Rocky R
B-10
B-8
Tick Cr
F-4
Bear Cr
B-4
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
3 0 3 6 Miles

CAPE FEAR SUBBASIN 030612

DESCRIPTION

Subbasin 12 contains the entire Rocky River watershed, and is located mainly in Chatham County. The Rocky River, a large tributary of the Deep River, is approximately 35 river miles in length and is contained completely within the Slate Belt. The major tributaries to the Rocky River are Bear Creek, Tick Creek, and Loves Creek. Streams within this ecoregion are rocky streams characterized by very low base flows during summer months, and smaller tributaries often dry up completely during prolonged low-flow periods.

Land use within this catchment is primarily forest, although pasture, cultivated crops and urban and built-up land uses also are significant. Chatham County has the largest number of cattle operations of all counties within the Cape Fear River Basin and is second only to Duplin County in the number of poultry operations. There are 4 permitted NPDES dischargers in the subbasin and only one facility has a permitted flow of 1 MGD or greater. Siler City discharges 4.0 MGD to Loves Creek.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site#	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1*	Rocky R	Chatham	US 64	Fair (s)	Good-Fair (s)
B-2*	Rocky R	Chatham	SR 2170	Good-Fair (s)	Good-Fair (s)
B-4	Rocky R	Chatham	US 15/501	Good (s)	Good (s)
B-8	Tick Cr	Chatham	SR 2120	no sample	Good-Fair (s)
B-10	Harlands Cr	Chatham	NC 902	no sample	Good /Good-Fair
FISH				1994	
F-1	Rocky R	Chatham	SR 1300	no sample	Fair
F-2	Loves Cr	Chatham	SR 2229	no sample	Good-Fair
F-3	Tick Cr	Chatham	US 421	Good-Fair	---
F-4	Bear Cr	Chatham	SR 2187	no sample	Good

(w) winter collection, (s) summer collection

*data available prior to 1993, see discussion below or data in Appendix 1.

LAKES

Rocky River Reservoir

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Rocky River at SR 1300	1998	9	0	0	No samples exceeded criteria

Ambient water quality data are being collected from one location in this subbasin: the Rocky River at US 15-501 near Center Grove. These data indicate good water quality conditions and no apparent changes in water quality conditions between basinwide investigations.

Benthic macroinvertebrate samples have been collected from three mainstem Rocky River locations in this subbasin. Data collected during recent investigations (1998 and 1997) have found Good-Fair bioclassifications at the two most upstream locations. A improvement in water quality was found at the Rocky River at US 64 (Fair in 1993 to Good-Fair in 1998), and long-term improvements were found at this site and at the Rocky River at SR 2170. No change in rating (Good bioclassification) was found at the US 15/501 location, which is near the confluence with the Deep River. Several freshwater mussel species have been collected from the Rocky River, which are proposed for state protection and Threatened North Carolina Protection status (Alasmidonta undulata, A. varicosa and Strophitus undulatus). In addition to these data, a fish community sample also was collected from a headwater reach of the Rocky River above the Rocky River Reservoir. A Fair NCIBI score was given to this location, possibly reflecting the effects of nonpoint source runoff and enrichment.

Benthic macroinvertebrate samples were collected from two tributaries during basinwide surveys in this subbasin. Good-Fair ratings were found at two sites on Tick Creek (a winter survey at US 421 and a summer survey at SR 2120). Although a Poor bioclassification was given to the US 421 site in 1993, a 5-year trend in these data is difficult to determine. Field notes from the 1993 survey indicated that stream flow was reduced, likely affecting benthic macroinvertebrate community structure rather than water quality. A 5-year improvement in bioclassification was seen at Harlands Creek, although the difference in EPT taxa richness values between surveys was minimal. In addition to benthic macroinvertebrate data, fish community samples also were collected from two tributary locations in this subbasin. Good and Good-Fair NCIBI ratings were given to Bear Creek and Loves Creek above the Siler City WWTP, respectively.

Fish tissue samples were collected from the Rocky River at SR 1300 during May 1998. Nine samples were analyzed for metals contaminants. All metals results were lower than EPA and FDA/NC limits.

Lake assessment investigations were conducted during three summer surveys from the Rocky River Reservoir. Data from these investigations resulted in a eutrophic status assigned to this waterbody during the June and July surveys.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Rocky River, SR 1300 (headwaters)

The headwaters of the Rocky River at SR 1300 flow alongside a narrow riparian zone bordering a pasture which provides the livestock with access to the stream. An abundance of nutrients, full sun through an open canopy, and unstable banks all contributed to a fish community which was rated as Fair. More fish (n = 672) were collected from this site than any other site monitored in the river basin in 1998. An unbalanced trophic composition and an absence of intolerant species were the metrics primarily responsible for the Fair rating. The two most abundant species were the bluehead chub and the redbreast sunfish (46% and 20%, respectively of all the fish collected).

Rocky River, US 64

Benthic macroinvertebrate samples have been collected from this site on four occasions. These samples include basinwide surveys in 1998 and 1993, and special studies of the Siler City WWTP in 1997 and 1989. The Rocky River at this location has flow and habitat characteristics that are typical of Slate Belt streams. Stream width is approximately 10 meters at this location, but varies considerably along the collection reach. This reach has infrequent boulder/rubble riffles and long coarse sand or gravel runs. This site also has productive snag and undercut bank habitats. The field team also noted prolific Aufwuchs growth on substrate material and very little bank erosion.

Good-Fair bioclassifications were found at this site in 1998 and 1997, while Fair ratings were given to this site during earlier surveys in 1993 and 1989. Very low EPT taxa richness and abundance values (and a high Biotic Index value) were found during the basinwide survey in 1993. Taxa richness and abundance values improve during 1997 and 1998 surveys, and the 1998 NCBI value is lower than all previous years. Several intolerant taxa were abundant only during 1997 or 1998 (Ceraclea ancylus and Hydropsyche demora, Isonychia, Neoperla). Dry weather water releases from the Rocky River Reservoir, which is located above US 64, have been occurring since 1995. The increase in flow permanence at US 64 may be a contributing factor for the slight improvement in water quality.

Year	Total S	EPT S	EPT N	NCBI	Flow	Bioclass
1998	78	16	107	6.40	Low	Good-Fair
1997	77	20	100	6.74	Low	Good-Fair
1993	69	12	54	6.97	Low	Fair
1989	57	16	101	6.70	Normal	Fair

Rocky River, SR 2170

The Rocky River at SR 2170 is approximately three miles below the confluence with Loves Creek, which receives the effluent from the Siler City WWTP. Data from this site and from the Rocky River at US 64 are used to assess impacts from the Siler City WWTP. The river at this site is about 30 meters wide with infrequent boulder/rubble riffles. Stream flow was very low during the 1998 sample, restricted to very short sections between long, slow-flowing runs.

Very similar water quality conditions (Good-Fair) have been recorded from this location during basinwide surveys in 1998 and 1993, and during the 1997 intensive investigation (19 EPT taxa each time). A Fair rating ((11 EPT) was given to this site in 1989. In 1991, the Siler City WWTP was upgraded, including dechlorination, and expanded from 1.8 MGD to 4.0 MGD. Improvements at this facility are contributing factors for better water quality at this location.

Rocky River, US 15/501

This is the most downstream Rocky River location prior to the confluence with the Deep River in Chatham County. The wet width of the stream during summer surveys at this location is extremely variable. Widths are constricted to 4 meters or less at riffle areas, but are 20 meters or more at run/pool reaches. The substrate, which is typical for Slate Belt streams, is composed mostly of infrequent boulder/rubble riffle areas and long, slow-flowing, sandy runs. The canopy was open up at this site, allowing for the development of prolific emergent macrophyte growths along wetted margins of the river. These dense growths of emergent macrophytes alter diurnal concentration of dissolved oxygen (4.9 mg/l in July 1998). The field team also noted prolific growths of Aufwuchs and Podostemum in the riffles.

Benthic macroinvertebrates have been collected from this site during basinwide surveys in 1998 and 1993, and during a special study in 1990. Good bioclassifications have been recorded from this site each year, suggesting no long-term change in water quality. These data also indicate that the Rocky River has recovered from upstream impacts before flowing into the Deep River.

Loves Creek, SR 2229 (above Siler City's WWTP)

The watershed of Loves Creek drains the area of the Town of Siler City south of US 64. The fish community in this small stream, which was sampled approximately 0.5 mi. above its confluence with the Rocky River, was rated as Good-Fair. The species diversity (n = 20) and fish abundance metrics scored high and the number of species of sunfish collected (6) indicated good instream pool habitat. However, the trophic metrics and the percentage of tolerant fish metrics scored in the mid- or lower range. The most abundant species collected was the tolerant redbreast sunfish (44% of all the fish collected were of this species).

Tick Creek, US 421 and SR 2120

The Tick Creek catchment is within the Slate Belt; however, the habitat characteristics at US 421 are not typical for this area. There is only one high quality riffle at an old mill dam within the sampling reach. During summer, low-flow conditions in 1993 this riffle was completely dry, which prevented an assignment of a bioclassification. Basinwide surveys in 1998 were conducted at two locations: US 421 in February and SR 2120 in August. The SR 2120 site is at the next downstream bridge crossing and appears to have habitat characteristics that are more typical for this area. Tick Creek at SR 2120 is about 4 meters wide and has infrequent boulder riffles. Bank erosion is severe along this reach and cattle have direct access to the stream. The land use at this location is mostly forested and pasture. Good-Fair bioclassifications were given to both of these locations in 1998. An undescribed crayfish species (Cambarus, subgenus Puncticambarus) has been collected from the US 421 location.

Harlands Creek, NC 902

This small tributary catchment of the Rocky River has a drainage area of 16 square miles at the confluence. The catchment appears to be mostly forested with some active pasture, although there are no confined animal operations in the catchment. Road construction activities along US 64 west of Pittsboro occurred during 1998 and may have delivered sediment to headwater reaches of Harlands Creek during spate events. The substrate at NC 902 is composed of high gradient boulder/rubble riffles and numerous pools that provide good habitat for fish.

Benthic macroinvertebrates were collected from this site twice in 1998 (February and July), and during an ORW study of the Rocky River catchment in 1990. A Good bioclassification, despite a higher biotic index, was given to this site during the July 1998 survey compared to a Good-Fair rating in 1990. These data suggest a long-term improvement in water quality. In addition, a slightly lower EPT taxa richness value, and a Good-Fair bioclassification, were found during the February survey compared to the July 1998 survey.

Bear Creek, SR 2187

The Bear Creek watershed drains a portion of the southwest corner of Chatham County. The fish community in the naturally slightly tannin-stained waters was rated as Good. The instream and riparian habitat also scored high. The only metric which scored well-below expectations was in the diversity of suckers; only one species was collected. The numerically dominant species was the highfin shiner.

SPECIAL STUDIES

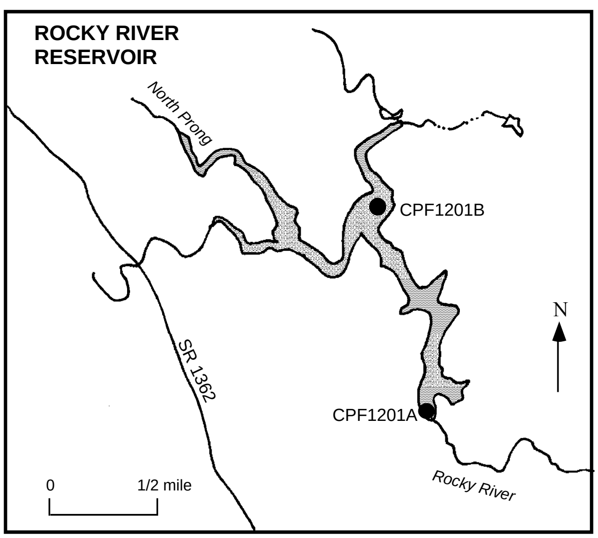
Two sites on Loves Creek and three sites on the Rocky River were sampled in 1997 to evaluate the effects of facility upgrades at the Siler City WWTP in 1991. Changes in the benthic community were noted at Loves Creek below the WWTP and the Rocky River at SR 2170, but bioclassifications did not change.

LAKE ASSESSMENT PROGRAM

Rocky River Reservoir

COUNTY:	Chatham	**CLASSIFICATION:**	WS-III CA
SURFACE AREA:	185 acres (75 hectares)	**MEAN DEPTH :**	33 feet (10 meters)
VOLUME:	1.6 x$10^6$$m^3$	**WATERSHED**:	23 mi^2 (59 km^2)

Rocky River Reservoir serves as a water supply for the Town of Siler City. Public access to the lake is restricted. The impoundment was enlarged in 1988 to raise the existing storage capacity from 60 million gallons (227,100 m^3) to 424 million gallons (1,604,840 m^3), raising the water level by approximately 10 feet (three meters). The watershed is primarily agricultural with some pasture immediately adjacent to the lake.



Rocky River Reservoir was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data collected for this lake are presented in Appendix L2. Surface dissolved oxygen in 1998 ranged from 4.9 mg/L at the sampling site near the dam in July to 9.2 mg/L at the upstream lake sampling site, also in July. Secchi depth was less than one meter at both sampling sites in June, July and August.. The highest values for total phosphorus and ammonia were observed at the sampling site near the dam in June. Concentrations of metals were less than the applicable state water quality standards. Rocky River Reservoir was eutrophic in June and July based on the NCTSI scores calculated for the days it was sampled in these months (Table L19).

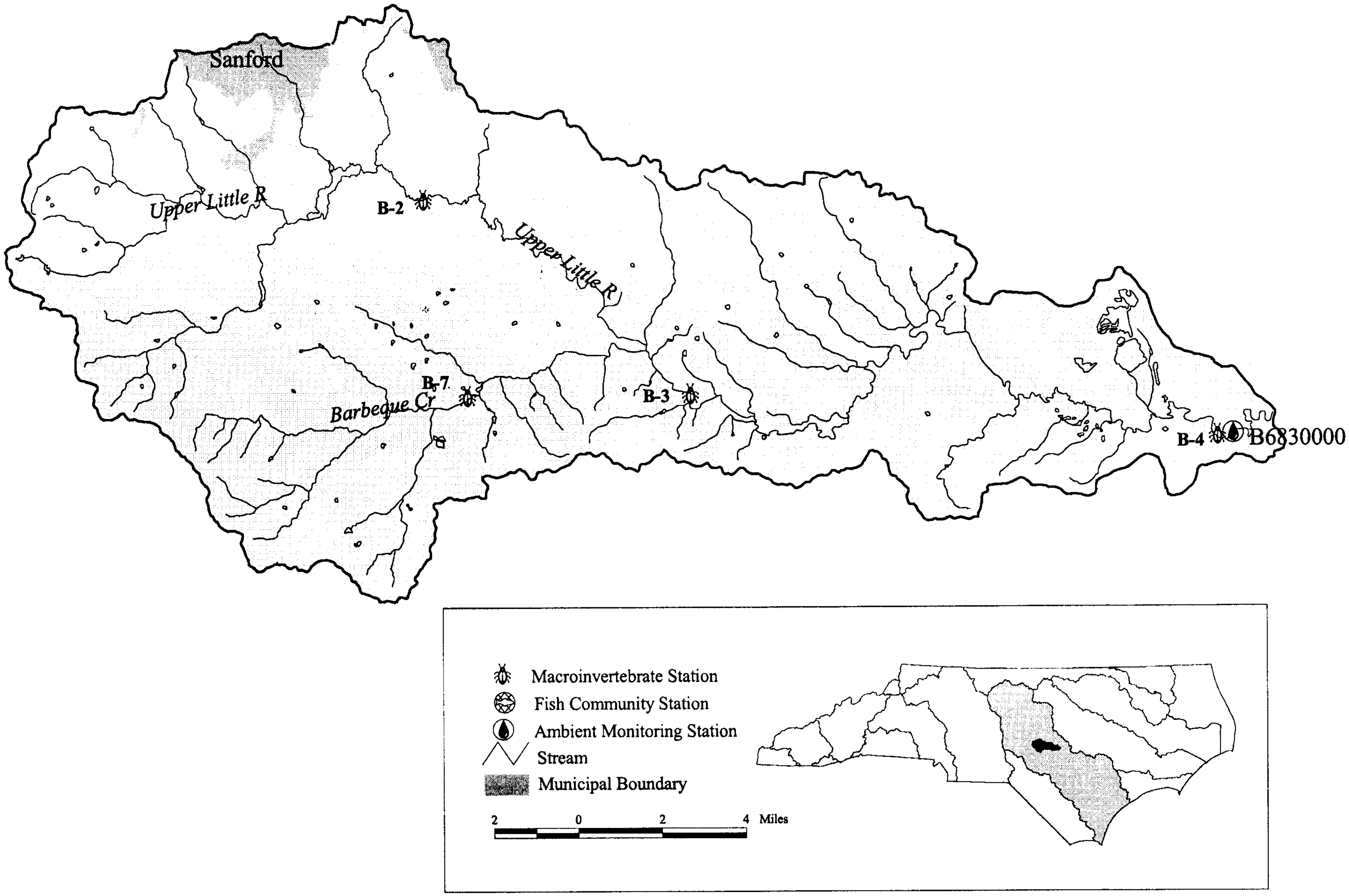
According to Mr. Kenneth Loflin, Supervisor for the Town of Siler City Water Treatment Plant, and Mr. Terry Green, Director of Public Works for Siler City, there have been no recent complaints regarding taste or odor problems. In the past, elevated levels of iron and manganese in the raw water resulted in taste and odor complaints (the water plant now treats the raw water for elevated manganese). The water treatment plant samples the lake at the intake for various water quality parameters including pH, iron, manganese, turbidity and alkalinity. Fecal coliform bacteria sampling is conducted monthly and sampling for inorganics and organics are sampled annually. Turbidity and low dissolved oxygen in Rocky River Reservoir have been observed after rainfall events. These problems are usually temporary. There have been no recent problems with algal blooms, nuisance levels of aquatic macrophytes or reports of fish kills. There has been some development of the watershed related to agriculture, but these changes are not expected to have a significant impact on the lake (Kenneth Loflin, Supervisor, Town of Siler City Water Treatment Plant, pers. com. ; Terry Green, Director of Public Works, Town of Siler City, pers. com.).

Ms. Shari Bryant, District 5 Fisheries Biologist, stated that she was unaware of any current or historical fish related issues for Rocky River Reservoir, or any special fisheries investigations conducted at this lake (Shari Bryan, District 5 Fisheries Biologist, Division of Inland Fisheries. Pers. com.).

Table L19. Rocky River Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Rocky River Res.	980806	no score	0.08	0.66	n/a	0.5
Rocky River Res.	980708	3.9[E]	0.07	0.51	35	0.4
Rocky River Res.	980603	4.1[E]	0.18	0.46	15	0.5
Rocky River Res.	930729	5.4[H]	0.10	0.92	38	0.4
Rocky River Res.	910801	4.1[E]	0.10	0.55	41	0.7

Cape Fear River 030613



CAPE FEAR SUBBASIN 030613

DESCRIPTION

Cape Fear subbasin 13 contains the Upper Little River and its tributaries, Juniper Creek and Barbeque Creek, in Harnett and Lee counties and a very short section of the Cape Fear River near Erwin. Subbasin 13 is surrounded in a clockwise direction by subbasins 7, 18, 14, 10 and 11. There are no urban areas (though Sanford and Lillington are just outside the subbasin) and most of the land is forested or used for agriculture. This watershed is in the Sandhills physiographic province.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-2	Upper Little R	Harnett	SR 1222	Good-Fair	Good-Fair
B-3	Upper Little R	Harnett	NC 27	Good	Good
B-4	Barbeque Cr	Harnett	SR 1209	Good-Fair	Good-Fair
B-7	Upper Little R	Harnett	SR 2021	Good	Excellent

Ambient water quality samples are currently being collected from one location in this subbasin: Upper Little River at SR 2021 near Erwin. Three sites were sampled for benthos on the Upper Little River in the headwaters, the middle section and at the ambient site near its mouth. The headwater and middle sites were barely flowing, even though this is a Sandhills stream, while the downstream site had good flow. The benthos ratings indicate a progressive improvement in water quality going downstream in this agricultural watershed: Good-Fair to Good to Excellent. Only the downstream site improved compared to 1993, when it was Good. Barbeque Creek, a slow flowing tributary of the Upper Little River was given a Good-Fair bioclassification in 1998, the same rating it had in 1988.

RIVER AND STREAM DATA, 1993-1998

Upper Little River, SR 1222

This site in the headwaters area is about 10 meters wide (drainage area =54 square miles) with just the barest hint of flow in the summer of 1998. There is a little rocky substrate, and the bottom is primarily sand and gravel. There were no riffles in the stream, and it had a swampy, low flow character. The bioclassification was Good-Fair in both basin years. However, the macroinvertebrate data for this site indicate an improvement in water quality between 1993 and 1998 when EPT taxa richness increased by 8 taxa to 21, while the BI increased only slightly. In 1988 there were 19 EPT taxa and a lower BI and a Good-Fair bioclassification, so there is no long term improvement.

Upper Little River, NC 27

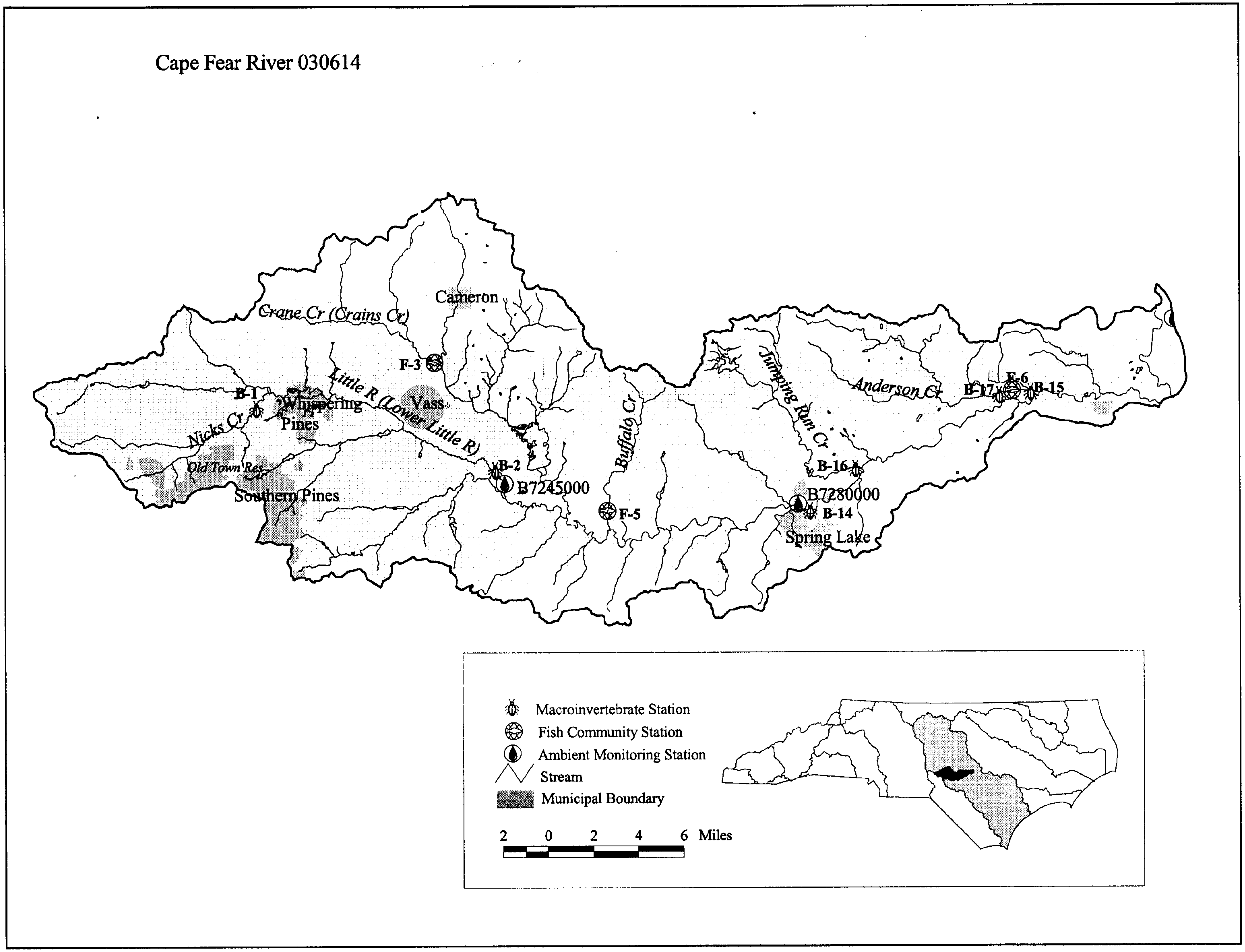
The river at this site in the middle section has much the same size and character as the upper site, even though drainage area has about tripled to 145 square miles: no riffles, barely flowing in summer, sand and gravel substrate. The site had a forest on one site and a silviculture area on the other. In addition, there were a lot a dead trees that had fallen into the stream. The increased habitat may help explain the improved water quality here compared to the SR 1222 site. Benthos samples resulted in Good bioclassifications during both basin assessment years, with remarkably consistent EPT taxa richness (26-27) and BI values (5.51-5.50). The caddisfly fauna was diverse, 14 taxa, with numerous taxa Abundant: Polycentropus, Brachycentrus numerosus, Cheumatopsyche, Nectopsyche exquisita, Oecetis morsei, and Protoptila.

Barbeque Creek, SR 1209

Barbeque Creek enters the Upper Little River just above the NC 27 site. This is another small (9 meters wide and drainage area is 31 square miles) slow flowing, sandy stream. Land use near the site was forest with some row crops. The macroinvertebrate community from this tributary site is similar to the Upper Little River at SR 1222. The bioclassification has remained Good-Fair since first sampled in 1988, though the 1998 benthos sample had 6 more EPT taxa than 1993 and was almost into the Good range. This site receives nonpoint runoff from agricultural areas.

Upper Little River, SR 2021 near Erwin

The river in this lower section is a little bigger (13 meters wide, but drainage area has increased to 217 square miles), with more boulder and rubble mixed in with the sand and gravel. There were some gravel riffles, but the rocks and logs were covered with filamentous algae. Surrounding land was forest and a hayfield. EPT taxa richness was fairly constant (27-25) from 1988 to 1993, with Excellent and Good bioclassifications. An Excellent rating was given in 1998 when 10 more EPT taxa (35) and a decrease in the BI were found. Six taxa of stoneflies were found in 1998, and intolerant taxa such as Chimarra, Micrasema wataga, Leucrocuta and Paragnetina fumosa were abundant. While this location is in an agricultural watershed, there appears to be little impact to the macroinvertebrate community.


Cape Fear River 030614
Cameron
Crane Cr (Crains Cr)
F-3
B-1
Whispering Pines
Vass
Little R (Lower Little R)
Nicks Cr
Old Town Res
Southern Pines
B-2
B7245000
Buffalo Cr
F-5
Jumping Run Cr
Anderson Cr
B-17
F-6
B-15
B-16
B7280000
B-14
Spring Lake
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 6 Miles

CAPE FEAR SUBBASIN 030614

DESCRIPTION

The (Lower) Little River and its tributaries, Nicks Creek, Mill Creek, Juniper Creek, Crane Creek, Jumping Run, and Anderson Creek, are located mainly in the Sandhills, but the lower watershed grades into the inner coastal plain in Cumberland County. The upper portion of this watershed is characterized by mostly rural areas, though Southern Pines is in the watershed of Mill Creek. The lower reaches flow through or near Fort Bragg or the urban areas of Spring Lake and Fayetteville. The (Lower) Little River was designated High Quality Waters from its source to Crane Creek, based on Excellent biological (benthos) data. Note: This has always been named the Lower Little River in biological reports, but the DWQ Schedule of Classifications names it the Little River, with Lower Little River in ( ).

DESCRIPTION

Cape Fear subbasin 14 is located in the Sandhills ecoregion and contains the Little River watershed and the towns of Southern Pines, Pinehurst, and Aberdeen. The major tributaries to the Little River are James Creek, Crains Creek, and Anderson Creek.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1	Nicks Cr	Moore	NC 22	Good	Excellent
B-2	(Lower) Little R	Moore	SR 2023	Excellent	Excellent
B-14	(Lower) Little R	Cumberland	NC 87/24	Good-Fair	Excellent
B-15	(Lower) Little R	Cumberland	US 401	Excellent	Excellent
B-16	Jumping Run Cr	Cumberland	NC 210	Good-Fair	Excellent
B-17	Anderson Cr	Harnett	SR 2031	Good-Fair	Good-Fair
FISH				1994	
F-3	Crains Cr	Moore	US 1	no sample	Fair
F-5	Buffalo Cr	Moore	SR 1001	no sample	Good-Fair
F-6	Anderson Cr	Harnett	SR 2031	no sample	Fair
LAKES					
Old Town Reservoir					

The (Lower) Little River was sampled for benthos at three sites. The upper site is in the HQW section of the river and has been Excellent, based on benthos data, since first sampled in 1988. The middle site near Manchester is below the Fort Bragg WWTP and has improved dramatically since 1986 and 1998 when water quality was Fair. The Fort Bragg WWTP completed an upgrade in 1991 and water quality improved to Good-Fair in 1993 and then to Excellent in 1998. EPT taxa richness increased from 18 in 1993 to 40 in 1998 at this site. This is the highest EPT taxa richness collected at any site in the entire Cape Fear River basin since 1983. Ambient chemistry is also collected at these two sites. The most downstream site had the second highest EPT value in the basin and was Excellent in both 1993 and 1998.

Nicks Creek is a headwater tributary that improved from Good in 1993 to Excellent in 1998 using benthos data. In contrast, a fish sample in 1996 resulted in a Fair NCIBI. Similar, lower, ratings for fish community samples in other Sandhills streams suggests that present IBI metrics are evaluating something different than the benthos community, which gives good evaluations of water quality.

Jumping Run Creek in Cumberland County showed a marked improvement from a Good-Fair rating in 1993 to Excellent in 1998, using benthos data. This was despite poor instream habitat, a very developed nearby watershed, and no apparent changes in land use since 1993.

Buffalo Creek and Anderson Creek both had Good-Fair bioclassifications. Even though an NCIBI rating of Fair was given to Anderson Creek, the overall discrepancies between benthos and fish suggest Good-Fair may be a more accurate evaluation of water quality, especially given the small size of the stream.

Old Town Reservoir on Mill Creek was sampled in 1998 and was oligotrophic in June and mesotrophic in July.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Nicks Creek, NC 22

This headwater tributary of the Lower Little River has a drainage area of about 27 square miles at this site, but is only about 5 meters wide. For a Sandhills stream, it has a lot of rubble and gravel substrate, with some boulder and sand. The site is just outside Whispering Pines and land use was forest with houses on wooded lots. Pinehurst is in the watershed. EPT taxa richness for benthos samples has changed little, 22 in 1988, 20 in 1993 and 24 in 1998. This slight increase raised the bioclassification to Excellent in 1998.

(Lower) Little River, SR 2023

This station is located in the HQW portion of the river upstream of the ambient site at Manchester and has received an Excellent benthos bioclassification in the four times it has been sampled since 1988 for the HQW study. EPT taxa richness values have always been in the 30's. Caddisflies were especially diverse in 1998 with 18 taxa. This is a typical Sandhills stream with a sand and gravel bottom, good flow, and no bank erosion. It is a pretty site about 8 meters wide, with forests and residential areas nearby. It has a drainage area of 154 square miles.

Crains Creek, US 1

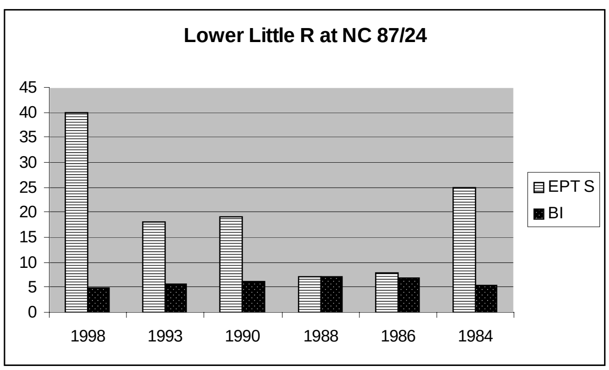
Crains Creek has been sampled twice for fish as part of the basinwide monitoring program. The sample collected at the SR 1001 access was 0.3 mi. below the man-made impoundment called Lake Surf. The sample collected in 1998 was further up the watershed and had a drainage area approximately one-third the size of the lower site. In 1998, the fish community was rated as Fair. Metrics for which the community scored well below expectations were in the number of intolerant species collected and the percentage of omnivores. The numerically dominant species was the bluegill.

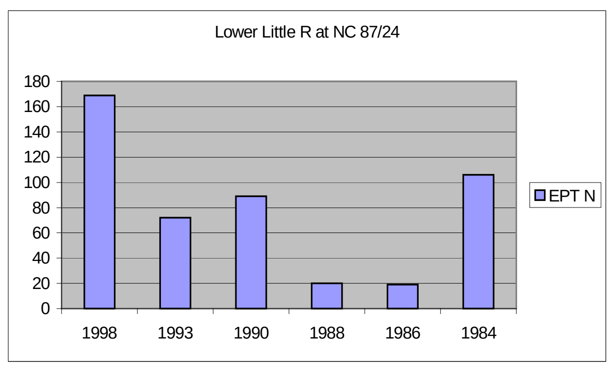
Buffalo Creek, SR 1001

Buffalo Creek is a low pH and specific conductance blackwater stream that also has a naturally low instream productivity. The fish community which consisted of six species and 28 fish (of which the chain pickerel was the most abundant species) was rated as Good-Fair. The riparian and instream habitat were also of high quality (i.e., stable banks, good shading, and a wide riparian zone along both shorelines).

(Lower) Little River, NC 87/24 near Manchester
This site in 1998 appears to be an incredible success story. The river at this point is in an industrial area of Manchester, with a cemetery also on one side. It has widened to about 14 meters (drainage area = 347 square miles), with some rubble in with the gravel and sand substrate. Though riffles are scarce, there is good flow and good snag habitat. This site has been sampled 6 times since 1984. There was a clear indication of stress in 1986 and 1988 when Fair ratings were found, followed by recovery in 1990 and 1993 (Good-Fair). This pattern can be attributed to changes at the Fort Bragg WWTP. This facility was out of compliance in 1986 and 1988, and operated under an SOC in 1990. A major upgrade in treatment was completed in 1991.

The 1998 sample had 83 taxa and 40 EPT taxa, more than twice what was collected in 1993 (18 EPT taxa). This is the most EPT collected at any site in the entire Cape Fear River basin since 1983, and the next downstream site had the second highest. Six stonefly taxa were collected, and four of those were Common or Abundant. Only four EPT were abundant in 1993 (no stoneflies or caddisflies), but 11 EPT taxa were Abundant in 1998. Even in 1984 when this site had a Good bioclassification, only 25 EPT taxa were collected. Since 1988 there has been an increase in intolerant taxa and a noticeable decrease of particularly pollution tolerant taxa.





(Lower) Little River, US 401
This site is near the mouth of the river in Cumberland County, where it has a drainage area of 459 square miles, is 15 meters wide with a rubble, gravel and sand substrate. The stream banks were stable, and surrounding land was mainly row crops and pasture. This site was Excellent in 1993 and 1998, but EPT increased by 12 taxa to 38 in 1998, and the BI decreased.

Jumping Run Creek, NC 210
This small tributary of the Lower Little River was sampled at its mouth (drainage area is 30 square miles) on the Cumberland/Harnett County line at NC 210. It was 4 meters wide with a gravel, sand and silt substrate. Flow was slow, and there were few snags or logs. Surrounding land was primarily developed-residential, commercial and industrial-with little intact riparian zone. Despite the poor habitat, 26 EPT taxa were collected from a benthos sample, only 10 of them Rare, and an Excellent bioclassification was assigned. This is a considerable improvement from the 16 EPT and Good-Fair bioclassification found in 1993. Chimarra, an intolerant

caddisfly, was abundant. No apparent changes in land use have occurred, and there is only one discharger in the watershed, a mobile home park.

Anderson Creek, SR 2031

Anderson Creek at SR 2031 is a tiny stream (3 meters wide)with extremely clear water, an unusual clay and sand substrate, and good flow. It does have a large drainage area (35 square miles) for its size. Much of its watershed appears to be agriculture and forest. Almost all the benthos in the EPT sample were found on snags and roots mats. Six more taxa were collected in 1998 (19) but the bioclassification remained Good-Fair. Abundant taxa were Stenonema modestum, Cheumatopsyche, Acroneuria carolina and Leuctra. Ten of the 19 taxa were Rare. This stream may be too small to be accurately evaluated with present criteria.

The fish community was rated as Fair. Metrics for which the community was scored well below expectations were in the fish abundance and percentage of omnivores. There was also an absence of sucker species. The riparian and instream habitat, however, scored high (i.e., stable banks, good shading, and a wide riparian zone along both shorelines).

SPECIAL STUDIES

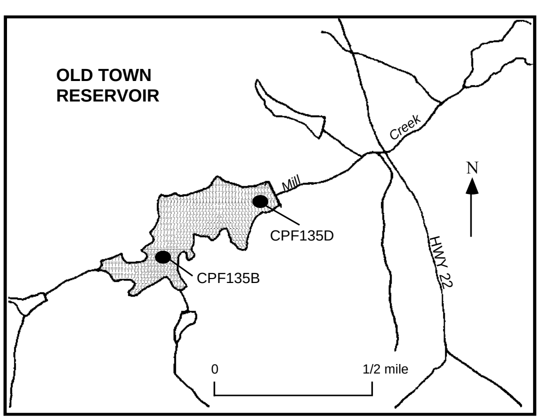
In 1996, the fish community in Nicks Creek was evaluated at the request of the North Carolina Division of Water Resources as part of a minimum flow study (F-960611). The community was rated as Fair. In 1998, an HQW study of Mill Creek above Crystal Lake resulted in an Excellent benthos rating at the only site that could be sampled.

LAKE ASSESSMENT PROGRAM

Old Town Reservoir

COUNTY:	Moore	**CLASSIFICATION:**	WS-III CA
SURFACE AREA:	60 acres (24 hectares)	**MEAN DEPTH :**	13 feet (4 meters)
VOLUME:	0.2 $x10^6 m^3$	**WATERSHED**:	0.4 mi^2 (1 km^2)

Located near Southern Pines in the Sandhills, Old Town Reservoir is an impoundment of Mill Creek. Built in 1925, this one-time water supply (discontinued in 1985) is now used for public recreation. Maximum lake depth is 23 feet (seven meters). The lake's watershed is relatively undeveloped with the exception of a golf course.



Old Town Reservoir was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The greatest nutrient values and chlorophyll *a* value were observed in July. Concentrations of metals in 1998 were less than the applicable state water quality standards. Based on the calculated NCTSI scores, Old Town

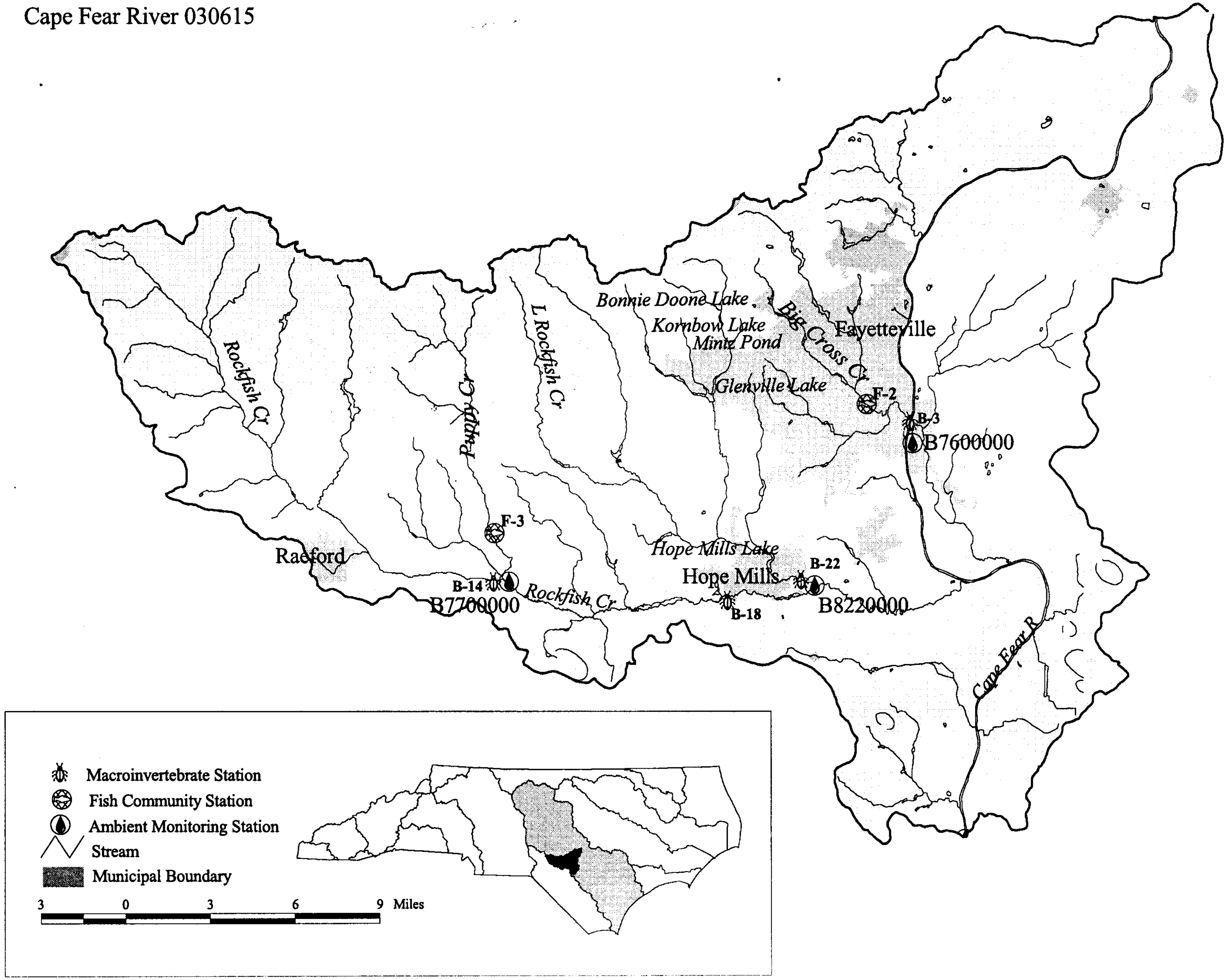
Reservoir was oligotrophic in June and mesotrophic in July (Table L20).

According to Mr. David McKee, Operator at the Town of Southern Pines Water Treatment Plant, raw water is drawn from Drowning Creek in Moore County and there are no current county or city water quality monitoring activities for Old Town Reservoir (David McKee, Operator, Town of Southern Pines Water Treatment Plant, pers. com.). Mr. Anthony Mullis, Piedmont Region Supervisor for the Division of Inland Fisheries, stated that he was unaware of problems related to the fish population in Old Town Reservoir (Anthony Mullis, Piedmont Region Supervisor, Division of Inland Fisheries. Pers. com.).

Table L20. Old Town Reservoir NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Old Town Res.	980804	no score	0.02	0.15	n/a	2.9
Old Town Res.	980715	-1.6[M]	0.04	0.15	15	3.3
Old Town Res.	980602	-2.9[O]	<0.01	0.30	6	1.6
Old Town Res.	930819	-3.8[O]	<0.01	0.19	4	2.0
Old Town Res.	930722	-2.9[O]	0.01	0.25	4	1.7
Old Town Res.	930629	-3.7[O]	<0.01	0.43	2	2.2
Old Town Res.	920819	-1.1[M]	0.02	0.31	13	2.6
Old Town Res.	920716	-2.5[O]	0.04	0.17	3	2.0
Old Town Res.	920602	-1.8[M]	0.02	0.23	6	1.2
Old Town Res.	910821	0.0[M]	0.05	0.23	18	1.7
Old Town Res.	910716	-1.2[M]	0.02	0.17	10	0.9
Old Town Res.	910620	-2.5[O]	0.02	0.18	5	1.3
Old Town Res.	880915	-2.3[O]	0.01	0.25	8	1.8

Cape Fear River 030615



CAPE FEAR SUBBASIN 030615

DESCRIPTION

This subbasin is located in the Sandhills ecoregion of the state. This subbasin contains the city of Fayetteville, the largest urban area, as well as the majority of the Fort Bragg Military Reservation. The Cape Fear River flows through Fayetteville in this subbasin, but most of the subbasin is made up of the Rockfish Creek and Little Rockfish Creek watersheds.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3	Cape Fear R	Cumberland	Person St	Good-Fair	Not Rated
B-17	Rockfish Cr	Hoke	SR 1432	Good	Excellent
B-21	Rockfish Cr	Cumberland	NC 87	Good	Excellent
B-25	Little Rockfish Cr	Cumberland	NC 59	Good	Good
FISH				1994	
F-2	Big Cross Cr	Cumberland	NC 87/210/24	no sample	Poor
F-3	Puppy Cr	Hoke	SR 1406	no sample	Good-Fair

LAKES

Hope Mills Lake, Kornbow Lake, Bonnie Doone Lake, Mintz Pond, Glenville Lake

There are currently three ambient water quality monitoring sites in this subbasin, one on the Cape Fear River and two on Rockfish Creek. The Rockfish Creek sites have low conductivity, but the upper site has fairly high nutrient values. This upper site is below the Raeford WWTP, and benthos bioclassifications have improved from Good-Fair in 1990 to Good in 1993 to Excellent in 1998. Upgrades in treatment at the WWTP are believed responsible for this improved water quality. The downstream Rockfish Creek site has been Excellent, using benthos data, since 1983, except for a slight decrease to Good in 1993. Little Rockfish Creek was also sampled above the confluence with Rockfish Creek. Even though the watershed is urban and agricultural, benthos ratings in both 1993 and 1998 were Good.

The Cape Fear River near Fayetteville is difficult to sample, even with a boat. Very different flow conditions in 1993 and 1998 appear to be structuring the benthic community more than other factors, so this site was not rated.

Cross Creek and Little Cross Creek are urban streams in Fayetteville that have been sampled for benthos or fish in 1993 and 1998. All data indicate these are impaired streams, but evaluations are complicated by the small size of headwater sites and lack of flow in the summer. When ratings have been given, they were either Poor or Fair.

Puppy Creek is a low pH, low productivity, Sandhills stream that, again, had a Good-Fair NCIBI rating with no apparent source of impact. The stream drains Fort Bragg and had good instream and riparian habitat. The dusky shiner dominated the fish community.

Four impoundments on Little Cross Creek, Boonie Doone, Kornbow, Mintz Pond and Glenville Lake, serve as backup water supply for Fayetteville. All were sampled in 1998 and were found to be oligotrophic or mesotrophic, except for Glenville which was eutrophic. Hope Mills Lake on Little Rockfish Creek was also sampled in 1998 and has been primarily eutrophic since 1984.

RIVER AND STREAM DATA, 1993-1998

Cape Fear River, Person Street in Fayetteville

The Cape Fear River in this reach is wide and deep and was sampled for benthos with a boat in both 1993 and 1998, over a 3 mile stretch of river. In 1993 a shallow riffle area was found, kick net samples were taken and the site was rated with Piedmont criteria (Good-Fair). In 1998, no comparable habitat was found and there was very little flow. Since flow conditions were so atypical and would call for using Coastal B criteria (resulting in an Excellent rating), it was decided to not rate the 1998 sample. Probably the 1993 sample should also not be rated, since flow seems to be structuring the benthic community more than other factors. EPT taxa richness dropped from 19 to 14 in 1998, and the abundant taxa were very different between years.

Big Cross Creek, NC 87/210/24

Big Cross Creek is an urban stream impounded several times above the 1998 monitoring site. Characteristic of many urban streams, the flow and the water levels are highly fluctuating, the instream and riparian habitats are poor, and man made trash was observed deposited within the stream. The fish community was rated as Poor. The numerically dominant species was the tolerant redbreast sunfish (84% of all the fish were of this species).

Puppy Creek, SR 1406

Puppy Creek is a low pH, specific conductance, and low productivity blackwater stream whose headwaters originate on the Fort Bragg Military Reservation. In 1962, nine species were collected with the most abundant species being the dusky shiner (Louder 1963). In 1998, eight species were collected and the dusky shiner was again the most abundant species collected. The fish community was rated as Good-Fair. It was the only fish community monitored in 1998 in which at least one species of sunfish was not collected. However, similar to other streams monitored in the Sandhills, the riparian and instream habitat were of high quality (i.e., stable banks, good shading, and a wide holly-bay forested riparian zone along both shorelines).

Rockfish Creek at SR 1432

This is a fairly deep, 10 meters wide, swamp-like stream with a sand, silt and detritus substrate. There was good flow in the channel, but many backwater areas with a silt bottom. Water was very low when sampled for benthos in July 1998. It is located below the Raeford WWTP. Since 1990, the Raeford WWTP has upgraded their pretreatment program, made improvements to their sludge management plan, and have required the House of Raeford (a chicken processing plant) to install a pretreatment operation. These upgrades have had a positive impact on the water quality in this stream. Bioclassifications have improved from Good-Fair in 1990 to Good in 1993 and 1994, to Excellent in 1998. Though taxa richness values did not change much between 1993 and 1998, EPT abundance increased just slightly enough to push the site into Excellent. This is not a real change in water quality.

Rockfish Creek, NC 87 near Hope Mills

This site has changed locations from US 301 in 1983 to I-95 in 1988 and 1990 and slightly further downstream to NC 87 in 1993. NC 87 is the most downstream site on Rockfish Creek, just above the confluence with the Cape Fear River (drainage area here is about 310 square miles). This stretch of Rockfish Creek is very scenic with large trees shading this wide (22 meters), deep (1+ meters and water levels were low), completely sand bottom section. The water quality in this extended segment of Rockfish Creek has remained Excellent since 1983, except in 1993, when it was Good. A diverse fauna was present again in 1998: EPT taxa increased from 23 to 32, and EPT abundance leaped from 64 to 194. Undoubtedly sampling conditions played a role in the lower 1993 rating.

Little Rockfish Creek, NC 59
This is a fairly large (15 meters wide, drainage area =84 square miles) sandy bottom, slow flowing stream. This site is in a commercial area between Fayetteville and Hope Mills, but there was a wide riparian zone and no evidence of eroding banks. Much of the watershed is in Fayetteville or is agricultural. However, benthos data show Good water quality for both 1993 and 1998, with EPT taxa richness of 23 and 22 respectively. It is interesting, though, that of the 32 total EPT taxa from the two years, 20 were found in one year, but not the other.

SPECIAL STUDIES
Cross Creek at NC 87/210 was a benthos basin assessment site in 1993. It was given a Fair bioclassification and added to the 303(d) list. It was not sampled in the summer of 1998 because there was water, but no flow in this small urban stream. Because it stops flowing in the summer, the stream should not be rated using flowing water criteria, and should be taken off the 303(d) list.

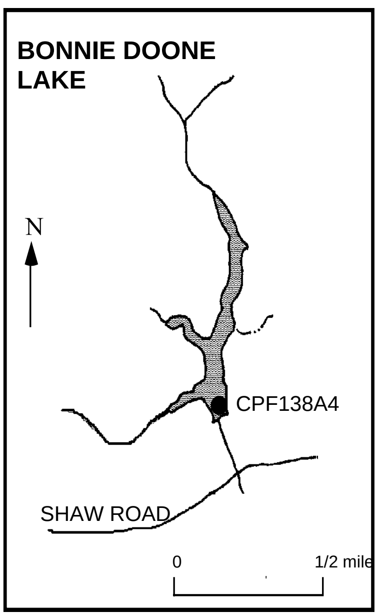
The Division of Water Resources requested a benthos sample from Little Cross Creek below Glenville Lake in Fayetteville as outlined in their regulations for determining minimum flow releases from dams. This small urban stream was given a Fair bioclassification. The impacts to the stream are likely a combination of low flows, urban runoff, and sedimentation from bank erosion.

In September 1998, Little Cross Creek above Glenville Lake, was sampled for benthos near Bragg Boulevard as part of 303(d) assessments. A UT to Little Cross Creek above the lake was also sampled as a potential small reference stream. Both sites could not be rated due to their small size or lack of flow. A prior (1990) sample from Little Cross Creek above the lake had a Poor bioclassification, but this probably is inaccurate.

LAKES ASSESSMENT PROGRAM
Bonnie Doone Lake

COUNTY:	Cumberland	**CLASSIFICATION:**	WS-IV
SURFACE AREA:	27 acres (11 hectares)	**MEAN DEPTH :**	2 feet (0.6 meters)
VOLUME:	$0.1 \times 10^6 m^3$	**WATERSHED**:	3 mi^2 (8 km^2)

Bonnie Doone Lake, a small lake impounded in the early 1900's. It is the first in a series of four lakes formed as impoundments of Little Cross Creek. The four lakes (Bonnie Doone, Kornbow, Mintz Pond and Glenville Lake) serve as a backup water supply for the City of Fayetteville. All four lakes are restricted to the public. Fort Bragg Military Base is located in close proximity to Bonnie Doone Lake. Firebreaks located on the base and the general soil type of the area contribute large amounts of sediments into the lakes through stormwater runoff. The surrounding shoreline of Bonnie Doone is forested. The western side of the lake beyond the forested buffer is urbanized.



Bonnie Doone Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data for this lake are presented in Appendix L2. The greatest total phosphorus and ammonia values were observed in June. Chlorophyll *a* values in 1998 were low. Concentrations of metals were less than the applicable state water quality standards except for zinc in July (80 µg/L) which was greater than the state water quality action level of 50 µg/L and iron (range = 1500 to 1700 µg/L) which was greater than the state water quality action level of 1.0 mg/L. Based on the NCTSI scores for June and July, Bonnie Doone Lake was oligotrophic (Table L21).

According to Mr. Sidney Post, Watershed Resource Specialist for the City of Fayetteville, there have not been problems with algal blooms or fish kills in Bonnie Doone Lake. Water clarity has improved in recent years due to the removal of sediment dredged from the lake in 1993 by the U.S. Army Corps of Engineers. Solids enter the lake from land disturbing activities within part of the watershed located on Fort Bragg. To preserve the water quality, work has been done to remove stormwater outlets which had drained into Bonnie Doone Lake. The City monitors the water quality of their lakes as well as the creeks and streams. Elevated levels of iron have been observed in streams, but no problems have been observed in the processed drinking water (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.).

Table L21. Bonnie Doone Lake NCTSI Data.

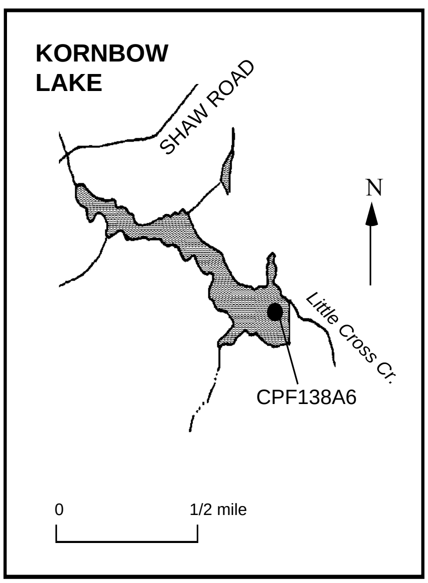
Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Bonnie Doone	980810	no score	0.01	0.18	n/a	1.7
Bonnie Doone	980713	-4.7[O]	0.01	0.09	3	1.7
Bonnie Doone	980622	-4.0[O]	0.03	0.16	<1	1.8
Bonnie Doone*	930817	*no score	0.12	0.61	1	0.2

* At the time Bonnie Doone Lake was sampled, the water level was being lowered in preparation for mechanical dredging of the accumulated sediments (NCTSI score = 2.6 [E]).

Kornbow Lake

COUNTY:	Cumberland	**CLASSIFICATION:**	WS-IV
SURFACE AREA:	57 acres (23 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	$0.3 \times 10^6 m^3$	**WATERSHED**:	5 mi^2 (12 km^2)

Kornbow Lake is the second and largest in the series of four impoundments located on Little Cross Creek. The immediate shoreline of the lake is forested and beyond that buffer are residential developments.



Kornbow Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The highest nutrient concentrations and lowest Secchi depth in Kornbow Lake were observed in June. Chlorophyll *a* values were low. Concentrations of metals were less than the applicable state water quality standards except for zinc in July (81 µg/L) which was greater than the state water quality action level of 50 µg/L and iron in July (1200 µg/L) and August (1100 µg/L) which was greater than the state water quality action level of 1000 µg/L. Based on the calculated NCTSI scores, Kornbow Lake was mesotrophic in June and oligotrophic in (Table L22).

According to Mr. Sidney Post, Watershed Resource Specialist for the City of Fayetteville, there have not been problems with fish kills in this lake. The City monitors the water quality of their lakes as well as the creeks and streams. Water clarity has decreased in recent years in the headwaters of Kornbow Lake due to sedimentation, but no change in water clarity has been observed near the dam. Kornbow Lake is 90% infested with variable-leaf water milfoil (*Myriophyllum heterophyllum*), according to Mr. Post. However, because this lake and its watershed are monitored by the North Carolina Natural Heritage Program, the city is discouraged from removing this plant. To protect Kornbow Lake, 150 acres in the headwaters have been purchased by the City with money received from the Clean Water Trust Fund.

Sanitary sewers and construction activities have been a threat to the water quality of this lake. Elevated levels of iron have been observed in streams, but no problems have been observed in the processed drinking water (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.).

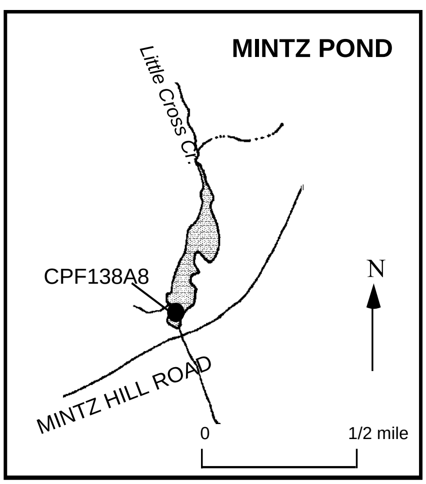
Table L22. Kornbow Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Kornbow	980810	no score	<0.01	0.18	n/a	2.3
Kornbow	980713	-2.9[O]	0.01	0.19	8	2.2
Kornbow	980622	-1.8[M]	0.05	0.16	4	2.0
Kornbow	930817	-0.0[M]	0.05	0.25	14	2.0

Mintz Pond

COUNTY:	Cumberland	**CLASSIFICATION:**	WS-IV
SURFACE AREA:	15 acres (6 hectares)	**MEAN DEPTH :**	2 feet (0.5 meters)
VOLUME:	0.3 $x10^6m^3$	**WATERSHED**:	6 mi^2 (16 km^2)

Mintz Pond is a small auxiliary water supply reservoir for the City of Fayetteville located in Cumberland County. The lake is the third in a series of four impoundments located on Little Cross Creek and is not open to the public. The immediate shoreline is forested is surrounded by residential and urban development. The impoundment is shallow with a depth of only five feet (two meters) at the dam.



Mintz Pond was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data for Mintz Pond are presented in Appendix L2. The greatest nutrient values in 1998 were observed in June. Concentrations of metals were less than the applicable state water quality standards except for zinc in July (57 µg/L) which was greater than the state water quality action level of 50 µg/L and iron in June, July and August (range = 1200 to 1700 µg/L) which was greater than the state water quality action level of 1000 µg/L. In June, beds of fragrant water lilies (*Nymphaea odorata*) were observed along the shoreline of Mintz pond. These beds expanded outward into the lake in July and August, but were not at nuisance levels. Along with the water lilies were smaller beds of watershield (*Brasenia schreberi*). The macroscopic alga, *Nitella* sp. was found growing at the bottom of Mintz Pond. This alga is an indicator of clear water with good light penetration. Mintz Pond was mesotrophic in June and July based on the calculated NCTSI scores (Table L23).

According to Mr. Sidney Post, Watershed Resource Specialist for the City of Fayetteville, there have not been problems with algal blooms or fish kills in this lakes. The City monitors the water quality of their lakes as well as the creeks and streams. A minor fish kill occurred in the Spring of 1998 which was related to the presence of the blue-green algae *Anabaena sp.* This lake experiences major sedimentation problems with decreased water clarity. Algal blooms have occurred in the past along with public complaints regarding water odor due to these blooms. Nutrients have entered the lake from a tributary which drains a small irrigation pond. To correct this problem, the City of Fayetteville has purchased the pond and is modifying it to prevent future algal blooms in Mintz Pond. In addition to nutrients and algal blooms, pesticide and herbicides from the watershed also threaten this lake. According to Mr. Post, Mintz Pond also has a problem with variable-leaf watermilfoil, which is found in 98% of the lake.
Elevated levels of iron have been observed in streams, but no problems have been observed in the processed drinking water (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.).

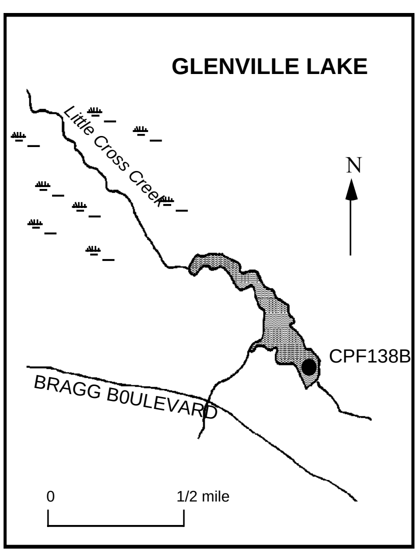
Table L23. Mintz Pond NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Mintz Pond	980810	no score	0.04	0.19	n/a	1.1
Mintz Pond	980713	-0.5[M]	0.03	0.18	16	1.2
Mintz Pond	980622	-0.3[M]	0.06	0.17	9	1.2
Mintz Pond	930817	1.0[E]	0.08	0.47	4	1.2

<u>Glenville Lake</u>

COUNTY:	Cumberland	**CLASSIFICATION:**	WS-IV CA
SURFACE AREA:	26 acres (11 hectares)	**MEAN DEPTH :**	10 feet (3 meters)
VOLUME:	0.2 x$10^6$$m^3$	**WATERSHED**:	10 mi^2 (25 km^2)

Glenville Lake is a small, backup water supply reservoir for the City of Fayetteville. The lake is the last in a series of four impoundments of Little Cross Creek. The immediate shoreline is forested with residential development located along the western side of the lake just beyond the forest buffer. The maximum depth is approximately 12 feet (four meters). This lake is not open to the public for recreational use.



Glenville Lake was most recently sampled in June, July and August, 1998. Physical and chemical data collected in 1998 are presented in Appendix L2. In June, an algal bloom had a density of 15,320 units/ml and the algal biovolume was 10,769 mm^3/m^3. The dominant algal species in the sample was a diatom (*Diatoma* sp.). Concentrations of metals were less than the applicable state water quality standards except for zinc in July (65 µg/L) which was greater than the state water quality action level of 50 µg/L and iron (range = 1100 to 1700 µg/L) which was greater than the state water quality action level of 1000 µg/L. Glenville Lake was determined to be eutrophic in June and July based on the calculated NCTSI scores for those months (Table L24).

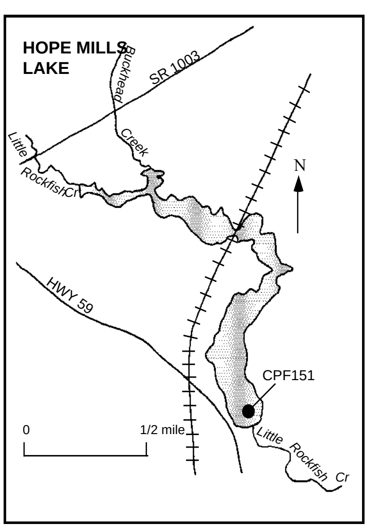
According to Mr. Sidney Post, Watershed Resource Specialist for the City of Fayetteville, a minor fish kill occurred in the early Spring of 1998 which was attributed to herbicides applied to a nearby ballfield by the Parks and Recreation Department. Sedimentation has been a problem in this lake which is gradually filling in. There has also been a problem with unsupervised public access to the lake and removal of riparian buffers in a City Park located in the upstream region of the lake. A stormwater management program has been performed by the City of Fayetteville, however, stormwater continues to present a water quality problem for this lake. Glenville Lake does not have a problem with aquatic macrophytes although the algal population has increased slightly in recent years. There have been public complaints regarding water odor, but these complaints have been related to lake drawdown by the water plant. The water treatment plant has not had any problems processing raw water drawn from Glenville Lake. The City monitors the water quality of their lakes as well as the creeks and streams (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.).

Table L24. Glenville Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Glenville Lake	980810	no score	0.05	0.30	n/a	0.9
Glenville Lake	980713	1.1[E]	0.04	0.23	27	0.8
Glenville Lake	980622	1.7[E]	0.07	0.28	25	1.0
Glenville Lake	930817	3.0[E]	0.07	0.53	32	1.0
Glenville Lake	910822	2.2[E]	0.05	0.38	30	0.8

Hope Mills Lake

COUNTY:	Cumberland	**CLASSIFICATION:**	B
SURFACE AREA:	110 acres (45 hectares)	**MEAN DEPTH :**	10 feet (3 meters)
VOLUME:	0.1 x$10^6$$m^3$	**WATERSHED**:	26 mi^2 (67 km^2)



Hope Mills Lake is a small, shallow reservoir located on Little Rockfish Creek in the Town of Hope Mills, North Carolina. The original dam was built in 1839 and rebuilt around 1921. The reservoir was constructed to provide an emergency fire fighting water supply for Dixie Yarn Incorporated located adjacent to the reservoir. A secondary purpose of the dam was to provide hydroelectric power to the Town of Hope Mills. Neither of these uses are presently required, and the lake is maintained for recreation. The lake drainage area is mostly forested with some urban and agricultural uses.

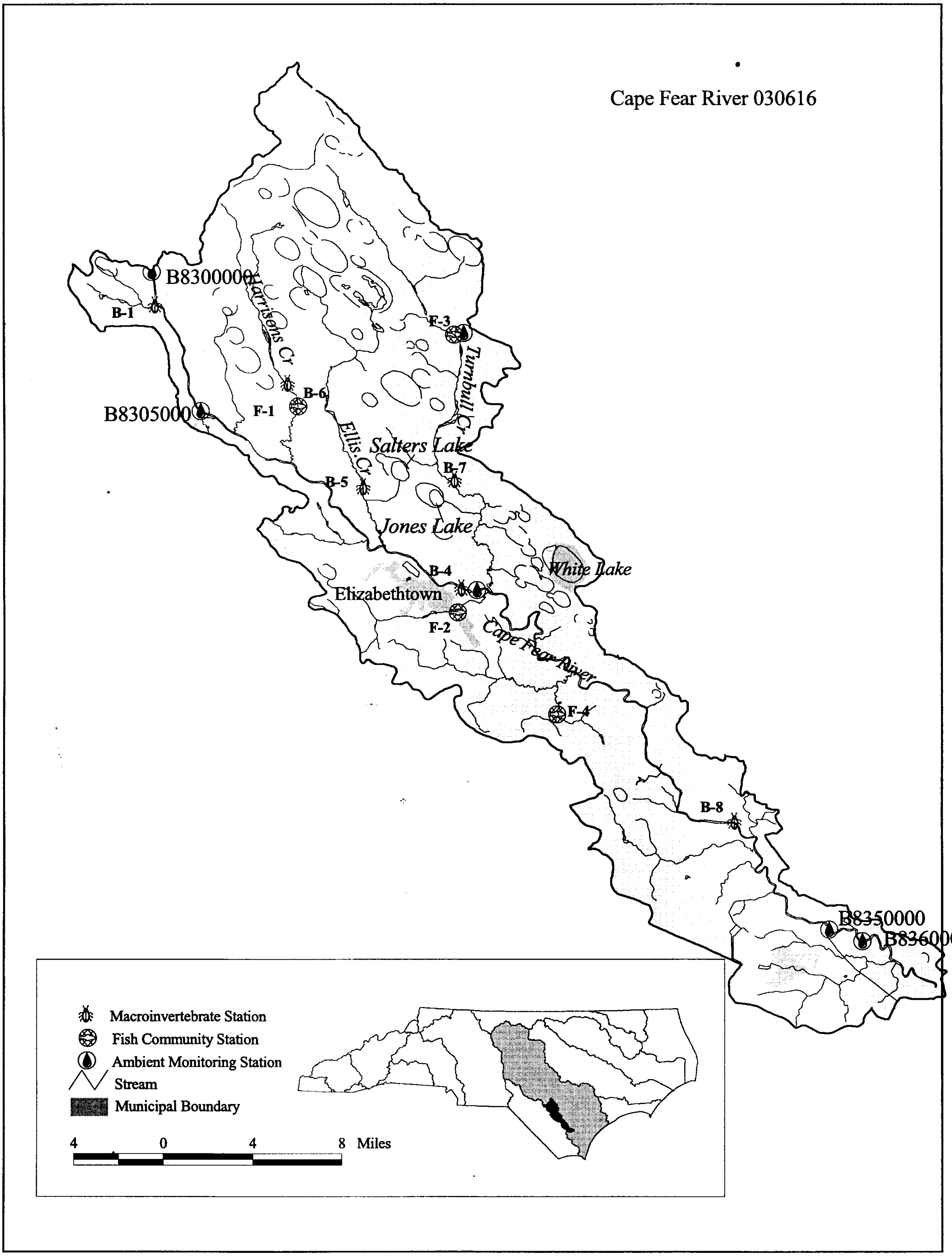
Hope Mills Lake was most recently sampled by DWQ in June, July and August, 1998. Chemical and physical data for this lake are presented in Appendix L2. A review of historical data based on water quality sampling by DWQ at Hope Mills Lake indicates an increase in nitrite plus nitrate since 1984 and a gradual decrease in total phosphorus concentration. Fecal coliform bacteria concentrations at the single lake sampling site ranged from 70 to 90 colonies per 100 ml.

According to Mr. William Farris, Interim Town Manager (pers. com), there had been no reported problems for this lake. There is concern, however, regarding the duck and Canada goose populations. These birds congregate at the swimming beach and efforts have been made to chase them from the area. There have been no fish kills or problems with aquatic macrophytes according to Mr. David Smith, Director, Hope Mills Parks and Recreation (pers. com.). There have been numerous public complaints regarding water odor at the dam and at the swimming beach, although there have been no reports of problems such as itching skin or burning eyes due to swimming in the lake. Mr. Smith also believes that fecal coliform bacteria may be a problem at the swimming beach and boat dock area due to waterfowl in these areas. There has also been significant urban development in the lake watershed which may be affecting the water quality of Hope Mills. The Wildlife Resources Commission has performed fish population studies at Hope Mills Lake every two years as part of a memorandum of agreement with the Town of Hope Mills. These studies have determined that the fish populations are excellent (Keith Ashley, District 4 Biologist, NC WRC, Division of Boating and Inland Fisheries, pers. com.).

Hope Mills Lake was previously sampled in 1994 and 1995 by DWQ. Physical and chemical data collected by DWQ are presented in Appendix L2. In 1995, surface dissolved oxygen at the single lake sampling site was 10.2 mg/L and surface pH was 6.5 s.u. Chlorophyll *a* concentration was 12 µg/L. Fecal coliform bacteria concentration was less than 10 colonies per 100/ml. AGPT results indicated that Hope Mills Lake had the ability to support nuisance levels of algae with a Control MSC of 11.13 (Appendix L1 and L2).

Table L25. Hope Mills Lake NCTSI Data

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Hope Mills Lake	980810	no score	0.03	0.30	n/a	1.1
Hope Mills Lake	980713	0.5[E]	0.03	0.28	19	1.0
Hope Mills Lake	980622	-0.6[M]	0.04	0.19	8	1.1
Hope Mills Lake	950711	1.4[E]	0.04	0.32	12	0.5
Hope Mills Lake	940908	-1.2[M]	0.04	0.23	1	0.5
Hope Mills Lake	880712	1.5[E]	0.05	0.28	30	1.0
Hope Mills Lake	870917	2.8[E]	0.05	0.39	53	0.8
Hope Mills Lake	840822	1.6[E]	0.07	0.29	13	0.7



Cape Fear River 030616
B8300000
B-1
Harrisons Cr
F-3
Turnbull Cr
B-6
B8305000
F-1
Ellis Cr
Salters Lake
B-7
B-5
Jones Lake
White Lake
B-4
Elizabethtown
F-2
Cape Fear River
F-4
B-8
B8350000
B8360000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
4
0
4
8
Miles

CAPE FEAR SUBBASIN 030616

DESCRIPTION

Cape Fear subbasin 16 is located in the inner coastal plain ecoregion, and contains the city of Elizabethtown. The Cape Fear River in this subbasin is deep and slow moving, with two locks to aid in navigation. Major tributaries include Harrison Creek, Turnbull Creek, and Ellis Creek. All tributaries in this subbasin tend to have little flow during summer droughts. The Bladen Lakes State Park is located in this subbasin, which includes several natural lakes. The streams and many of the natural bay lakes within this subbasin are tannin stained or low pH black water systems.

Land use in subbasin 16 is mostly forest and marsh, with some agriculture. There are 8 permitted dischargers in subbasin 16, mostly near Elizabethtown. Four of the largest dischargers are Veeder-Root (5.0 MGD), Smithfield Foods, Inc. in Tarheel (3.0 MGD), Alamac Knit Fabrics in Elizabethtown (2.5 MGD) and Dupont of Fayetteville (2.0 MGD). All of these discharge into the Cape Fear River.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1	Cape Fear R	Bladen	SR 1355 nr Duarte	Fair	Good-Fair
B-4	Cape Fear R	Bladen	nr Elizabethtown	Good-Fair	Good-Fair
B-5	Ellis Cr	Bladen	NC 53	Good-Fair	Good-Fair
B-6	Harrison Cr	Bladen	SR 1318	Fair	Good-Fair
B-7	Turnbull Cr	Bladen	SR 1511	no sample	Good
B-8*	Cape Fear R	Bladen	SR 1730 nr Kelly	Fair	Good-Fair
FISH				1994	
F-1	Harrison Cr	Bladen	SR 1318	Good-Fair	Good-Fair
F-2	Browns Cr	Bladen	NC 87	Poor	Poor
F-3	Turnbull Cr	Bladen	NC 242	no sample	Fair
F-4	Whites Cr	Bladen	SR 1704	no sample	Good

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Salters Lake, Jones Lake, White Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Cape Fear R at Elizabethtown	1994	21	2	0	EPA mercury limit exceeded in 1 bass/1 bowfin samples
		1995	8	3	0	EPA mercury limit exceeded in 3 bowfin samples, FDA/NC mercury limit exceeded in 1 bowfin sample
		1998	19	1	0	EPA mercury limit exceeded in 1 bass sample
FT-2	Cape Fear at Lock and Dam 3	1998	10	0	0	No samples exceeded criteria
FT-3	Cape Fear at Lock and Dam 2	1998	10	1	0	EPA mercury limit exceeded in 1 catfish sample

The fish community was evaluated at four sites in this subbasin in 1998. Two of these sites Harrison Creek (Good-Fair) and Browns Creek (Poor) did not change between 1993 and 1998.

Turnbull Creek at NC 242 (Fair) and Whites Creek at SR 1704 (Good) were added as basin assessment sites in 1998.

Of the 68 fish tissue samples analyzed since 1994, 5 samples exceeded the EPA mercury limit. These samples were from bass, bowfin, and catfish. Only one bowfin sample exceeded the FDA/NC mercury limit.

Salters and Jones Lakes are Carolina Bay Lakes receiving almost no overland inputs of water, relying on precipitation and groundwater for recharge. Both of these lakes are located in state forests and are therefore protected and undeveloped. They are both classified as dystrophic. White Lake, also a Carolina Bay Lake has been classified as oligotrophic. Although the state owns the property around the lake to the mean high water mark, the land above this is privately owned and extensively developed.

Of the 5 sites sampled in both 1993 and 1995 for benthos, three improved in bioclassification and the others remained the same. Two of the three Cape Fear River sites, the Cape Fear River near Duarte and the Cape Fear River near Kelly, increased from Fair to Good-Fair. The Cape Fear River at Elizabethtown remained the same (Good-Fair), as did Ellis Creek (Good-Fair). Harrison Creek also increased from Fair to Good-Fair between 1993 and 1995. Turnbull Creek, with a Good bioclassification, had the best water quality in this subbasin.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Cape Fear River, SR 1355, nr Duarte

The Cape Fear River at this site, located at Lock and Dam #3, was 40 meters wide. The midstream substrate was composed mostly of sand and coarse gravel. The shoreline habitat was sparse due to the low water level in the summer of 1998. The banks were relatively stable and there were adequate riparian buffers. Water quality has improved at this site since 1993. This is reflected in the benthos bioclassification change from Fair to Good-Fair, and an increase in EPT taxa and abundance.

Fish tissue samples were collected from the Cape Fear River at Lock and Dam 3 during October 1998 as part of a study conducted by the US Fish and Wildlife Service to assess mercury levels in catfish species along the Cape Fear. All ten samples had mercury results lower than EPA and FDA/NC limits.

Harrison Creek, SR 1318

Harrison Creek, a low pH, low productivity blackwater stream, has been sampled twice for fish as part of the basinwide program. In both periods, the fish community has been rated as Good-Fair. In 1998, the metrics which scored well below expectations were in the number of species of darters collected and in the number of intolerant species. Both darters and intolerant species were absent. Nine species of fish were collected and all species were represented by only 1-4 specimens each. The instream habitat showed some evidence of historical channelization and the riparian zone along the right shoreline was sparsely vegetated and narrow.

The benthos bioclassification of this 6 meter wide site changed from Fair to Good-Fair since 1993. This site was one EPT taxa away from a rating of Good in 1998, using Coastal A criteria.

Harrison Creek was a sandy stream with abundant instream habitat, and good flow. Some intolerant taxa collected in 1998, but not 1993, included Oecetis morsei, two species of Nectopsyche, and Triaenodes ignitus. During sampling in 1993, DOT was working on the bridge at this site and the field crew noticed an oil sheen on the water's surface. This could have affected the previous collection, and explain the improvement in water quality at this site.

Cape Fear River, US Lock and Dam #2, nr Elizabethtown

The River at this site was about 45 meters wide with a sandy substrate. It was located downstream of several permitted dischargers, including Alamac Knit Fabrics (2.5 MGD) and the Elizabethtown WWTP (0.7 MGD). There has been no change in the benthos bioclassification (Good-Fair) since 1993. Shoreline habitat was sparse in 1998 due to the low flow.

Fish tissue samples were collected from the Cape Fear River at Elizabethtown during May 1994, August 1995, and September 1998 and analyzed for metals contaminants. Of the 48 samples collected during the period, 6 samples composed of bass or bowfin contained mercury levels exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits. Ten fish tissue samples were also collected from the Cape Fear River at Lock and Dam 2 during October 1998 as part of a study conducted by the US Fish and Wildlife Service to assess mercury levels in catfish species along the Cape Fear. One channel catfish sample contained mercury levels exceeding the EPA screening value of 0.6 ppm. All other mercury results were lower than EPA and FDA/NC limits.

Ellis Creek, NC 53

This 6 meter wide swampy tributary enters the Cape Fear River just above Elizabethtown. The substrate was sandy, instream habitat was abundant, the riparian area was extensive and there is little evidence of bank erosion. The benthos bioclassification at this site (Good-Fair) has not changed since 1993. The low pH at the time of sampling in 1998 (5.2) may inhibit the presence of intolerant mayfly taxa.

Browns Creek, NC 87

The watershed of Browns Creek includes Elizabethtown. Although the water was darkly stained, the pH was 6.2. The fish community has been sampled three times: once by the NC Wildlife Resources Commission in 1962 (Louder 1963) and twice by the NCDWQ in 1992 and 1998. In 1962, the fish community was dominated by a large school of eastern silvery minnows (79% of the 500 fish collected were of this species). In 1992 and in 1998, the fish community was rated as Poor. Metrics for which the community deviated greatly from the expected included the abundance, sunfish and intolerant species diversity, and two of the trophic metrics (percentage of omnivores and insectivores). Five fewer species and 74% fewer fish were collected in 1998 in contrast to the numbers collected in 1992. The instream habitat consisted of deep pools and runs, white sand substrate, and prior evidence of greatly elevated water levels resulting from recent hurricanes.

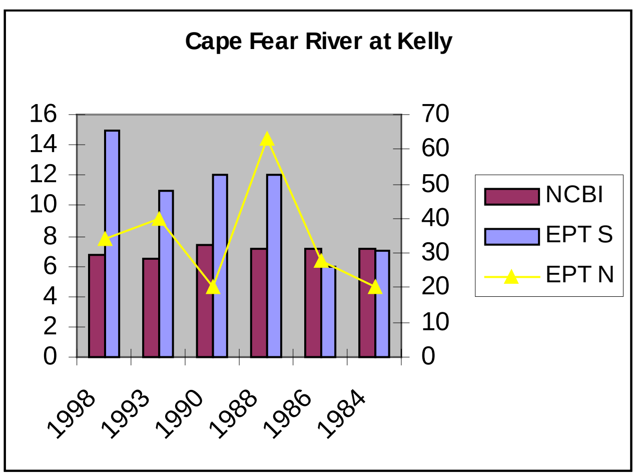
Turnbull Creek, SR 1511

This major tributary of the Cape Fear River was first sampled for benthos in 1998, resulting in a bioclassification of Good. Turnbull Creek at this location was about 7 meters wide with a sandy substrate, good instream habitat and a good riparian zone. However, the acidic conditions at the time of sampling (pH of 5.0) may inhibit the presence of some mayfly taxa. Stenonema modestum was the only mayfly collected.

Turnbull Creek, NC 242
Turnbull Creek originates in the lower part of Cumberland County and flows through the bay area of Bladen County. At the NC 242 bridge crossing, this very low pH (pH = 3.9) and low productivity blackwater stream flows through bottomland bay forest. The substrate consisted of sand, organic matter, and mud; flocculent organic matter was observed suspended in the water column. The fish community was rated only as Fair primarily because of the absence of darters, suckers, intolerant species, and only 2 of the six species showed evidence of having multiple age groups (evidence of poor recruitment). The most abundant species was the redfin pickerel.

Whites Creek, SR 1704
Whites Creek, a tributary to Hammond Creek, is a tannin-stained stream having a greater pH (pH = 6.4) than many of the other more typical blackwater streams in the subbasin. The instream habitat consisted of shallow sand and gravel riffles; the riparian zone was intact, wide and consisted of a beech forest with a bluff along the left shoreline. The fish community was rated as Good (NCIBI =52, the highest rating of all 52 sites monitored within the Cape Fear River basin in 1998). The fish community included 2 species of suckers, 6 species of sunfish, 4 species of minnows, and 2 species of darters. The most abundant species collected were the dusky shiner and American eel.

Cape Fear River, SR 1730, near Kelly
This ambient monitoring site has been sampled six times since 1984, and has consistently received a rating of Fair until 1998, when benthic macroinvertebrate sampling resulted in a rating of Good-Fair. Between 1993 and 1998 there was an increase in total EPT taxa. The River was about 70 meters wide at this site with a sandy substrate. At the time of sampling in 1998 there was a silt/clay layer covering the logs and the shoreline was very silty.



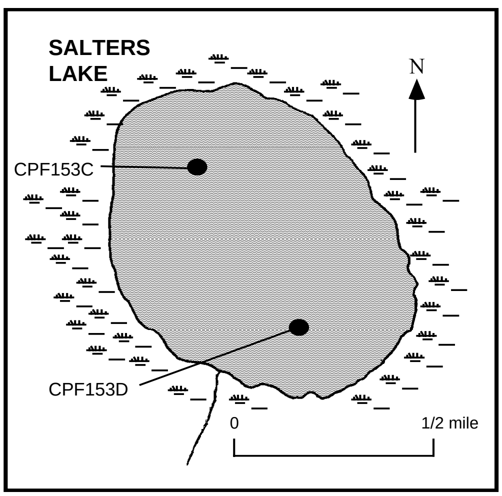
SPECIAL STUDIES
A special study investigating the effects of the high concentration of hog farms in the lower Cape Fear basin was conducted in 1998. This study included Ellis, Turnbull, and Harrison Creeks

from subbasin 16. These three streams were associated with few or no hog farms in their watersheds.

LAKE ASSESSMENT PROGRAM
Salters Lake

COUNTY:	Bladen	**CLASSIFICATION:**	C
SURFACE AREA:	450 acres (182 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	$0.3 \times 10^6 m^3$	**WATERSHED**:	27 mi^2 (7 km^2)

Salters Lake is a shallow, Carolina Bay Lake owned by the State of North Carolina. Bladen Lake State Forest is the protected area which contains the lake and the lake is part of the Jones Lake State Park. All of the coastal drainage area is wetland or forest. This undeveloped lake has limited public access via a permit which is obtained from the Jones Lake State Park rangers.



Salters Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data for Salters Lake are presented in Appendix L2. Secchi depths were less than one meter at both lake sampling sites The low Secchi depth readings observed during the summer of 1998 are not unusual for Carolina Bay Lakes which have naturally dark, tea-colored water which reduces light penetration. No nuisance level beds of aquatic macrophytes were observed in Salters Lake in June, July or August. Because Salters Lake is dystrophic, a trophic status of the lake cannot be accurately determined through the NCTSI scores (Table L26; Appendix L1).

According to Mr. Keith Ashley, District 4 Fisheries Biologist, there have been no reports of fish kills, algal blooms or problems with aquatic macrophytes in Salters Lake. This lake has controlled public access and is relatively isolated, both of which contribute to low public fishing pressures. Potential impacts in the future may result from an increase in animal operations within Salters Lake's watershed (Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries, pers. com.). Mr. Bill Ross, Park Superintendent at Jones Lake State Park noted that Salters Lake tends to become dark after rainfalls due to an increase in tannins, and becomes clearer during periods of dry weather. Mr. Ross has not noticed problems related to aquatic macrophytes, algal blooms or water odor (Bill Ross, Park Superintendent, Jones Lake State Park, pers. com.).

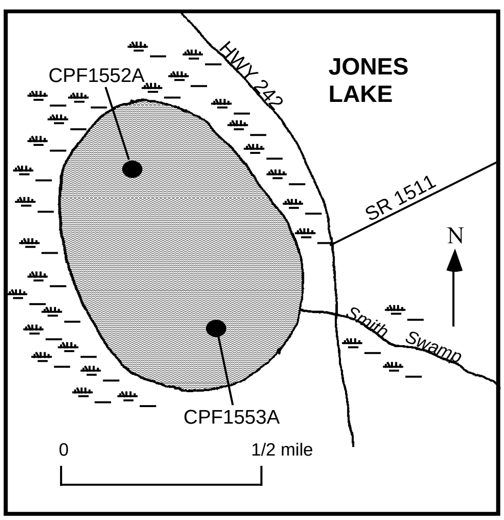
Table L26. Salters Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Salters Lake	980804	no score	0.02	0.36	*	0.5
Salters Lake	980714	0.6[D]	0.02	0.35	10	0.5
Salters Lake	980616	-3.7[D]	<0.01	0.30	<1	0.5
Salters Lake	930824	-2.4[D]	0.03	0.21	1	0.6
Salters Lake	880712	-2.0[D]	0.02	0.18	7	1.8
Salters Lake	810804	-0.4[D]	0.02	0.30	14	1.0

Jones Lake

COUNTY:	Bladen	**CLASSIFICATION:**	B
SURFACE AREA:	225 acres (91 hectares)	**MEAN DEPTH :**	3 feet (1 meters)
VOLUME:	0.09 x$10^6 m^3$	**WATERSHED**:	2 mi^2 (4 km^2)

Jones Lake is a small, shallow, natural lake situated in the flat swampy terrain of Jones Lake State Park. Jones Lake has a maximum depth of 10 feet (three meters). Like other Carolina Bay Lakes, Jones receives almost no overland inputs of water, relying instead on precipitation and groundwater for recharge. Jones Lake is classified as dystrophic due to naturally occurring acidic water which has a dark coloration due to dissolved organic material (tannin-stained). A public park with a swimming area is located on the southeastern shoreline of this lake.



Jones Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data for Jones Lake are presented in Appendix L2. Secchi depths were less than one meter at both lake sampling sites. The low Secchi depth readings observed during the summer of 1998 are not unusual for Carolina Bay Lakes which have naturally dark, tea-colored water which reduces light penetration. Fecal coliform bacteria concentrations in Jones Lake was ≤10 colonies per 100 ml in June and August. No nuisance level beds of aquatic macrophytes were observed in Jones Lake in 1998. Because this lake is dystrophic, a trophic status of the lake cannot be accurately determined through the NCTSI scores (Table L27; Appendix L1).

According to Mr. Keith Ashley, District 4 Fisheries Biologist, fish kills occasionally occur in Jones Lake as a result longterm stress due to the low pH of the lake's water. Species affected are yellow perch (*Perca flavescens*), fliers (*Centrachus macropterus*) and warmouth (*Lepomis gulosus*). To Mr. Ashley's knowledge, there have been no complaints regarding algal blooms or aquatic macrophytes (Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries, pers. com.). There have been no complaints of problems related to swimming in Jones Lake, according to Mr. Bill Ross, Park Superintendent for Jones Lake State Park. The lake's water does turn darker following rainfalls due to an increase in tannins in the water, but becomes clearer during periods of dry weather (Bill Ross, Park Superintendent, Jones Lake State Park, pers. com.).

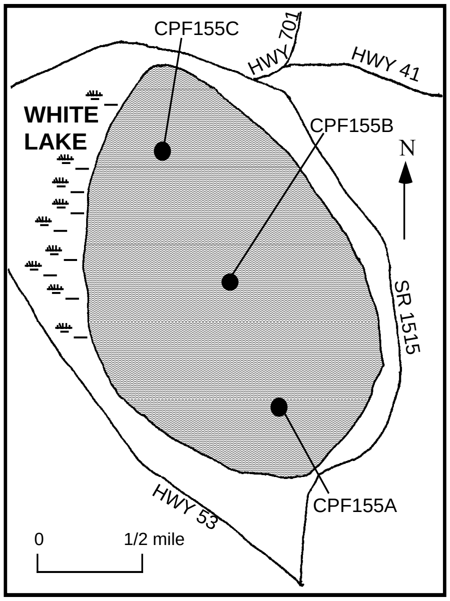
Table L27. Jones Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Jones Lake	980804	no score	0.02	0.32	n/a	0.5
Jones Lake	980714	-0.7[D]	0.02	0.31	3	0.5
Jones Lake	980616	-3.2[D]	<0.01	0.30	1	0.4
Jones Lake	930805	-0.4[D]	0.03	0.31	3	0.6
Jones Lake	930701	-1.0[D]	0.03	0.42	<1	0.6
Jones Lake	930603	-2.0[D]	0.02	0.46	<1	0.6
Jones Lake	920820	-2.7[D]	0.01	0.30	2	1.0
Jones Lake	920709	-4.6[D]	<0.01	0.26	<1	0.9
Jones Lake	920603	-3.7[D]	<0.01	0.36	<1	1.1
Jones Lake	910827	-3.3[D]	0.01	0.22	1	0.7
Jones Lake	910724	-4.6[D]	0.02	0.13	<1	1.3
Jones Lake	910626	-4.3[D]	<0.01	0.30	<1	0.9
Jones Lake	870903	-5.3[D]	0.01	0.13	1	2.2
Jones Lake	810729	-5.9[D]	0.01	0.12	1	2.5

White Lake

COUNTY:	Bladen	**CLASSIFICATION:**	B
SURFACE AREA:	1050 acres (425 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	9.5 x$10^6$$m^3$	**WATERSHED**:	Unknown

White Lake is a Carolina Bay Lake located east of Elizabethtown, North Carolina. White Lake is shallow with maximum depth of 10 feet (three meters). The lake has a mean hydraulic retention time of 292 days. Although the State of North Carolina owns the property around the lake to the mean high water mark, the land above this demarcation is privately owned. The land adjacent to White Lake is extensively developed. This development includes motels, rooming houses, campgrounds, permanent residences, mobile home parks and weekend cottages. White Lake is used extensively for water based recreational activities such as swimming, boating and fishing. The lake receives the majority of its water inputs from precipitation and from submerged natural springs. Lands surrounding the lake are primarily swamps and forests. While it is a Carolina Bay Lake, White Lake is unusual in that the water of the lake is exceptionally clear instead of tannin-stained (tea colored).



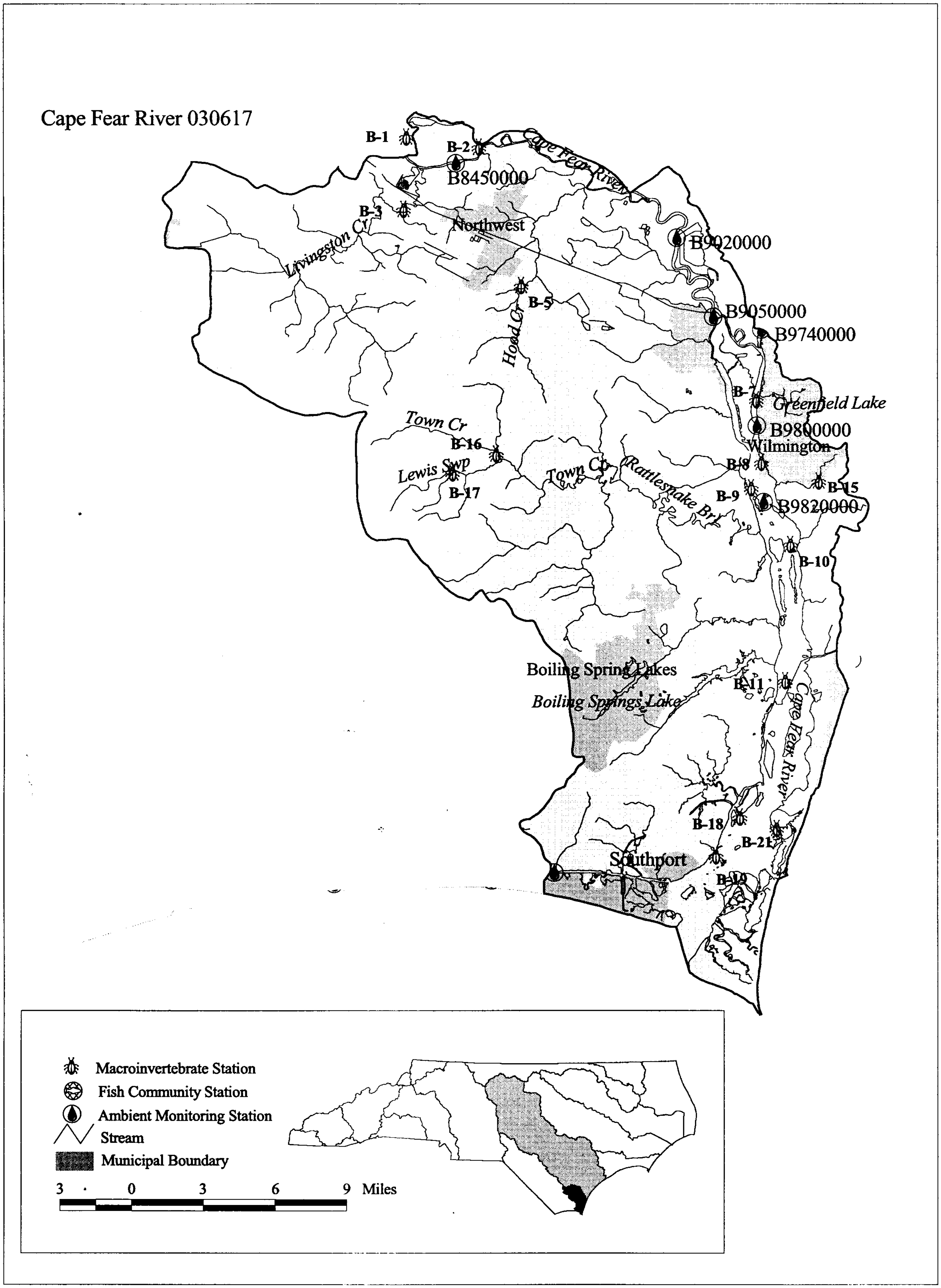
White Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. Secchi depth ranged from 2.0 to 2.6 meters. Total phosphorus and nitrite plus nitrate concentrations were low (≤0.01 mg/L) and ammonia ranged from <0.01 to 0.08 mg/L. Chlorophyll *a* in White Lake in 1998 was consistently <1 µg/L. Beds of the submerged algae *Ulothrix* sp. were observed at the bottom of the lake. This algae forms dense mats on the bottom and occasionally break free and float to the surface of the lake. Fecal coliform bacteria concentrations in White Lake were <10 colonies per 100 ml in 1998. The calculated NCTSI score for White Lake determined that the lake was oligotrophic in June and July and has remained oligotrophic since 1981 when it was first monitored by DWQ (Table L28).

There have been no public reports of problems regarding the water quality of White Lake, problems resulting from swimming or water skiing in the lake, or reports of fish according to Mr. Tim Frush, Public Works Director for the Town of White Lake. There have been complaints related to decaying algae and plant material that washes up along the lake shoreline. This material grows at the bottom of the lake and boating activity at White Lake is believed to contribute to the dislodging of this material from the lakebed and its subsequent decay and odor along the shore in the summer (Tim Frush, Public Works Director, Town of White Lake; Mr. David Colburn, Parks Superintendent, Singletary Lake State Park, pers. com.). Fish are occasionally stressed by the low pH of White Lake and kills may result in yellow perch (*Perca flavescens*), fliers (*Centrachus macropterus*) and warmouth (*Lepomis gulosus*) according to Mr. Keith Ashley, District 4 Biologist. White Lake has a poor fish population due to high public use and the developed watershed (Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries, pers. com.).

Table L28. White Lake NCTSI Data

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
White Lake	980805	no score	<0.01	0.05	n/a	2.5
White Lake	980714	-6.8[O]	0.01	0.07	<1	2.1
White Lake	980616	-7.3[O]	<0.01	0.09	<1	2.4
White Lake	930805	-5.7[O]	0.01	0.05	1	2.4
White Lake	930701	-3.6[O]	0.02	0.28	<1	2.2
White Lake	930603	-7.1[O]	0.01	0.07	<1	3.0
White Lake	920820	-5.9[O]	0.01	0.16	<1	2.8
White Lake	920709	-8.9[O]	0.01	0.04	<1	2.7
White Lake	920603	-7.4[O]	0.01	0.09	<1	2.4
White Lake	910829	-7.4[O]	0.01	0.07	<1	2.1

White Lake	910724	-5.2[O]	0.01	0.15	<1	2.2
White Lake	910626	-6.5[O]	0.01	0.14	<1	2.2
White Lake	900724	-4.4[O]	0.01	0.09	6	2.4
White Lake	880720	-5.5[O]	0.02	0.08	1	2.9
White Lake	870903	-5.3[O]	0.01	0.14	1	2.6
White Lake	850729	-5.5[O]	0.01	0.12	1	2.4
White Lake	820715	-3.5[O]	0.02	0.12	4	2.4
White Lake	810729	-6.0[O]	0.01	0.07	3	2.2


Cape Fear River 030617
B-1
B-2
B8450000
Cape Fear River
B-3
Northwest
Livingston Cr
B9020000
B-5
Hood Cr
B9050000
B9740000
B-7
Greenfield Lake
B9800000
Wilmington
Town Cr
B-16
Lewis Swp
B-17
Town Cr
Rattlesnake Br
B-8
B-9
B-15
B9820000
B-10
Boiling Spring Lakes
Boiling Springs Lake
B-11
Cape Fear River
B-18
B-21
Southport
B-19
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
3 0 3 6 9 Miles

CAPE FEAR SUBBASIN 030617

DESCRIPTION

Cape Fear subbasin 17 is located in the outer Coastal Plain and estuarine ecoregions and contains the city of Wilmington and the town of Southport. This area comprises the lower end of the Cape Fear River including the Brunswick River, Town Creek, Smith Creek and Livingston Creek. Most tributaries in this subbasin are either tannin and slow-to-not moving or tidal. Two man-made lakes in this subbasin are Greenfield Lake and Boiling Springs Lake.

Forest and agriculture are the primary land uses, however urban Wilmington and surrounding suburban areas also provides sources of nonpoint source pollution. There are 49 permitted dischargers in subbasin 17, half of which discharge directly into the Cape Fear River. Ten of these are major dischargers (> 1 MGD), with the largest dischargers being Federal Paper (50 MGD, Cape Fear River), Wilmington North Side WWTP (8 MGD, Smith Creek) and Wilmington South Side WWTP (12 MGD, Cape Fear River).

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1	Cape Fear R	Columbus	ab Federal Paper	Good-Fair	Excellent
B-2	Cape Fear R	Columbus	be Federal Paper	Fair	Fair
B-3	Livingston Cr	Columbus	US 74	Fair	Good-Fair
B-5	Hood Cr	Brunswick	US 74/76	no sample	Good
B-9	Barnards Cr	Brunswick	US 421	no sample	Fair-Good
B-10	Town Cr	Brunswick	ab SR 1413	no sample	Good-Fair
B-11	Lewis Swp	Brunswick	SR 1410	no sample	Good-Excellent
B-18*	Cape Fear R	Brunswick	Snows Marsh	Moderate	Moderate

* Estuarine site -Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Greenfield Lake, Boiling Springs Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Cape Fear R at Riegelwood	1998	23	8	0	EPA mercury limit exceeded in 4 bowfin and 4 bass samples, FDA/NC mercury limit exceeded in 1 bass sample
FT-2	Livingston Cr near Acme	1998	20	11	0	EPA mercury limit exceeded in 11 samples of bass, bowfin , pickerel, FDA/NC mercury limit exceeded in 3 samples of bass and bowfin
FT-3	Cape Fear R below Riegelwood	1994	15	3	0	EPA and FDA/NC mercury limit exceeded in 3 bowfin samples

Benthic macroinvertebrate data indicated improved water quality at sites most affected by nonpoint problems in subbasin 17 during this low flow year. Excellent (using draft criteria) conditions were recorded from the Cape Fear River above Federal Paper and a Good-Fair rating was assigned to Livingston Creek, up from Good-Fair and Fair, respectively, in 1993. It is likely that these ratings reflect reduced nonpoint inputs in a low flow year. Cape Fear River below the Federal Paper discharge showed no change in water quality (Fair). In the estuarine area, water quality has remained stable at Cape Fear River at Snows Marsh with only Moderate impacts. Samples were collected for the first time at ten additional locations. Water quality at these sites will be discussed in the Basin Monitoring section below.

The highest incidence of elevated mercury in fish tissue was in Livingston Creek. Over half of the fish tested, including bass, bowfin and pickerel, had levels of mercury above EPA levels. Samples from the Cape Fear River near Riegelwood found lower, but still significant levels of mercury in bass and bowfin tissues.

Greenfield Lake was found to be eutrophic, however, not as bad as in previous years. Nitrogen and phosphorus levels decreased and water clarity increased. The lake still has nuisance levels of filamentous algae and aquatic plants. Boiling Springs Lake was a dystrophic lake with no trend in water quality.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Cape Fear River above Federal Paper

This portion of the Cape Fear River was approximately 100 meters (m) wide, nearly 7 m deep and was barely flowing upstream, indicating a tidal influence. The substrate is largely sand with gravel and silt, with most intolerant taxa found on snags. It was usually affected by agricultural runoff, as indicated by the conductivity of 140 µmhos/cm, but with the low flows in 1998, runoff was minimized and the water quality rose to Excellent, using draft Coastal B benthos criteria.

Year	Total S	EPT S	EPT N	NCBI	Flow	Bioclass
1998	51	13	47	6.36	Low	Excellent
1993	45	8	32	6.61	Normal	Good-Fair

Cape Fear River below Federal Paper

This portion of the Cape Fear River was approximately 90m wide, nearly 8 m deep and was barely flowing upstream, indicating a tidal influence. The conductivity here of 461 µmhos/cm indicate both estuarine influences and influence from the paper mill. The substrate is largely sand with gravel and silt, with most intolerant taxa found on snags and cypress knees. This portion of the river had a Fair bioclassification (4-5 EPT taxa), based on benthos data in 1993 and 1998, using draft Coastal B criteria.

Cape Fear River at Riegelwood

Fish tissue samples were collected from the Cape Fear River at Riegelwood during September 1998. Twenty-three samples were analyzed for metals contaminants. Ten samples composed of largemouth bass or bowfin contained mercury exceeding the EPA screening value and FDA/NC limit of 0.6 ppm and 1.0 ppm respectively. All other metals results were lower than EPA and FDA/NC limits. Two largemouth bass samples were also analyzed for chlorinated pesticides and PCB arochlors. Results showed undetectable levels of these contaminants in the bass tissue.

Cape Fear River below Riegelwood

Fish tissue samples were collected from the Cape Fear River near Neils Eddy Landing during August 1994. Of the 15 samples analyzed for metals contaminants, 3 bowfin samples contained mercury exceeding the EPA screening value and FDA/NC limit of 0.6 ppm and 1.0 ppm respectively. All other metals results were lower than EPA and FDA/NC limits.

Livingston Creek, US 74
This site was nine meters wide and about 1 meter deep in most locations. The substrate was primarily sand with some silt and detritus. Most macroinvertebrate habitat was provided by snags, root mats and macrophytes. Bends in the stream were frequent, as were pools and the stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. The change in bioclassification from Fair in 1993 to Good-Fair in 1998 reflects a marked increase in the total taxa, intolerant taxa and overall intolerance of the benthic community. This improvement is probably related to less nonpoint inputs due to low flows.

Year	Total S	EPT S	EPT N	NCBI	Flow	Bioclass
1998	83	20	77	6.30	Low	Good-Fair
1993	68	9	24	7.71	Normal	Fair

Fish tissue samples were collected from Livingston Creek near Acme during October 1998 and analyzed for metals contaminants. Of the 2 samples collected during the period, 11 samples composed of bass pickerel or bowfin contained mercury levels exceeding the EPA screening value of 0.6 ppm. Three samples of bass or bowfin exceeded the FDA/NC limit of 1.0 ppm. All other metals results were lower than EPA and FDA/NC limits.

Hood Creek, US 76/74
This site was 11 meters wide and over 1 meter deep in most locations when it was sampled in March. July sampling found a much smaller stream, only 5 meters wide and 0.3 meters deep. The substrate was primarily sand with some detritus. Most macroinvertebrate habitat was provided by snags, root mats and macrophytes. Bends in the stream were frequent, as were pools and the stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. This was one of the few streams in the outer coastal plain to support stoneflies; Perlesta placida and Strophopteryx sp. in the winter and Acroneuria abnormis in the summer. The mussel subspecies collected here, Elliptio complanata livingstonensis, appears to have a distribution limited to Brunswick County. Sampling in September, following Hurricane Bonnie, showed a decline in water quality from Good to Good-Fair.

Barnards Creek, US 421
This site was five meters wide and > 1 meter deep in most locations when it was sampled in March and drains the rapidly developing area of southern Wilmington. The substrate was nearly an even mix of sand, silt and detritus. Most macroinvertebrate habitat was provided by macrophytes (Valisneria, Typha, Ludwigia etc), and a beaver dam. Bends in this braided stream were infrequent, as were pools. The stream had minimal shading since it provided right-of-way for power lines. Stream banks and the surrounding riparian zone were stable and intact, but relatively narrow (12 meters or less). A draft swamp rating of Fair-Good was given using benthos data. However the community appeared to be impacted, with only five intolerant taxa collected and a very high Biotic Index (7.75).

Town Creek, upstream of SR 1413
This site was nine meters wide and 1.3 meters deep in most locations when it was sampled in March. July sampling found a much smaller stream, only six meters wide and 0.2 meters deep. The substrate was primarily sand with some silt and detritus. Most macroinvertebrate habitat was provided by snags, sticks and root mats. Bends in the stream were frequent, as were pools and the stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. This was one of the few streams in the outer coastal plain to support the stonefly, Acroneuria abnormis as well as the mussel, Elliptio complanata livingstonensis. However, it was given a Good-Fair bioclassification using benthos data. The Greenfield ramshorn (Helisoma eucosmiun), previously thought to be extinct, has been recently rediscovered in Town Creek. Sampling in September, following Hurricane Bonnie, showed little change in water quality, unlike more developed watersheds.

Lewis Swamp, SR 1410
This site was seven meters wide and < 1 meter deep in most locations when it was sampled in March. The substrate was primarily sand with detritus. Most macroinvertebrate habitat was provided by snags, root mats and leaf packs. Bends in the stream were frequent, but pools were not. The stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. The stonefly Perlesta placida was collected here, as was the mayfly Eurylophella doris and the chironomid Uniella multioculata. A draft rating of Good-Excellent was given to this stream, based on winter benthos data. This site was dry when revisited in July.

ESTUARINE SITES
Cape Fear River, Wilmington Docks
This site was located just upstream of the Port of Wilmington docks and about 25 meters offshore. A 10 meter wide, often broken marsh buffer, was between this site and a petroleum storage facility. Substrate here was very muddy so no additional habitats could be reached. Salinity at the time of sampling was 8 ppt and DO was 3.3 mg/l. This was the most heavily impacted site in this subbasin, with only 22 total taxa, and no intolerant taxa, collected. The Estuarine Biotic Index (EBI) at this site was 1.24, the lowest in this subbasin. Sampling in 1993 found hydrocarbons in the sediment, and while evidence for them were not observed during this sampling, the low abundance of most of the taxa collected here suggest toxic impacts, as well as stress from low oxygen.

Cape Fear River, Southside WWTP
This site was located off of the outfall from the Wilmington South Side WWTP. Substrate here was muddy with a little sand. Spartina in the shallows provided extra habitat as well as a five meter wide buffer between the WWTP grounds. Salinity was 11ppt and dissolved oxygen was 3.8 mg/l during this dawn sampling, indicating some potential problems with oxygen limitation. A moderate number of taxa were collected here, as well as a few intolerant taxa, however the EBI indicated a relatively stressed community so this site was given a rating of Elevated Impact. Mallin et al. (1997) found elevated nutrient levels at a site one km from here, which they ascribed to the WWTP outfall.

Cape Fear River, Marker 56
This site was located near the upstream end of an old spoil island. The substrate was sandy mud, with a few bricks that provided hard substrate for barnacles and bryozoans. Salinity was 12 ppt and dissolved oxygen was 4.0mg/l just before dawn. A moderate number of taxa were collected here (31 taxa) with an EBI of 2.08. While this site was assigned a rating of Moderate Impact, this site had the best water quality in the upper portions of the Cape Fear estuary. This site was near one monitored by Mallin et al (1997), who also found their site to be dominated by tolerant, opportunistic, euryhaline species.

Cape Fear River, Marker 40
This site was located near the north end of Keg Island. The substrate here was hard packed sand in the shallows, overlain by a layer of mud and peat deeper, below the area of strongest wave action. Additional habitat was provided by some Spartina, peat clumps and shallows. Salinity at this site was 11 ppt and DO was only 5.7 mg/l late in the day, when oxygen levels would be expected to be at their highest. The wave action at this site, possibly from boat traffic, severely reduced the polychaete fauna (only a single Neanthes succinea was found). The community was dominated by epibenthic taxa, grass shrimp and brown shrimp, and the marsh clam Rangia cuneata, which is not affected by shifting sediments. The rating of Moderate Impact assigned to this site reflects the shifting sediments and low oxygen at this site.

Cape Fear River, Marker 35
This site was located just upstream of the prohibited area surrounding the Sunny Point Military Terminal. The substrate was mostly muddy sand mixed with detritus. Heavily eroded Spartina marsh provided extra habitat as well as some pilings and shallows. Salinity at this site was 15 ppt and DO was 6.0 mg/l. EMAP sampling in 1994 (Hyland et al. 1996) and 1995 (Hyland et al. 1997) found a benthic community with a low taxa richness and high abundance. In 1994 they found elevated levels of Tri-butyl Tin (an antifoulant), Dieldrin and Alkanes, however, in 1995, no pollutants were found to be elevated.

Cape Fear River, Snows Marsh
This site was located in Snows Marsh near the water intake of the CP&L Brunswick plant. The substrate here was muddy sand, grading to sandy mud in deeper areas, with hard clam shells sporting growths of Gracillaria. Shallow areas and Spartina also provided habitat. Salinity at this site was 27 ppt. This site was given a rating of Moderate Impact each of the last three times it has been sampled, in 1993, 1996 and 1998. Though taxa richness has varied between years, the tolerance of the invertebrate community has remained relatively stable, indicating little change in water quality.

Cape Fear River, Southport
This site was north of Southport's town park. The substrate was sand with scattered bricks and cement pieces, some with Gracillaria. The intertidal area was mostly unvegetated with a few patches of Spartina grading up to a rip rap wall that prevents erosion of the road. Salinity here was 30 ppt on an outgoing tide. This site was given a rating of Moderate Impact, probably due to runoff from downtown Southport and the sporadic peaks in metals found by Mallin et al. (1997). Sampling after Hurricane Bonnie showed a steep decline in soft-bodied taxa, including polychaetes and all but the thickest shelled crustaceans (hermit crabs, blue crabs and penaeid

shrimp). This is similar to what was seen in the New River estuary following Hurricane Fran and appears to be related to scour from sediments moved by the storm, rather than changes in water quality.

The Basin, The Rocks
This site was located in The Basin at the junction of Zekes Island and The Rocks. The substrate was muddy fine sand. Oysters, shallows and Spartina also provided habitat. The shallow (1 cm) redox layer indicates a poorly flushed system. Salinity was 28 ppt. Daytime dissolved oxygen levels here (6.9 mg/l) were 2 mg/l higher than on the Cape Fear River side of The Rocks 30 m away, indicating elevated algal activity in this shallow (0.5 m maximum) basin. The macroinvertebrate community was very limited, only 38 total taxa were collected, and the community was dominated by tens of thousands of mud snails (Ilynassa obsoleta). While the fauna was reduced, the invertebrate community only reflected a moderate level of impact (2.09 EBI) indicating that most of the problems are related to nutrient enrichment, rather than anything toxic. Collecting in 1985 found 61 taxa and a much more intolerant community (EBI 2.52). This sampling site was located in a channel area which received much greater tidal exchange which probably alleviated the enrichment problems found at the 1998 site. EMAP sampling found another location in The Basin impacted in 1994 due to elevated arsenic levels (Hyland et al. 1996), however resampling in 1995 found no impacts (Hyland et al. 1997).

SPECIAL STUDIES
Three special studies have been conducted in this subbasin since 1993. Benthic macroinvertebrates were collected above and below a stormwater runoff pond near Jumping Run Branch, a tributary to Greenfield Creek, before construction in September 1994 and after, in May 1995. No sites were assigned a bioclassification due to small stream size, but changes in community structure appeared to be more related to seasonal differences, rather than water quality improvements from pond construction.

Benthic macroinvertebrates were collected from Town Creek, Barnards Creek and Lewis Branch in March 1998 as part of a final effort to develop and validate biocriteria for swamps. PH and channel type were found to play major roles in the variability of these systems in determining the structure of the benthic community.

Benthic macroinvertebrates were collected from three sites in this subbasin (Hood Creek, Town Creek and Cape Fear River at Southport) as part of a study to determine the effects of Hurricane Bonnie on local streams. Streams with a large percentage of agricultural land use showed severe impacts on the macroinvertebrate community, while streams with a mostly undisturbed catchment suffered very few negative impacts. In the estuary, soft-bodied taxa suffered mortality due to abrasion and sediment movement, however hard-shelled taxa showed a much smaller decline in taxa richness and abundance.

OTHER DATA
Mallin et al (1997). The Center for Marine Science at the University of North Carolina-Wilmington has been sampling the lower Cape Fear River for water chemistry, macroinvertebrates and fish since June 1995. Eleven chemistry sites, three macroinvertebrate sites and four fish sites in this subbasin were sampled, often monthly, for nearly two years (1995-

1997). This report summarizes their findings. This report found a 15% increase in BOD below Federal Paper. In one of the few incidents of elevated metals in this subbasin, copper also was found below Federal Paper. Livingston Creek was found to be a source of Total Nitrogen, possibly from the old Kaiser Chemical site which had contaminated the groundwater with fertilizer in the 1980s. In the estuarine part of this subbasin, water quality problems appear to be isolated to the upper and lower portions of the Cape Fear River. The upper portions of the estuary suffer from the lowest dissolved oxygen in the subbasin, though it is rarely low enough to cause problems. Mallin et al (1997) attributed this to discharge from the NE Cape Fear River and a series of dischargers around the CP&L Sutton facility. The turbidity maxima of the river, where many of the ions that were dissolved in freshwater flocculated and settled out when coming in contact with salt water, was located just below the City of Wilmington, near the South Side WWTP. In addition, Mallin felt that elevated levels of NH3, TKN, PO4, and TP might also have been from the nearby South Side WWTP. Near the mouth of the river, between Snows Marsh and Southport where salinities were highest and tidal flushing greatest, nutrient levels were the lowest in the subbasin. Sporadic occurrences of Cr, Cu and Ni were documented in this area.

Hyland et al. (1996). This is the first of NOAA's reports from their EMAP-Estuaries program assessing water quality in the Carolinian faunal province, which includes North and South Carolina, Georgia and eastern Florida. In 1994, two samples from this subbasin were collected. The benthos were characterized and sediments were tested for toxicity and chemically evaluated for a wide range of pollutants. TBT, Dieldrin and Alkanes were found in sediments in the Cape Fear River near Marker 35, and Arsenic was found in the sediments of Zekes Island. Both sites suffered from low taxa richness (4 taxa).

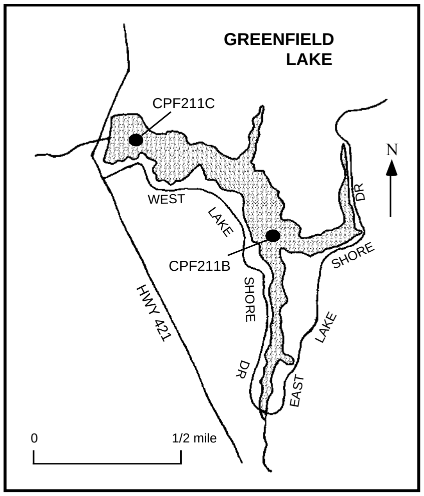
Hyland et al. (1997). This NOAA report details EMAP-Estuaries' 1995 sampling program in the Carolinian faunal province. The two sites in this subbasin sampled in 1994, were resampled in 1995. No pollutants were found at either site. Taxa Richness improved at Zekes Island, but did not change for the Cape Fear River.

LAKE ASSESSMENT PROGRAM

Greenfield Lake

COUNTY:	New Hanover	**CLASSIFICATION:**	C Sw
SURFACE AREA:	115 acres (46 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	0.07 $x10^6 m^3$	**WATERSHED**:	4 mi^2 (9 km^2)

Greenfield Lake is owned by the City of Wilmington and was built before 1750. Originally a cypress swamp, the lake was impounded to provide water for milling and irrigation for the Greenfields Plantation which surrounded it. The city encompasses the lake and its watershed. Greenfield Lake is currently swampy and cypress-filled, with a maximum depth of 12 feet (four meters).



Greenfield Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data are presented in Appendix L2. The greatest chlorophyll *a* (69 µg/L), total phosphorus, and ammonia concentrations were observed at the sampling site near the dam in July. An algal bloom sample was collected in June at the sampling site near the upper end of the lake due to the presence of floating flecks of green material in the water and the greenish discoloration of the water. Analysis of the sample determined that an algal bloom was not present at the sampling site. Small green algas along with the large colonial green alga, *Volvox* sp., were present in the sample. Significant beds of submerged filamentous algae and floating mats of duckweed (*Lemna* sp.) and watermeal (*Wolffia* sp.) were observed at nuisance levels in the lake in 1998. The NCTSI scores for Greenfield Lake indicated that the lake was eutrophic in June and July (Table L29).

According to Mr. Richard King, Director of Public Works, the city no longer dredges the lake but is treating the aquatic macrophytes with chemicals and grass carp. In the summer of 1998, there was a fish kill in Greenfield Lake which occurred following a rainfalll event. The filamentous algae in the lake also appeared to be worse in 1998 as compared with previous years, while the clarity of the water in the lake appeared to have improved in the past few years (Richard King, Director of Public Works, City of Wilmington, pers. com.).

Historical data collected at Greenfield Lake from 1981 through 1998 for the four constituents of the NCTSI (Secchi depth, total phosphorus, total organic nitrogen and chlorophyll *a*) are summarized using box and whisker plots in Figure L16. Secchi depth was slightly better at the upper end of the lake sampling site as compared with the Secchi depth observed near the dam. There was also a slight difference in total phosphorus and total organic nitrogen concentrations between the two sampling sites. These concentrations were also elevated at both sampling sites. Chlorophyll *a* values were historically elevated in Greenfield Lake. The sampling site located near the dam had a greater range of chlorophyll *a* values as compared with the site located at the upper end of the lake from 1981 through 1998 (Appendix L2).

Figure L16 . Greenfield Lake Data Analysis, 1981 – 1998.

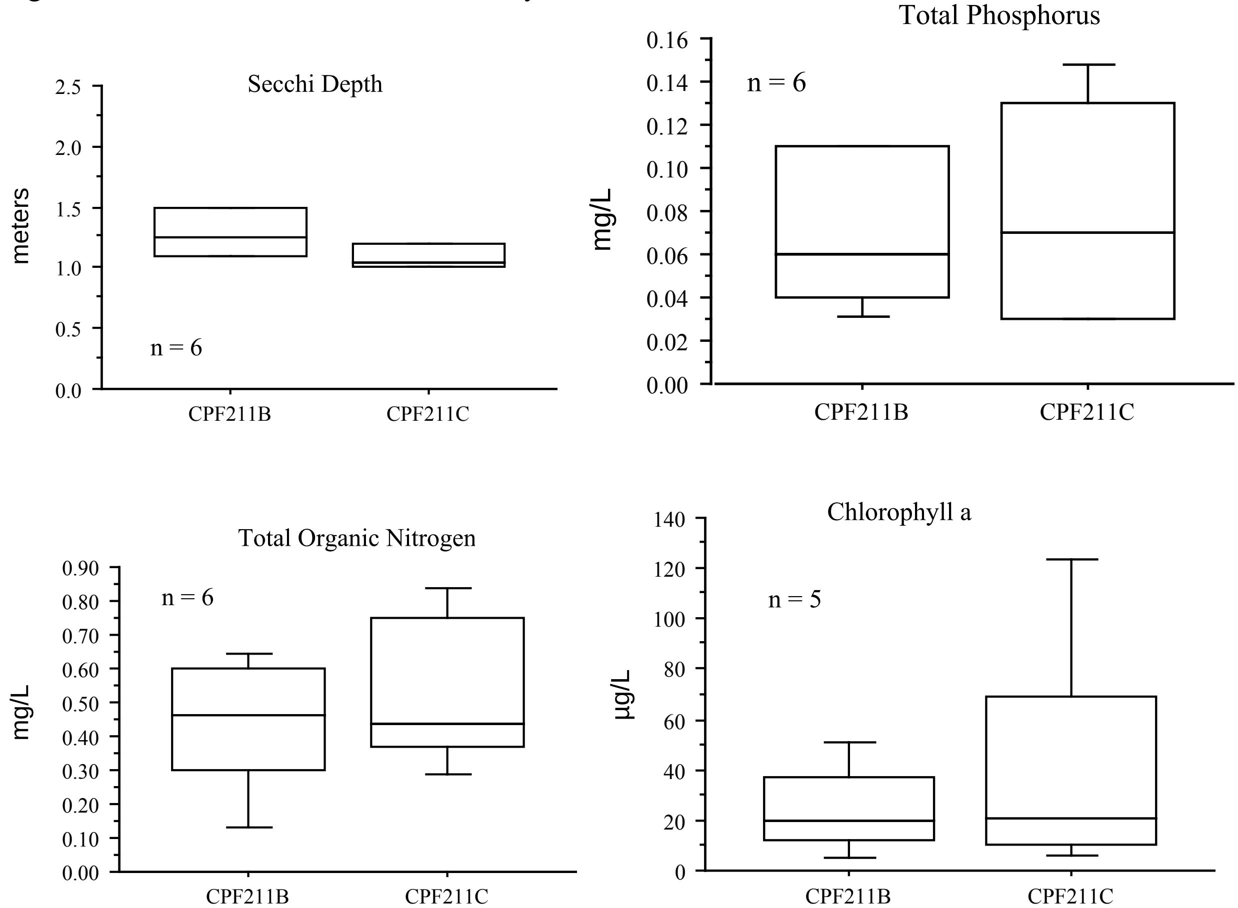


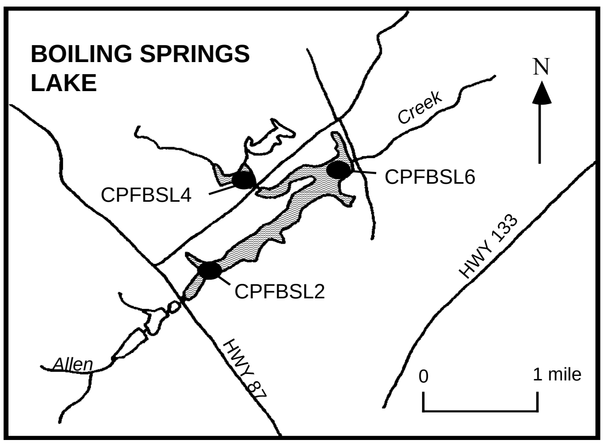
Table L29. Greenfield Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Greenfield Lake	980803	no score	0.06	0.44	n/a	1.3
Greenfield Lake	980707	1.5[E]	0.06	0.24	51	1.5
Greenfield Lake	980608	0.4[E]	0.03	0.35	14	1.3
Greenfield Lake	930715	2.3[E]	0.12	0.59	6	1.1
Greenfield Lake	880921	4.9[E]	0.13	0.75	91	1.2
Greenfield Lake	810715	1.9[M]	0.05	0.48	24	1.1

Boiling Springs Lake

COUNTY:	Brunswick	**CLASSIFICATION:**	B Sw
SURFACE AREA:	1120 acres (453 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	$3.8 \times 10^6 m^3$	**WATERSHED**:	10 mi^2 (26 km^2)

Boiling Springs Lake, a coastal blackwater lake located in eastern Brunswick County, is owned by the Town of Boiling Springs. This lake was impounded in 1961. Land use upstream of the lake is mostly forested and residential. The lake is used for fishing and boating and is fed by several springs. The maximum depth is approximately 26 feet (eight meters) deep.



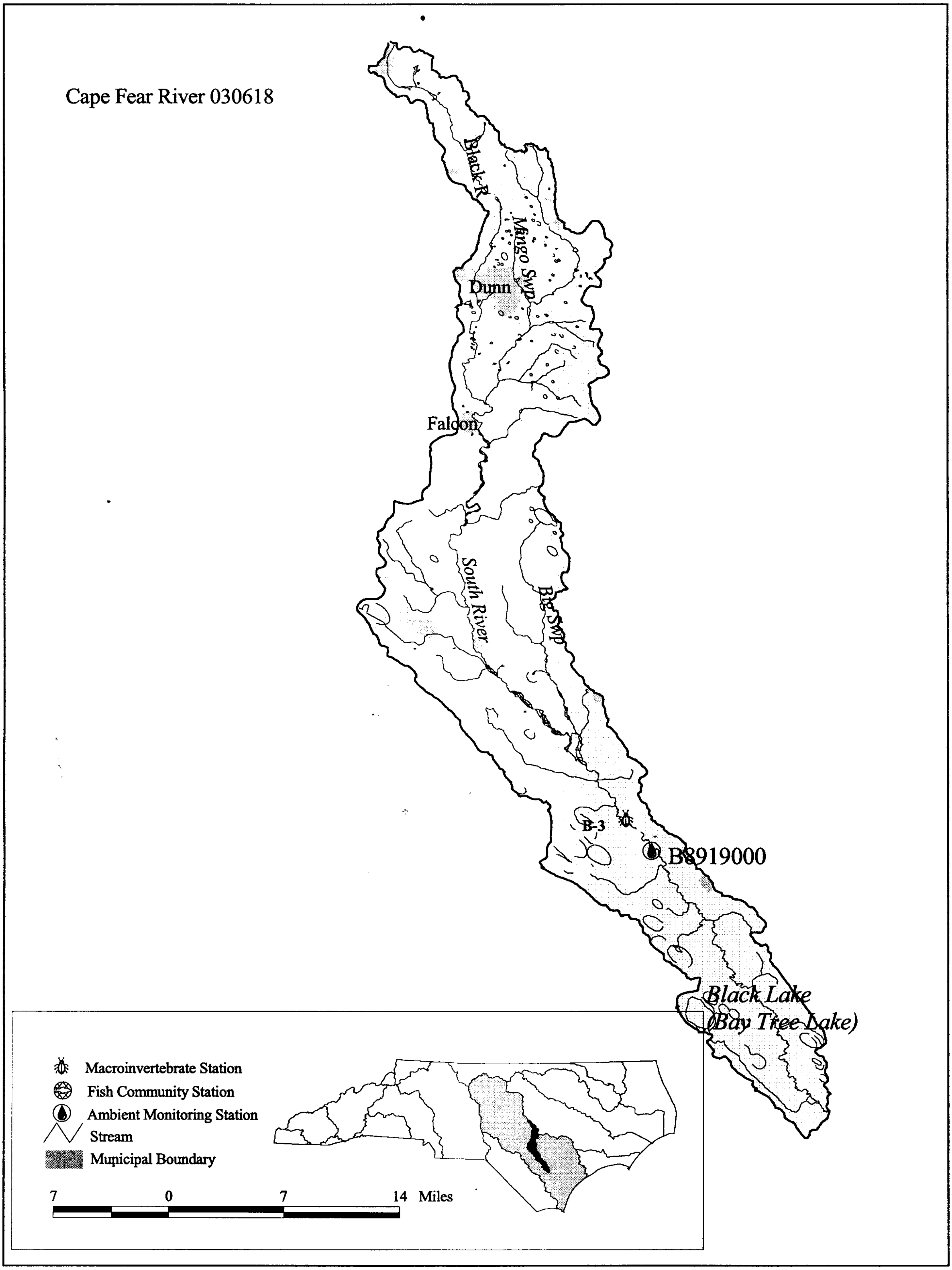
Boiling Springs Lake was most recently monitored by DWQ on June, July and August, 1998. Physical and chemical data collected by DWQ for this lake are presented in Appendix L2. Secchi depths were less than one meter at all three lake sampling sites. No nuisance levels of aquatic macrophytes were observed in the lake in 1998. Fecal coliform bacteria concentrations in June, July and August ranged from <10 to 130 colonies per 100 ml. Because this lake is dystrophic, a trophic status of the lake cannot be accurately determined through the NCTSI scores (Table L30; Appendix L1).

According to Ms. Barbara Cumbee, City Clerk for the Town of Boiling Springs, there have been no public complaints regarding fish kills, aquatic weeds or algal blooms, or complaints of problems related to swimming in Boiling Springs Lake. There has been an increase in development within the lake's watershed in recent years, but no impacts have occurred to the lake as a result (Barbara Cumbee, City Clerk, Town of Boiling Springs, pers. com.). Mr. Charles Schneiders, Commissioner of Public Parks (pers. com.), also stated that there have been no public reports of water quality problems related to Boiling Springs Lake. There is an absence of forage fish in the lake which is being investigated by Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries.

Table L30. Boiling Springs Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Boiling Springs Lake	980803	no score	0.01	0.30	n/a	0.6
Boiling Springs Lake	980707	-1.7[D]*	0.02	0.31	1	0.6
Boiling Springs Lake	980608	-3.8[D]	<0.01	0.20	2	0.6
Boiling Springs Lake	930715	-0.1[D]	0.04	0.37	1	1.2
Boiling Springs Lake	900723	-2.3[D]	0.01	0.27	2	0.7

* Calculations based on two of three sampling sites



Cape Fear River 030618
Black R
Mingo Swp
Dunn
Falcon
South River
Big Swp
B-3
B8919000
Black Lake
(Bay Tree Lake)
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
7 0 7 14 Miles

CAPE FEAR SUBBASIN 030618

DESCRIPTION

Cape Fear subbasin 18 is located in the inner coastal plain ecoregion, and contains the cities of Dunn and Roseboro. Major tributaries of the Cape Fear River in this subbasin include the South and Black Rivers. The South River below Big Swamp was designated ORW in 1994. Land use in this subbasin is primarily agriculture in the form of animal operations, mostly hog farms. Streams in this subbasin are characterized as slow moving black-water streams, swampy in nature. There are 3 permitted dischargers in subbasin 18, none with a design flow > 0.05 MGD.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-3*	South R	Bladen	SR 1502, nr Parkersburg	Good	Good

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Bay Tree Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	South R near NC 701	1998	20	16	0	EPA mercury limit exceeded in 16 samples of multiple species, FDA/NC mercury limit exceeded in 6 samples

The ambient site on the South River near Parkersburg has consistently received a rating of either Good or Excellent since 1983. Fish tissue samples collected from the South River in 1998 contained significant mercury burdens. Elevated mercury was measured in multiple species including warmouth, suckers, pickerel, perch and bass.

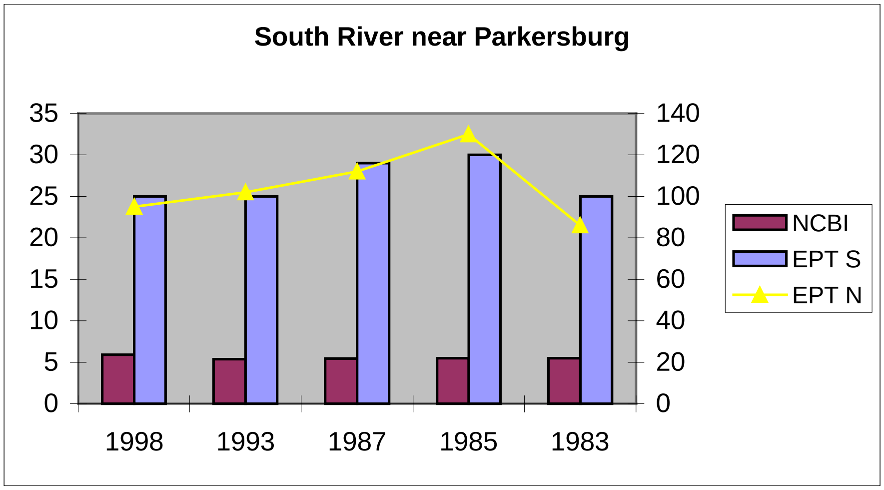
Bay Tree Lake is a Carolina Bay lake located in Bay Tree State Park. It was monitored by DWQ in 1998 and found to be dystrophic.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

South River, SR 1502 near Parkersburg

The South River at this site was about 12 meters wide. This site has changed drastically in character since Hurricane Fran in 1996. Snags had been removed from the stream and there were no riffle areas. The site has maintained a benthos rating of Excellent or Good since 1983, however, sampling in 1998 resulted in the lowest total taxa (but no change in EPT taxa richness), the highest BI and a decrease in EPT abundance. Some sensitive aquatic species that were not collected or were reduced in abundance in 1998 as compared to previous years include: Cloeon,



Eurylophella, Paraleptophlebia, Pteronarcys dorsata, and Brachycentrus numerosus. This site also experienced a reduction in several species associated with snag habitat: Lype diversa, Neureclipsis, Nyctiophylax, and Pycnopsyche.

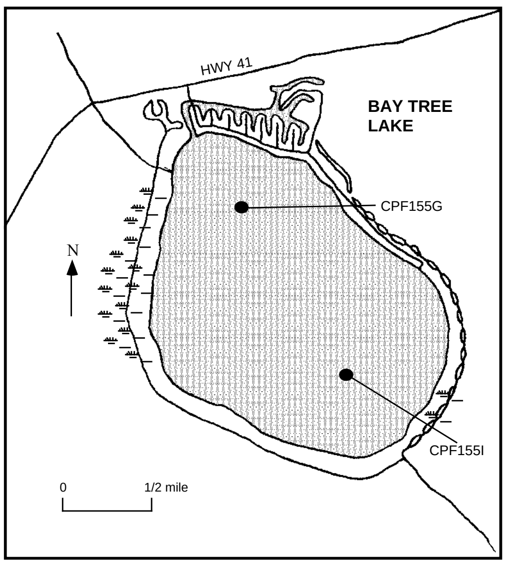
South River near NC 701
Fish tissue samples were collected from the South River near NC 701 during October 1998. Twenty samples were analyzed for metals contaminants. Samples collected from the South River during 1998 contained significant mercury burdens -16 of the 20 samples contained mercury levels exceeding the EPA screening value of 0.6 ppm. Six samples contained mercury above the FDA/NC limit of 1.0 ppm as well. Elevate mercury was measured in multiple species including warmouth, suckers, pickerel, perch, and bass. All other metals results were lower than EPA and FDA/NC limits.

SPECIAL STUDIES
A special study investigating the effects the high concentration of hog farms in the lower Cape Fear basin was conducted in 1998. This study included Starlins Swamp, which was not rated, and Big Creek (Good-Fair). Starlins Swamp was a 15 meter wide, braided channel, swamp-like stream. Big Creek was a small (5 meter wide) stream where sampled. These streams were associated with few or no hog farms in their watersheds.

LAKE ASSESSMENT PROGRAM
Bay Tree Lake

COUNTY:	Bladen	**CLASSIFICATION:**	C Sw
SURFACE AREA:	1400 acres (567 hectares)	**MEAN DEPTH :**	3 feet (1 meters)
VOLUME:	0.6 x$10^6$$m^3$	**WATERSHED**:	4 mi^2 (10 km^2)

Bay Tree Lake (also called Black Lake) is a shallow, natural lake located in the Coastal Plain near Elizabethtown, North Carolina. The lake is located in Bay Tree State Park and is owned by the State of North Carolina. Typical of Carolina Bay Lakes, Bay Tree Lake receives no significant overland inflows. The maximum depth of this lake is six feet (two meters). Bay Tree Lake has a network of drainage canals built on its northern and eastern shores. The surrounding land is primarily flat, composed of wetlands and upland forests. Bay Tree Lake is used for fishing and boating. A private residential community is located along the northern and northeastern shoreline of the lake.



Bay Tree Lake was most recently monitored by DWQ in June, July and August, 1998. Physical and chemical data for this lake are presented in Appendix L2. No nuisance level beds of aquatic macrophytes were observed in the lake in 1998. Metals were less than the applicable state water quality standards except for copper in July (7.7 µg/L) which was slightly greater than the state water quality action level of 7.0 µg/L. Because Bay Tree Lake is dystrophic, a trophic status of the lake cannot be accurately determined through the NCTSI scores (Table L31; Appendix L1).

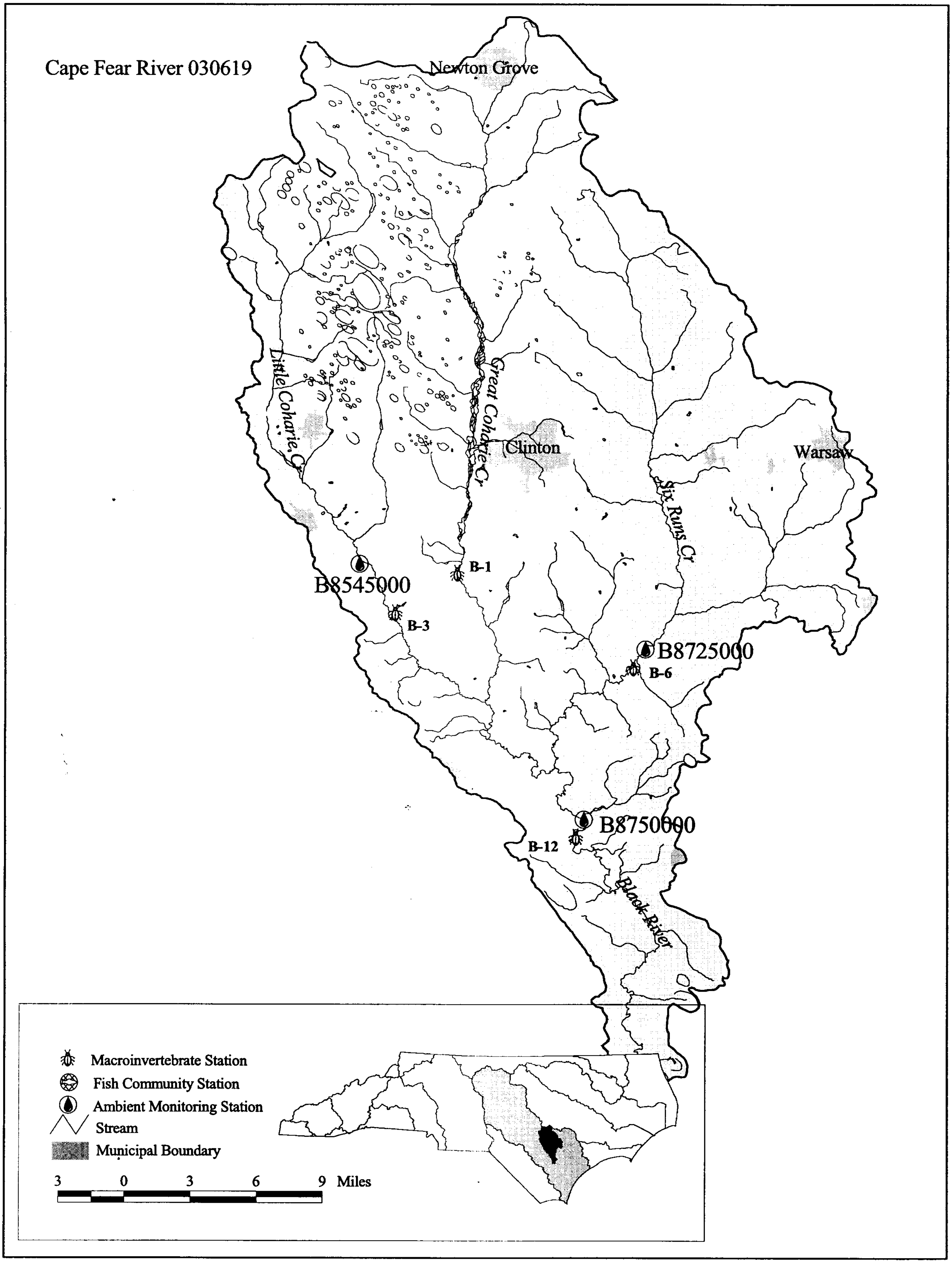
According to Mr. Keith Ashley, District 4 Fisheries Biologist, Bay Tree lake has a die-off of yellow perch (*Perca flavescens*) every summer due to longterm exposure to the low pH waters of the lake. Mr. Ashley stated that there have been no increases in aquatic macrophytes or algae in recent years nor have there been any public complaints regarding problems related to swimming in the lake (Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries, pers. com.). Mr. David Colburn, Park Superintendent for Singletary Lake State Park stated that there has been an increase in residential development in the watershed with about ten piers added to the shoreline in recent years. Mr. Colburn also stated that there had been no reports of water quality problems in Bay Tree Lake (David Colburn, Park Superintendent, Singletary Lake State Park. pers. com.).

In 1994, a fish consumption advisory was issued for Baytree Lake which remains in effect. This is an "No Consumption" advisory which has been placed on largemouth bass bowfin taken from the lake, which have been found to contain higher than normal levels of mercury (NCDENR, June, 1997).

Table L31. Bay Tree Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Bay Tree Lake	980805	no score	<0.01	0.25	n/a	0.9
Bay Tree Lake	980714	-1.1[D]	0.02	0.25	6	1.0
Bay Tree Lake	980616	-2.2[D]	0.01	0.19	7	0.8

Bay Tree Lake	930824	-5.3[D]	0.03	0.06	1	1.3
Bay Tree Lake	890731	-3.1[D]	0.02	0.18	3	1.5
Bay Tree Lake	850729	-1.4[D]	0.03	0.22	4	1.0
Bay Tree Lake	810729	4.5[D]	0.12	0.62	15	0.3



Cape Fear River 030619
Newton Grove
Little Coharie Cr
Great Coharie Cr
Clinton
Warsaw
Six Runs Cr
B-1
B8545000
B-3
B8725000
B-6
B8750000
B-12
Black River
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
3 0 3 6 9 Miles

CAPE FEAR SUBBASIN 030619

DESCRIPTION

Cape Fear subbasin 19 is located in the coastal plain ecoregion. It contains the section of the Black River upstream of the confluence with the South River, Six Runs Creek, Great Coharie Creek, and Little Coharie Creek. The Black River, plus Six Runs Creek below Quewhiffle Swamp, were designated ORW in 1994. Land adjacent to the Black River is primarily undisturbed forest. This subbasin also has a very high concentration of hog farms. The town of Clinton is the largest developed area within this subbasin. There are 7 permitted dischargers in this subbasin, the largest of which is the Town of Clinton WWTP (3.0 MGD) which discharges to Williams Old Mill Branch. The remaining all discharge < 0.8 MGD.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1*	Great Coharie Cr	Sampson	SR 1214	Good	Good-Fair
B-3*	Little Coharie Cr	Sampson	SR 1214	Good-Fair	Good-Fair
B-6	Six Runs Cr	Sampson	SR 1960	Excellent	Good
B-12*	Black R	Sampson	NC 411	Excellent	Excellent

*Data available prior to 1993, see discussion below or data in Appendix B-1.

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Black R near Ivanhoe	1995	7	3	0	EPA mercury limit exceeded in 3 bowfin samples

Analysis of these data has been complicated by the de-snagging of these streams as part of the Emergency Watershed Protection Program. This program, administered by the USDA's Natural Resources Conservation Service (NRCS), provides technical and financial assistance to preserve life and property threatened by excessive erosion and flooding. The federal government granted monetary assistance to those counties in North Carolina that were most affected by Hurricane Fran in 1996. This money was used to clear hurricane debris (blow-down) from clogged waterways. These streams were totally de-snagged, removing nearly all of the valuable snag habitat available for macroinvertabrate colonization. This makes it difficult to determine whether any changes that may have occurred in the macroinvertebrate community were due to changes in water quality or lack of suitable habitat.

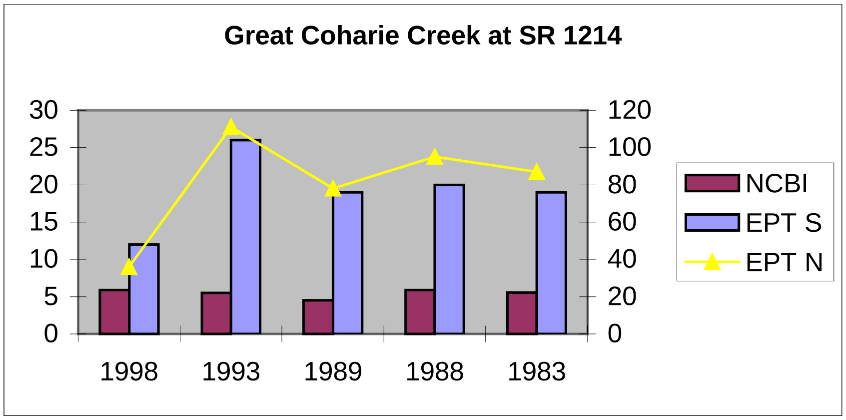
Great Coharie Creek and Six Runs Creek both dropped one level of bioclass between 1993 and 1998. All the streams in this subbasin have many hog farms in their watersheds. The Black River has maintained a rating of Excellent since 1985, however, some intolerant taxa were not collected in 1998 that were present in previous years' sampling.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Great Coharie Creek, SR 1214

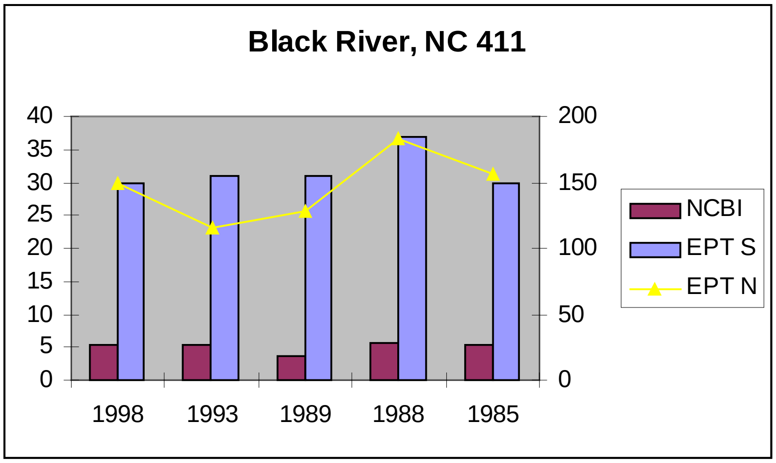
This 12 meter wide tributary to the Black River has had a rating of Good in 1988, 1989, and 1993. The bioclass dropped to Good-Fair in 1998. There was a significant decrease in the number of intolerant EPT taxa, as well as an increase in the Biotic Index. This site is downstream of the Clinton WWTP and also is associated with many hog farms.



Little Coharie Creek, SR 1214
Little Coharie Creek at this site was 7 meters wide with a sandy substrate. Good flow however, occurred only in limited areas. Instream habitat was somewhat sparse and erosion areas were present. This stream was Good in 1988, based on benthos data, but was Good-Fair in 1993 and 1998, with little change in EPT taxa richness (17-16).

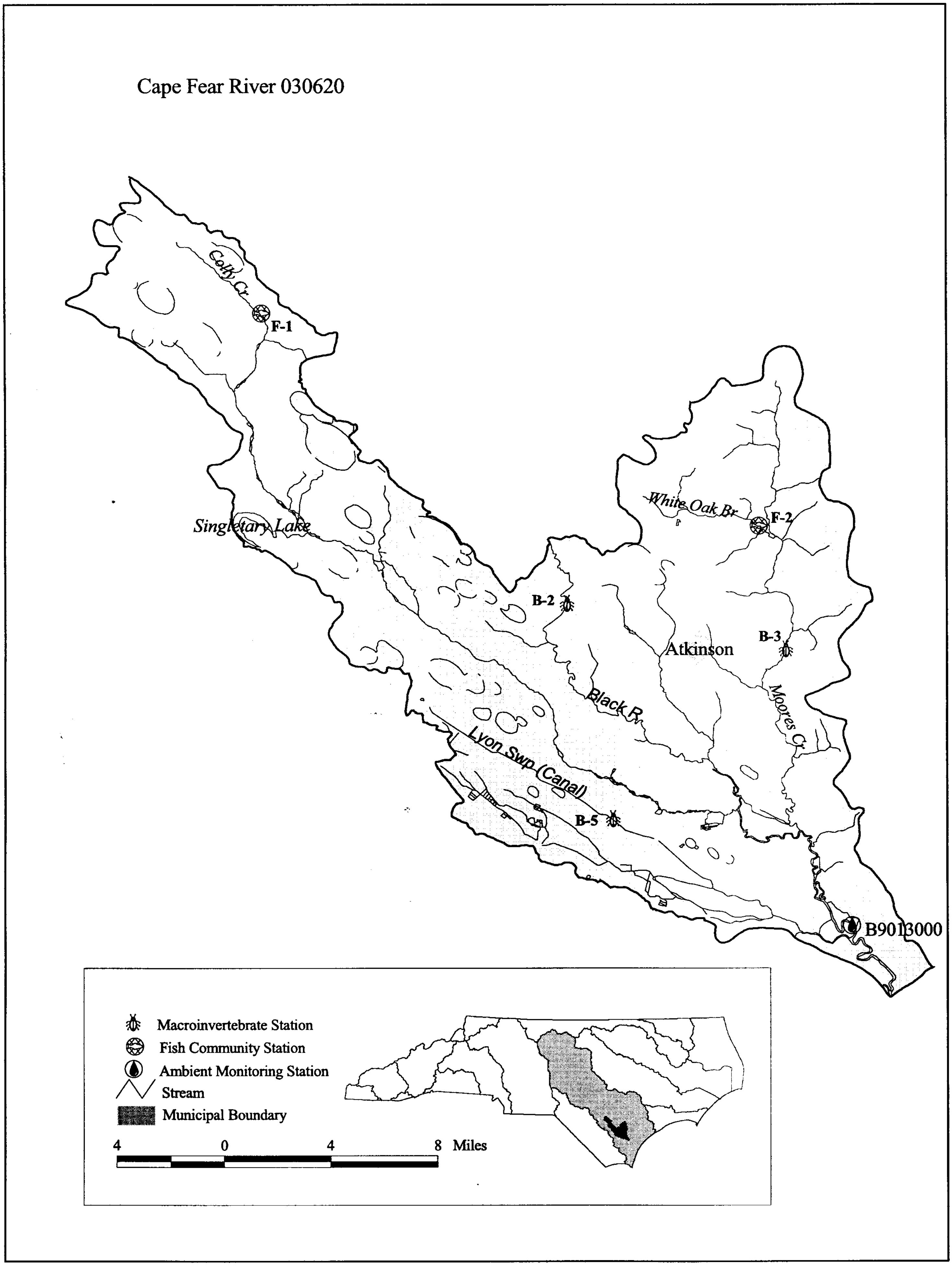
Six Runs Creek, SR 1960
Snag habitat in this 16 meter wide stream was almost non existent. Recent stream clearing by the NRCS had removed most of the snag habitat in this sandy bottomed stream. The bioclass at this site decreased from Excellent to Good between 1993 and 1998. This is reflected in a reduction in the number of intolerant EPT taxa collected. Some of these are associated with snag habitat: Brachycentrus numerosus, and Lepidostoma sp.

Black River, NC 411 near Tomahawk
This site has consistently received a rating of Excellent since 1985. A rating of Good in October 1998 was the result of flooding due to Hurricane Bonnie the previous month. There is an unusually diverse aquatic community found in this large (17 meters wide) black-water river. However, investigators noted during sampling in 1998 that most of the snag habitat had been removed from the river. Also, some intolerant taxa were not collected in 1998, but were present in previous years' collections. These taxa include: Baetisca gibbera, Paraleptophlebia, Pteronarcys dorsata, and Lepidostoma sp. Other taxa changes noted were an increase in enrichment indicator species such as, Dicrotendipes, Rheotanytarsus, and Dugesia tigrina. This watershed is in an area of high concentration of hog farms. The lower NCBI experienced in 1989 could be the result of higher flow during that sampling event.



<u>Black River near Ivanhoe</u>
Bowfin tissue samples were collected from the Black River near Ivanhoe during August 1995. Seven samples were analyzed for metals contaminants. Three bowfin contained mercury levels exceeding the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.

SPECIAL STUDIES
Six Runs Creek and Stewarts Creek were sampled in November of 1996 as part of an investigation to determine the amount of damage done to NC streams and rivers after Hurricane Fran. Crane Creek at SR 1004 was sampled in 1998 (Good-Fair) as part of benthos survey investigating water quality relationships to density of hog farms.


Cape Fear River 030620
Colly Cr.
F-1
Singletary Lake
White Oak Br
F-2
B-2
B-3
Atkinson
Black R.
Moores Cr.
Lyon Swp (Canal)
B-5
B9013000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
4 0 4 8 Miles

CAPE FEAR SUBBASIN 030620

DESCRIPTION

Cape Fear subbasin 20 is located in the coastal plain ecoregion. The subbasin contains no major urban areas, but includes the towns of White Lake, Currie and Atkinson. This area comprises the lower Black River, and its tributaries Colly Creek, Lyons Swamp Canal and Moores Creek. The characteristics of streams in this subbasin are typical of most coastal plain areas; low geographic relief, tannin stained wate, low pH, and a tendency for all but the largest rivers to stop flowing in summer.

The Black River in this area has been classified as Outstanding Resource Waters (ORW). Agriculture is the major land use, and nonpoint source pollution is the major water quality problem, especially in the tributaries. There is one permitted discharger in subbasin 20, the White Lake WWTP (0.6 MGD, UT Colly Creek).

OVERVIEW OF WATER QUALITY

The following site was sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-2*	Black R	Bladen	NC 11 nr Atkinson	Good	Good
B-	Moores Cr	Bladen	NC 53	no sample	Good
B-	Lyons Swamp Canal	Bladen	NC 11	no sample	Fair
FISH				1994	
F-1	Colly Cr	Bladen	US 701	---	Good-Fair
F-2	White Oak Br	Pender	SR 1206	---	Good-Fair

*Data available prior to 1993, see discussion below or data in Appendix B-1.

LAKES

Singletary Lake

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Black R nr Atkinson	1994	20	13	0	EPA mercury limit exceeded in 13 samples of bass or bowfin, FDA/NC mercury limit also exceeded in 3 bowfin
	Black R nr Atkinson	1998	36	26	0	EPA mercury limit exceeded in 26 samples, FDA/NC mercury limit also exceeded in 12 samples
FT-2	Black R at NC 210	1995	6	4	0	EPA mercury limit exceeded in 4 bowfin samples, FDA/NC mercury limit also exceeded in 1 bowfin

Water quality in this subbasin appears to be generally good. Benthic macroinvertebrate data indicated stable water quality in the Black River for nearly a decade. Tributaries to the Black River in subbasin 20 stop flowing in the summer, so water quality assessments of tributary streams were conducted in the winter. Fair conditions were recorded at the Lyons Swamp Canal, mostly as a result of habitat degradation and heavy agricultural land use. Moore Creek had Good water quality due to its relatively undisturbed local land use and the generally lower levels of agricultural intensity in the catchment.

Fish community data suggests uniform water quality of Good-Fair in Colly Creek and White Oak Branch. Fish tissue data have found elevated levels of mercury in most bowfin and bass as has been found throughout the coastal plain.

Singletary Lake is a dystrophic system that appears to have become more enriched in the last 5 years, including reduced water clarity, higher chlorophyll *a* and reports of expanding areas of algae and alligator weed.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Black River, NC 11 (near Atkinson)

This site is difficult to sample because of its depth and its slow moving nature. Water quality at this blackwater site has been stable for the last 10 years with the exception of the summer 1990 sample when the river was experiencing very low flows. An EPT sample later that same year, under higher flow conditions, showed a return to high water quality. The Black River, including this section, was reclassified to Outstanding Resource Waters (ORW) in 1994 based on its Excellent water quality and exceptional state recreational and ecological significance, including the presence of rare taxa. Its ecological significance is shown by the presence of rare and intolerant taxa. It is the only location in North Carolina where the mayfly Amercaenis sp. has been collected and is only one of three locations statewide where the chironomid Chernovskia obscura has been found.

Fish tissue samples were collected from the Black River near Atkinson during July1994 and October 1998. A total of 56 samples were analyzed for metals contaminants. Samples collected near Atkinson during 1994 and 1998 contained significant mercury burdens –39 of 56 samples contained mercury levels exceeding the EPA screening value of 0.6 ppm. Fifteen samples contained mercury above the FDA/NC limit of 1.0 ppm as well. Nearly all elevated mercury levels were measured in samples of largemouth bass and bowfin. All other metals results were lower than EPA and FDA/NC limits.

Black River at NC 210

Fish tissue samples were collected from the Black River at NC 210 during August 1995. A total of 6 bowfin samples were analyzed for metals contaminants. Four bowfin samples contained mercury levels exceeding the EPA screening value of 0.6 ppm. One sample also contained mercury at a level exceeding the FDA/NC limit of 1.0 ppm. All other metals results were lower than EPA and FDA/NC limits.

Colly Creek, US 701

Colly Creek originates in Big Colly Bay which is part of the Bladen Lakes State Forest. Colly Creek is a low pH (pH = 3.5, the most naturally acidic stream monitored within the Cape Fear River basin in 1998) and low productivity blackwater stream. The monitoring site consisted of high quality instream and riparian habitat. The section of the stream which was monitored had recently been snagged by hand as a result of woody debris falling into the stream from recent hurricanes. The fish community was rated as Good-Fair. Metrics which deviated greatly from the expected were the diversity of darters, suckers, and intolerant species. No species of these three groups were collected. Redfin pickerel and bluespotted sunfish were the most abundant species collected.

Moores Creek, NC 53
This sample was located approximately half-way up the Moores Creek watershed. The main channel of the stream was 10 meters (m) wide at this point, with a moderate to swift current and water inundating the flood plain up to a width of 60m. Depth of the main channel was > 2m in winter and was still 1.5m in summer when the flow ceased. Substrate was mostly sand with detritus, with macrophytes, snags and pools more common in the floodplain than in the channel. Local land use appeared to be mostly forest, although a few fields were visible. Despite 10 hog farms, with a capacity of approximately 10,000 hogs, upstream of this site, water chemistry appeared to be generally good, with a pH of 5.6 and a conductivity of 28 µmhos/cm, indicating little local input. Water quality was rated Good using benthos data with 11 intolerant (EPT) taxa collected.

Lyons Swamp Canal, NC 11
This stream is the straightened, desnagged and dredged headwaters of Lyons Swamp. This seven meter wide stream was barely flowing in March, and had not flowed in quite some time when it was revisited in July. Habitat here was limited to aquatic macrophytes in the shallows along the banks and a few sticks trapped in the macrophytes. The substrate was mostly mud to sandy-mud with no pools or riffles. Stream shading was only provided by the large, steep, well-mowed banks. The riparian zone was a < 2m wide strip of mowed grass at the edge of fields fallow for winter. Some mixture of land use was noted, with a hog operation visible upstream. A Fair benthos bioclassification was given to this site during winter sampling.

White Oak Branch, SR 1206
The fish community in 1962 in White Oak Branch was characterized as being an excellent fishing stream with an unexploited redfin pickerel population (Louder 1963). In 1998, the redfin pickerel remained the numerically dominant piscivore in this small blackwater stream. The fish community was rated as Good-Fair. Although the pH of the stream was 5.0, the stream was productive in terms of the number of fish which were collected (n = 304). No metric deviated greatly from the expected; 8 of the 12 metrics were scored as a “3”. The yellow bullhead was the most abundant species collected. Perhaps as a result of the recent hurricanes and recently timbered riparian zones, there were significant quantities of woody debris within the stream channel creating snag-type riffles and pools.

OTHER DATA
Mallin et al (1997). The Center for Marine Science at the University of North Carolina-Wilmington has been sampling the lower Cape Fear River for water chemistry, macroinvertebrates and fish since June 1995. Two chemistry sites in this subbasin were sampled for nearly two years (1995-1997). This report summarizes their findings. Monitoring by UNC-W found most parameters within acceptable ranges at Colly Creek at NC 53 and Black River at NC 210, the two sites monitored in this subbasin. TKN was elevated at both sites in 1996 (mean 1.1 mg/l for Black River and mean 1.8 mg/l for Colly Creek), but it was felt that most of this was due to the naturally organic-nature of blackwater streams. They attributed some of the elevated

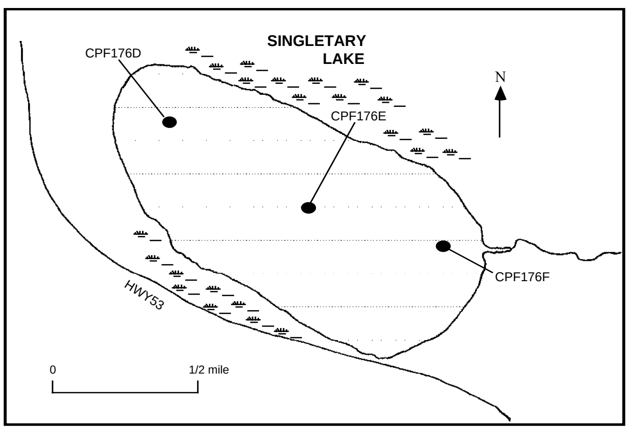
TKN and periodic low DO events in Colly Creek to the four hog farms approximately 15 miles upstream, which have a capacity of approximately 35,000 hogs.

LAKES ASSESSMENT PROGRAM

Singletary Lake

COUNTY:	Bladen	**CLASSIFICATION:**	B Sw
SURFACE AREA:	572 acres (237 hectares)	**MEAN DEPTH :**	7 feet (2 meters)
VOLUME:	0.3 x$10^6 m^3$	**WATERSHED**:	2 mi^2 (4 km^2)

Singletary Lake, located near Black Lake and White Lake in Bladen County, is a natural Carolina Bay Lake. The surrounding terrain is flat and swampy with almost no overland water inputs. The lake is owned by the State of North Carolina and used for swimming, boating, and fishing.

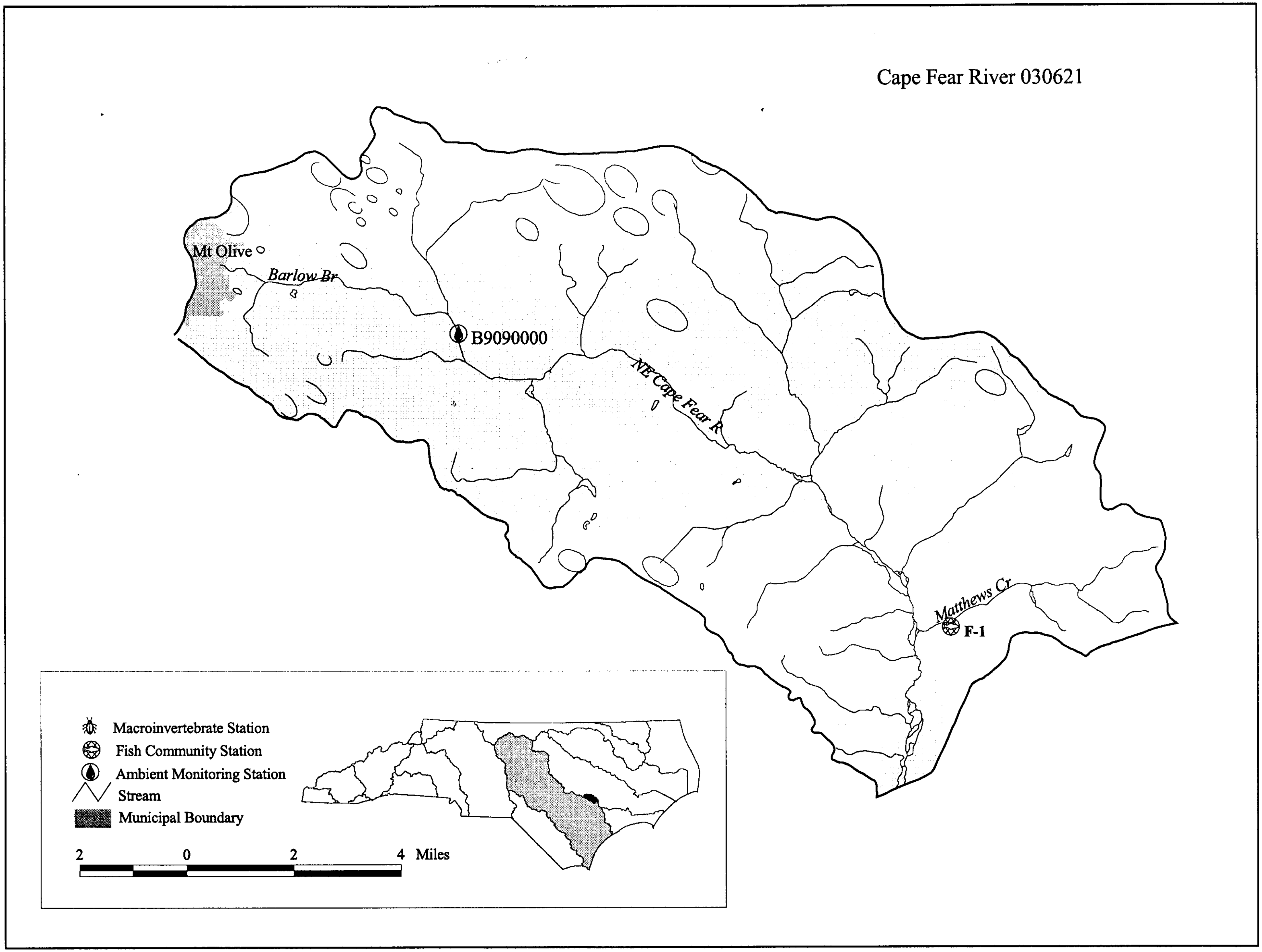


Singletary Lake was most recently sampled by DWQ in June, July and August, 1998. Physical and chemical data collected by DWQ for this lake are presented in Appendix L2. Secchi depths were less than one meter at all three lake sampling sites in June, July and August. The low Secchi depth readings observed during the summer of 1998 are not unusual for Carolina Bay Lakes which have naturally dark, tea-colored water which reduces light penetration. No nuisance levels of aquatic macrophytes were observed in the lake. Concentrations of metals were less than applicable state water quality standards. Because Singletary Lake is dystrophic, a trophic status of the lake cannot be accurately determined through the NCTSI scores (Table L32; Appendix L1).

According to Mr. Keith Ashley, District 4 Fisheries Biologist, an occasional fish kill occurs at Singletary Lake and is often due to longterm stress from the low pH waters of the lake. Species affected were commonly yellow perch (*Perca flavescens*), fliers (*Centrachus macropterus*) and warmouth (*Lepomis gulosus*). Mr. Ashley stated that he had not received any reports of nuisance macrophytes or complaints of problems related to swimming in the lake. There had been a slight increase in algae in the lake in recent years but no changes in water clarity (Keith Ashley, District 4 Biologist, NC Wildlife Resources Commission, Division of Boating and Inland Fisheries, pers. com.). According to Mr. David Colburn, Park Superintendent for Singletary Lake State Park, there has been an increase in alligator weed (*Alternanthera philoxeroides*) near the lake spillway in 1998 along with public complaints of odor from decaying plant material that had washed up along the lake shoreline (David Colburn, Park Superintendent, Singletary Lake State Park. pers. com.).

Table L32. Singletary Lake NCTSI Data.

Lake	Date	NCTSI	TP	TON	CHLA	SECCHI
Singletary Lake	980805	no score	0.02	0.27	n/a	0.6
Singletary Lake	980714	0.8[D]	0.03	0.23	15	0.4
Singletary Lake	980616	-1.0[D]	<0.01	0.24	12	0.5
Singletary Lake	930902	-1.0[D]	0.02	0.28	3	0.6
Singletary Lake	870903	-3.0[D]	0.01	0.19	4	1.4
Singletary Lake	810729	-2.0[D]	0.03	0.24	3	1.7


Cape Fear River 030621
Mt Olive
Barlow Br
B9090000
NE Cape Fear R
Matthews Cr
F-1
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 Miles

CAPE FEAR SUBBASIN 030621

DESCRIPTION
Cape Fear subbasin 21 is located in the inner coastal plain ecoregion, and contains the headwaters of the Northeast Cape Fear River and its tributaries. Most of this subbasin is in northern Duplin County, with approximately one-third of the subbasin in southern Wayne County. Land use is primarily agriculture. The only town in this area is Mt. Olive. The only significant dischargers in this subbasin are Mt. Olive Pickle Company, (0.4 MGD) to Barlow Branch, and the Town of Mt. Olive (1 MGD) to the Northeast Cape Fear River.

OVERVIEW OF WATER QUALITY

Site #	Stream	County	Location	1994	1998
FISH				**Bioclassification**	
F-1	Mathews Cr	Duplin	NC 111/903	---	Good

*Data available prior to 1993, see discussion below or data in Appendix B-1.

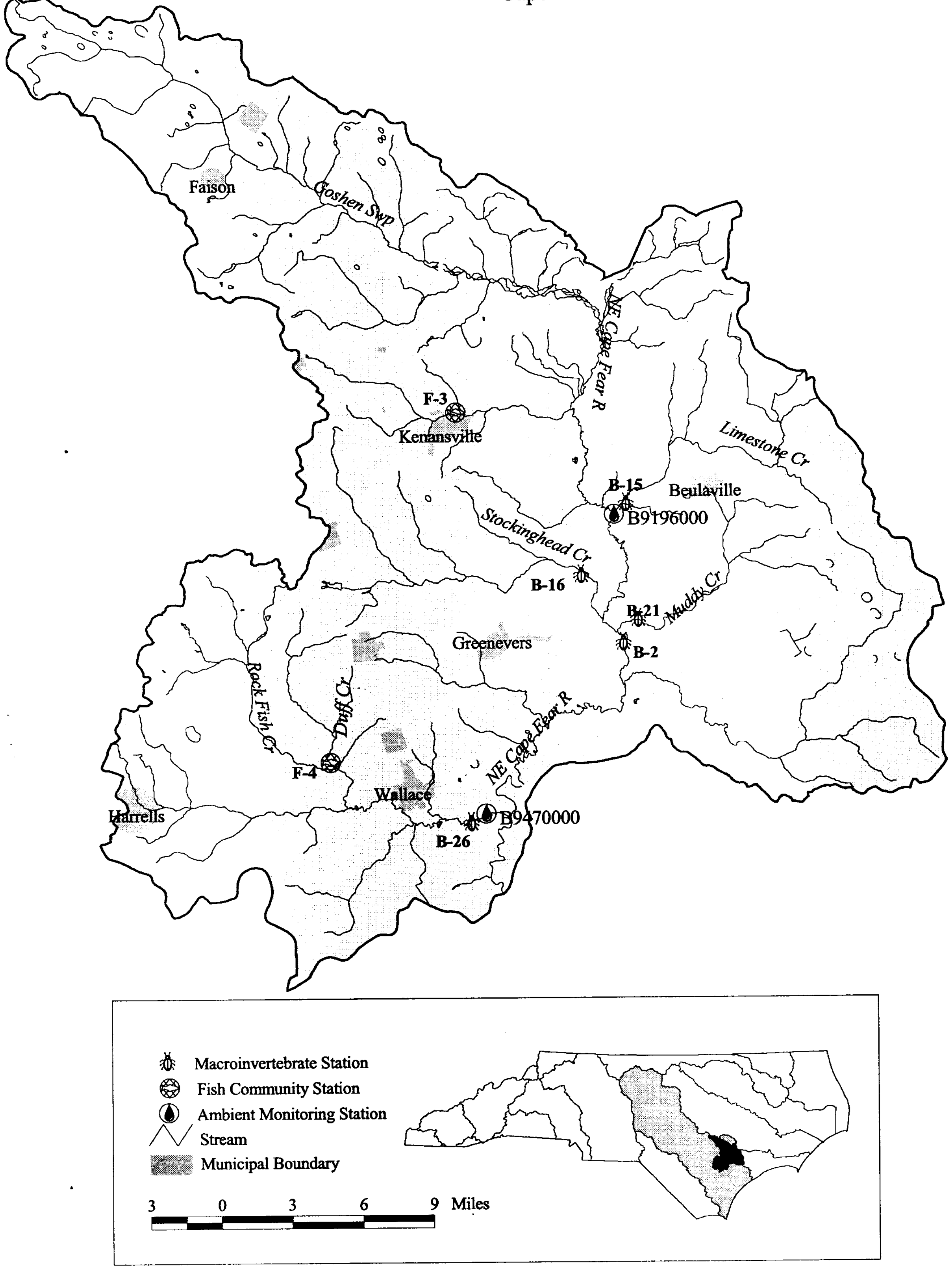
Due to lack of flow, no sites were sampled for macroinvertebrates in 1998. Fish community sampling gave Mathews Creek an NCIBI Good rating.

RIVER AND STREAM DATA, 1993-1998
BASIN MONITORING

Mathews Creek, NC 111/903

Mathews Creek is a small tributary to the headwaters of the Northeast Cape Fear River. The small, sandy bottom blackwater stream flows through a high canopy swamp forest. The species-rich fish community included seven species of sunfish (more species of sunfish than any other site monitored in the entire river basin in 1998) and four species of catfish. The fish community was rated as Good. Even though 20 species were collected, there was an absence of intolerant species. The dusky shiner was the numerically most abundant species in the community.

Cape Fear River 030622



CAPE FEAR SUBBASIN 030622

DESCRIPTION

This subbasin contains the Northeast Cape Fear River and its tributaries in Duplin County. Most of the catchment is agricultural, including both row crops and a dense concentration of animal operations (poultry and swine). The towns of Beulaville, Kenansville, Rose Hill, and Wallace are within this subbasin. The largest discharger is Stevecoknit Fabrics (5.0 MGD to Little Rockfish Creek). Other large dischargers include Guilford Mills (1.5 MGD to NE Cape Fear River), Swift-Eckrich/Butterball (1.5 MGD) and the Town of Wallace (1.0 MGD). The last two listed facilities both discharge to Rockfish Creek.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-1*	NE Cape Fear R	Duplin	NC 11/903	Excellent	Good-Fair
B-2**	NE Cape Fear R	Duplin	NC 41	Good	Good
B-15	Limestone Cr	Duplin	SR 1702	Excellent	Good-Fair
B-16	Stockinghead Cr	Duplin	SR 1953	Good-Fair	Good-Fair
B-21	Muddy Cr	Duplin	NC 41	Not Rated	Fair
B-25	Rockfish Cr	Duplin	SR 1165	Good-Fair	Fair
B-26	Rockfish Cr	Duplin	I-40	Fair	Good-Fair
FISH				1994	
F-3	Grove Cr	Duplin	NC 11/903	Good	Good-Fair
F-4	Duff Cr	Duplin	SR 1170	---	Good

*Data available prior to 1993, see discussion below or data in Appendix B-1.

**This site was sampled after Hurricane Bonnie in Sept 98 and received a rating of Poor

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Northeast Cape Fear R at NC 24	1994	26	9	0	EPA mercury limit exceeded in 9 samples, FDA/NC mercury limit exceeded in 3 samples

Analysis of these data has been complicated by the de-snagging of these streams as part of the Emergency Watershed Protection Program. These streams were totally de-snagged, removing nearly all of the valuable snag habitat available for macroinvertabrate colonization. This makes it difficult to determine whether any changes that may have occurred in the macroinvertebrate community were due to changes in water quality or lack of suitable habitat.

Benthos data indicated Good to Excellent water quality in the Northeast Cape Fear River. The section of the River between Muddy Creek and Rockfish Creek has been classified as High Quality Waters. The site at NC 41 was sampled again in September 1998 to determine any affects from Hurricane Bonnnie, and resulted in a bioclassification of Poor. Water quality in the upper reach of the NE Cape Fear River has decreased by two bioclassifications since 1993. Most of the tributaries (Limestone Creek, Stockinghead Creek and Rockfish Creek) are rated Fair or Good-Fair, usually due to nonpoint sources of pollution. All the streams in this subbasin have many hog farms in their watersheds.

The fish community was evaluated at 2 sites in this subbasin in 1998. Grove Creek was rated Good-Fair, down from a Good rating received in 1994. Duff Creek, sampled for the first time in 1998 received a rating of Good.

Fish tissue samples were collected from the Northeast Cape Fear River at NC 24. Nine of the 26 samples analyzed contained mercury at a level exceeding the EPA screening value of 0.6 ppm. Three samples also contained mercury exceeding the FDA/NC limit of 1.0 ppm.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

NE Cape Fear River, NC 11/903

This site is near the headwaters of the NE Cape Fear River below Mt. Olive. It was about 12 meters wide, with a substrate of predominately fine sand and silt. Flow was limited to a few shallow segments. The stream at this site had been recently de-snagged, removing much of the habitat. Most of the logs available were too "new" to be utilized for macroinvertebrate colonization. Conductivity at the time of sampling was very high (414 µmhos/cm) and some salinity was detected, suggesting some input from the upstream pickle plants. The canopy here has been reduced because the tops of trees were snapped off by storm damage. The drastic reduction in bioclass at this site can be attributed to the disappearance of many species of Trichoptera associated with snag habitat. Caddisflies associated with snag habitat that were not collected in 1998 but, were abundant or common in 1993, include: Brachycentrus numerosus, Hydropsyche venularis, Lype diversa, and Nyctiophylax moestus. The Fair rating in 1986 was due to an input of salt due to the brine handling methods at the Mt. Olive Pickle Company, which have since improved.

Year	EPT S	EPT N	NCBI	Bioclass
1998	17	79	-	Good-Fair
1993	23	116	5.33	Excellent
1986	8	30	5.47	Fair

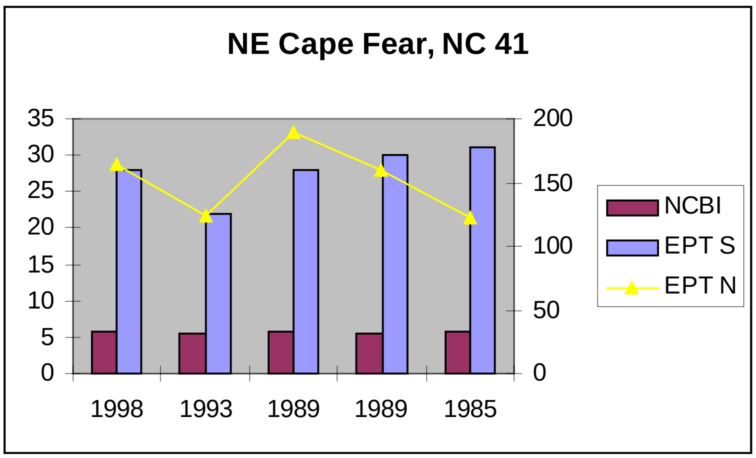
Grove Creek, NC 11/903 (below the Town of Kenansville's WWTP)

The fish community in Grove Creek has been evaluated twice as part of the basinwide monitoring program. The monitoring site (at the NC 11/903 bridge) is downstream of the town of Kenansville's WWTP. The instream and riparian habitats were generally of high quality (e.g., stable banks, wide riparian zones along both shorelines, and complex and diverse benthic substrates). In 1998, the community was rated as Good-Fair (NCIBI = 48); in 1994 the community was rated as Good (NCIBI = 52). A slightly unbalanced trophic structure resulted in the biggest difference in the ratings between the two years. The community in 1998 was dominated by eastern mosquitofish, bluespotted sunfish, American eel, and redfin pickerel.

Northeast Cape Fear River at NC 24

Fish tissue samples were collected from the Northeast Cape Fear River at NC 24 during April 1994. A total of 26 samples were analyzed for mercury. Nine fish samples contained mercury levels exceeding the EPA screening value of 0.6 ppm. Three samples also contained mercury at a level exceeding the FDA/NC limit of 1.0 ppm. All other metals results were lower than EPA and FDA/NC limits.

Northeast Cape Fear River, NC 41
This ambient monitoring station was about 30 meters wide and had a predominately sand substrate with some gravel. The banks were stable, and the riparian zone was intact. There were few pools and instream habitat was sparse. This stream also was recently de-snagged, effectively removing most habitat available for macroinvertebrate colonization. This site has maintained an Excellent or Good rating since 1985, except for one sampling event in September 1998. This sample was collected after Hurricane Bonnie, and resulted in a bioclassification of Poor. No caddisflies or stoneflies that were collected before the hurricane were collected after the hurricane. Based on the 1985-1989 data, this stretch of the river has been reclassified as High Quality Waters. The reduction in number and abundance of Plecoptera in 1993 and 1998, reflect the noticeable loss of habitat such as stable leaf packs and snags. There also was an increase of enrichment indicator species including: Cricotopus bicinctus, Dicrotendipes sp., and Polypedilum illinoense.



Limestone Creek, SR 1702
Limestone Creek at this site was 6 meters wide with a substrate of unstable fine sand and a trace of gravel. This stream was recently de-snagged. There was evidence that heavy machinery had been used in and next to the stream, promoting heavy erosion. Recent sand deposits were eroding back to the stream. Instream habitat was scarce because of this input of sand. Pools were essentially absent and the heavy machinery had effectively eliminated the riparian zone on the right bank. In June 1995, there was a spill of chicken waste into Limestone Creek after a period of heavy rainfall. Sampling after this spill resulted in a rating of Poor. This rating improved to Good-Fair in 1998. The benthic macroinvertebrate community has recovered somewhat from the spill, but still is suffering from the effects of habitat removal and nonpoint source inputs.

Year	EPT S	EPT N	NCBI	Bioclass
1998	14	78	-	Good-Fair
1995	4	8	5.48	Poor
1993	26	84	4.5	Excellent

Stockinghead Creek, SR 1953
This Northeast Cape Fear River tributary was 7 meters wide at this site. The substrate was predominately sand with good instream habitat. This site was not de-snagged. Pool habitat was

good, the banks were stable and the riparian zone was intact. The rating for this site (Good-Fair) has not changed since 1993 and is not due to lack of suitable habitat. Conductivity at the time of sampling was rather high (156 µhos), suggesting some nonpoint input. There are numerous hog farms surrounding Stockinghead Creek.

Muddy Creek, NC 41
This stream was about 7 meters wide and the substrate was composed of sand and silt. Despite the rating of Fair, the habitat, bank condition and riparian zone were all very good here. This watershed also contains many hog farms. This stream was not rated in 1993 because of its small size. It was recorded to be only 1 meter wide in 1993. This change in width was probably due to Hurricane Fran, which came through this area in 1996. Although it was not rated previously, there has been an increase in stream quality, as evident by the increase of intolerant EPT taxa that were collected between 1993 and 1998.

Rockfish Creek, SR 1165
This site, above the town of Wallace, was about 12 meters wide with sand substrate and good instream habitat. However, the riparian zone was poor. There was evidence that heavy equipment had been in the stream and some of the bank had been pushed in, most likely during the de-snagging operation. The rating at this site declined from Good-Fair in 1993 to Fair in 1998. There was a decrease in some intolerant EPT taxa that are associated with snag habitat (Brachycentrus, Hydrosyche, and Pycnopsyche). An increase in organic enrichment indicator taxa also was noticed (Cricotopus bicinctus, Dicrotendipes sp., Chironomus, and Phaenopsectra).

Rockfish Creek, I-40
This site, downstream of Wallace was about 14 meters wide with a predominately sand substrate. Instream habitat was sparse, but pools were frequent, the banks were stable and the riparian zone was good. Water quality at this lower site on Rockfish Creek improved from Fair to Good-Fair between 1993 and 1998. The rating of Fair in October 1998 was the result of sampling after Hurricane Bonnie.

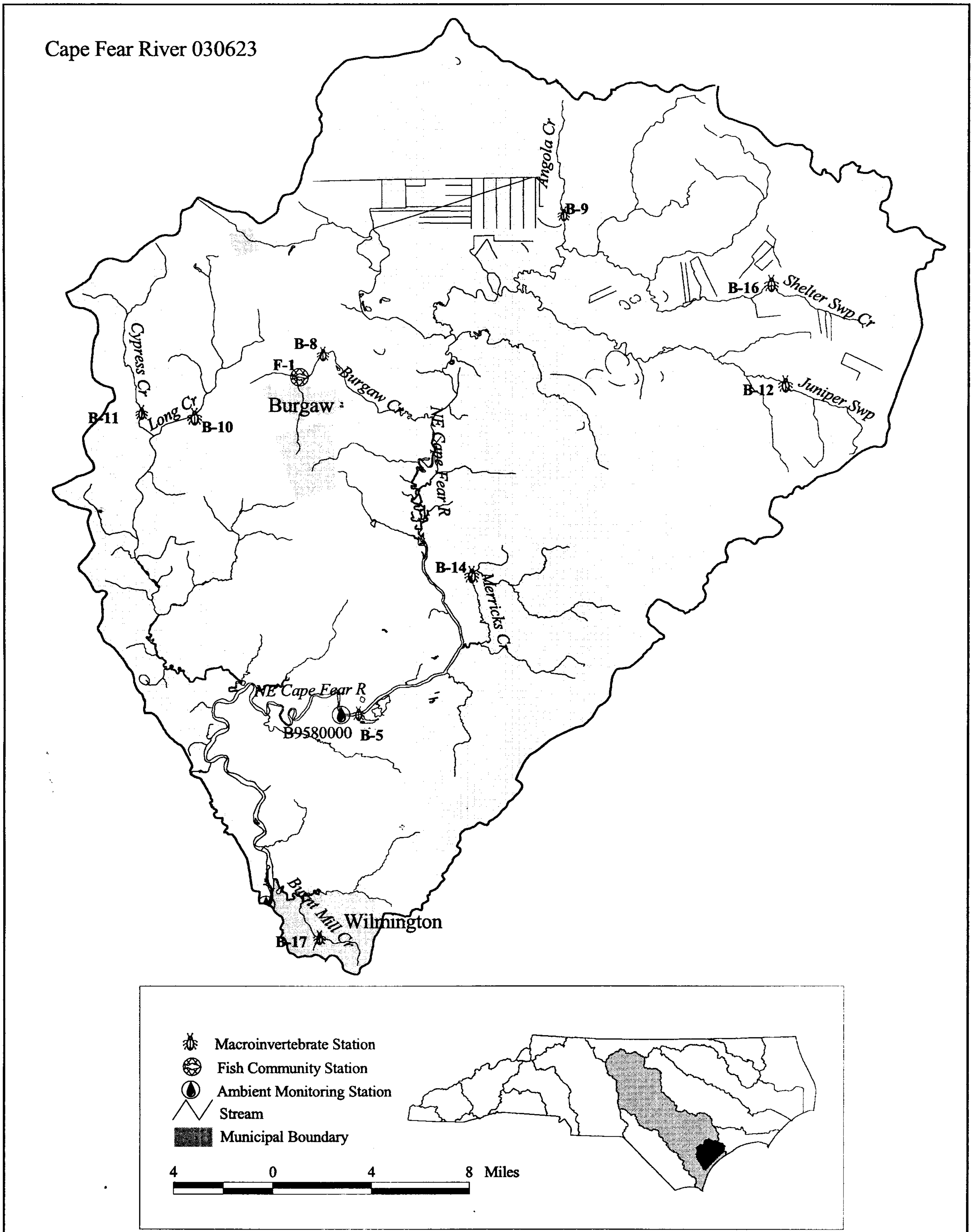
Year	EPT S	EPT N	NCBI	Bioclass
Oct 1998	6	44	7.30	Fair
Aug 1998	16	76	6.97	Good-Fair
1993	12	34	6.83	Fair

Duff Creek, SR 1170
Duff Creek is a tributary to Rockfish Creek. The fish community in Duff Creek was evaluated above the Butterball turkey processing facility's discharge which enters Rockfish Creek immediately below the mouth of Duff Creek (approximately one-third mile below the monitoring site). At the SR 1170 bridge crossing, Duff Creek does receive some gravel parking lot runoff (from where the poultry transporting trucks park) and filamentous algae was abundant. However, the instream and riparian habitats were generally of high quality (e.g., stable banks, wide riparian zones along both shorelines, and a variety of pool sizes). The fish community was rated as Good. Because of an abundance of the tolerant eastern mosquitofish (49% of all the fish collected were of this species), the community scored well below expectations in the percentage of tolerant fish metric.

SPECIAL STUDIES

Data from Limestone Creek, Stockinghead Creek, Muddy Creek, and the Northeast Cape Fear River in 1998 were used in a benthos investigation relating stream health and density of hog farms. Limestone Creek was also sampled for benthos after a spill of chicken waste in 1995. A sharp decline in water quality was observed between 1993 and 1995.

In 1992, the fish communities in Halls Marsh Run and Herrings Marsh Run were evaluated prior to implementation of agricultural best management practices within their two watersheds. The two fish communities at Halls Marsh Run and Herrings Marsh Run were rated as Poor.



Cape Fear River 030623
Angola Cr
B-9
B-16
Shelter Swp Cr
Cypress Cr
B-8
F-1
Burgaw Cr
Burgaw
B-12
Juniper Swp
B-11
Long Cr
B-10
NE Cape Fear R
B-14
Merricks Cr
NE Cape Fear R
B9580000
B-5
Burnt Mill Cr
Wilmington
B-17
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
4
0
4
8
Miles

CAPE FEAR SUBBASIN 030623

DESCRIPTION

Cape Fear subbasin 23 is located in the outer Coastal Plain ecoregion, an area characterized by slow-flowing blackwater streams, and contains the town of Burgaw. This area includes the lower North East Cape Fear River, and its major tributaries; Holly Shelter Creek, Long Creek and Burgaw Creek. Most of the streams in this subbasin stop flowing or dry up during the summer. Much of this subbasin is undeveloped and included in either the Holly Shelter Game Refuge or the Angola Bay Game Refuge.

There are 6 permitted dischargers in subbasin 23, with the largest dischargers being Occidental Chemical (1.0 MGD, NE Cape Fear River), Thorn Apple Valley (0.6 MGD, UT Juniper Swamp) and Burgaw WWTP (0.5 MGD, Burgaw Cr).

DESCRIPTION

Cape Fear subbasin 23 is located entirely within the lower Coastal Plain and includes the lower half of the Northeast Cape Fear River watershed.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-5*	NE Cape Fear R	New Hanover	US 117	Good-Fair	Good
B-8	Burgaw Cr	Pender	I-40	no sample	Poor
B-9	Angola Cr	Pender	NC 53	Fair	Fair
B-11	Cypress Cr	Pender	NC 53	Good	Good
B-12	Juniper Swp	Onslow	NC 50	Good-Exc	Good-Exc
B-14	Merricks Cr	Pender	NC 210	Good-Exc	Good-Exc
B-16	Shelter Swp	Onslow	NC 50	no sample	Good-Exc
B-17	Burnt Mill Cr	New Hanover	Metts Ave.	no sample	Poor
FISH					
F-1	Burgaw Cr	Pender	US 117	no sample	Fair

*Data available prior to 1993, see discussion below or data in Appendix B-1.

FISH TISSUE

				No. Samples Exceeding Criteria		
Station	Description	Year Sampled	Total Samples	Metals	Organics	Comments
FT-1	Cape Fear R at NC 53	1995	6	1	0	EPA mercury limit exceeded in 1 bowfin sample
FT-2	Northeast Cape Fear R at Castle Hayne	1994	21	8	0	EPA mercury limit exceeded in 8 bowfin/ bass samples
		1998	25	3	0	EPA mercury limit exceeded in 3 samples, FDA/NC mercury limit exceeded in 1 sample

Ambient chemistry data shows average nutrient levels in the Northeast Cape Fear River at US 117 to be lower than more upstream river sites.

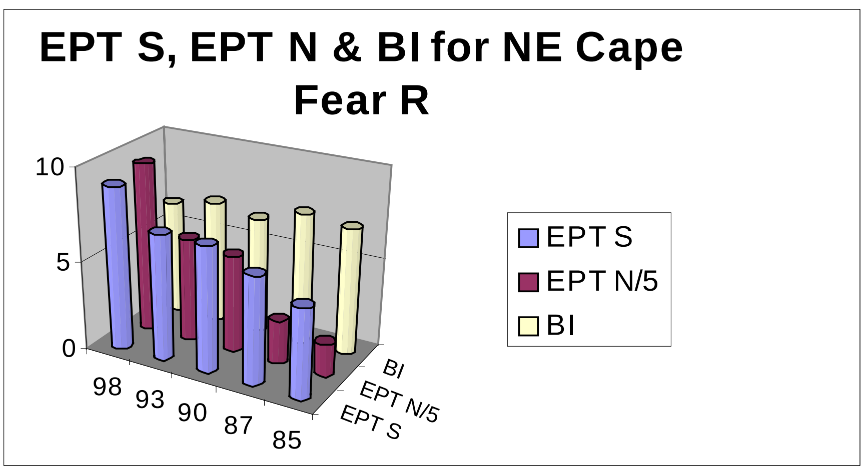
Benthic macroinvertebrate data indicated stable water quality at most sites in subbasin 23, except for the mainstem Northeast Cape Fear, which has shown steady improvement from Fair water quality in 1985 to a Good rating in 1998. Fair conditions were maintained at Angola Creek and Cypress Creek maintained its Goodrating. Most other sites were not rated using macroinvertebrate data because of their swampy character. Burgaw Creek, below the WWTP, and Burnt Mill Creek, in Wilmington, were rated Poor.

The fish community in Burgaw Creek below the WWTP was also impacted, receiving a Fair NCIBI rating. Mercury is also found in the tissue of bass and bowfin in this subbasin.

RIVER AND STREAM DATA, 1993-1998
BASIN MONITORING

<u>Northeast Cape Fear River at NC 53</u>
Six bowfin samples were collected from the Northeast Cape Fear River at NC 53 during August 1995 and analyzed for mercury. One sample exceeded the EPA screening value of 0.6 ppm. All other metals results were lower than EPA and FDA/NC limits.

<u>Northeast Cape Fear River, US 117 (Castlehayne)</u>
This lower portion of the Northeast Cape Fear River is several hundred meters in width. The substrate is largely muddy sand. Water levels were very low in 1998, so most root mats were exposed. This limited optimal benthos habitat to infrequent snags near the shoreline. The river was tidal in this location and was flowing upstream during sampling. The conductivity at this site was 245 μmhos/cm in 1998, which is about average for this site, and salty enough to support several estuarine crustaceans.



As can be seen in the above graph, there appears to be a steady improvement in the Biotic Index, the number of intolerant taxa (EPT N) and the abundance of these intolerant taxa, especially between 1993 and 1998. Water quality improvement at this site is probably due to the removal of two local dischargers: Occidental Chemical and Ammons North Chase Corporation, two nearby mines. Water quality further upstream has tended to decline in the past five years.

Fish tissue samples were collected from the Northeast Cape Fear River at Castle Hayne during April 1994 and October 1998. A total of 46 samples were analyzed for metals contaminants. Eleven samples contained mercury exceeding the EPA screening value of 0.6 ppm. One bowfin sample collected in 1998 contained mercury equal to the FDA/NC limit of 1.0 ppm. All other metals results were lower than EPA and FDA/NC limits.

Burgaw Creek, US 117 (below the Town of Burgaw's WWTP)
The fish community in Burgaw Creek was evaluated approximately 0.2 miles below the mouth of Osgood Canal which carries the treated effluent from Town of Burgaw. At the US 117 bridge crossing, the slow moving stream has been channelized, the canopy is open, and the substrate is soft silt. The pH and specific conductance were elevated, the dissolved oxygen concentration was depressed and the percent saturation was only 48% of normal. The fish community was rated as Fair. The metrics for which the community was rated well below expectations were in the diversity of darter and intolerant species, percentage of tolerant fish, and percentage of species with multiple age groups. No darters or intolerant species were present, 76% of all the fish were classified as tolerant, and only 3 of the 11 species were represented by multiple age groups. The tolerant eastern mosquitofish constituted 73% of all the fish collected.

Burgaw Creek, I-40
This four meter wide channelized creek was sampled once in March and again in July 1998. The substrate was entirely sand, however a few snags and an overabundance of alligator weed and algae mats provided ample habitat for the taxa that could survive here. With a few notable exceptions, bank erosion was not a problem here. There was little streamside shading, which stimulated the growth of filamentous algae in the stream. Large growths of algae elevate DO during the day (it was 16 mg/l here in July), but takes up most of the oxygen at night. These lush macrophyte growths are being supported by nutrients discharged from the Burgaw WWTP. Mallin et al. (1997) found the highest mean levels of nutrients in the lower Cape Fear area (NH_3 1.1 mg/l, NO_2+NO_3 1.3 mg/l, TKN 2.2 mg/l, TN 3.5 mg/l and PO_4 0.47 mg/l) near this location. As a result, this site had the most tolerant macroinvertebrate community in this subbasin (BIEPT 6.46 in March and 6.11 in July) and was given a Poor bioclassification in July.

Angola Creek, NC 53
This stream was only four meters wide, 0.1 meters deep and not flowing in most locations when it was sampled in July. Large numbers of Elliptio complanata had been stranded on the banks and many were dying or dead. The north side of this stream had been recently logged, however a buffer strip still provided minimal shading. The substrate was mostly sand with a small amount of silt, while most of the invertebrate habitat was provided by sticks and snags. This segment of the river is downstream of 17 hog farms, which have a capacity of approximately 60,000 hogs. A conductivity value of 107 µmhos/cm here suggests some impacts from nonpoint sources. The presence of nine tolerant EPT taxa (BIEPT 6.06) gave this site a bioclassification of Fair.

Cypress Creek, NC 53
This site was eight meters wide and > 1 meter deep in most locations when it was sampled in March. Upstream of NC 53, both sides of the stream had been logged, however downstream remained undisturbed. The substrate was primarily sand with some silt and detritus. Most macroinvertebrate habitat was provided by snags, sticks and root mats. Bends in the stream were frequent and the stream was well shaded. Water quality has changed little since 1993 when nine EPT taxa were collected as well. This stream had ceased flowing by July.

Juniper Swamp, NC 50
This site was seven meters wide and > 1 meter deep in most locations when it was sampled in March. The substrate was primarily sand with some silt and detritus. Most macroinvertebrate habitat was provided by macrophytes, snags, sticks and root mats. Bends in the stream were infrequent, as were pools. The stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. Conductivity here was 75 µmhos/cm and the pH was 4.0. This site was felt to represent Good-Excellent conditions using DWQ draft criteria for swamps.

Merricks Creek, NC 210
This site was seven meters wide and > 1 meter deep in most locations when it was sampled in March. The substrate was primarily organic detritus. Most macroinvertebrate habitat was provided by snags and sticks. Bends and braids in the stream were frequent and the stream was well shaded, but pools were infrequent. Stream banks and the surrounding riparian zone were stable and intact. Conductivity here was 54 µmhos/cm and the pH was 4.4. This site was felt to represent Good-Excellent conditions using draft swamp criteria.

Shelter Swamp, NC 50
This site was seven meters wide and > 1 meter deep in most locations when it was sampled in March. The substrate was primarily sand with some silt and detritus. Most macroinvertebrate habitat was provided by macrophytes, snags, sticks and a few root mats. Bends in the stream were frequent, as were pools and the stream was well shaded. Stream banks and the surrounding riparian zone were stable and intact. Conductivity here was 85 µmhos/cm and the pH was 3.8. This site was felt to represent Good-Excellent conditions using draft swamp criteria.

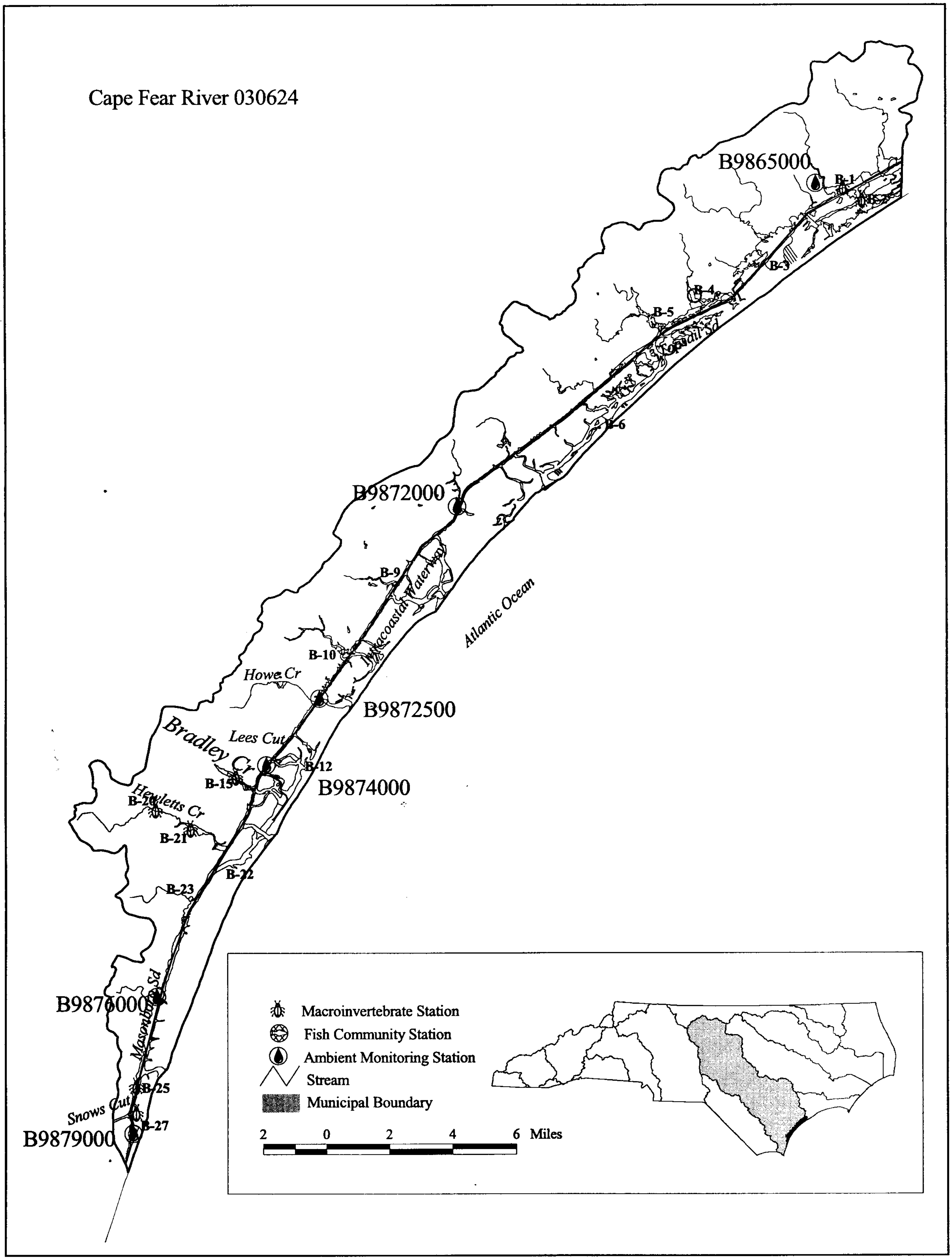
Burnt Mill Creek, Metts Ave, Wilmington
This five meter stream drains an older suburban section of Wilmington. The riparian zone was nearly nonexistent, providing almost no shading. The channel had been dredged and banks were steep; the right bank was mesh gabion, and the left was eroding badly during high flows. The substrate was a uniform sand bottom with a few bricks, sticks and macrophytes providing the habitat. Conductivity was high (205 µmhos/cm in winter and 285 in summer) indicating that the creek receives large amounts of runoff. A Poor bioclassification was assigned to this stream since no more than 5 intolerant (EPT) taxa were collected during either sample.

SPECIAL STUDIES
Benthic macroinvertebrates were collected at four swamps (Angola Creek, Juniper Swamp, Merricks Creek and Sandy Run Swamp) during four seasons in 1993 in an effort to develop a sampling methodology and metrics for swamps.

Benthic macroinvertebrates have been collected at Juniper Swamp, Lillington Creek, Merricks Creek and Shelter Swamp in 1997 and 1998 to validate biocriteria for swamps. It has been found that pH and stream channel type play a major factor in determining the benthic community.

OTHER DATA
Mallin et al (1997). The Center for Marine Science at the University of North Carolina-Wilmington has been sampling the lower Cape Fear River for water chemistry, macroinvertebrates and fish since June 1995. Four chemistry sites, one macroinvertebrate site

and one fish site in this subbasin were sampled, often monthly, for nearly two years (1995-1997). This report summarizes their findings. Elevated TKN values at many blackwater sites in this subbasin (Northeast Cape Fear River at US 117 and Angola Creek at NC 53) appear to be due to the organic-rich nature of blackwater streams (Mallin et al. 1997). Elevated levels of PO_4 (0.89 mg/l mean) and some of the elevated TKN in Angola Creek (Fair bioclassification based on macroinvertebrate data) could be attributed to the 18 hog farms upstream of this site. Mallin et al. (1997) also found Burgaw Creek to have the lowest water quality in this subbasin. Low DO, and elevated levels of nitrogen (NH_3, NO_2+NO_3, TKN and TN) and PO_4 were attributed to the Burgaw WWTP. Elevated turbidity and fecal coliforms were attributed to sources upstream of the WWTP.



Cape Fear River 030624
B9865000
B-1
B-3
B-4
B-5
Topsail Sd
B-6
B9872000
B-9
Intracoastal Waterway
Atlantic Ocean
B-10
Howe Cr
B9872500
Bradley Cr
Lees Cut
B-12
B9874000
B-15
Hewletts Cr
B-20
B-21
B-22
B-23
B9876000
Masonboro Sd
B-25
Snows Cut
B-27
B9879000
Macroinvertebrate Station
Fish Community Station
Ambient Monitoring Station
Stream
Municipal Boundary
2 0 2 4 6 Miles

CAPE FEAR SUBBASIN 030624

DESCRIPTION

Cape Fear subbasin 24 is located in the tidal and estuarine region of the coast and contains portions of Wilmington and the towns of Wrightsville Beach and Carolina Beach. This area comprises a series of small tidal creeks that flow into Masonboro Sound, Topsail Sound and the Intracoastal Waterway, which are connected to the Atlantic Ocean by a series of inlets. The characteristics of streams in this subbasin are strongly affected by geology and soil type.

Suburban development is the major land use, and nonpoint source pollution is the major water quality problem. There are 4 permitted dischargers in subbasin 24, but none larger than 0.5 MGD.

OVERVIEW OF WATER QUALITY

The following sites were sampled to collect data for basin assessments:

Site #	Stream	County	Location	1993	1998
BENTHOS				**Bioclassification**	
B-15	Bradley Cr	New Hanover	US 76	Heavy	Heavy
B-21	Hewletts Cr	New Hanover	at bend	Moderate	Moderate

Water quality appears to be high in most of the sounds, and many creeks, in this subbasin. Masonboro Sound, Middle Sound, Topsail Sound and Stump Sound are all classified as Outstanding Resource Waters (ORW). Many creeks (Turkey, Cedar Snag, Butler, Howe and John) and channels (Howard, Long Point, Green and Nixon) also have been designated ORW. The Masonboro Island National Estuarine Research Reserve is also located in this subbasin.

The largest water quality problem in this subbasin appears to be the rapid urbanization of this area and the increasing runoff that comes with this development. DWQ sampling suggests that water quality also appears to decline at either end of this subbasin (Snows Cut and Everett Bay) where the only flushing comes from areas of poorer water quality (Cape Fear River and New River, respectively).

Benthic macroinvertebrate data indicated stable water quality at most sites in subbasin 24. Poor conditions were recorded at heavily urbanized Bradley Creek, while more moderate conditions were found in Hewletts Creek, where there were fewer impacts from urban runoff. Generally good water quality was found in lightly urbanized areas, such as Topsail Sound.

RIVER AND STREAM DATA, 1993-1998

BASIN MONITORING

Everett Bay

This poorly flushed, shallow (<1 meter) embayment was located at the northern end of this subbasin. The substrate was largely mud with a small strip of muddy sand at the base of an intertidal sand bar and salt marsh. Stakes for several pound nets were visible, but they were not in use at the time. Local land use was primarily single family homes on large, grassed lots, and undeveloped salt marsh. Benthos at this site appeared to be impacted primarily by poor flushing and lack of habitat variety or structure. Only 42 taxa were collected here. The mud snail Ilyanassa obsoleta dominated the invertebrate community, but few other epifaunal taxa were found. Despite the reduced number of taxa, the Biotic Index at this site (2.36) indicated a moderately intolerant community. The water quality problems at this site apparently are not as great as was first indicated and are probably related to nonpoint runoff of lawn fertilizer and occasional inputs of water from the New River. EMAP sampling in Everett Bay classified this area as Impacted based on the 4th highest level of Endrin (0.44 ug/l) and 5th highest level of Lindane (0.75 ug/l) recorded by this program in North Carolina. It was also based on a low Shannon-Weiner Index (H') score (1.86) due to the overabundance of several taxa skewing species evenness (Balthis et al. 1998).

Spicer Bay
This bay was also very shallow (<0.5m) and poorly flushed. The substrate was muddy, with small amounts of sand and an occassional oyster shell along the fringe of the salt marsh. Local land use was entirely undeveloped salt marsh and forest, but upstream Spicer Creek has been placed on the State's impaired streams list (303d) because of fecal coliform runoff. The invertebrae community at this site was very similar to Everett Bay, however slightly increased habitat complexity (subtidal peat and oyster shell) increased the total number of taxa to 54. This does not appear to indicate better water quality than Everett Bay, however, since the Biotic Index here, 2.24, is lower than the Bay.

Bradley Creek, US 76
This site is located between the Boat House Marina and US 76. There was a good mix of habitat here, with mud in still areas and oyster shell over sand in the channel where current was swift. This site has been sampled 10 times since 1993 for a series of studies designed to develop and validate biocriteria for North Carolina estuaries. Criteria developed from these studies rated this site Heavy Impact on all sampling occasions. The benthic community was usually dominated by the pollution tolerant polychaetes Streblospio benedicti, Neanthes succinea and Polydora ligni and the relatively tolerant amphipods Melita nitida and Corophium acherusicum. The Bradley Creek watershed primarily drains urban and suburban Wilmington. Mallin et al. (1998) found that this site suffered from periodic low oxygen events and that the sediments contained slightly elevated levels of copper and cadmium. They also found that Bradley Creek was the most heavily impacted tidal creek in this subbasin.

Hewletts Creek, SR 1492
This sample was in the small freshwater headwaters area of Hewletts Creek. The stream here was five meters wide with a sandy bottom containing a good variety of pools with snags in a variety of flow regimes. Root mats and leaf packs could also be found. The banks were stable, and the riparian zones were wide (12-25 m) for a suburban stream. This stream drains portions of suburban Wilmington and the Pine Valley Golf Course.

This stream was sampled both in February and July 1998. At neither time was a bioclassification assigned to this site. In February, the stream was sampled using swamp methods. The sample collected in July could have been assigned a Fair bioclassification, but it was felt that the chronic low salinity at this site, as evidenced by the presence of the estuarine taxa Cyathura polita, Gammarus daiberi, Cassidinidea ovalis and Uca sp., depressed the number of taxa that would normally have been collected. Mean salinity here, found by Mallin et al. (1998), was 2.2 ppt (range 0-28 ppt), which supports this idea. Orthophosphate (mean 10.8 ppb, range 0.5-40.0 ppb) and nitrate+nitrite concentrations (mean 227.5 ppb, range 0.5-698 ppb) here are among the highest in this subbasin, therefore the low taxa richness is not entirely due to salinity effects.

Hewletts Creek, at Bend
This portion of Hewletts Creek is about 20 meters in width. The substrate was sandy with Spartina and oysters intertidally. The local land use is primarily single family homes, most with docks extending beyond the fringing marshes. Water quality has been stable here; a Moderate Impact rating was assigned to this site every time it was sampled during the criteria development process. The area had been dredged to almost 1.5m deep at mean low water since it was last sampled in 1996. Before dredging, the channel was only half that depth. Coincident with dredging is the decline in taxa richness from 90+ taxa before dredging to 80 taxa after dredging. Much of this decline was in the number and abundance of shrimp taxa. It may be that dredging has allowed more fish further upstream which have been preying on the shrimp. Dredging may, in the long run, improve water quality here by increasing the rate of flushing in the lower creek. 1998 was the first year that large amounts of Cladophora have not regularly been flushed out of Hewletts Creek, suggesting that nutrients may not be staying in the creek as long as they used to.

Masonboro Channel, National Estuarine Research Reserve
This site was located in Masonboro Channel at an unnamed creek draining the Masonboro Island Estuarine Research Reserve. The substrate here was primarily shells in sand with some Spartina on Masonboro Island. This site was given a rating of No Impact based on the large number of taxa collected at this site (123 total, 25 amphipods and shrimp). Rare and unusual taxa collected here included the amphipod Colomastix halichondriae and the pencil urchin Eucidaris tribuloides. Samples collected near here by EMAP in 1994 and 1995 found no elevated levels of contaminants and an Undegraded benthic community.

Intracoastal Waterway, Marker 156
This site is located in Myrtle Grove Sound approximately one mile north of Snows Cut. The substrate here was sandy with hard clam and oyster shells sporting tufts of Gracillaria. Dock pilings and Spartina also provided habitat. This site was given a rating of Moderate Impact based on the moderate number of taxa present (67 total, 14 amphipods and shrimp) and the intermediate Estuarine Biotic Index (2.16). DWQ chemistry data suggests that some of the impact observed here is coming from the Cape Fear River through Snows Cut.

SPECIAL STUDIES
Five special studies have been conducted in this subbasin since 1993. Initial efforts to find a way to measure water quality in North Carolina’s estuaries focused on quantitative sampling in Howe, Bradley and Hewletts Creeks (B-930603). Results indicated the need for some equipment modifications. It also found that a Biotic Index, similar to the one used by DWQ for fresh waters, was the most accurate method of assessing water quality in estuaries as well.

A reassessment of 1993 basinwide data for seven sites in this subbasin and two in subbasin 17 was conducted to assess the effectiveness of the Estuarine Biotic Index (EBI) as a tool for separating impacted sites from reference areas (B-931222). Sites in this subbasin included Topsail Sound, Black Mud Channel, Carolina Inlet Marina and four sites on the ICWW. It was found that in seven of eight comparisons, the EBI correctly rated the reference site better than the impacted site.

Three methods of collecting, quantitative infaunal, quantitative epifaunal and semi-quantitative multihabitat, were tested at Howe, Bradley and Hewletts Creeks to see which of 17 metrics could correctly rank the water quality of the three creeks (B-940510). For the quantitative infaunal sampler (petite ponar), no metric always ranked the sites correctly, but the EBI and the % Molluscan taxa ranked the sites correctly most often. For the quantitative epifaunal sampler (trawl), the EBI and %Oligochaeta and Pelecypoda metric ranked the sites correctly. The semi-quantitative multihabitat sampler (sweep) ranked the three sites correctly with the following metrics: EBI, Amphipoda and Caridian Shrimp Taxa, Total Taxa, and Gastropoda taxa.

Benthic macroinvertebrates were collected in an UT to Hewletts Creek above and below Tyndall Pond, a subdivision stormwater runoff pond, in September 1994 (B-941130). Neither site received a bioclassification due to small stream size. Changes in community structure due to varying flow patterns masked any differences due to pond runoff.

Following determination that several metrics collected by a timed sweep could be used to separate sites of differing water quality for North Carolina estuaries, a study was undertaken to develop biocriteria using the metrics EBI, Ampipoda and Caridian Shrimp Taxa and Total Taxa, and then validate these findings (B-971216). Samples from Howe, Bradley and Hewletts Creeks were used, in addition to samples from all other coastal basins, to develop numeric biological criteria for North Carolina's estuaries. As part of the validation of these biocriteria, Hewletts and Bradley Creeks were sampled six times in two months to demonstrate that the criteria could give repeatable results over a wide range of time scales. With three water quality classes, the criteria were accurate 100% of the time. With five classes, the accuracy rate dropped to 85%, which still compares well to criteria developed by another organization (EMAP) for North Carolina which had 76% accuracy for only two water quality classes (Van Dolah et al., 1997).

OTHER DATA

Balthis et al (1998). This NOAA report summarizes results from EMAP-Estuaries' sampling program in the North Carolina from 1994-1996. Two samples from this subbasin were collected in 1996. Both Masonboro Sound and Myrtle Grove Sound had Healthy benthic communities and only Endrin was found slightly elevated in Masonboro Sound.

Hyland et al. (1996). This is the first of NOAA's reports from their EMAP-Estuaries program assessing water quality in the Carolinian faunal province, which includes North and South Carolina, Georgia and eastern Florida. In 1994, two samples from this subbasin were collected. The benthos were characterized and sediments were tested for toxicity and chemically evaluated for a wide range of pollutants. Both Masonboro Island National Estuarine Research Reserve (NEER) and Topsail Sound were found to be Unimpacted by any pollutants.

Hyland et al. (1997). This NOAA report details EMAP-Estuaries' 1995 sampling program in the Carolinian faunal province. This year, Two samples were collected from this subbasin. Everett Bay was found to have slightly elevated levels of the pesticides Lindane and Endrin, and the benthic community was found to be impacted. A resurvey of the Masonboro Island NEER again found no contaminants and a healthy community.

Mallin et al (1998). This was a four year study of the water quality of the tidal creeks of New Hanover county. Primary findings of this study have been summarized in the Overview of Water Quality section above, and included the observation that percent impervious surfaces in a watershed is a good inverse predictor of stream water quality. Mallin et al. (1998) conducted a four year review of the tidal creeks of New Hanover county where the authors demonstrated a very close parallel between water quality in the creeks and the amount of impervious surfaces in the watershed. Overall, Bradly Creek (22% impervious surfaces) had the worst water quality, followed by Hewletts Creek (18% impervious surfaces), then Howe Creek (14% impervious surfaces), with Futch Creek (7% impervious) not quite as good as Pages Creek (8% impervious). The highest nitrate concentrations were found below golf courses and the Landfall development, while high nitrate levels and the highest chlorophyll-a concentrations were found in the headwater areas of all the creeks. Chronic, stream-wide oxygen problems only occurred in Bradley Creek. Metals usually occurred in muddy sediments near a definable source: Copper near marinas in Bradley Creek and Pages Creek, Lead near on old rifle range on Howe Creek, and several metals below a road in Hewletts Creek. The presence of the toxic dinoflagellate, Pfisteria, has been documented in Hewletts Creek.

Mallin et al. report " Environmental Assessment of the Lower Cape Fear River System, 1997-1998," stated that "chlorophyll *a* values indicate that phytoplankton activity was low to moderate in the Lower Cape Fear River System". This river basin generally has fewer phytoplankton problems than the other North Carolina river basins (Mallin 1994). They attributed the difference to the water's shorter retention time which is created by the Cape Fear River's swift currents, high turbidity and an open connection to the sea. They reported that the North Carolina state standard of 40µg/L was only exceeded twice during the 1997-1998 monitoring period. These were both times of low flow and low turbidity. Their sampling for the previous three years, 1995-1997, found chlorophyll *a* values to be inversely correlated to flow and rainfall in the piedmont. They determined that high turbidity negatively effects chlorophyll *a* values by creating light limitations and thereby reducing algal production.

It was also found that estuarine phytoplankton patterns occur both spatially and temporally. Spatially, high turbidity reduces phytoplankton growth in the upper estuary where nutrient limitations from mixing reduces growth in lower estuaries. Temporally, cooler temperatures, high flow and turbidity reduce phytoplankton growth in Fall and Winter. Increased phytoplanton growth occurs in Spring and Summer during times of low flow as waters warm and more nutrients are available from within the sediments and agricultural runoff.

SUMMARY OF ALGAL ANALYSES IN THE CAPE FEAR RIVER BASIN

Seventy three algal samples were analyzed from the Cape Fear River basin from 9/1/93 to 8/30/98. Algal samples were collected to identify the taxa present during suspected blooms, fish health events, or as nuisance growths.

Environmental factors that affect algal blooms include retention time, nutrients, light and temperature. Most blooms occur in the summer when rainfall decreases and photoperiod and water temperature increase. Sixty-seven percent of the samples were submitted from June to September; however, blooms can occur anytime during the year as favorable growth conditions arise.

Forty seven algal samples were collected as suspected blooms. Suspected blooms are collected when the waterbody becomes visually discolored or elevated levels of dissolved oxygen (D.O.), pH or chlorophyll *a* (Chl-*a*) are found. Fifty nine percent of samples were considered to be blooms by meeting one of the following criteria, Chl-*a* $\geq$ 40 µg/L, cell density $\geq$10,000 units/ml, or biovolume $\geq$ 5000 mm^3/m^3.

Nine algal samples were collected as nuisance growths. Nuisance growths can be aesthetic, such as floating mats which engulf ponds or small lakes, or dense growths that can choke a creek. Other nuisance algae may cause taste and odor problems or may be potentially toxic to livestock and waterfowl (Palmer 1977).

Seventeen samples were taken during or after fish health events such as fish kills or fish with sores. Some algal species can effect fish health directly by releasing toxins or indirectly when normal metabolic processes such as photosynthesis and respiration alter environmental conditions.

Not all algal samples were quantified but were only qualitatively analyzed for dominant taxa. Other samples were analyzed for the presence/absence of potentialy toxic taxa.
Total nitrogen (TN) and total phosphorous (TP) information is listed when available.

Classes of algae identified

Common name	Class	Code	Common name	Class	Code
blue-greens	cyanophyta	cya	yellow-greens	xanthophyceae	xan
greens	chlorophyta	chl	diatoms	bacillariophyceae	bac
dinoflagellates	pyrrhophyta	din	reds	rhodophyte	rho
cryptomonads	cryptophyta	cry		chloromonadophyta	chm
euglenoids	euglenophyte	eug		prasinophyceae	pra

Subbasin 02

Water Body: Haw River
Sampled: 6/7/94, 6/20/94
Analyzed for: suspected bloom, visual water discoloration.
Site Description: Two sites were sampled on the Haw River: one downriver of a dam (6/7/94) and one upriver (6/20/94). Upriver of the dam, the flow of the river slows creating lake-like conditions. Downriver of the dam, normal flow is restored.

6/7/94

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Skelotonema potamos	bac	25,000	91	4,000	91

6/20/94

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Skelotonema potamos	bac	23,400	43	3,200	26
Cyclotella sp.	bac	15,000	26	1,200	10
Cryptomonas erosa	cry	5,200	10	3,200	26

Conclusions: considered blooms. Cell densities and biovolumes exceeded 10,000 units/ml or 5000 mm^3/m^3. Nutrient levels were recorded (6/7/94; TN 4.2 mg/L, TP 0.95 mg/L, 6/20/94; TN 3.1 mg/L, TP 0.51 mg/L). Taxa found are commonly found in eutrophic conditions.

Water Body: Chockley Pond
Sampled: 8/27/96
Analyzed for: visual water discoloration/suspected bloom
Site Description: Small impoundment on tributary of Stag Creek.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Gonyostomum intermedium	clo	NA	100	NA	100

Conclusions: considered a bloom. Chl-*a* value (220 μg/L). This taxon is commonly found in bogs, swamps and acidic water.

Water Body: Wildlife Lake
Sampled: 6/2/98
Analyzed for: fish kill
Site Description: Small lake near Bass Mountain

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Schroederia setigera	chl	170	1	1,000	44
Gleocystis gigas	chl	37,400	96	900	41
Trachelomonas volvocina	eug	170	1	300	12

Conclusions: considered a bloom. Cell density exceeded 10,000 units/ml. Nutrient levels were recorded (TN 1.82 mg/L, TP 0.16 mg/L). Taxa are commonly found in eutrophic conditions.

Subbasin 03
Water Body: Lake Hempstead
Sampled: 8/1/97
Analyzed for: fish kill
Site Description: Farm pond in a pasture

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Anacystis cyanea	cya	NA	NA	NA	NA
Trachelomonas sp.	eug	NA	NA	NA	NA

Conclusions: sample was not quantified. Taxa are commonly found in eutrophic conditions. Anacystis cyanea has been known to cause taste and odor problems and may be toxic to livestock and waterfowl.

Subbasin 04
Water Body: Unnamed farm pond in Alamance County
Sampled: 9/16/94
Analyzed for: nuisance growth
Site Description: Small farm pond on a private land near Eli Whitney

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Anabaena planktonica	cya	NA	NA	NA	NA
Raphidiopsis mediterranea	cya	NA	NA	NA	NA
Trachelomonas volvocina	eug	NA	NA	NA	NA

Conclusions: not considered a bloom. Chl-*a* value (17 µg/L). Nutrients were recorded (TN 1.32 mg/L, TP 0.12 mg/L). Taxa are commonly found in eutrophic conditions.

Water Body: Robeson Creek,
Sampled: 6/21/94, 10/18/94, 6/22/95, 7/29/96, 8/22/96, 5/22/97, 6/30/97, 5/27/98, 6/11/98, 7/29/98, 8/31/98, 9/28/98, 10/28/98
Analyzed for: suspected blooms
Site Description: Ambient monitoring site B2450000 at the bridge on SR 1939 near Seaforth NC. A few hundred yards upstream from Jordan Lake, water flow slows and begins to pool.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
6/21/94					
Chlamydomonas sp.	chl	7,700	33	1,400	11
Cyclotella sp.	bac	5,200	23	470	4
Peridinium aciculiferum	din	930	4	5,900	50
10/18/94					
Carteria sp.	chl	7,480	61	11,700	93
Phormidium angustissimum	cya	1,960	16	120	1
6/22/95					
Chlamydomonas sp.	chl	41,900	90	44,000	98
7/29/96					
Cyclotella sp.	bac	4,200	10	350	5
Ochromonas sp.	chr	4,200	10	110	2
Anabaenopsis raciborskii	cya	4,700	11	350	5
Oscillatoria geminata	cya	22,300	49	2,600	36
Peridinium aciculiferum	din	170	1	1,100	15
Euglena proxima	eug	170	1	740	10
8/22/96					
Dactylococcopis sp.	cya	10,500	18	230	5
Oscillatoria geminata	cya	38,100	64	3,200	67

5/22/97

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Cyclotella sp.	bac	2,970	14	270	10
Skelotonema potamos	bac	5,400	26	830	29
Tetraedron trigonum	chl	170	1	830	29
Synechococcus sp.	cya	8,800	41	20	1

6/30/97

Euglena sp.	eug	NA	NA	NA	NA
Trachelomonas sp.	eug	NA	NA	NA	NA
Peridinium sp.	din	NA	NA	NA	NA
Glenodinium quadridens	din	NA	NA	NA	NA

5/27/98

Skelotonema potamos	bac	9,800	38	1,500	34
Chlorella sp.	chl	7,200	28	290	6
Merotrichia capitata	chm	90	1	460	10

6/11/98

Chlamydomonas sp.	chl	4,000	4	2,400	15
Westella botryoides	chl	18,000	17	970	6
Chroomonas minuta	cry	16,600	16	620	4
Cryptomonas ovata	cry	1,000	1	2,000	13
Aphanothece saxicola	cya	12,000	11	1,900	12

7/29/98

Westella botryoides	chl	22,400	17	2,500	19
Cryptomonas ovata	cry	1,400	1	2,700	20
Lyngbya lagerheimii	cya	17,500	13	100	1
Phormidium angustissimum	cya	51,400	40	4,000	29

8/31/98

Westella botryoides	chl	26,000	33	4,400	38
Cryptomonas ovata	cry	3,800	5	2,400	20
Phormidium angustissimum	cya	9,100	12	610	5

9/28/98

Lyngbya lagerheimii	cya	14,500	38	90	8
Phormidium angustissimum	cya	23,200	61	970	87

10/28/98

Chroomonas minuta	cry	7,300	12	270	2
Cryptomonas ovata	cry	7,300	12	4,500	26
Cryptomonas erosa	cry	2,200	4	4,200	24
Phormidium angustissimum	cya	12,800	21	1,100	6

Conclusions: considered blooms (excluding 6/30/97). Cell densities and biovolumes exceeded 10,000 units/ml or 5000 mm^3/m^3. Nutrients were monitored monthly (TN $\bar{x} = 1.17$, s.d. $\pm$ 0.51, n = 63, TP $\bar{x} = 0.14$, s.d. $\pm$ 0.07, n = 63) Taxa are commonly found in eutrophic conditions. Chlamydomonas sp. and Cryptomonas erosa are known to cause taste and odor problems.

Subbasin 07
Water Body: CAPE FEAR RIVER
Sampled: 6/21/94, 6/30/97, 7/16/97, 6/11/98, 8/31/98, 9/28/98, 10/28/98
Analyzed for: suspected bloom, visual water discoloration, elevated pH and DO

Site Description: ambient monitoring site B6160000 at bridge on NC HWY 42 near Corinth, NC. Downstream from Jordan Lake and confluence of the Deep and Haw Rivers. Flow slows and begins to pool before the dam that lies a few hundred yards downriver.

Dominant taxa	Class	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
6/21/94					
Dictyosphaerium pulchellum	chl	NA	30	NA	NA
Phormidium angustissimum	cya	NA	21	NA	NA
Closteriopsis longissima	chl	NA	NA	NA	16
Tetraedon trigonum	chl	NA	NA	NA	16
6/30/97					
Pandorina charkowensis	chl	NA	NA	NA	NA
Eudorina elegans	chl	NA	NA	NA	NA
Chlorogonium sp.	chl	NA	NA	NA	NA
Phormidium angustissimum	cya	NA	NA	NA	NA
7/16/97					
Cyclotella sp.	bac	17,500	38	1,800	18
Rhizosolenia sp.	bac	700	2	2,500	25
Anacystis sp.	cya	900	2	1,500	15
Dactylococcopsis sp.	cya	12,900	28	300	3
6/11/98					
Chlamydomonas sp.	chl	4,100	7	2,400	29
Chlorogonium euchlorum	chl	7,000	13	700	8
Chroomonas minuta	cry	18,600	33	700	8
Cryptomonas ovata	cry	700	1	1,300	16
9/28/98					
Lyngbya lagerheimii	cya	4,000	13	24	2
Phormidium angustissimum	cya	24,600	80	1,000	82
10/28/98					
Chroomonas caudata	cry	7,500	12	1,300	7
Chroomonas minuta	cry	12,400	20	460	2
Cryptomonas erosa	cry	6,900	11	4,200	23
Cryptomonas ovata	cry	3,700	6	7,100	38

Conclusions: considered blooms. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrients were measured monthly (TN $\bar{x}$ = 0.98, s.d. ± 0.33, n = 67, TP $\bar{x}$ = 0.15, s.d. ± 0.18, n = 18). Taxa are commonly found in eutrophic conditions.

Water Body: Utley Creek (Holly Springs Pond)
Sampled: 6/13/96, 7/11/96, 7/15/97
Analyzed for: suspected bloom, fish and mussel, nuisance algal growth
Site Description: Utley Creek flows from the town of Holly Springs, is impounded in the Shearon Harris game reserve (Holly Springs Pond/ Utley Creek Pond), then flows into the Shearon Harris Reservoir. Samples were collected above the weir and above the impoundment

6/13/96

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Oedogonium sp.	chl	NA	NA	NA	NA
Scenedesmus quadricauda	chl	NA	NA	NA	NA
Trachelomonas sp.	eug	NA	NA	NA	NA

7/11/96

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Oscillatoria tenuis	cya	15,200	66	37,300	97

7/15/97

Chlorogonuim euchlorum	chl	1,100	21	110	1
Scenedesmus quadricauda	chl	1,300	24	270	3
Oscillatoria tenuis	cya	2,100	39	8,000	89

Conclusions: considered blooms. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrients were recorded (7/11/96: TN 4.07 mg/L, TP 0.87 mg/L, 7/15/97: TN 9.0 mg/L, TP 0.60 mg/L). Taxa are commonly found in eutrophic conditions.

Subbasin 10

Water Body: Buffalo Creek
Sampled: 5/7/98
Analyzed for: algal mats
Site Description: Buffalo Creek is a blackwater stream that flows into the Little River.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Batrachospermum sp.	rho	NA	NA	NA	NA

Conclusions: DWQ stream assessment crew came across a a large concentration of algae which coated all surfaces of the stream bed. The algae was Batrachospermum sp., commonly found in cool low light streams and is an indicator of low nutrient conditions

Subbasin 11

Water Body: Deep River
Sampled: 6/25/96, 8/31/98, 9/28/98
Analyzed for: visual water discoloration
Site Description: Ambient monitoring site B5575000 at the bridge on NC HWY 42 near Carbonton, NC.
8/31/98

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Skelotonema potamos	bac	2,500	6	540	18
Westella botryoides	chl	21,500	51	1,200	43
Calycomonas ovalis	chr	8,600	20	340	12

9/28/98

Cyclotella sp.	bac	17,700	47	390	5
Chroomonas minuta	cry	7,300	20	270	3
Cryptomonas erosa	cry	9,800	26	6,000	75
Cryptomonas ovata	cry	520	1	1000	12

Conclusions: considered blooms. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrient levels were measured monthly (TN $\bar{x}$=1.26 mg/L, s.d. ± 0.59, n = 5 9, TP $\bar{x}$= 0.17 mg/L s.d. ± 0.08, n = 59). Taxa found on 9/28/98 are commonly found in eutrophic conditions.

Subbasin 12

Water Body: Rocky River
Sampled: 7/18/96, 9/28/98, 10/27/98

Analyzed for: visual water discoloration
Site Description: ambient monitoring site B6000000 at the bridge of NC HWY 902 near Pittsboro, NC.
9/28/98

Dominant taxa	**Class code**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Cocconesis sp.	bac	60	56	40	83
Chroomonas minuta	cry	30	33	1	3
Cryptomonas erosa	cry	10	11	7	14

Conclusions: not considered blooms. Chl-*a* values (< 4 µg/L). Nutrient levels were recorded (TN $\bar{x}$ = 2.53 mg/L, s.d. ± 2.30, n = 13; TP $\bar{x}$ = 0.11 mg/L, s.d. ± 0.10, n = 13).

Subbasin 15
Water Body: Hendrick's pond
Sampled: 3/25/98
Analyzed for: nuisance growth
Site Description:

Dominant taxa	**Class code**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Spyrogyra sp.	chl	NA	NA	NA	NA
Oedogonium sp.	chl	NA	NA	NA	NA
Zygnema sp.	chl	NA	NA	NA	NA
Mougeotia sp.	chl	NA	NA	NA	NA

Conclusions: not quantified. Nutrient levels were recorded (TN 1.09 mg/L, TP 0.2 mg/L). Taxa are commonly found in eutrophic conditions. The large number of resident Canada Geese being fed in the pond are likely to contribute to elevated nutrient conditions.

Water Body: Palmer Pond
Sampled: 4/9/98
Analyzed for: fish kill
Site Description: located west of Raeford

Dominant taxa	**Class code**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Tribonema bombycinum	cry	NA	NA	NA	NA
Mougeotia sp.	chl	NA	NA	NA	NA
Ulothrix sp.	chl	NA	NA	NA	NA
Oedogonium sp.	chl	NA	NA	NA	NA
Fragilaria sp.	bac	NA	NA	NA	NA

Conclusions: not considered a bloom. Chl-*a* values (9 µg/L). Taxa are commonly found in eutrophic conditions.

Subbasin 16
Water Body: Hammonds Pond
Sampled: 4/6/98
Analyzed for: nuisance growth
Site Description: small impoundment that feeds into an unnamed tributary into Hammonds Creek.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Hyalotheca dissiliens tridentula	chl	NA	NA	NA	NA
Mougeotia sp.	chl	NA	NA	NA	NA
Zygnema sp.	chl	NA	NA	NA	NA
Fragilaria sp.	chl	NA	NA	NA	NA

Conclusions: sample not quantified. Nutrient levels were recorded (TN 0.88 mg/L, TP 0.05 mg/L). Taxa are commonly found in eutrophic conditions.

Water Body: Singletary Pond
Sampled: 7/29/98
Analyzed for: suspected bloom, nuisance growth
Site Description: small pond off of Crawley Swamp

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Synura sp.	cry	NA	NA	NA	NA
Mallomonas akrokomaos	cry	NA	NA	NA	NA
Mallomonas caudata	cry	NA	NA	NA	NA

Conclusions: not considered a bloom. Chl-*a* values (6 µg/L). Nutrients were recorded (TN 0.62 mg/L, TP 0.03 - 0.11 mg/L). Taxa are commonly found in eutrophic conditions. Synura sp. and Mallomonas caudata are known to cause taste and odor problems.

Water Body: White Lake Wastewater Treatment Plant
Sampled: 8/4/98
Analyzed for: visual water discoloration
Site Description:

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Euglena sp.	eug	NA	NA	NA	NA
Lyngbya sp.	cya	NA	NA	NA	NA
Merismopedia punctata	cya	NA	NA	NA	NA
Dictyosphaerium pulchellum	chl	NA	NA	NA	NA

Conclusions: not quantified. Taxa are commonly found in eutrophic conditions.

Subbasin 17

Water Body: Cape Fear River
Sampled: 10/2/97, 4/7/98, 6/16/98
Analyzed for: fish kill/fish with sores
Site Description: 4 sites, all estuarine, as the Cape Fear River enters the ocean. 10/2/97 at Bald Head harbor, 4/7/98 two locations near Zeke's island, and 6/16/98 upstream the confluence of the Cape Fear River and the Brunswick River.

10/2/97

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Leptocylindrus minimus	bac	NA	NA	NA	NA
Skelotonema costatum	bac	NA	NA	NA	NA
Gyrodinium sp.	din	NA	NA	NA	NA

4/7/98

Chroomonas caudata	cry	NA	NA	NA	NA
Cryptomonas erosa	cry	NA	NA	NA	NA
Cryptomonas reflexa	cry	NA	NA	NA	NA
Cryptomonas ovata	cry	NA	NA	NA	NA
Pleurosigma sp.	bac	NA	NA	NA	NA
Coscinodiscus sp.	bac	NA	NA	NA	NA
Gymnodinium sp.	din	NA	NA	NA	NA

Conclusions: Samples were analyzed for presence/absence of potentially toxic taxa, none were found. Taxa are commonly found in eutrophic conditions.

Water Body: Carolina Beach Harbor
Sampled: 4/19/94, 7/11/94, 3/13/95, 12/27/95, 5/22/96, 4/30/97, 5/22/97, 6/8/98, 12/7/98
Analyzed for: suspected bloom, elevated D.O.
Site Description: ambient monitoring site B9879000 located behind the breakwater within the harbor near the channel markers R6 and G7.

4/19/94

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Skelotonema costatum	bac	6,500	37	900	16
Prorocentrum aporum	din	60	1	920	17
Prorocentrum minimum	din	500	3	580	11

7/11/94

Cyclotella sp.	bac	NA	82	NA	13
Peridinium trochoideum	din	NA	NA	NA	16
Gyrodinium aureolum	din	NA	NA	NA	68

3/13/95

Eutreptia lanowii	eug	11,900	96	3,800	98

12/27/95

Chroomonas amphioxeia	cry	6,500	20	5,489	38.8
Katodinium rotundatum	din	23,400	71	8,078	57.1

5/22/96

Synedra rumpens	bac	2,000	43	130	5
Heterosigma sp.	chm	1,700	36	1,100	44
Peridinium sp.	din	300	7	1,000	39

4/30/97

Chaetoceras sp.	bac	NA	NA	NA	NA
Cyclotella sp.	bac	NA	NA	NA	NA
Peridinium sp.	din	NA	NA	NA	NA
Chroomonas caudata	cry	NA	NA	NA	NA
Cryptomonas erosa	cry	NA	NA	NA	NA
Heterosigma sp.	clo	NA	NA	NA	NA

5/22/97

Cyclotella sp.	bac	180,000	98	3,900	93

6/8/98

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Cyclotella sp.	bac	7,500	60	170	8
Cryptomonas erosa	cry	800	6	500	25
Cryptomonas ovata	cry	300	2	570	28

Eutreptia viridis	eug	400	3	430	21

12/7/98

Calycomonas ovalis	chr	7,059	32.0	282	3.3
Ochromonas sp.	chr	4,543	20.6	122	1.4
unidentified chrysophyte	chr	3,494	15.8	7,367	87.0

Conclusions: five of the nine samples were considered to be blooms. Cell densities and biovolumes exceeded 10,000 units/ml or 5000 mm^3/m^3. Nutrient levels were monitored monthly (TN $\bar{x}$ = 0.62 mg/L, s.d. ± 0.20, n = 60, TP $\bar{x}$ = 0.05 mg/L, s.d. ± 0.03, n =9). Taxa are commonly found in eutrophic conditions.

Water Body: Carolina Beach Lake
Sampled: 9/3/97
Analyzed for: fish kill
Site Description: Small lake in residential area next to harbor, small outlet leads to ocean

Dominant taxa	**Class**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Anabaena aphanizomenoides	cya	4,500	5	6,000	37
Lyngbya sp.	cya	10,100	11	300	2
Gymnodinium sp.	din	4,900	5	7,500	46
prasinophyceae	pra	65,400	69	1,700	10

Conclusions: considered a bloom. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrients levels were recorded (TN 1.60 mg/l, TP 0.19 mg/l). Taxa are commonly found in eutrophic conditions.

Water Body: Silver Lake
Sampled: 7/18/97
Analyzed for: suspected bloom, visual water discoloration, surface specks
Site Description: a small lake within a residential area, near Myrtle Grove Junction.

Dominant taxa	**Class**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Anabaenopsis raciborskii	cya	39,500	75	9,000	61
Anacystis cyanea	cya	11,500	22	5,200	36

Conclusions: considered a bloom. Cell densities and biovolumes exceeded 10,000 units/ml or 5000 mm^3/m^3. Nutrient levels were recorded (TN 1.10 mg/L, TP 0.09 mg/L). Anacystis cyanea has been known to cause taste and odor problems and may be toxic to livestock and waterfowl.

Water Body: Sunset Lake ponds
Sampled: 6/24/97
Analyzed for: nuisance growth
Site Description: Series of ponds within golf course, small outlet that empties into Intercoastal Waterway

Dominant taxa	**Class**	**Density units/ml**	**% total Density**	**BioVol mm^3/m^3**	**% total BioVol**
Oedogonium sp.	chl	NA	NA	NA	NA
Mougeotia sp.	chl	NA	NA	NA	NA
Euastrum sp.	chl	NA	NA	NA	NA
Pediastrum sp.	chl	NA	NA	NA	NA
Anabaena sp.	cya	NA	NA	NA	NA

Conclusions: not quantified. Taxa are commonly found in eutrophic conditions.

Water Body: Cape Pond
Sampled: 2/11/97
Analyzed for: nuisance growth, odor complaint
Site Description: Small pond on a golf course

Dominant taxa	Class	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Anacystis cyanea	cya	NA	NA	NA	NA
Anabaena planktonica	cya	NA	NA	NA	NA
Anabaena spiroides	cya	NA	NA	NA	NA
Trachelomonas sp.	eug	NA	NA	NA	NA

Conclusions: possible link between odor complaint and nuisance algal growth. Nutrient levels were recorded (TN 1.80 mg/L, TP 0.17 mg/L). Anacystis cyanea and Anabaena planktonica are known to cause taste and odor problems. Anacystis cyanea may be toxic to livestock and waterfowl.

Subbasin 18
Water Body: South River
Sampled: 7/6/98
Analyzed for: fish kill
Site Description: below Rhodes Lake, upstream of the confluents of the drainage from Mingo Swamp river.

Dominant taxa	Class	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
unidentified chrysophyte	chr	12,000	93	340	20
Euglena sp.	eug	230	2	350	20
Trachelomonas abrupta	eug	120	1	440	25
Trachelomonas volvocina	eug	230	2	370	21

Conclusions: not considered a bloom. Chl-*a* value (15 µg/l). Nutrients levels were recorded (TN 0.60 mg/L, TP 0.31 mg/L). Taxa are commonly found in eutrophic conditions.

Subbasin 19
Water Body: Little Coharie Creek
Sampled: 6/4/96
Analyzed for: baseline data
Site Description: at bridge crossings of SR 1214 and SR 1211 and SR 1134, surrounded by agricultural area, close to Roseboro, NC.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Synedra sp.	bac	NA	NA	NA	NA
Peridinium inconspicuum	din	NA	NA	NA	NA
Cryptomonas erosa.	cry	NA	NA	NA	NA

Conclusions: not quantified. Synedra sp. and Cryptomonas erosa are known to cause taste and odor problems. Taxa are commonly found in eutrophic conditions.

Subbasin 21
Water Body: Middle Sound
Sampled: 9/29/97
Analyzed for: fish with sores
Site Description: A dock on the south of Figure Eight Island that reaches out into the middle sound.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Skeletonema costatum	bac	NA	NA	NA	NA
Chaetoceras sp.	bac	NA	NA	NA	NA
Gymnodinium sp.	din	NA	NA	NA	NA

Conclusions: Sample was analysed for presence/absence of potentially toxic taxa. A Pfiesteria-like species was present at 0-12 cells/ml.

Water Body: Limestone Lake
Sampled: 7 locations on 5/24/94
Analyzed for: baseline data, concerns of nutrient loading from surrounding swine farms
Site Description: lake recently created by damming Cabin Creek (69 acres) for recreational purposes
site 1

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Asterococcus spinosus	chl	1,000	31	550	11
Gleocystis versiculosa	chl	1,600	47	3,800	80

site 2

Asterococcus spinosus	chl	1,200	44	660	7
Gleocystis versiculosa	chl	2,200	42	7,000	74
Cryptomonas erosa	cry	770	15	950	10

site 3

Gleocystis versiculosa	chl	2,200	16	2,500	16
Gonyostomum semen	chm	90	1	2,800	19
Chroomonas caudata	cry	2,300	17	390	3
Euglena sp.	eug	310	2	1,700	11

Conclusions: Only one of the 7 sites that were sampled on 5/24/94 was considered a bloom. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrient levels were recorded (TN $\bar{x}$ = 0.89 mg/L, s.d. ± 0.09 mg/L, n = 7, TP $\bar{x}$ = 0.10 mg/L, s.d. ± 0.01 mg/L, n = 7). Taxa found in sites 2 and 3 are commonly found in eutrophic conditions.

Water Body: Goshen Swamp
Sampled: 8/30/95
Analyzed for: fish kill
Site Description:

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Carteria sp.	chl	4,600	92	420	64
Cryptomonas erosa	cry	170	4	110	17
Trachelomonas volvocina	eug	40	1	70	11

Conclusions: considered a bloom. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Taxa are commonly found in eutrophic conditions.

Water Body: Taylor Lake
Sampled: 5/9/95
Analyzed for: visual water discoloration
Site Description: small lake on a tributary to Bear Creek, adjacent to landing strip, north of Warsaw, NC.

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Anacystis cyanea	cya	140,500	2	7,700	83
Phormidium angustissimum	cya	184,500	96	1,300	14

Conclusions: considered a bloom. Cell densities and biovolumes exceeded 10,000 units/ml and 5000 mm^3/m^3. Nutrient levels were recorded (TN 2.34 mg/l, TP 0.25 mg/l). Anacystis cyanea is known to cause taste and odor problems and may be toxic to livestock and waterfowl.

Subbasin 23

Water Body: Baker's Marina
Sampled: 8/28/97, 6/22/98
Analyzed for: fish kill
Site Description: on Cape Fear River near the confluence of the Brunswick River and upstream from the Wilmington North WWTP.
Conclusions: not considered a bloom. Chl-*a* values (8/28/97, 8 µg/L, 6/22/98, 22 µg/L). Samples were analyzed for the presence/absence of potentialy toxic taxa. On 8/28/97 no Pfeisteria-like species present. On 6/22/98 Pfeisteria-like species were present at 12cells/ml. Nutrient levels were recorded (8/28/97 TN 0.80 mg/L, TP 0.11 mg/L, 6/22/98, TN 1.02 mg/L, TP 0.16 mg/L)

Water Body: Northeast Cape Fear River
Sampled: 7/24/97
Analyzed for: human health concerns
Site Description: Northeast Cape Fear river near Castle Hayne between I - 40 and US 117

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Ankistrodesmus sp.	chl	NA	NA	NA	NA
Skelotonema potamus	bac	NA	NA	NA	NA
Gleocystis sp.	chl	NA	NA	NA	NA
Cryptomonas erosa	cry	NA	NA	NA	NA

Conclusions: not quantified. Taxa are commonly found in eutrophic conditions. No known reports of health risks associated with any of the taxa found.

Water Body: Pages Creek
Sampled: 9/19/97
Analyzed for: fish kill
Site Description: runs through tidal flat, empties into Intercoastal Waterway.
Conclusions: Sample was analyzed for presence/absence of of potentialy toxic taxa. Pfiesteria-like species present at 17 cells/ml

Water Body: Stone Pond
Sampled: 5/27/97
Analyzed for: fish kill
Site Description: Small, private pond near Burgaw

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Helicodictyon planctonicum	chl	NA	100	NA	100

Conclusions: not quantified. Considered a monoculture surface bloom.

Water Body: Lanier Pond
Sampled: 8/31/94
Analyzed for: fish kill
Site Description: Small pond

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Lyngbya sp.	cya	1,400	14	200	7
Raphidiopsis curvata	cya	6,800	66	700	24
Trachelomonas hispida punctata	eug	120	1	600	21
Trachelomonas volvocina	eug	520	5	830	29

Conclusions: not considered a bloom. Biovolume was less than 5000 mm^3/m^3 and cell densities was only slightly above 10,000 units/ml. Taxa are commonly found in eutrophic conditions.

Subbasin 24
Water Body: Atlantic Ocean
Sampled: 9/19/97
Analyzed for: fish with bite marks
Site Description:

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Rhizosolenia sp.	bac	NA	NA	NA	NA
Gymnodinium sp.	din	NA	NA	NA	NA

Conclusions: Sample analyzed for presence/absence of potentially toxic taxa, none were found. Taxa are commonly found in eutrophic conditions.

Water Body: Intercoastal Waterway
Sampled: 4/18/96
Analyzed for: suspected bloom
Site Description: Ambient monitoring site B9865000 on Intercoastal Waterway near Morris Landing, NC.

Dominant taxa	Class	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Chaetoceras sp.	bac	NA	NA	NA	NA

Conclusions: not considered a bloom. Chl-*a* values (10 µg/L).

Water Body: North Chase Creek
Sampled: 11/19/96
Analyzed for: suspected bloom, visual water discoloration
Site Description: Storm water pond in New Hanover County

Dominant taxa	Class code	Density units/ml	% total Density	BioVol mm^3/m^3	% total BioVol
Anabaena planktonica	cya	NA	NA	NA	NA
Aphanizominon flos-aquae	cya	NA	NA	NA	NA
Gymnodinium sp.	din	NA	NA	NA	NA
Ceratium hirundinella	din	NA	NA	NA	NA

Conclusions: considered a bloom. Chl-a values (580 µg/L). Nutrient levels were recorded (TN 2.31 mg/L, TP 0.58 mg/L). Taxa are commonly found in eutrophic conditions.

OTHER ALGAL DATA
Mallin et al. report " Environmental Assessment of the Lower Cape Fear River System, 1997-1998," stated that "chlorophyll *a* values indicate that phytoplankton activity was low to moderate in the Lower Cape Fear River System". This river basin generally has fewer phytoplankton problems than the other North Carolina river basins (Mallin 1994). They attributed the difference to the water's shorter retention time which is created by the Cape Fear River's swift currents, high turbidity and an open connection to the sea. They reported that the North Carolina state standard of 40µg/L was only exceeded twice during the 1997-1998 monitoring period. These were both times of low flow and low turbidity. Their sampling for the previous three years, 1995-1997, found chlorophyll *a* values to be inversely correlated to flow and rainfall in the piedmont. They determined that high turbidity negatively effects chlorophyll *a* values by creating light limitations and thereby reducing algal production.

It was also found that estuarine phytoplankton patterns occur both spatially and temporally. Spatially, high turbidity reduces phytoplankton growth in the upper estuary where nutrient limitations from mixing reduces growth in lower estuaries. Temporally, cooler temperatures, high flow and turbidity reduce phytoplankton growth in Fall and Winter. Increased phytoplanton growth occurs in Spring and Summer during times of low flow as waters warm and more nutrients are available from within the sediments and agricultural runoff.

AQUATIC TOXICITY MONITORING

One hundred twenty-four facility permits in the Cape Fear Basin currently require whole effluent toxicity (WET) monitoring. Ninety-six facility permits have a WET limit; 28 specify monitoring with no limit. The great majority of the monitoring facilities (22) are petroleum storage facilities with episodic discharges associated with rain events.

SB	Facility	NPDES#	Receiving Stream	County	Flow(MGD)	IWC(%)
01	Glen Raven Mills	NC0003913/001	Haw R	Alamance	0.150	2.6
	Pentecostal Holiness Church	NC0046809/001	UT Benaja Cr	Guilford	0.020	30.6
	Reidsville WWTP	NC0024881/001	L Troublesome Cr	Rockingham	5.000	97.0
	Trinity American Corporation	NC0086029/001	Caraway Cr	Randolph	0.072	100.0
02	Amoco Oil Co.	NC0003671/001	UT Horsepen Cr	Guilford	NA	100.0
	AMP Inc.	NC0085821/001	UT N Buffalo Cr	Guilford	0.058	100.0
	Apex Oil Company	NC0071463/001	UT Horsepen Cr	Guilford	NA	100.0
	BP Oil Company	NC0086380/001	UT Horse Pen Cr	Guilford	NA	100.0
	Burlington East WWTP	NC0023868/001	Haw R	Alamance	12.000	36.0
	Burlington-South WWTP	NC0023876/001	Big Alamance Cr	Alamance	12.000	86.0
	Cone Mills Greensboro-001	NC0000876/001	N Buffalo Cr	Guilford	1.250	79.0
	Graham WWTP	NC0021211/001	Haw R	Alamance	3.500	14.0
	Greensboro N Buffalo Cr WWTP	NC0024325/001	N Buffalo Cr	Guilford	16.000	96.5
	Greensboro Osborne WWTP	NC0047384/001	S Buffalo Cr	Guilford	22.000	93.7
	Haw River Realty, Inc.	NC0084328/001	UT Haw R	Alamance	0.150	100.0
	Mebane WWTP	NC0021474/001	Moadams Cr	Alamance	2.500	100.0
	Monarch Hosiery	NC0001210/001	Reedy Fk Cr	Alamance	0.050	0.2
	Urethane Technologies	NC0084778/001	UT N Buffalo Cr	Guilford	0.110	100.0
	Worth Chemical Corp.	NC0078000/001	UT S Buffalo Cr	Guilford	0.216	21.8
04	Pittsboro WWTP	NC0020354/001	Robertson Cr	Chatham	0.750	100.0
05	Durham Co.-Triangle WWTP	NC0026051/001	Northeast Cr	Durham	6.000	100.0
	South Durham WRF	NC0047597/001	New Hope Cr	Durham	20.000	99.5
06	OWASA/Mason Farm	NC0025241/001	Morgan Cr	Orange	10.000	92.5
	UNC-CH Power Plant	NC0025305/001	UT Morgan Cr	Orange	0.048	100.0
07	Allied Signal Fibers/001	NC0001899/001	Haw R	Chatham	0.244	0.9
	Allied Signal Fibers/002	NC0001899/002	UT Shaddox Cr	Chatham	NA	NA
	Buies Creek WWTP	NC0030091/001	Cape Fear R	Harnett	0.500	0.1
	CP&L-Cape Fear SE/007	NC0003433/007	UT Cape Fear R	Chatham	NA	100.0
	CP&L-Shearon Harris E&E Center	NC0039586/007	Harris L.	Wake	0.020	NA
	CP&L-Shearon Harris/006	NC0039586/006	Harris Reservoir	Chatham	18.600	NA
	Fuquay-Varina/Kenneth Br WWTP	NC0028118/001	Kenneth Cr	Wake	1.200	100.0
	Holly Springs WWTP	NC0063096/001	Utley Cr	Wake	0.500	100.0
	Lillington WWTP	NC0021636/001	Cape Fear R	Harnett	0.600	0.2
	Neste Resins Corp.	NC0000892/001	Haw R	Chatham	0.100	0.4
08	Amerada Hess-Greensboro Term	NC0069256/001	UT E Fk Deep R	Guilford	NA	NA
	Ashland Petroleum Co-Greensboro	NC0065803/001	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/001	NC0031046/001	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/002	NC0031046/002	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/003	NC0031046/003	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/004	NC0031046/004	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/005	NC0031046/005	UT E Fk Deep R	Guilford	NA	100.0
	Colonial Pipeline/006	NC0031046/006	UT E Fk Deep R	Guilford	NA	100.0
	Exxon/Greensboro Marketing Term	NC0000795/001	UT E Fk Deep R	Guilford	NA	100.0
	GNC Energy Corp/ 001	NC0074241/001	UT E Fk Deep R	Guilford	VAR	100.0
	High Point Eastside WWTP	NC0024210/001	Richland Cr	Guilford	16.000	96.0
	LCP Plastics, Inc.	NC0036366/001	UT W Fk Deep R	Guilford	NA	100.0
	Louis Dreyfus Energy Corp.	NC0026247/001	UT E Fk Deep R	Guilford	NA	100.0
	Plantation Pipeline Co. (001)	NC0051161/001	UT E Fk Deep R	Guilford	NA	NA
	Plantation Pipeline Co. (002)	NC0051161/002	UT E Fk Deep R	Guilford	NA	NA
	Randleman WWTP	NC0025445/001	Deep R	Randolph	1.745	35.0
	Texaco Refining/Star Enterprise	NC0022209/001	UT Long BR	Guilford	VAR	100.0
	Triad Terminal Co.	NC0042501/001	UT E Fk Deep R	Guilford	VAR	100.0

	Williams Energy-Greensboro	NC0074578/002	UT Long Branch Cr	Guilford	0.007	100.0
09	Asheboro WWTP	NC0026123/001	Haskett's Cr	Randolph	6.000	100.0
	Faith Christian School	NC0042030/001	UT Deep R	Randolph	0.005	100.0
	Hancock Country Hams	NC0084077/001	UT Sandy Cr	Randolph	0.100	100.0
	Ramseur WWTP	NC0026565/001	Deep R	Randolph	0.480	6.3
	SS Mobile Home Park	NC0038300/001	UT Brush Cr	Chatham	0.010	100.0
	Thomasville Furniture	NC0084816/001	UT Polecat Cr	Guilford	0.029	100.0
10	Robbins WWTP	NC0062855/001	Deep R	Moore	1.000	8.9
	Star WWTP	NC0058548/001	Cotton Cr	Montgomery	0.600	100.0
11	Golden Poultry	NC0072575/001	Deep R	Lee	1.000	9.1
	Sanford-Big Buffalo WWTP	NC0024147/001	Deep R	Lee	6.800	39.0
12	Siler City WWTP	NC0026441/001	Loves Cr	Chatham	4.000	96.1
13	Carolina Trace Subdivision WWTP	NC0038831/001	Upper Little R	Lee	1.000	76.0
	Dunn/Blackriver WWTP	NC0043176/001	Cape Fear R	Harnett	3.750	1.0
	Erwin WWTP	NC0064521/001	Cape Fear R	Harnett	1.200	0.3
	Swift Textiles	NC0001406/001	Cape Fear R	Harnett	2.500	0.7
14	Fort Bragg WWTP/001	NC0003964/001	Little R	Cumberland	8.000	26.0
	Spring Lake WWTP	NC0030970/001	Lower Little R	Cumberland	1.500	5.5
15	Fayetteville-Cross Creek WWTP	NC0023957/001	Cape Fear R	Cumberland	22.000	4.9
	Fayetteville-Rockfish WWTP	NC0050105/001	Cape Fear R	Cumberland	14.000	3.1
	Monsanto/001,002	NC0003719/002	Cape Fear R	Cumberland	1.300	0.2
	Raeford WWTP	NC0026514/001	Rockfish Cr	Hoke	3.000	8.7
15	Alamac Knit Fabrics-E'town Plant	NC0003522/001	Cape Fear R	Bladen	2.500	0.5
	Carolina Food Processors, Inc.	NC0078344/001	Cape Fear R	Bladen	3.000	0.4
	Cogentrix Eastern Carolina Corp.	NC0058297/003	Cape Fear R	Bladen	NA	0.1
	Dupont De Nemours	NC0003573/001	Cape Fear R	Bladen	17.000	3.3
	Elizabethtown WWTP	NC0026671/001	Cape Fear R	Bladen	0.700	0.1
	Veeder Root Corp/004	NC0001121/004	Cape Fear R	Bladen	NA	NA
17	AAF/McQuay, Inc.	NC0083658/002	UT Barnards Cr	New Hanover	0.360	100.0
	AAF/McQuay, Inc.	NC0083658/001	UT Barnards Cr	New Hanover	0.288	100.0
	Amerada Hess Corp.	NC0066711/001	Cape Fear R	New Hanover	NA	NA
	Arcadian Corporation	NC0003727/001	NE Cape Fear R	New Hanover	0.280	NA
	Archer Daniels Midland Co./001	NC0027065/001	Cape Fear R	Brunswick	3.500	NA
	Arteva Specialties-Wilm Plant	NC0001112/001	NE Cape Fear R	New Hanover	1.400	7.4
	Arteva Specialties-Wilm Plant	NC0001112/002	Cape Fear R	New Hanover	1.250	NA
	Carolina Beach WWTP	NC0023256/001	Cape Fear R	New Hanover	1.850	NA
	CP&L-Sutton/001	NC0001422/001	Cape Fear R	New Hanover	NA	NA
	CTI of North Carolina	NC0082970/001	Cape Fear R	New Hanover	VAR	NA
	EI Dupont Denemours/001	NC0000663/001	Cape Fear R	Brunswick	2.300	0.4
	Exxon USA Wilmington Terminal	NC0073181/001	Cape Fear R	New Hanover	VAR	NA
	Federal Paper Board Co., Inc.	NC0081507/001	Burnt Mill Cr	New Hanover	0.050	37.0
	Federal Paperboard Co.	NC0003298/001	Cape Fear R	Columbus	50.000	8.3
	Fortron Industries/001	NC0082295/001	Cape Fear R	New Hanover	0.240	1.2
	General Electric Co-001	NC0001228/001	NE Cape Fear R	New Hanover	1.800	9.4
	JLM Terminals/Cape Fear Term	NC0028568/001	Cape Fear R	New Hanover	NA	NA
	Koch Refining Co-North Term	NC0076732/001	Cape Fear R	New Hanover	0.100	NA
	Leland Industrial Park WWTP	NC0065676/001	Cape Fear R	Brunswick	0.250	0.1
	New Hanover Co. Landfill	NC0049743/001	NE Cape Fear R	New Hanover	0.050	NA
	New Hanover Co. Airport WWTP	NC0081736/001	Cape Fear R	New Hanover	4.000	NA
	Paktank Corp-Wilmington Term	NC0073172/001	Cape Fear R	New Hanover	NA	NA
	Smith Cr Sewage LLC	NC0000817/001	Smith Cr	New Hanover	0.100	34.0
	Southport WWTP	NC0021334/001	Intracoastal Wway	Brunswick	0.800	NA
	Takeda Chemical Products	NC0059234/001	Cape Fear R	New Hanover	1.000	1.0
	Wilmington Northside WWTP	NC0023965/001	Cape Fear R	New Hanover	8.000	NA
	Wilmington Southside WWTP	NC0023973/001	Cape Fear R	New Hanover	12.000	1.6
	Wright Chemical Corp/002	NC0003395/002	Livingston Cr	Columbus	0.200	34.0
18	National Mechanical Carbon Corp.	NC0060747/001	Juniper Cr	Harnett	0.026	100.0
19	Clinton-Larkins WPCF	NC0020117/001	Williams Old Mill Br	Sampson	5.000	100.0
	Roseboro WWTP	NC0026816/001	Little Coharie Cr	Sampson	0.700	52.0
21	Mt. Olive Pickle	NC0001074/001	Barlow Branch	Wayne	0.400	100.0
	Mt. Olive WWTP	NC0020575/001	NE Cape Fear R	Wayne	1.000	100.0
22	Charles F. Cates & Sons	NC0001970/001	UT Panther Br	Duplin	0.500	100.0

	Cogentrix Leasing Corp-003	NC0058271/003	UT NE Cape Fear R	Duplin	NA	90.0
	Guilford Mills East	NC0002305/001	NE Cape Fear R	Duplin	1.500	27.0
	Rose Hill WWTP	NC0056863/001	Reedy Br	Duplin	0.450	100.0
	Stevcoknit	NC0003450/002	Little Rockfish Cr	Duplin	5.000	99.0
	Swift-Eckrich, Inc.	NC0003344/001	Rockfish Cr	Duplin	1.500	57.0
	Wallace WWTP	NC0020702/001	Rockfish Cr	Duplin	1.000	20.5
23	Burgaw WWTP	NC0021113/001	Burgaw Cr	Pender	0.750	100.0
	Occidental Chemical Corp/001	NC0003875/001	NE Cape Fear R	New Hanover	0.780	4.6
	Thorn Apple Valley Of Carolina	NC0007757/001	UT Juniper Swp	Onslow	0.650	100.0
24	Holly Ridge WWTP	NC0025895/001	UT Kings Cr	Onslow	0.100	100.0

Whole effluent toxicity monitoring results for all dischargers in the Cape Fear Basin are presented in Appendix T.1.

Figure A-1.1 Ambient Monitoring Stations in the upper Cape Fear River Basin

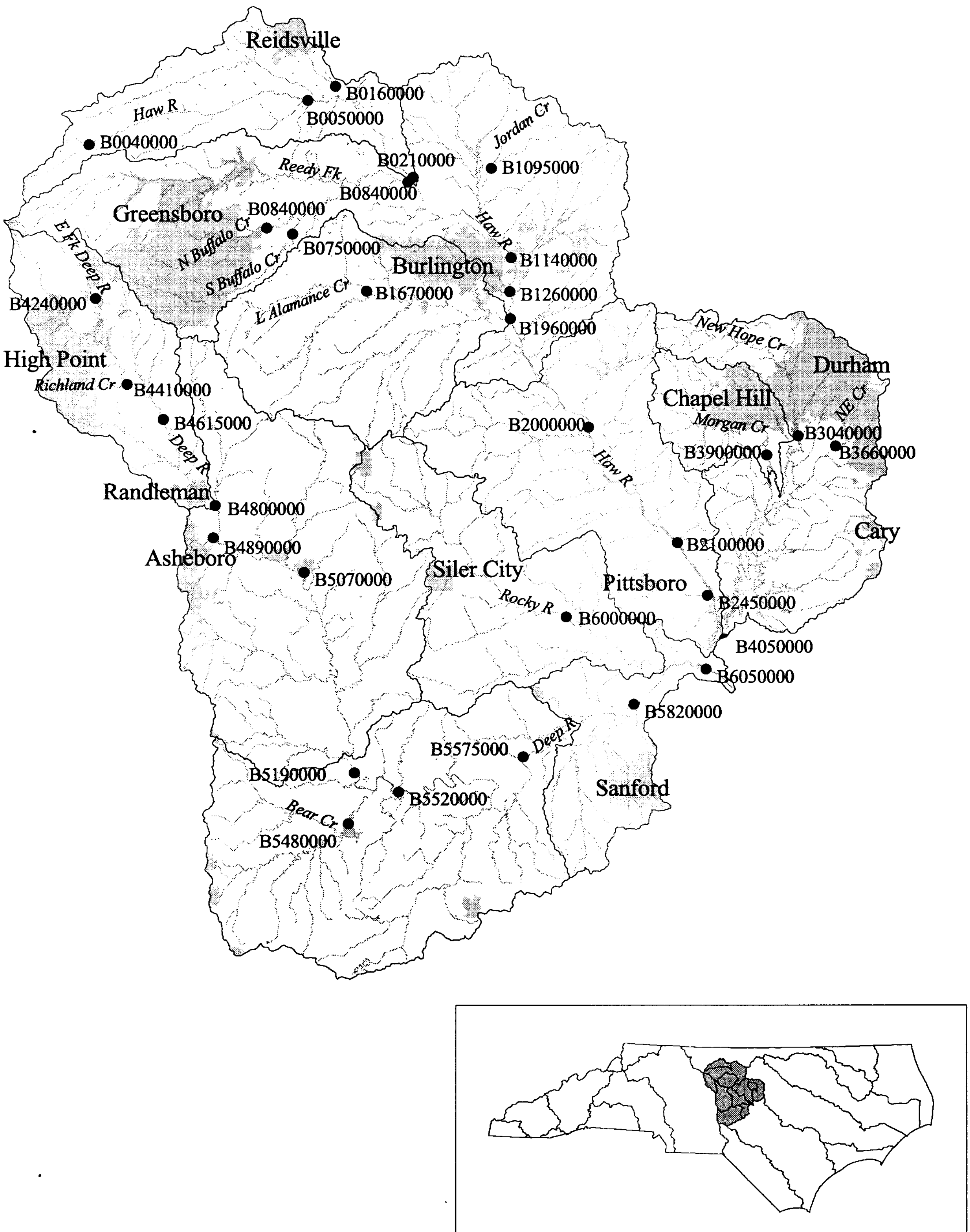
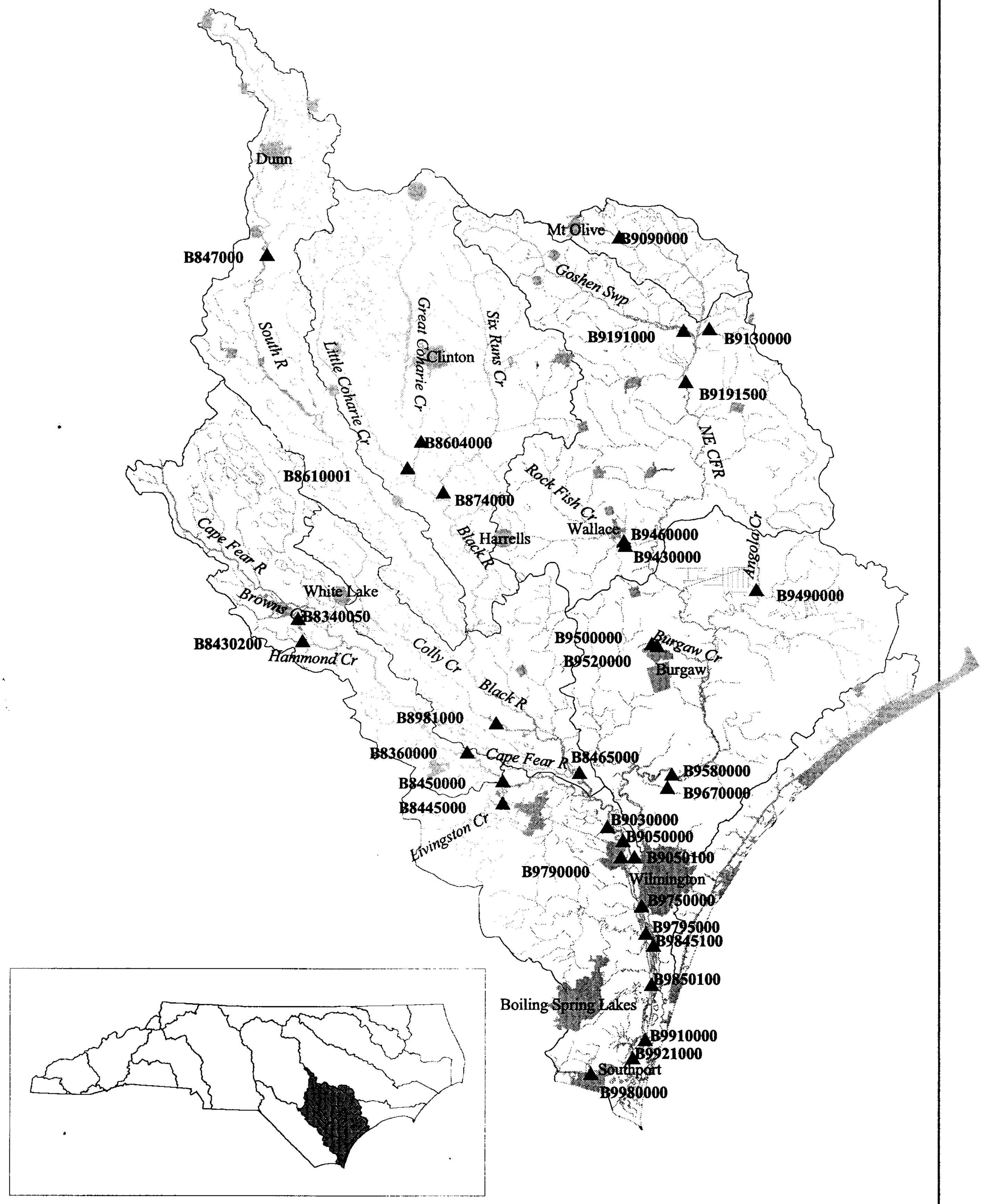


Figure A-1.2 Ambient Monitoring Stations in the mid Cape Fear River Basin

Figure A-1.3 Ambient Monitoring Stations in the lower Cape Fear River Basin

Figure A-1.4 Lower Cape Fear River Coalition Monitoring Stations



AMBIENT MONITORING SYSTEM

Introduction

Assessments of water quality can be obtained from information about the biological (fish and insect) communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures. Discussions of the various water quality parameters may be found on the world wide web at: http://esb.ehnr.state.nc.us/glossary.htm

The Division of Water Quality (DWQ) collects ambient water quality information from approximately 380 monitoring stations statewide. Complementing the data collected from the monitoring stations managed by DWQ are data collected by associations of NPDES dischargers. These coalitions of dischargers serve an important role in water quality management and are described further below.

This section of the basin assessment report presents data collected from 68 monitoring stations by the DWQ, and 34 stations by the Lower Cape Fear River Program (Tables A-1 and A-2). All stations are located within the Cape Fear watershed. Data are summarized graphically in box and whisker plots (box plots; see Fig. A-2) and by plotting the values of selected parameters by sample dates (Fig. A-12 provides an example). Data presented include parameters measured in the field (pH, dissolved oxygen and conductivity) and measured at the chemistry laboratory (nutrients, metals and fecal coliform bacteria).

Data collected from September 1993 to the end of 1997 were used in the box plots, however data from longer periods (ca. 1980 to 1997) were used for the graphs of the values of parameters by sample dates. The box plots provide measures of central tendency and variation, and are used to depict differences in the measurements of selected parameters among stations, and provide the range of values at a monitoring station (Figure A-2 provides an explanation of box plots.) The graphs of selected parameters by sample date show the temporal patterns of a parameter at one station. Simple linear regression lines were fitted to many of the plots showing temporal changes. The parameters presented here are those commonly measured and were also presented in the previous basin assessment report (Basinwide Assessment Report Support Document - Cape Fear River Basin, April 1995).

Coalitions of NPDES dischargers

Complementing the North Carolina Division of Water Quality's basin-wide approach for planning and management of water resources, associations of NPDES dischargers are voluntarily forming in our state’s river basins. The concept of these coalitions is to integrate instream sampling requirements as set forth in their NPDES permits with DWQ's basinwide management strategy. Monitoring sites and parameters are strategically located and established such that instream monitoring is more efficient, effective, basin-oriented, and potentially yields better quality, more usable data. A Memorandum of Agreement (MOA) specifies that one organization (usually a contract lab) conducts all the instream sampling and performs the required analyses, instead of each discharger conducting individual sampling. Two such associations are active in the Cape Fear River Basin and another is in the formative stage.

Table A-1. Locations of the ambient monitoring stations.

STORET Number	Subbasin (0306-)	County	Location
Haw River Mainstem			
B0040000	01	Guilford	SR 2109 near Oak Ridge
B0050000	01	Rockingham	NC Hwy 29A near Benja
B0210000	01	Alamance	SR 1561 near Altamahaw
B1140000	02	Alamance	NC Hwy 49N at Haw R.
B2000000	02	Alamance	SR 1005 near Saxapahaw
B2100000	04	Chatham	US Hwy 15-501 near Bynum
B4050000	04	Chatham	Below Jordan Dam near Moncure
Haw River Tributaries			
B0160000	01	Rockingham	Little Troublesome Creek at SR 2600 near Reidsville
B0540000	02	Guilford	North Buffalo Creek at SR 2832 near Greensboro
B0750000	02	Guilford	South Buffalo Creek at SR 2821 at Mcleansville
B0840000	02	Alamance	Reedy Fork at NC Hwy 87 at Ossipee
B1095000	02	Alamance	Jordan Creek at SR 1754 near Union Ridge
B1260000	02	Alamance	Town Branch at SR 2109 near Graham
B1960000	02	Alamance	Alamance Creek at SR 2116 at Swepsonville
B1670000	03	Guilford	Little Alamance Ck at NC Highway 61 near Whitsett -- See Footnote
B2450000	04	Chatham	Robeson Creek at SR 1939 near Seaforth
B3040000	05	Durham	New Hope Creek at SR 1107 near Blands
B3660000	05	Durham	Northeast Creek at SR 1100 near Nelson
B3900000	06	Chatham	Morgan Creek at SR 1726 near Farrington
Deep River Mainstem			
B4240000	08	Guilford	East Fork Deep R. at SR 1541 near High Point
B4615000	08	Randolph	SR 1921 near Randleman
B4800000	09	Randolph	SR 2122 at Worthville
B5070000	09	Randolph	Main St at Ramseur
B5190000	09	Moore	SR 1456 near High Falls
B5520000	10	Moore	NC Hwy 22 at High Falls
B5575000	11	Chatham	NC Hwy 42 at Carbonton
B5820000	11	Lee	US Hwys 15-501 near Sanford
B6050000	11	Chatham	CSX Railroad Bridge at Moncure
Deep River Tributaries			
B4410000	08	Guilford	Richland Creek at SR 1145 near High Point
B4890000	09	Randolph	Hasketts Creek at SR 2128 near Central Falls
B5480000	10	Moore	Bear Creek at NC Hwy 705 at Robbins
B6010000	12	Chatham	Rocky R. at US Highway 15-501

Note: Station 15 - B1670000 was included in the previous basin assessment report. It is now part of Lake Macintosh therefore this station is now discussed as a lake station.

Table continued on next page

Table A-1. Locations of the ambient monitoring stations.

STORET Number	Subbasin (0306-)	County	Location
Cape Fear Mainstem			
B6160000	07	Chatham	NC Hwy 42 near Corinth
B6370000	07	Harnett	US Hwy 401 at Lillington
B6840000	13	Harnett	NC Hwy 217 near Erwin
B7600000	15	Cumberland	NC Hwy 24 at Fayetteville
B8300000	16	Bladen	Huske Lock near Tar Heel
B8305000	16	Bladen	SR 1316 near Tarheel
B8340000	16	Bladen	Lock And Dam #2 near Elizabethtown
B8350000	16	Bladen	Lock #1 near Kelly
B8360000	16	Bladen	NC Hwy 11 near Kelly
B8450000	17	Columbus	Above Neils Eddy Landing near Acme
B9020000	17	Brunswick	Below Hale Point Landing near Phoenix
B9050000	17	Brunswick	Navassa
B9800000	17	New Hanover	Channel Marker #55 at Wilmington
B9820000	17	New Hanover	Channel Marker #50 near Wilmington
Cape Fear Tributaries			
B6830000	13	Harnett	Upper Little R. at SR 2021 near Erwin
B7280000	14	Cumberland	Little R. (Lower) at SR 1451 at Manchester
B7245000	14	Moore	Lower Little R. at SR 2023 near Lobelia
B7700000	15	Hoke	Rockfish Creek at SR 1432 near Raeford
B8220000	15	Cumberland	Rockfish Creek at US Highway 301 near Hope Mills
B8445000	17	Columbus	Livingston Creek at mouth near Riegelwood
Black River Mainstem and Tributaries			
B8750000	19	Sampson	NC Highway 411 near Tomahawk
B9013000	20	Pender	Below Raccoon Island near Huggins
B8919000	18	Bladen	South R. at SR 1503 near Parkersburg
B8545000	19	Sampson	Little Coharie Creek at SR 1240 near Roseboro
B8725000	19	Sampson	Six Runs Creek at SR 1960 near Taylors Bridge
Northeast Cape Fear River Mainstem and Tribuaries			
B9080000	21	Wayne	SR1937 near Mt. Olive
B9290000	22	Duplin	NC Highway 41 near Chinquapin
B9580000	23	New Hanover	US Highway 117 at Castle Hayne
B9740000	17	New Hanover	US Highway 421 at Wilmington
B9470000	22	Duplin	Rockfish Creek at I-40 near Wallace
Coastal Area			
B9879000	24	New Hanover	Carolina Beach Harbor near Ch Marker R6 & G7
B9874000	24	New Hanover	ICW @ US Hwys 74 & 76 @ Wrightsville Beach
B9860000	24	Onslow	ICW at NC Highway 210 at Goose Bay
B9876000	24	New Hanover	ICW at Ch Marker G151 near Everett Creek
B9872500	24	New Hanover	ICW at Ch Marker G123 near Howe Point
B9872000	24	Pender	ICW near Long Point
B9865000	24	Onslow	ICW near Morris Landing

Table A-2 Location of Lower Cape Fear River Program stations and the geometric mean[1] of fecal coliform bacteria data. (N= number of samples.)

STORET	WATERBODY	LOCATION	N	Geometric Mean
B8360000	Cape Fear R	NC 11 just below Lock	29	21.2
B8450000	Cape Fear R	Acme below Federal Paper	29	27.2
B8465000	Cape Fear R	DuPont Intake just upstream confluence with Black R.	20	28.7
B9030000	Cape Fear R	Indian Cr further below Federal Paper	29	33.4
B9050000	Cape Fear R	Navassa cluster of dischargers	29	66.2
B9050100	Cape Fear R	Horsehoe bend cluster of dischargers	28	69.0
B9750000	Cape Fear R	Marker 61 at port	29	60.0
B9795000	Cape Fear R	Marker 54 near Town Creek	29	40.6
B9845100	Cape Fear R	Marker 42 Keg Island	28	23.4
B9850100	Cape Fear R	Marker 35 Sunny Point/Olde Brunswick Towne	29	15.7
B9910000	Cape Fear R	Marker 23 area near CP&L intake canal	28	9.2
B9921000	Cape Fear R	Marker 18 area of Southport	29	9.6
B9090000	NE Cape Fear	NC 403 upstream site, below Mt. Olive pickle	20	88.5
B9191500	NE Cape Fear	Near Sarecta below Guilford Mills	30	48.3
B9580000	NE Cape Fear	US 117 above GE	29	39.2
B9670000	NE Cape Fear	Below GE	29	41.3
B8340050	Browns Cr	NC 87, mouth	30	120.4
B8340200	Hammond Cr	SR 1704	30	103.2
B8445000	Livingston Cr	At mouth below Wright Chem.	29	28.8
B8470000	South R	US 13 below Dunn	30	56.6
B8604000	Gr Coharie Cr	SR 1214 below Clinton	30	49.8
B8610001	L Coharie Cr	SR 1207	30	45.9
B8740000	Six Runs Cr	SR 1003	30	42.2
B8981000	Colly Cr	NC 53	30	33.6
B9000000	Black R	At NC 210 bridge	29	43.1
B9130000	Panther Br	Below Cates pickle	29	96.9
B9191000	Goshen Sw	NC	30	89.0
B9430000	Rockfish Cr	US 117 below Wallace WWTP, above L Rockfish Cr	30	73.6
B9460000	L Rockfish Cr	NC 11 below Stevecoknit	30	340.1
B9490000	Angola Cr	NC 53	30	40.1
B9500000	Burgaw Canal	Old RR track above Burgaw WWTP discharge	30	187.4
B9520000	Burgaw Canal	US 117 below Burgaw WWTP discharge	30	155.1
B9790000	Brunswick R	At Brunswick R sturgeon area	29	72.0
B9980000	ICW	1000 ft.west Southport's discharge	10	15.1

[1] All data collected between January 1996 and December, 1998 except for B9090000 (Jan 1997 to Dec 1998) and B9980000 (March 1998 to December 1998).

Each discharger association monitoring network complements the State's ambient statewide system of approximately 380 sampling sites. Consequently, more water quality data are available which benefits both DWQ and the discharging facilities. These sampling programs increase efficiency and significantly improve water quality monitoring data. The discharger association concept allows for a collective voice among the dischargers located in the Cape Fear River Basin and fosters better communication within the association itself and with DWQ.

The Lower Cape Fear River Program (LCFRP) is comprised of 19 NPDES dischargers and began sampling in 1996. The LCFRP currently collects water quality data at 34 sites located throughout the lower portion of the basin; results are presented in this report. This association contracts with the University of North Carolina at Wilmington (UNCW) to collect the water quality samples and benefits from additional work that UNCW conducts such as fisheries ecology and benthic infaunal community studies.

The Middle Cape Fear River Basin Association (MCFRBA) has 16 members and began sampling 30 stations in July 1998. Twenty-five of the stations are required in the MOA and the other 5 stations are sampled voluntarily by the Association. The MCFRBA contracts with a commercial lab to collect and analyze the water quality. Summaries of the MCFRBA water quality data will appear in the next round of basin planning when sufficient data are available. A discharger association is being discussed in the Upper Cape Fear River Basin. Prospective members are holding organizational meetings and weighing the benefits of membership in such an association. The DWQ has proposed a draft list of stations for the Upper Cape Fear River Basin Association.

Discussion

Data, grouped by major drainage, are presented below. Ambient water quality data collected by the DWQ are presented first, followed by data collected by the Lower Cape Fear River Program.

Flow

Flow can influence the measurements of many water quality parameters. The US Geological Survey routinely measures flow, and patterns from four monitoring stations are provided in Figure 3. High flow dilutes nutrients and other parameters, and low flow, particularly during the summer can be stressful for aquatic life. Figure A-3 shows a sustained period of low flow during the summer of 1993, and higher than usual flow during the winter of 1997. These high flows were associated with El Nino. Data were obtained from the links provided through the world wide web: http://wwwnc.usgs.gov/.

Haw River and Tributaries : (Figs A- 4, 5, 16, 18, 20, 22, and 24-30)

The Haw River mainstem stations generally show an increase in pH, dissolved oxygen conductivity (Fig. A-4), and some nutrients (Fig. A-5) from Oak Ridge to Haw River, after which concentrations are fairly constant or decrease. The influence of two Greensboro wastewater treatment plants can be seen in North and South Buffalo Creeks. Lower levels of dissolved oxygen, and high conductivities (Fig. A-4) , and high nutrient (Fig. A-5) and fecal coliform concentrations (Fig. A-16) are associated with these discharges.

Deep River and Tributaries: (Figs. A- 6, 7, 16, 18, 20, 22, and 31-37)

Field measurements for pH, dissolved oxygen and conductivity show no discernable patterns among the mainstem stations for the Deep River (Fig. A-6). However high concentrations for some nutrients begin at Randleman and decrease downstream (Fig. A-7). Also noteworthy are high conductivities and nutrients in Richland and Hasketts Creeks, below the High Point and Asheboro wastewater treatment plants.

Cape Fear River and Tributaries: (Figs. A- 8, 9, 17, 19, 21, 23, and 38-45)

There are no major differences for pH, dissolved oxygen and conductivity among the mainstem stations of the Cape Fear River until the river becomes influenced by salinity near Wilmington. Higher conductivities resulting from higher ocean salinities begin near Phoenix (Fig. A-8). Slightly lower concentrations of dissolved oxygen also begin near Phoenix (Fig A-8). Concentrations of phosphorus increase slightly from Corinth, the furthest station upstream, to Tar Heel, and then begin to decrease (Fig. A-9).

For the field parameters, Livingston Creek shows a higher pH and conductivity, and a lower concentrations of dissolved oxygen (Fig A-8). However, the Little River at Manchester, Rockfish Creek at Raeford, and Livingston Creek show elevated concentrations for some nutrients (Fig. A-9).

Black, South, NE Cape Fear Rivers and Tributaries: (Figs A- 10-13, 17, 19, 21, 23)

A decrease in median dissolved oxygen occurs between the upstream and downstream stations along the Black River (Fig. A-10). The station along the South River has the lowest pH, with a median less than 6.0 s.u.

Conductivity was very high at the Northeast Cape Fear station near Mt. Olive, resulting from the discharge associated with a pickle manufacturer (Fig.A-10). In addition to the high conductivity were low concentrations of dissolved oxygen, and high nutrients (Figs A-10, A-11). However, time series plots (Figs. A-12, A-13) show improvements in these parameters associated with improvements in the wastewater discharge. The river in this area has extensive riparian wetlands, and improvements in dissolved oxygen were not noted.

High conductivities and high nutrient concentrations, particularly phosphorus occur in Rockfish Creek (Fig. A-10, A-11), below the Wallace wastewater treatment plant.

Coastal Stations: (Figs A- 14, 15, 17, 19, 21, 23)

Dissolved oxygen concentrations and pH are relatively similar among the coastal stations (Fig. A-14). Although a graph for conductivity is presented, this parameter is influenced more by salinity from the ocean than by any anthropogenic discharge. The station at Carolina Beach show higher concentrations of nitrite+nitrate nitrogen and slightly higher concentrations of phosphorus (Fig. A-15). Fecal coliform bacteria also are greater at the Carolina Beach station (Fig. A-17).

Metals

Figures A-18 through A-23 depict concentration patterns for arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel and mercury. Concentrations for many metals were at or below detection limits resulting in graphs that resemble straight lines (see chromium, Fig. A-18 for an example.). Arsenic, cadmium, chromium lead and nickel show some samples with values greater than the detection level among coastal stations, that is those stations located in salt water (Figs. A-19, A-21, and A-23).

<u>Temporal Trends Among Mainstem Stations</u>: (Figs. A-24 to A-45)

Field and nutrient data collected at mainstem stations with long term data (since ca. 1980) along the Haw, Deep and Cape Fear Rivers were plotted to determine any temporal patterns. In general, increases in conductivity were noted for most all stations (Figs. A-25, A-32, A-39). These increases may be the result of increased development in these watersheds. Modest increases in pH can also be noted for many stations (Figs. A-24, A-31, A-38). No patterns were noted for dissolved oxygen (Figs. A-26, A-33, Fig. 40).

The most noteworthy patterns occur for nutrients. For most stations there has been a decrease or nondetectable change in nutrient concentrations since 1980. Major decreases in total Kjeldahl nitrogen (TKN) occurred in the Haw River at Haw River (Fig. A-28) and for TKN and ammonia nitrogen the Deep River near Randleman (Fig. A-34, A-35). However increases for nitrite+nitrate nitrogen occurred in the Deep River near Randleman (Fig. A-36).

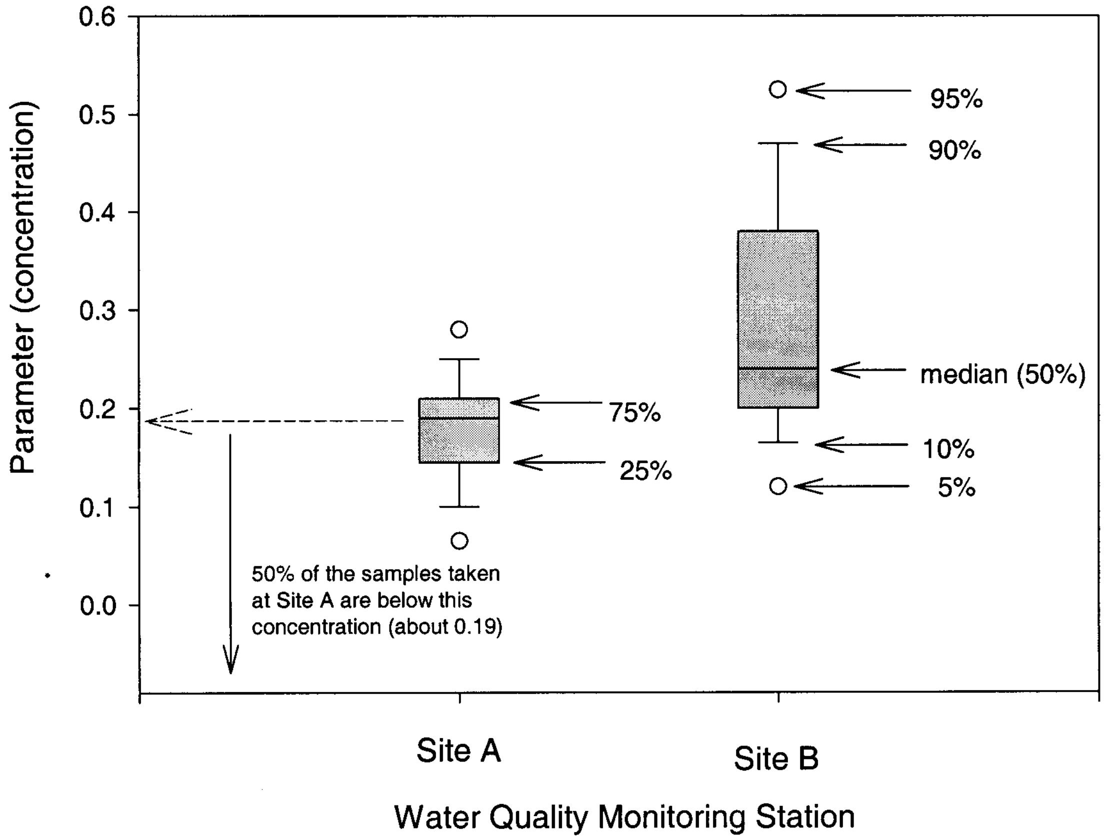
Nutrient patterns for the stations along the Cape Fear River are more difficult to discern since nutrients were not collected between 1987 to 1991. However for some nutrients and stations there was a greater frequency of samples with high nutrient concentrations during the early 1980s (Figs. A-41, A-42, A-44).

<u>Lower Cape Fear River Program</u>**:** (Figs A- 45-49)

The data collected by the Lower Cape Fear River Program are presented in Figures A-45 to A-49. These graphs depict different patterns than the graphs of the ambient data collected by the DWQ. In part these differences can be attributed to different sample locations at which some sites were established to measure the impacts associated with an NPDES discharger.

Stations located along the mainstem of the Cape Fear river show pH increasing from upstream to downstream into the more saline portions of the river. There is a modest sag in concentrations of dissolved oxygen between the stations located near the DuPont intake to Horseshoe Bend (Fig. A-45). Concentrations of total Kjeldahl nitrogen remain constant among the mainstem stations, whereas concentrations of other nutrients decrease from upstream to downstream (Fig. A-47).

Field measurements and concentrations of nutrients and fecal coliform bacteria range widely among the tributary stations (Figs A-46, A-48, A-49). High values may be the result of nearby discharges.



Explanation of Box Plots

Box plots (or box and whisker plots) show the distribution of measurements of a parameter. Here the distribution of measurements of a hypothetical parameter are compared between two stations (Site A and Site B). The percentage of measurements at or below a particular concentration are indicated on the figure. *Note that the median and variation of measurements taken at Site B are greater than the median of Site A.*

Note that the range in values along the y-axis for a particular parameter may vary among graphs.

Figure A-2. Interpreting box and whisker plots of ambient water quality data.

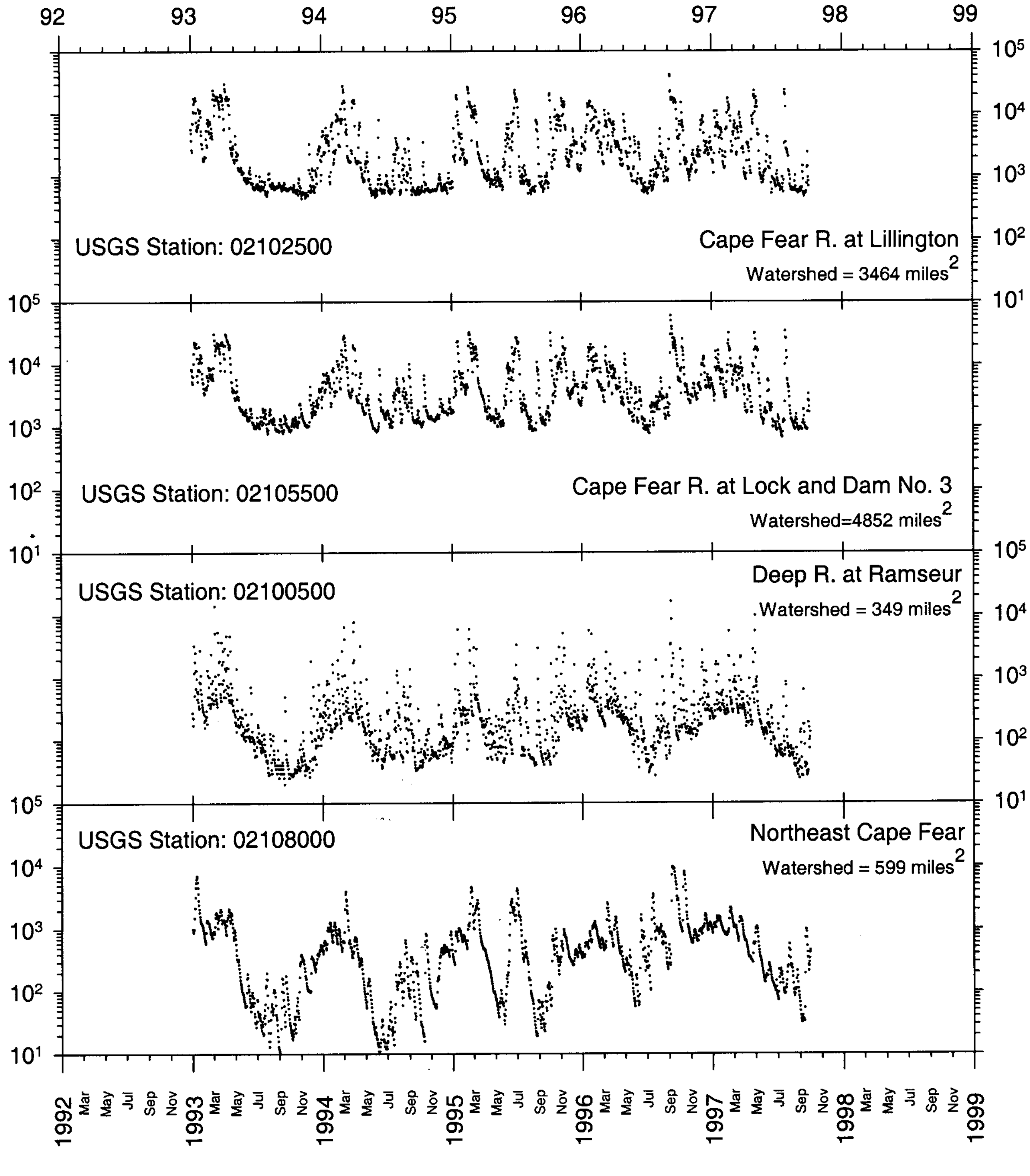


Figure A-3. Flow (cfs) at various United States Geological Survey (USGS) monitoring stations within the Cape Fear River Basin. Note the logarithmic scaling for the y-axis [flow]. Data were downloaded from the USGS North Carolina home page [http://wwwnc.usgs.gov/]. Data for October 1, 1996 through September 30, 1997 are provisional.

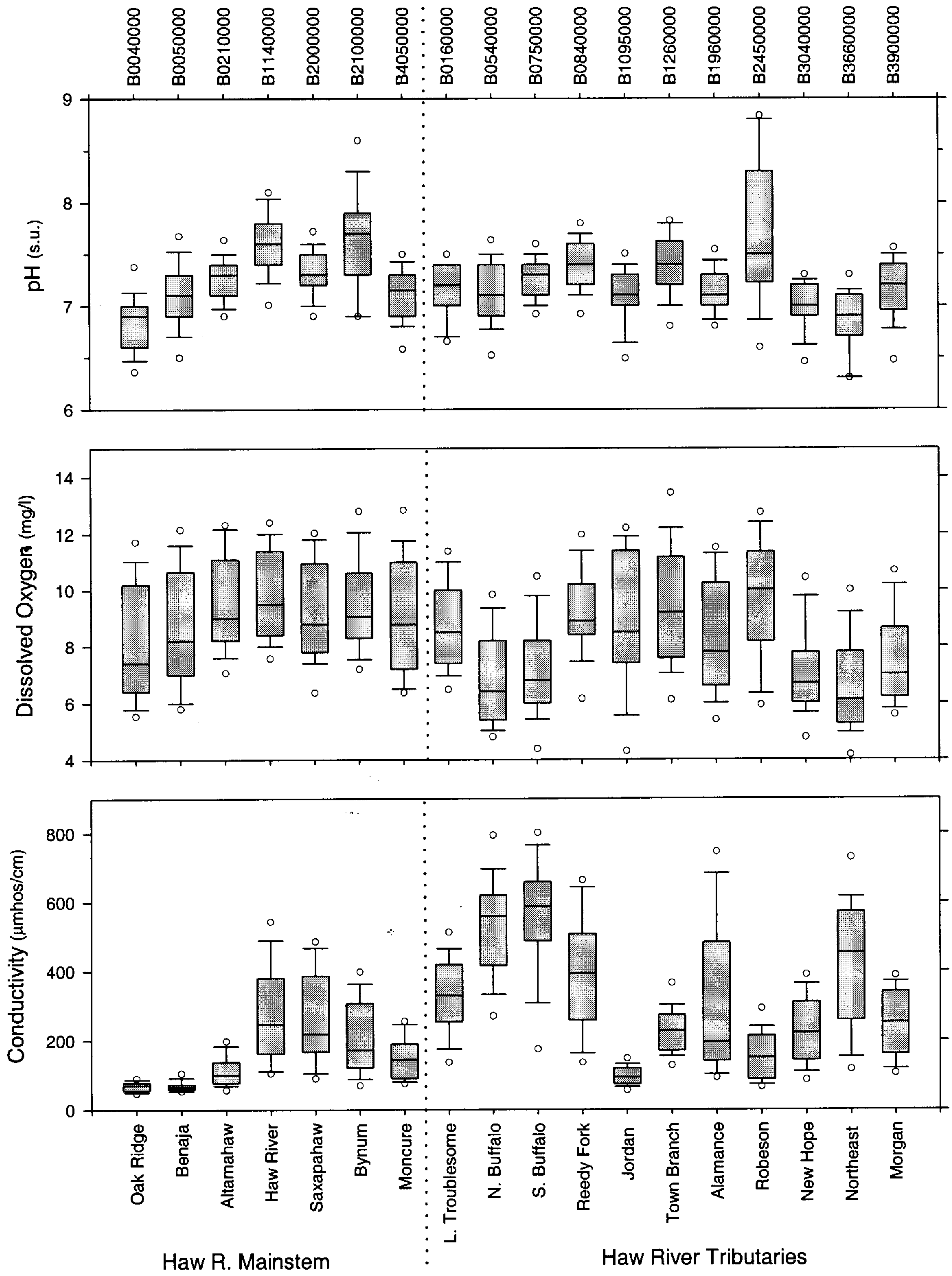


Figure A-4. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along the mainstem and tributaries of the Haw River (1993-1997).

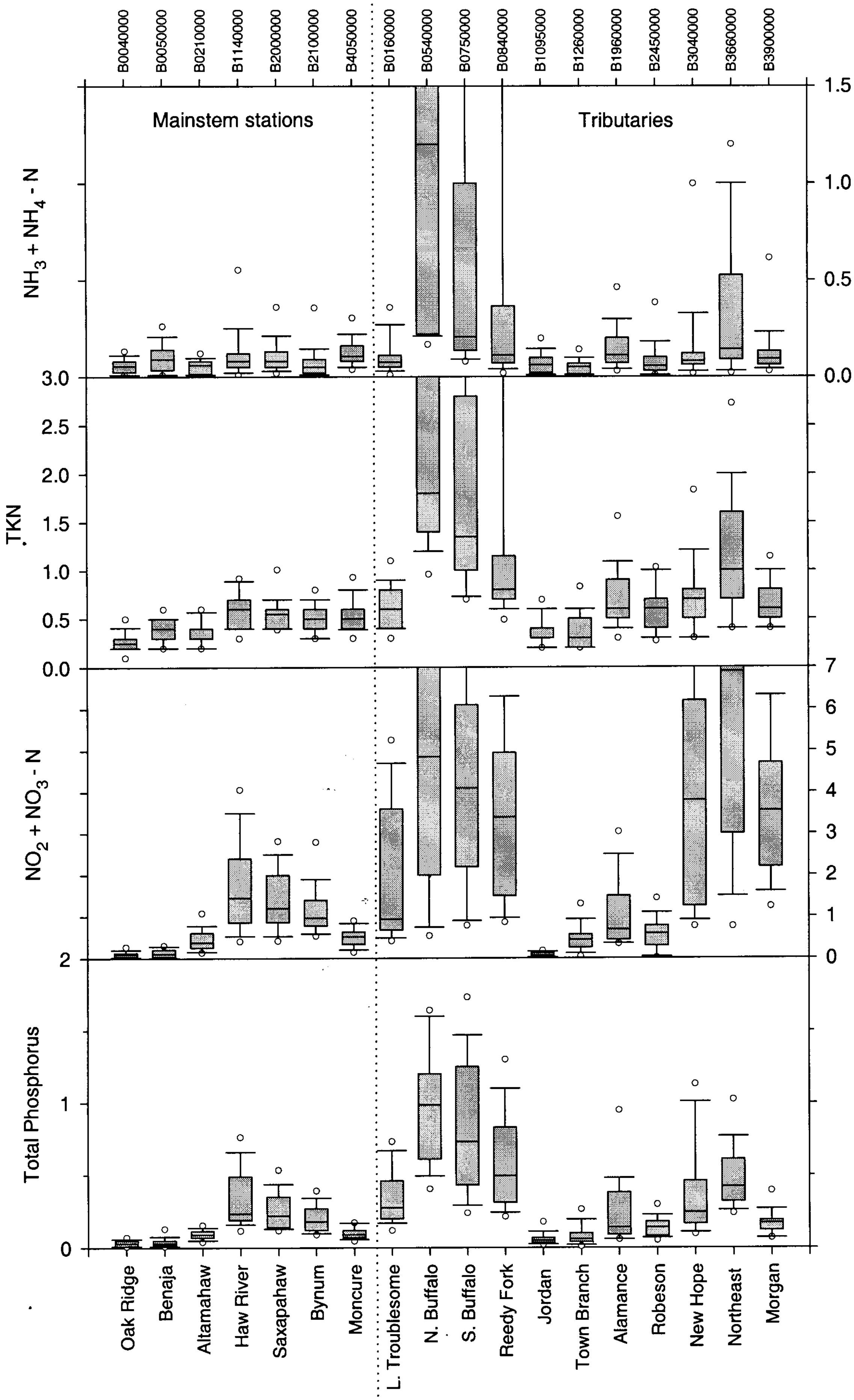


Figure A-5. Nutrients (mg/l) for the Haw R. mainstem and tributaries (1993-1997).

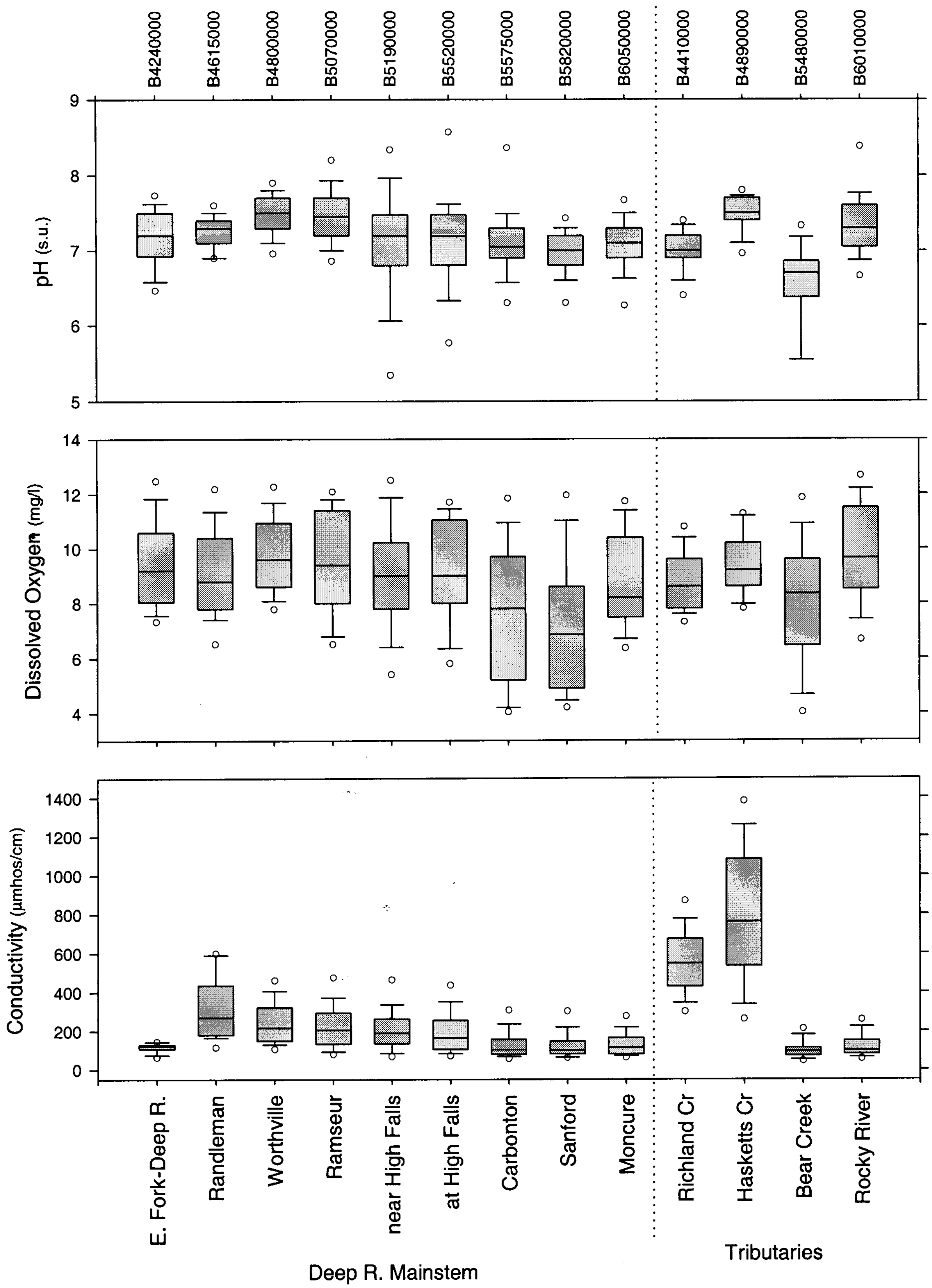


Figure A-6. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along the mainstem and tributaries of the Deep River (1993-1997).

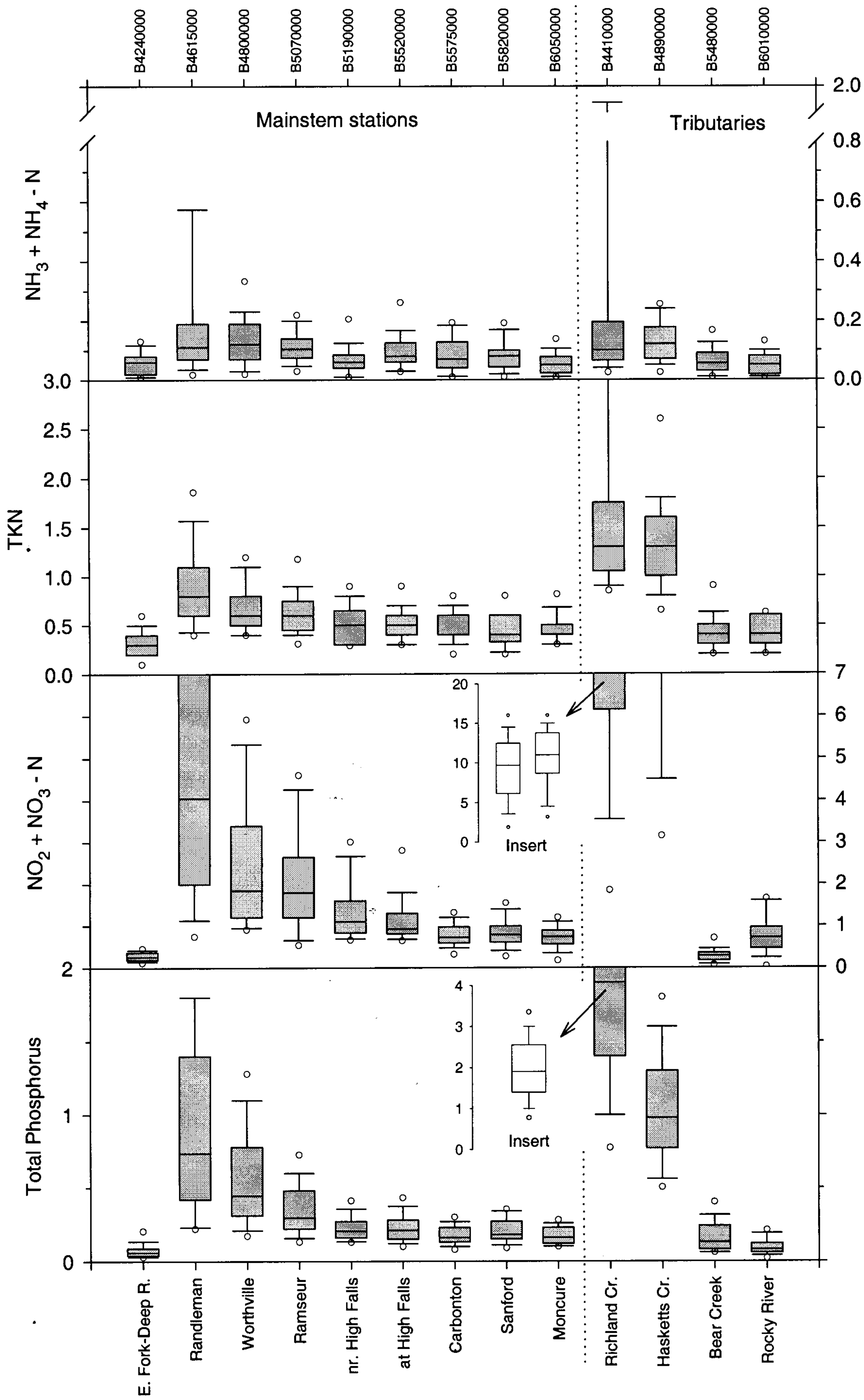


Figure A-7. Nutrients (mg/l) for the Deep R. mainstem and tributaries (1993-1997).
(Inserts represent exanded views of adjacent plots)

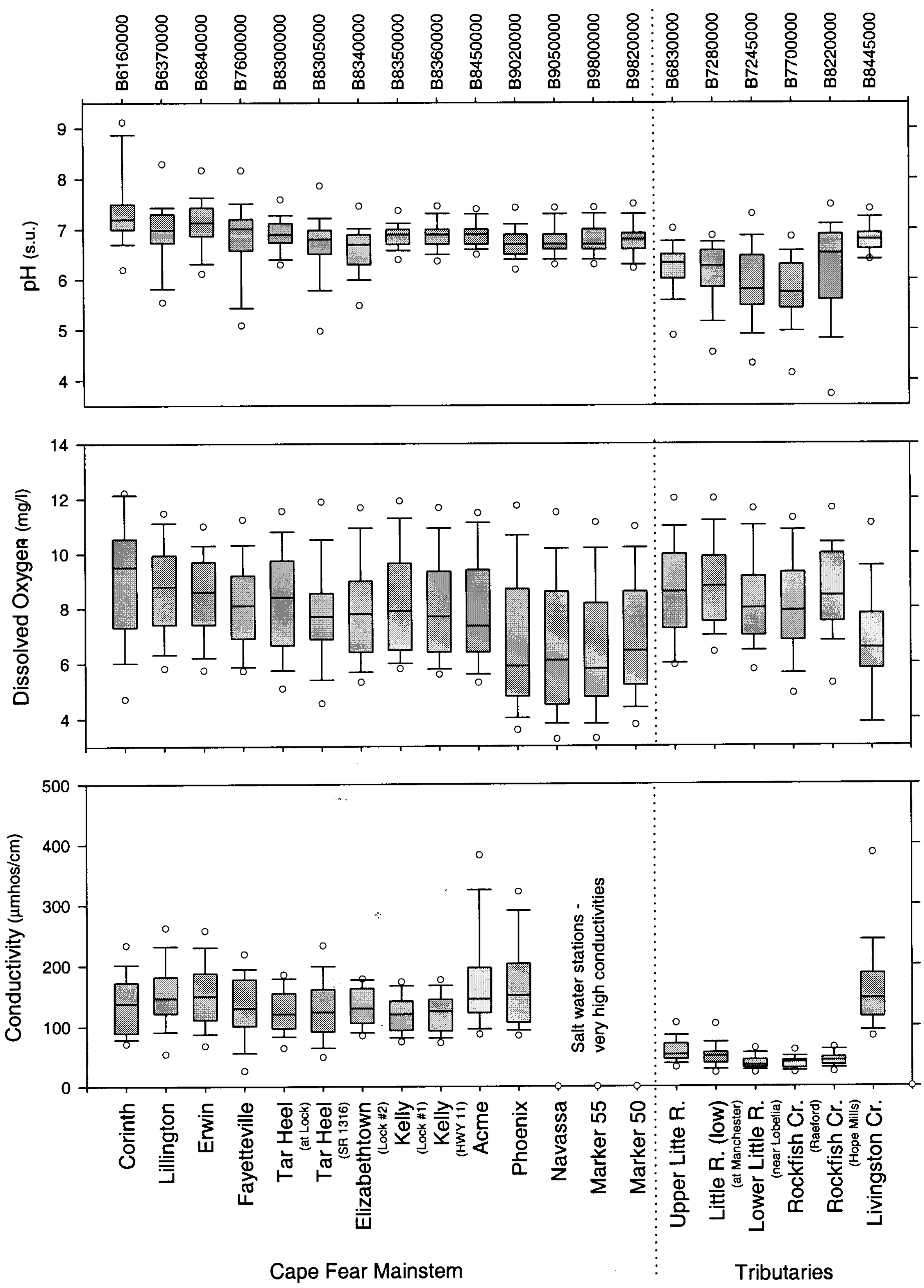


Figure A-8. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along the mainstem of the Cape Fear River (1993-1997).

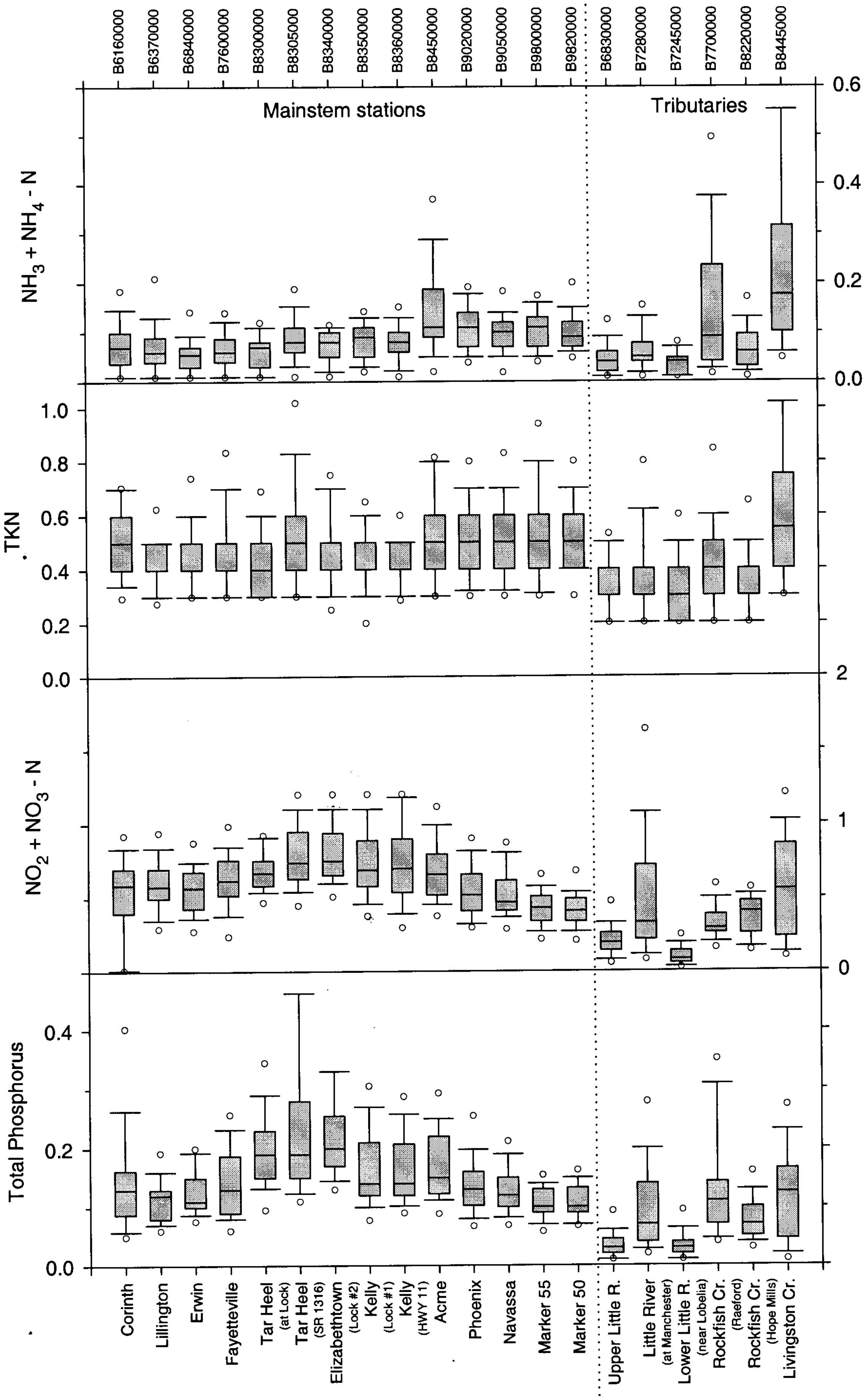


Figure A-9. Nutrients (mg/l) for the Cape Fear R. mainstem and tributaries (1993-1997).

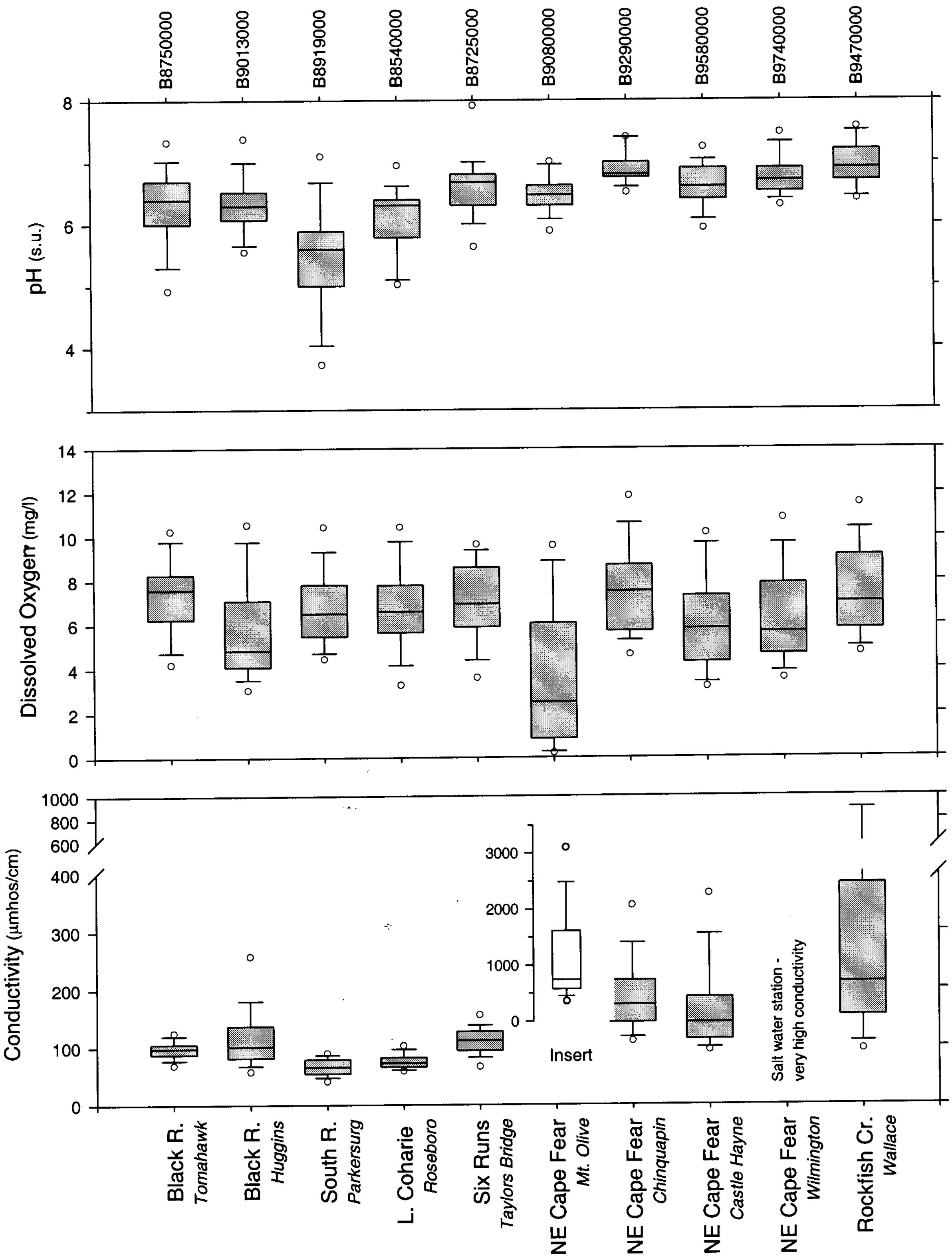


Figure A-10. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along the Black, South, NE Cape Fear Rivers and various tributaries (1993-1997). Figure 12 provides the temporal patterns of these parameters for station B9080000 near Mt. Olive.

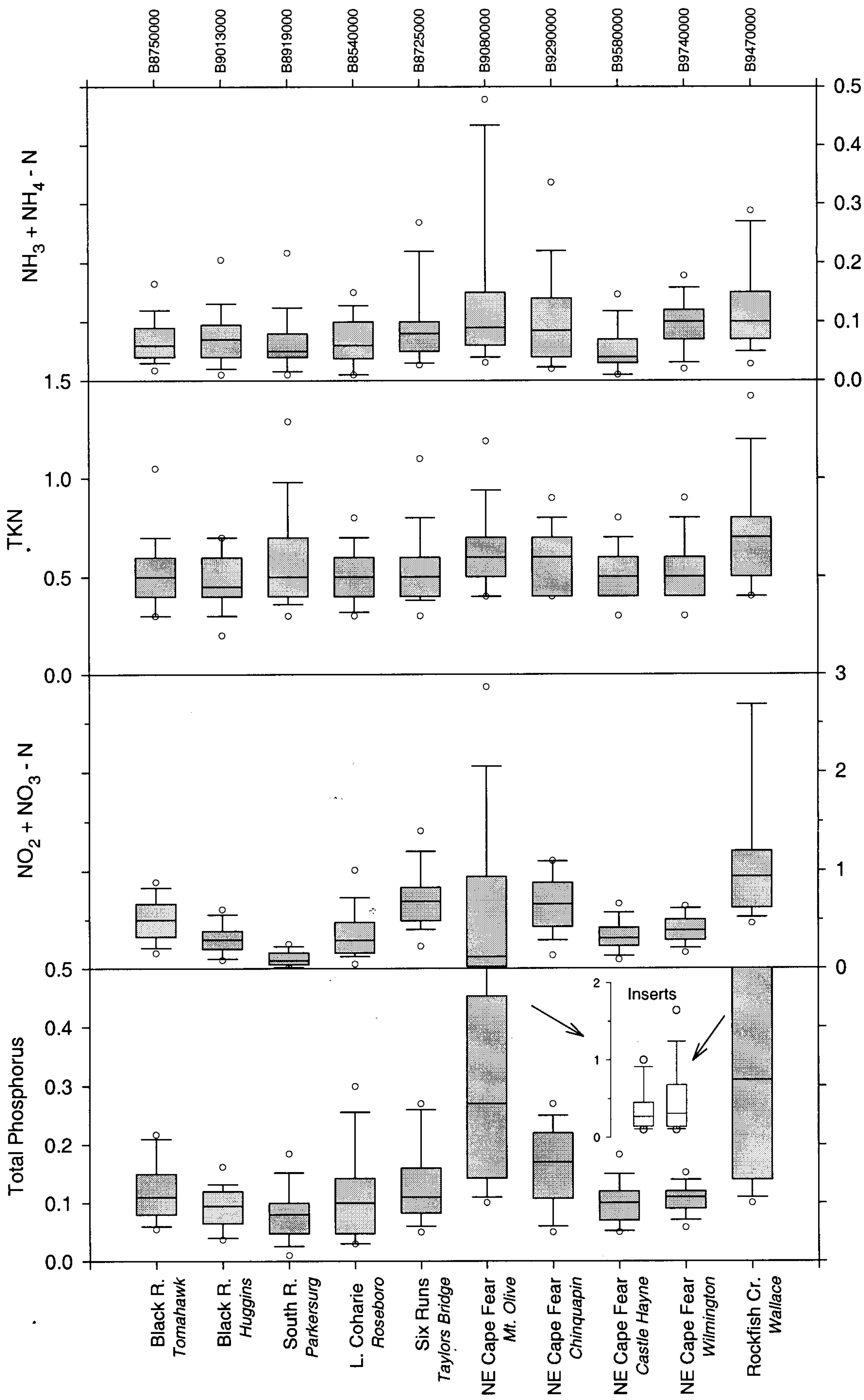


Figure A-11. Nutrients (mg/l) for the Black, South and NE Cape Fear Rivers and various tributaries (1993-1997; Insert represents expanded views of plots. Figure 13 provides the temporal patterns of these parameters for station B9080000 near Mt. Olive)

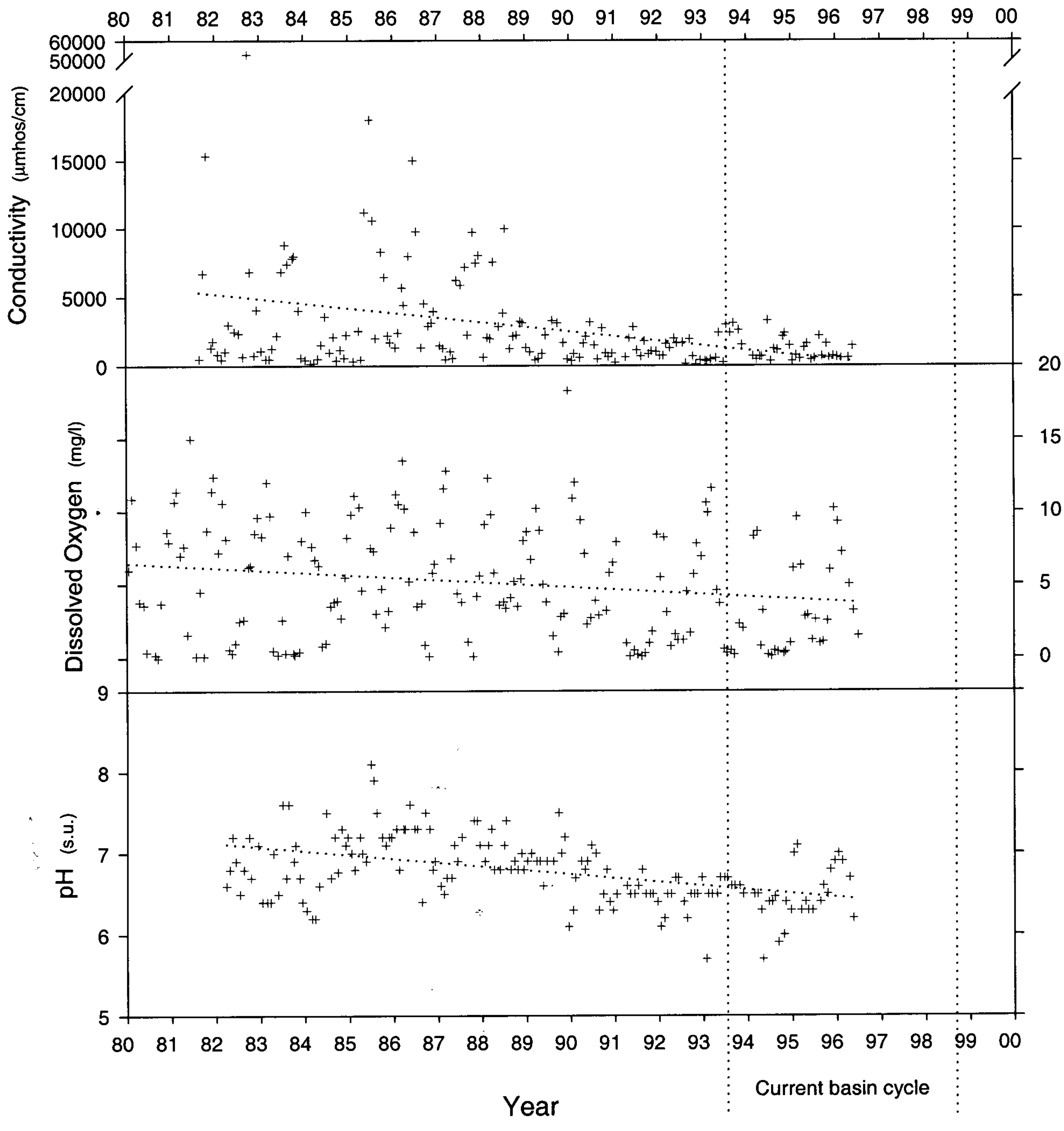


Figure A-12. Temporal patterns for conductivity, dissolved oxygen and pH for station B9080000, NE Cape Fear at SR 1937 near Mt. Olive.

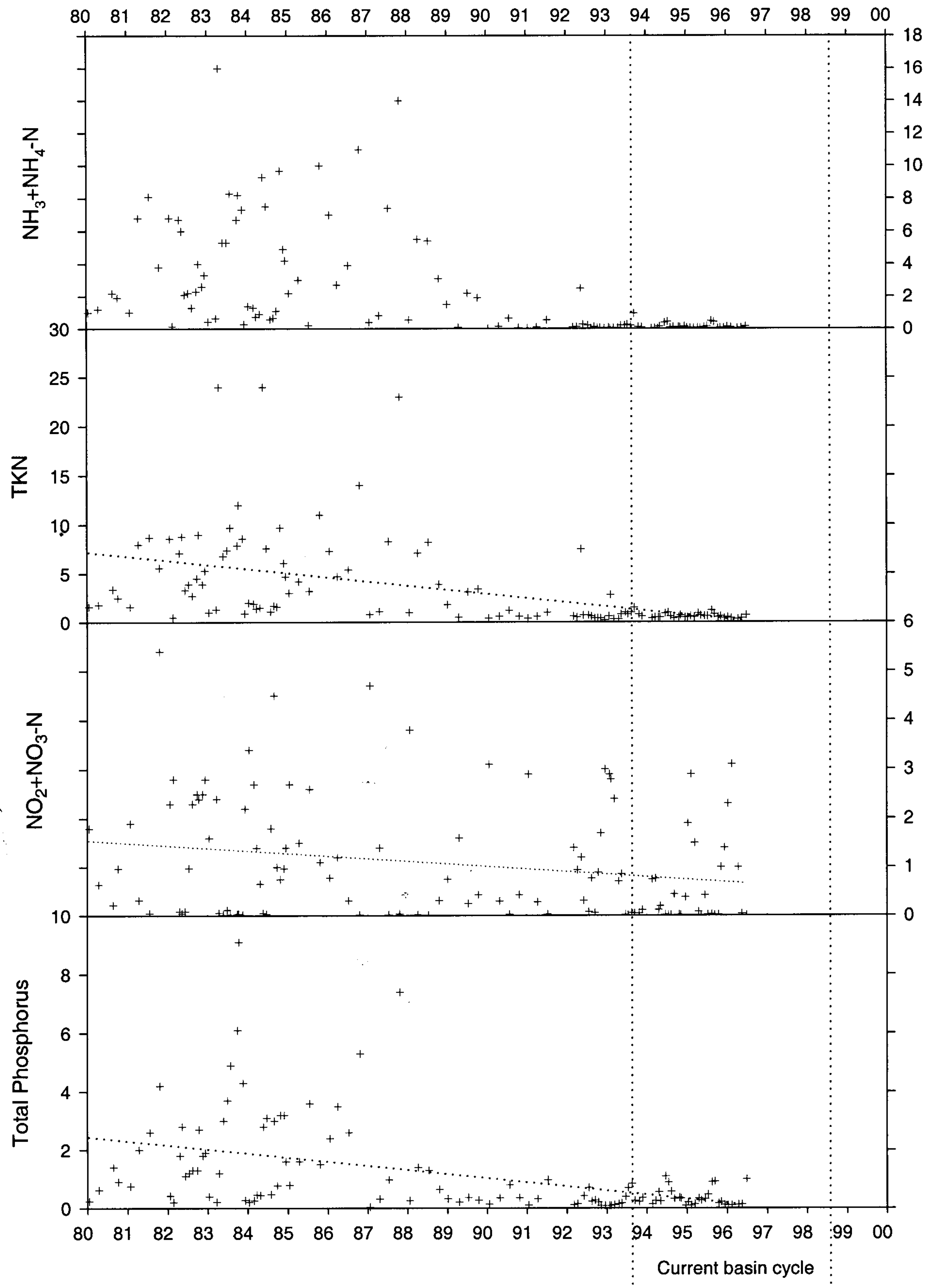


Figure A-13. Temporal patterns for nutrients (all mg/l) for station B9080000, NE Cape Fear at SR 1937 near Mt. Olive

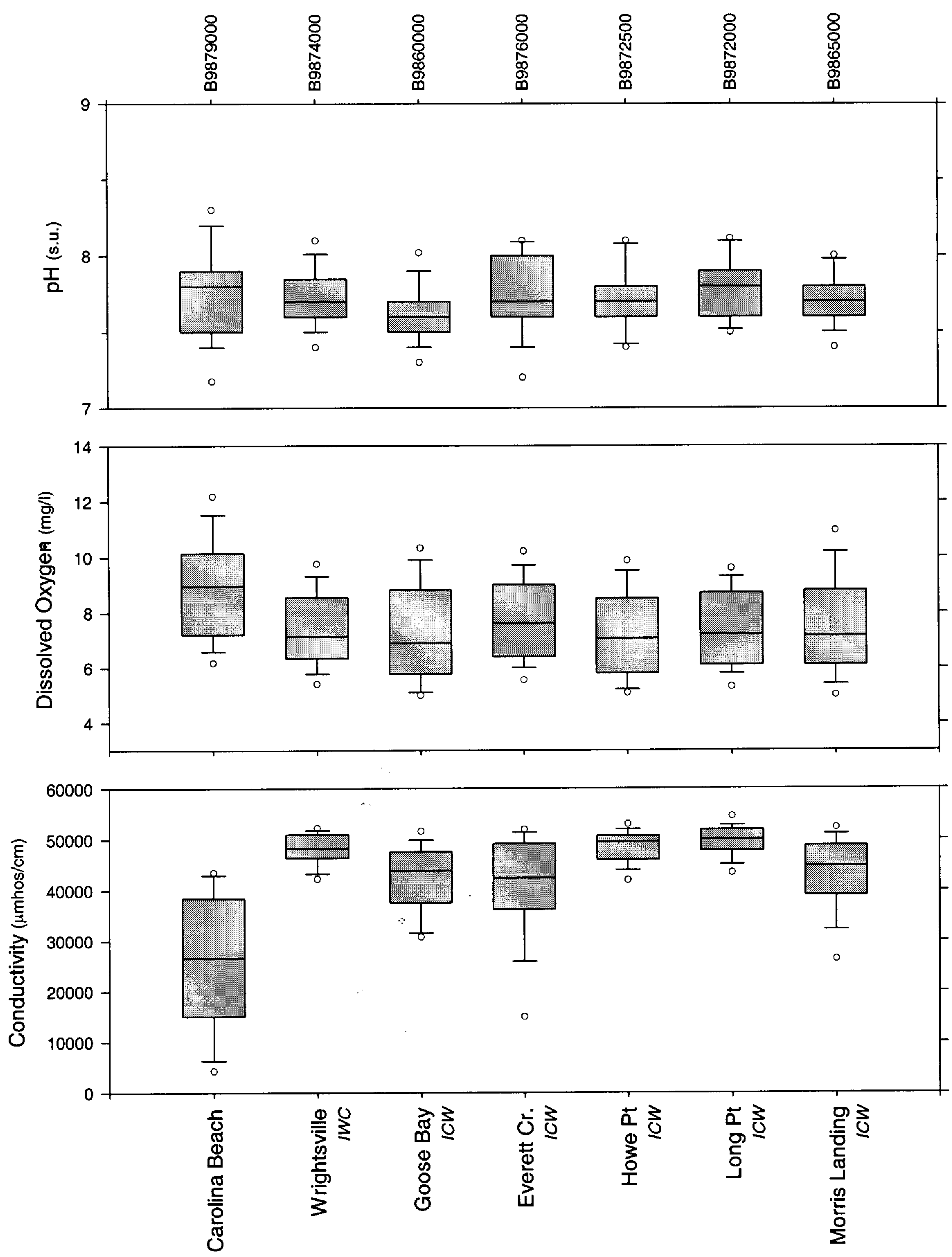


Figure A-14. Box plots for dissolved oxygen, pH and conductivity for seven monitoring stations along the coast (1993-1997). Note: Conductivity is not a useful parameter for interpreting water quality at saline stations. The data are presented here in order to be consistent with the other graphs.

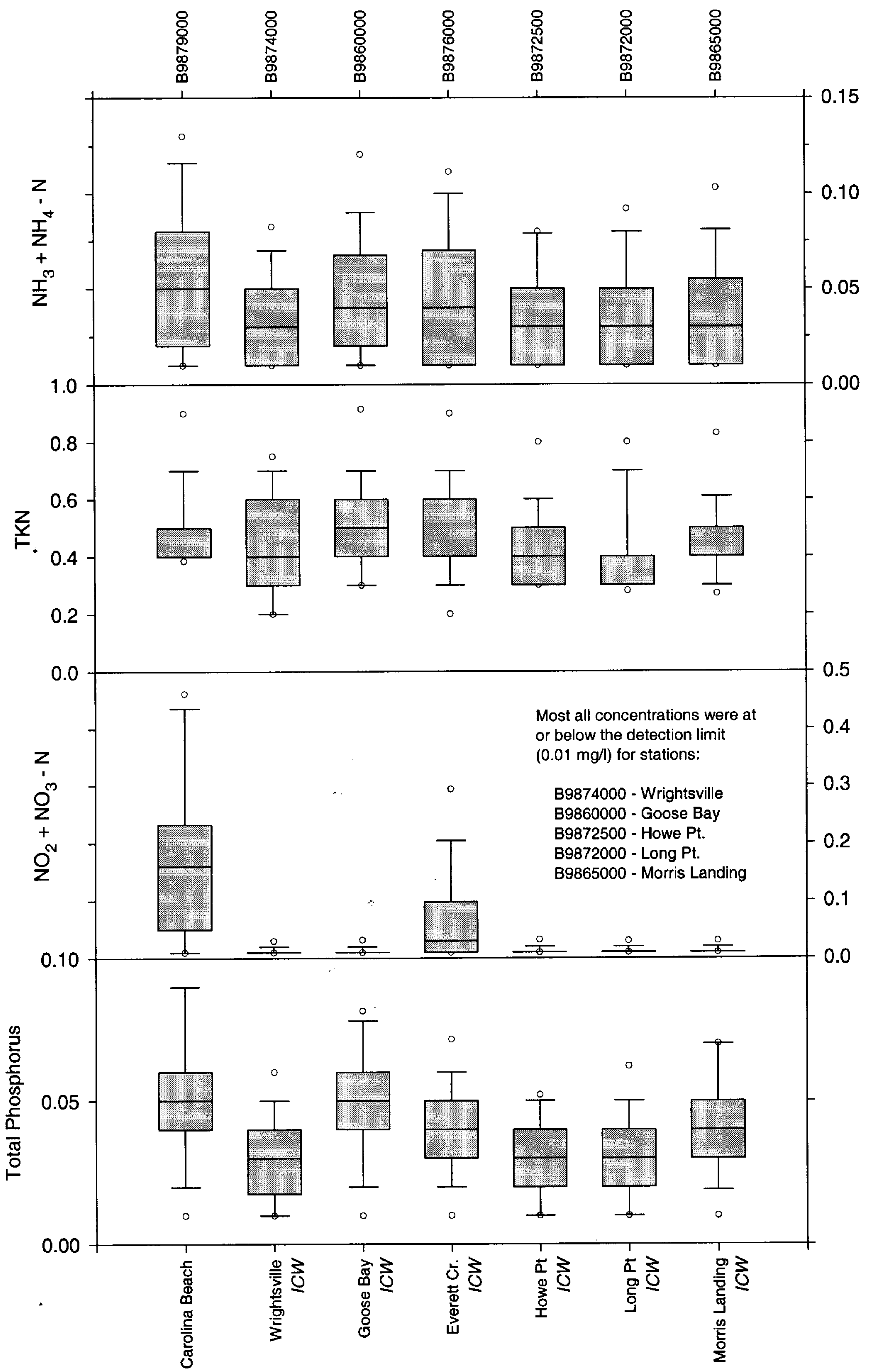
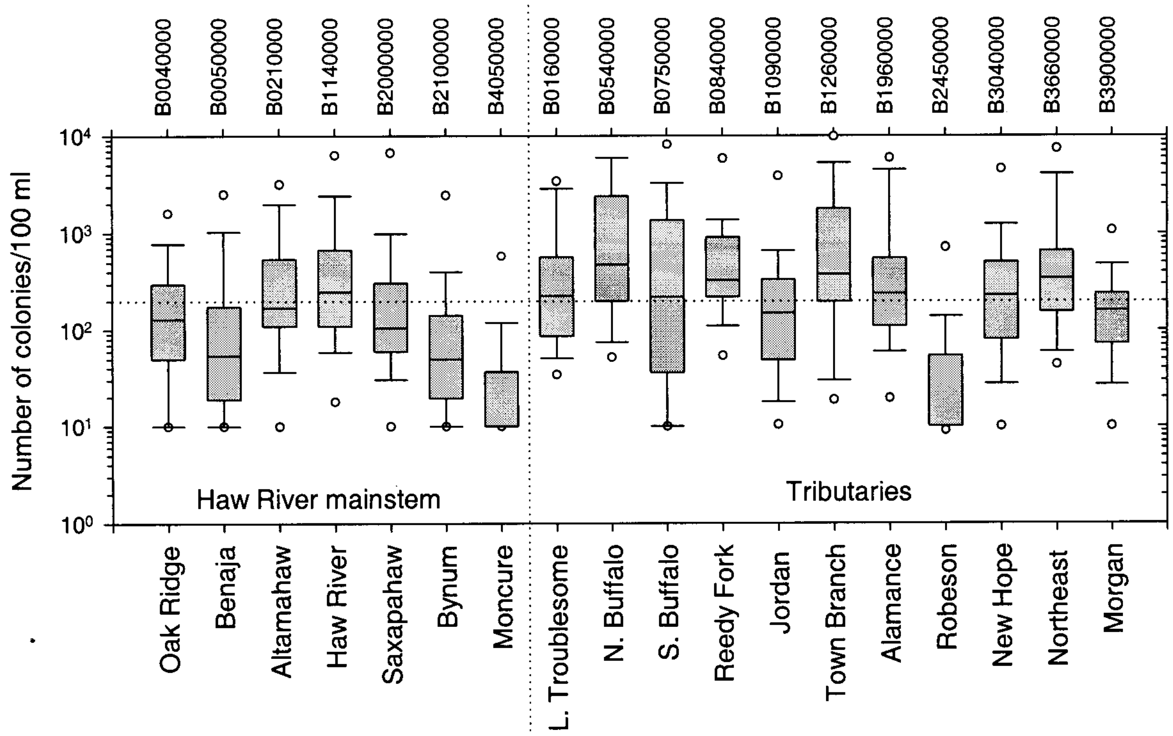


Figure A-15. Nutrients (mg/l) for the coastal stations (1993-1997).



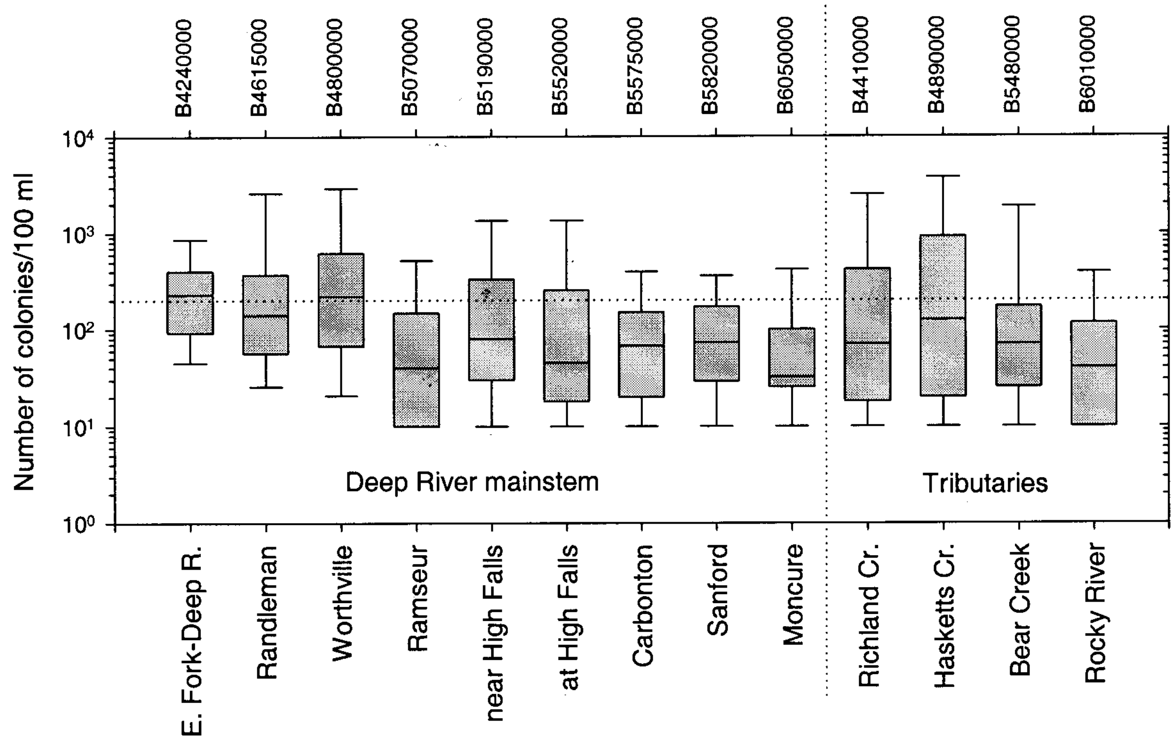


Figure A-16. Concentrations of fecal coliform bacteria 1993-1997. (Note the logarithmic scaling for the y-axis. A reference line representing 200 colonies per 100 milliliters is provided.)

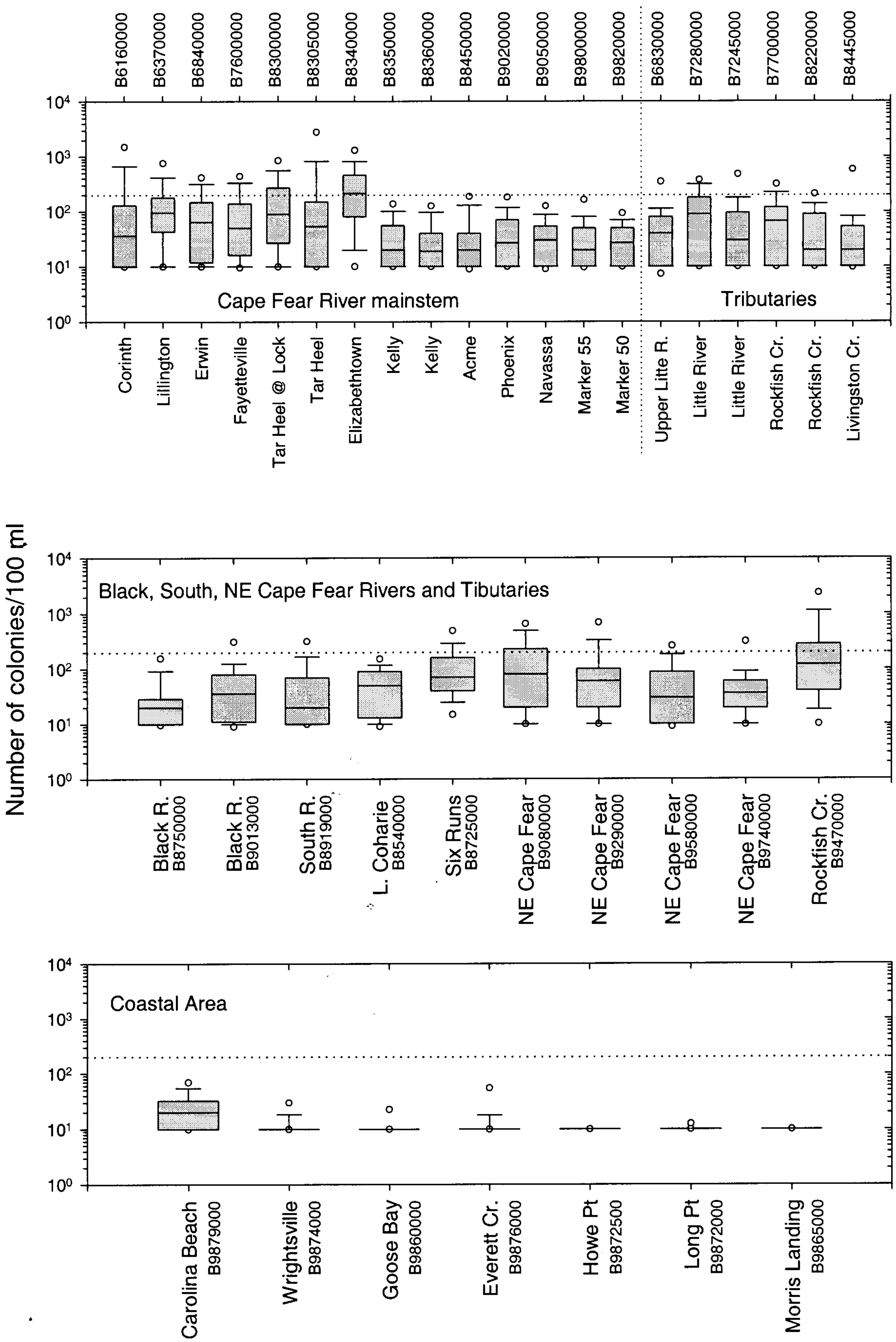


Figure A-17. Concentrations of fecal coliform bacteria (1993-1997). (Note the logarithmic scaling for the y-axis. A reference line representing 200 colonies per 100 milliliters is provided.)

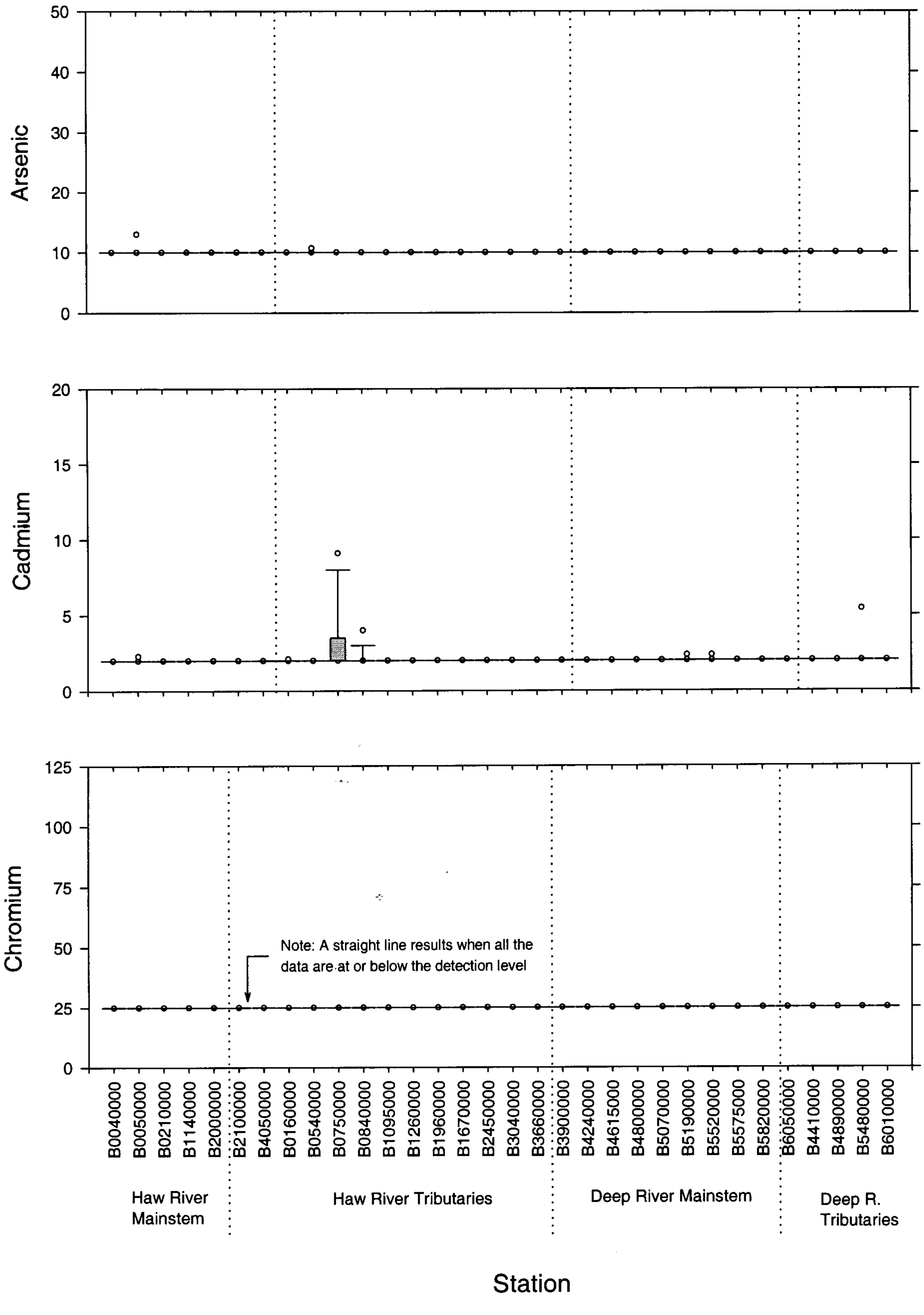


Figure A-18. Box plots of the concentrations (µg/l) of arsenic, cadmium and chromium for monitoring stations along the Haw and Deep rivers

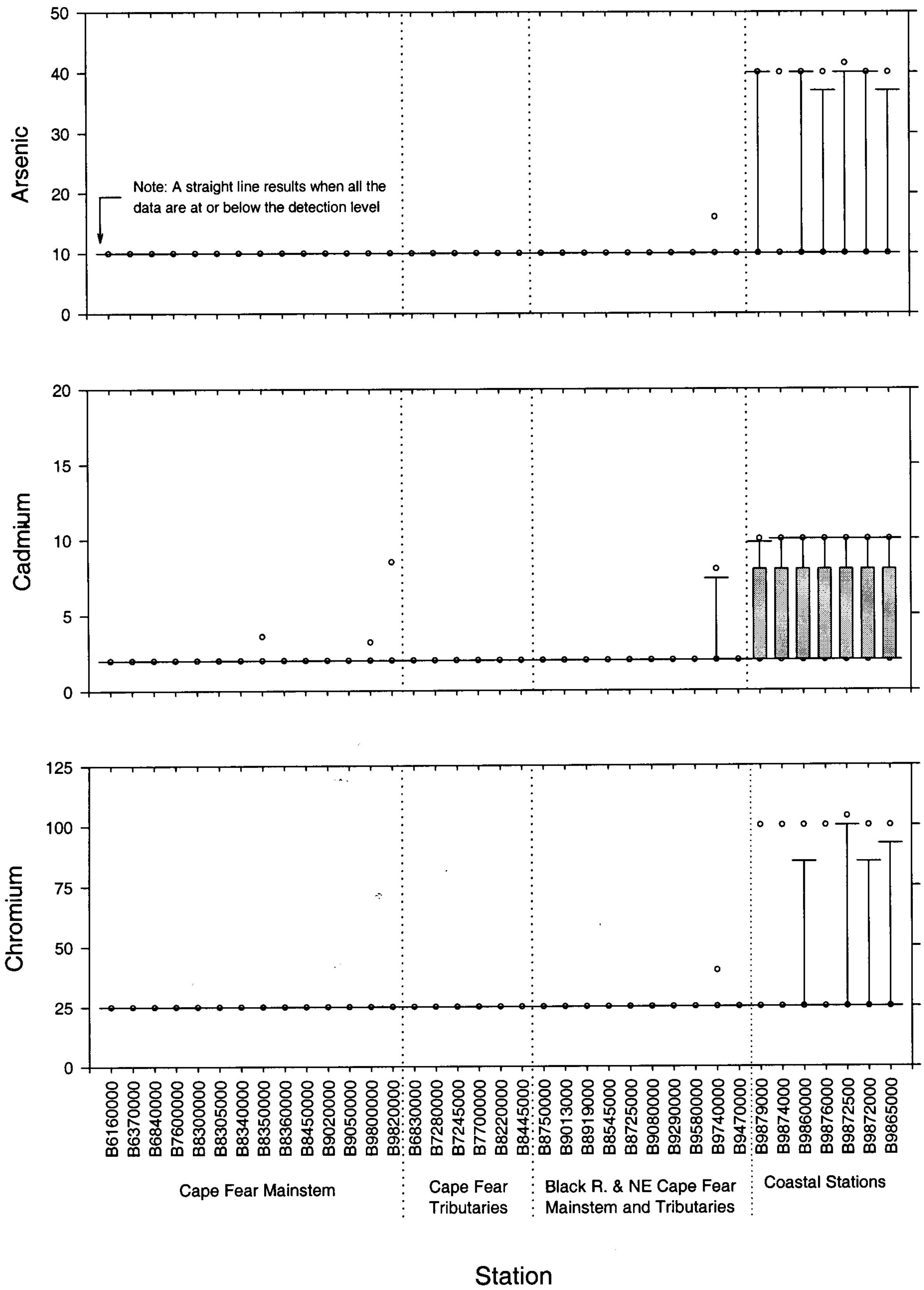


Figure A-19. Box plots of the concentrations (µg/l) of arsenic, cadmium and chromium for monitoring stations along the Cape Fear, Black, NE Cape Fear rivers and along the coast.

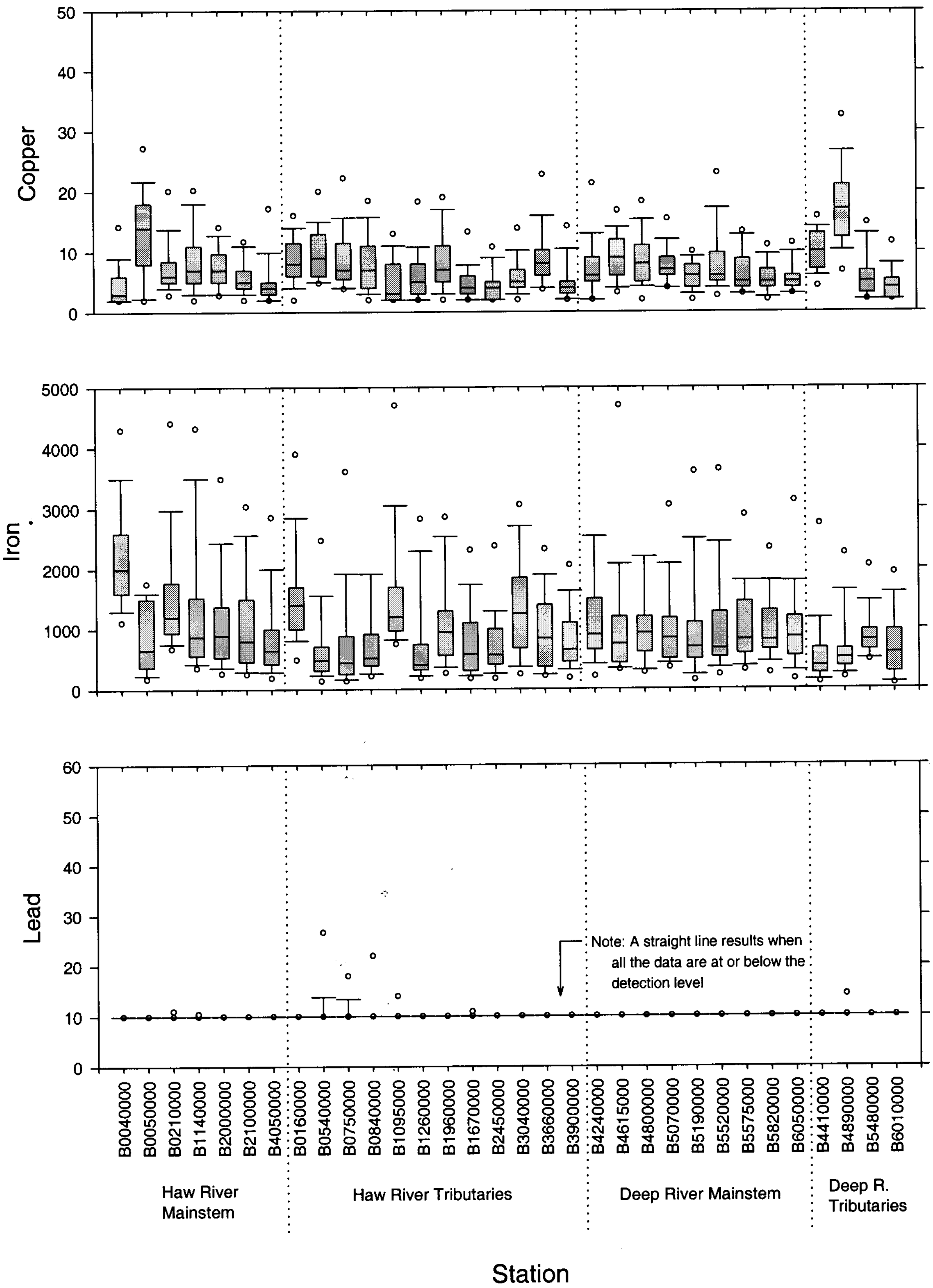


Figure A-20. Box plots of the concentrations (μg/l) of copper, iron and lead for monitoring stations along the Haw and Deep rivers.

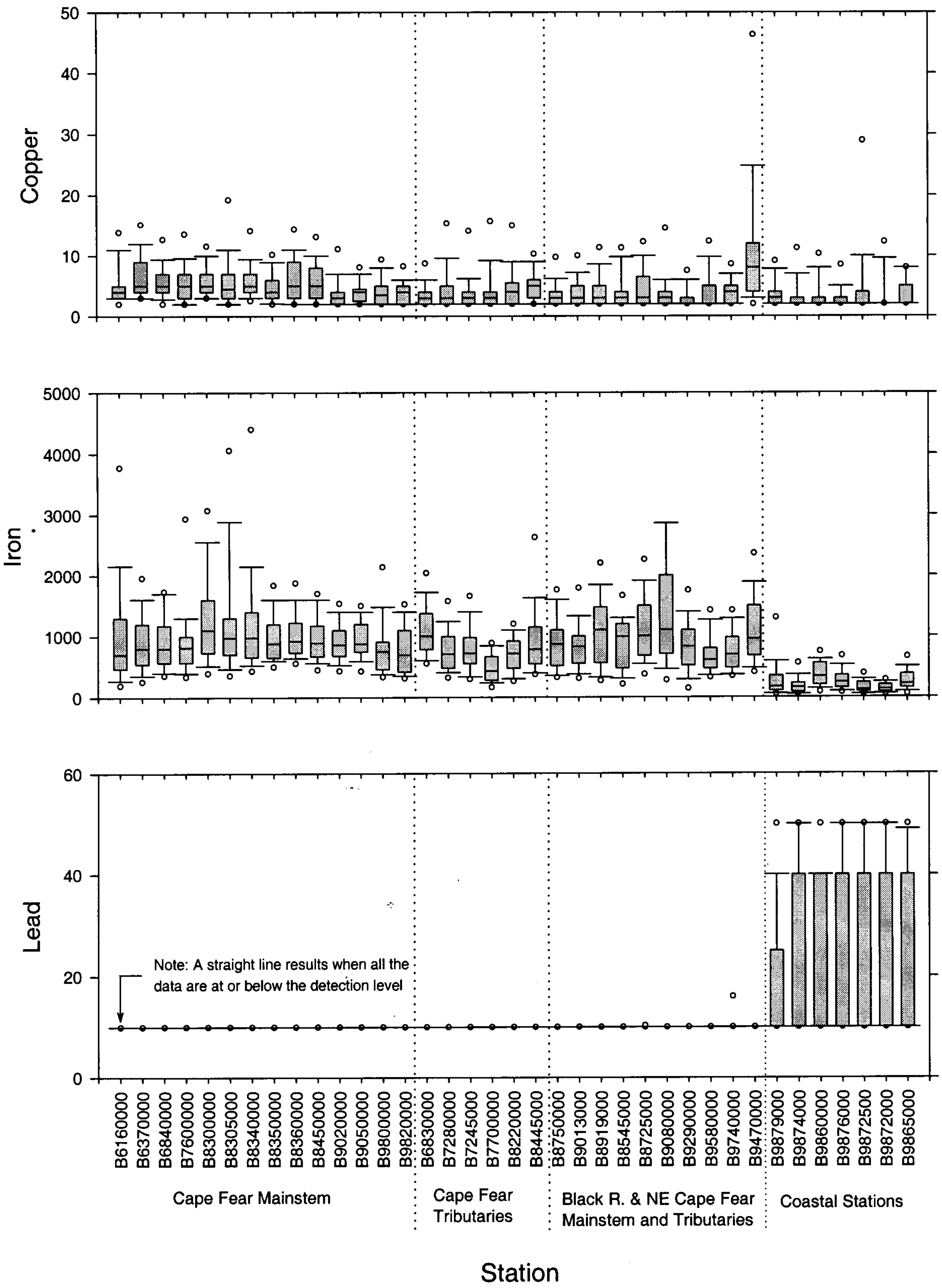


Figure A-21. Box plots of the concentrations (µg/l) of copper, iron and lead for the monitoring stations along Cape Fear, Black, NE Cape Fear rivers, and along the coast.

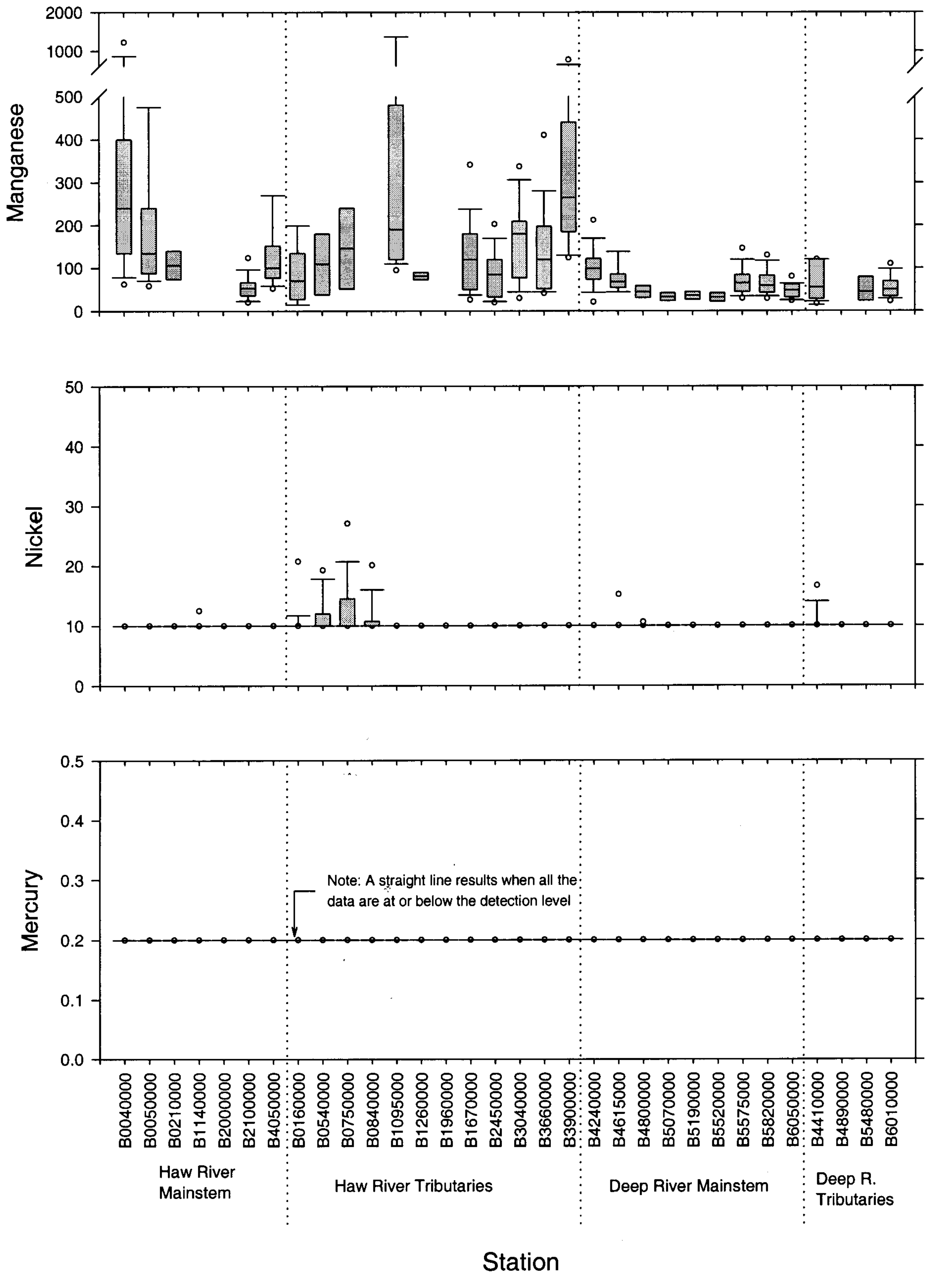


Figure A-22. Box plots of the concentrations (μg/l) of manganese, nickel and mercury for monitoring stations along the Haw and Deep rivers.

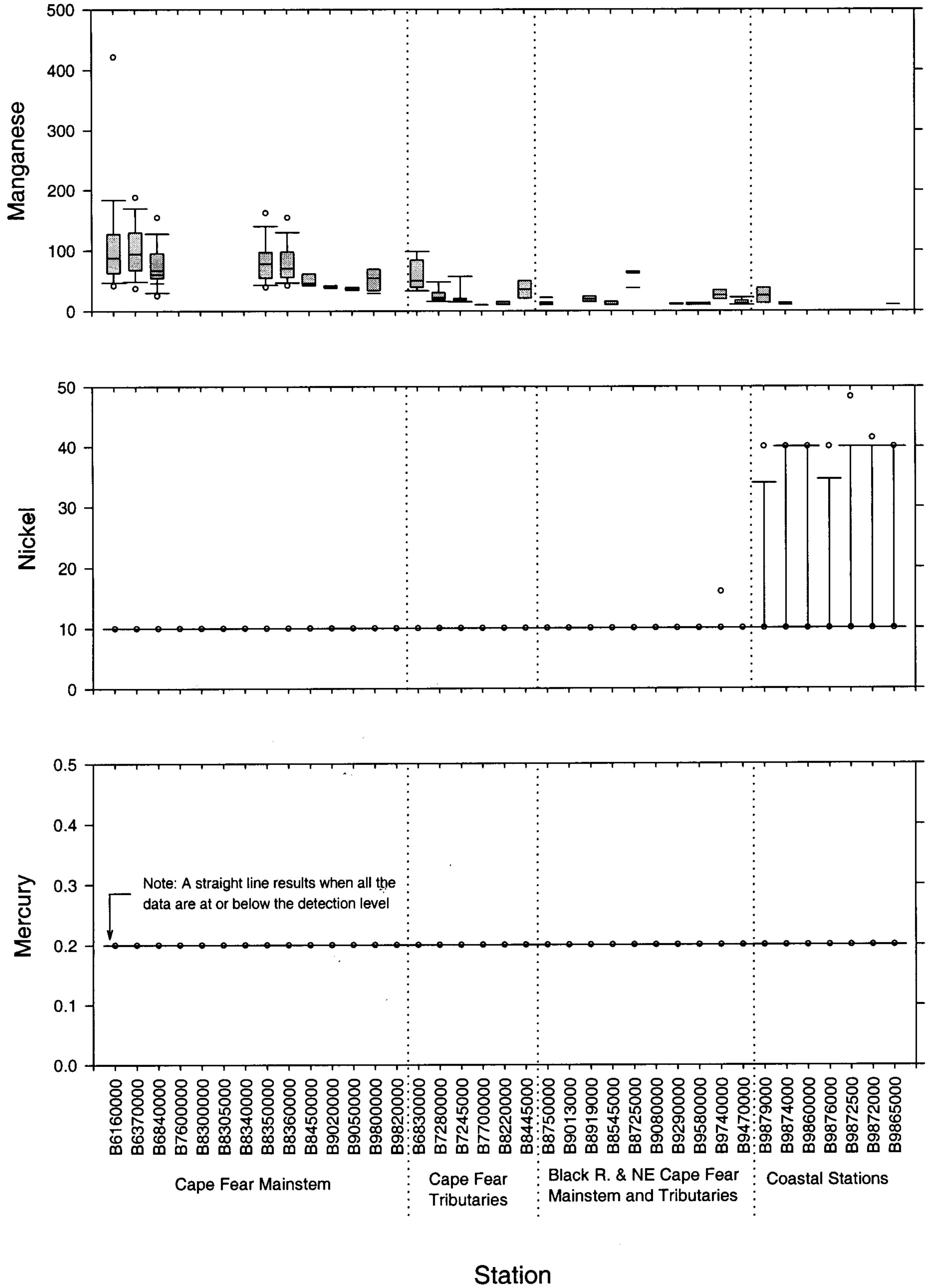


Figure A-23. Box plots of the concentrations (µg/l) of manganese, nickel and mercury for monitoring stations along the Cape Fear, Black, NE Cape Fear rivers, and along the coast.

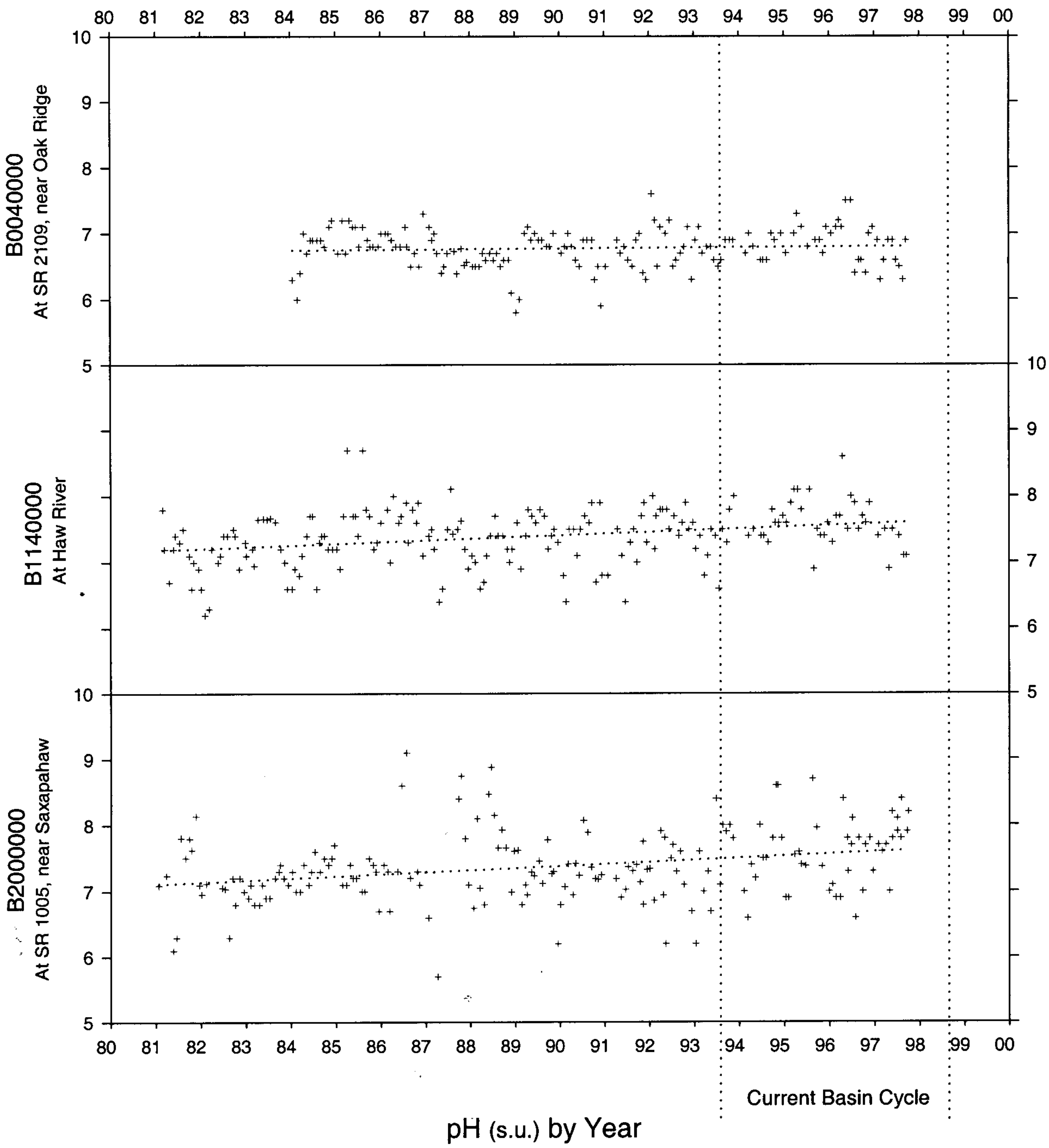


Figure A-24. Measurements of pH (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

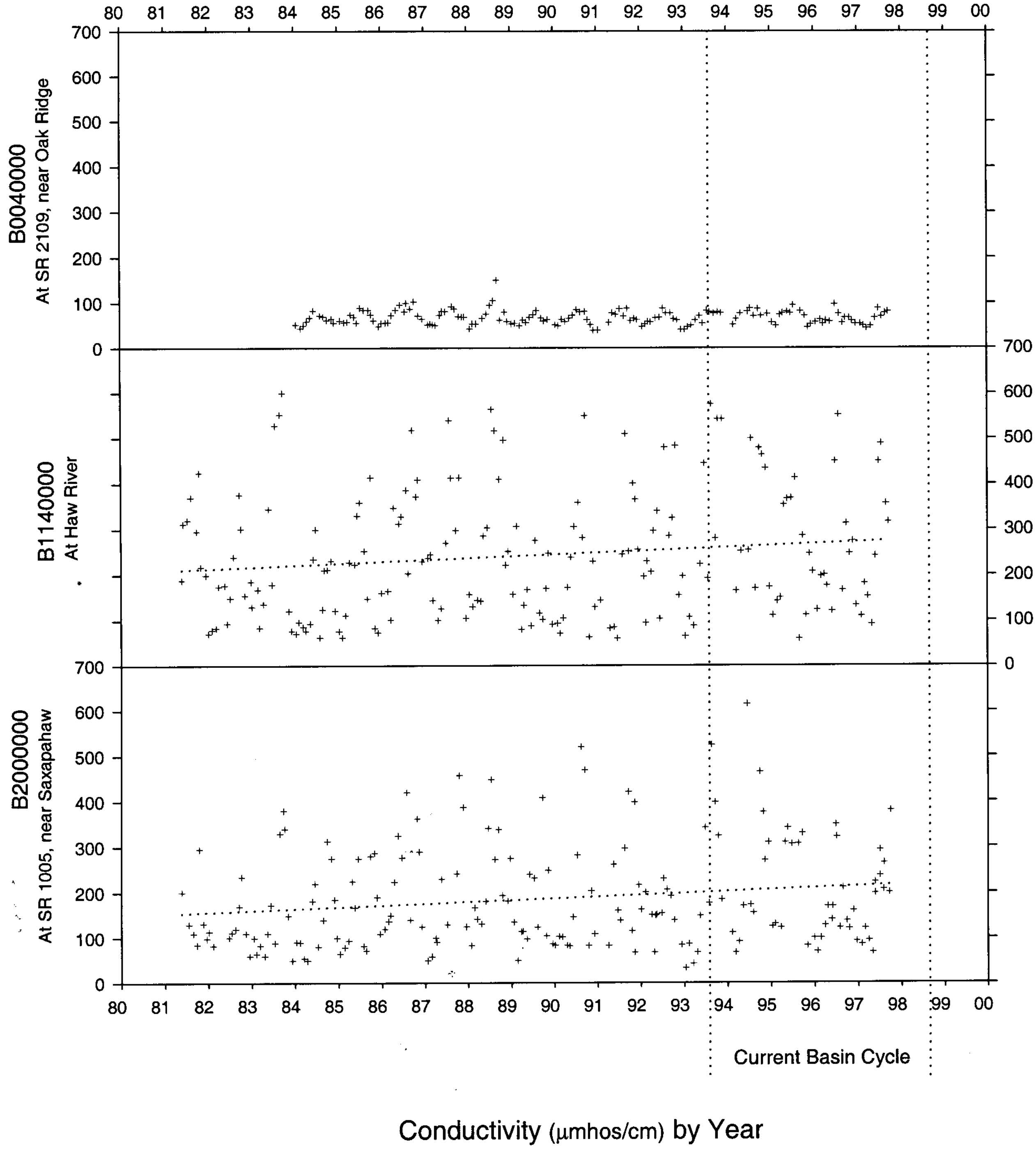


Figure A-25. Measurements of conductivity (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

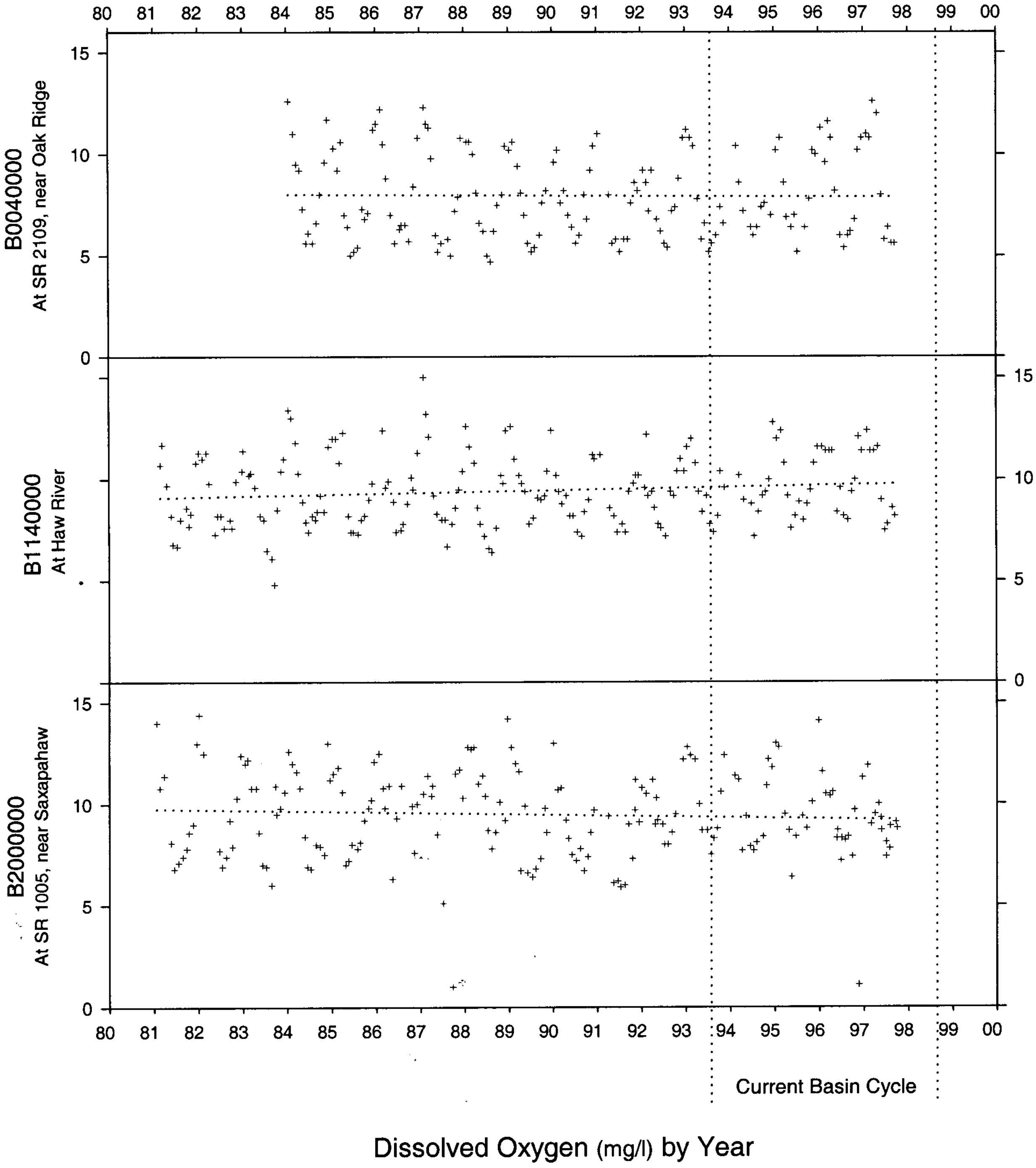


Figure A-26. Measurements of dissolved oxygen (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

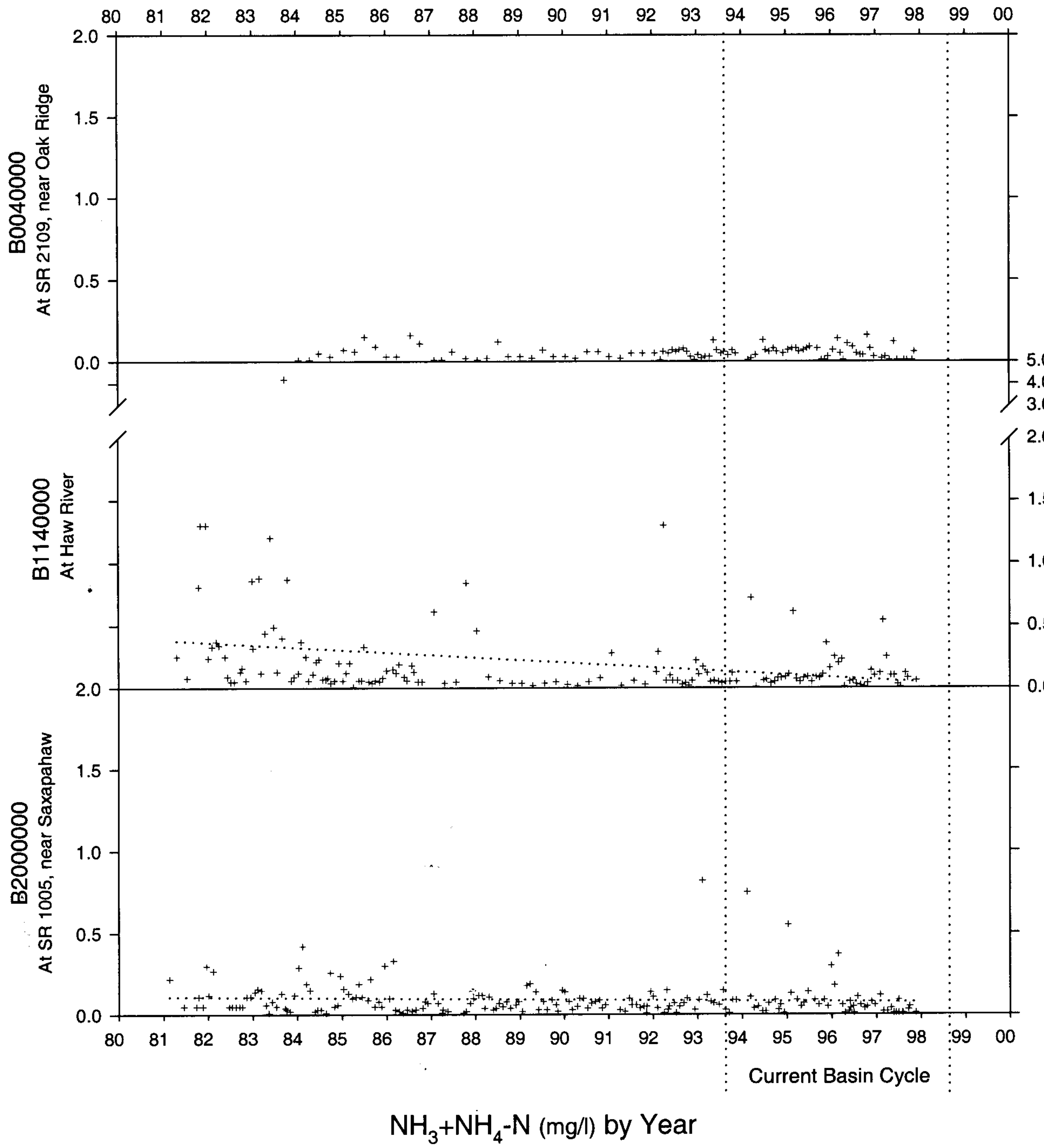
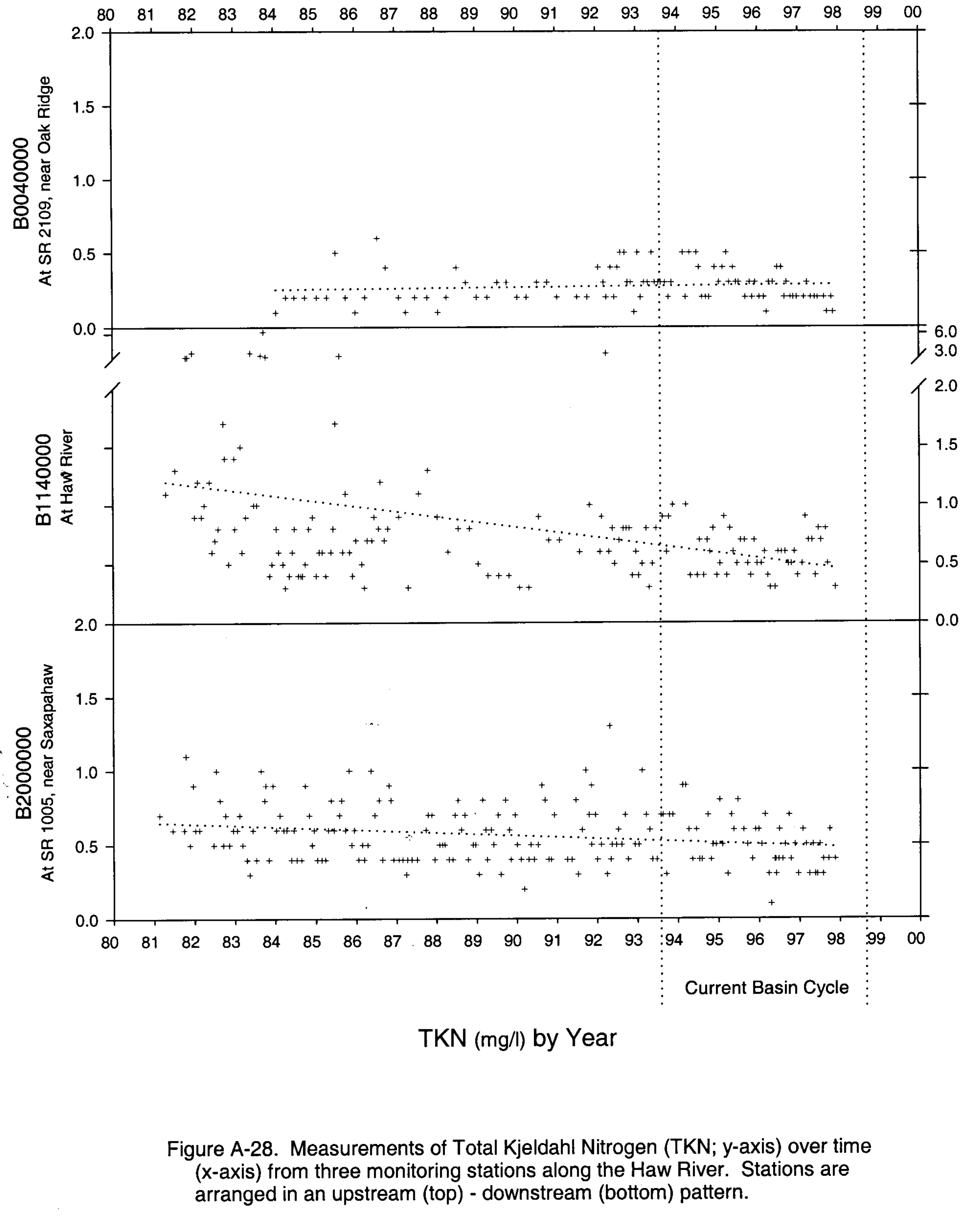


Figure A-27. Measurements of ammonia nitrogen (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.



TKN (mg/l) by Year

Figure A-28. Measurements of Total Kjeldahl Nitrogen (TKN; y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

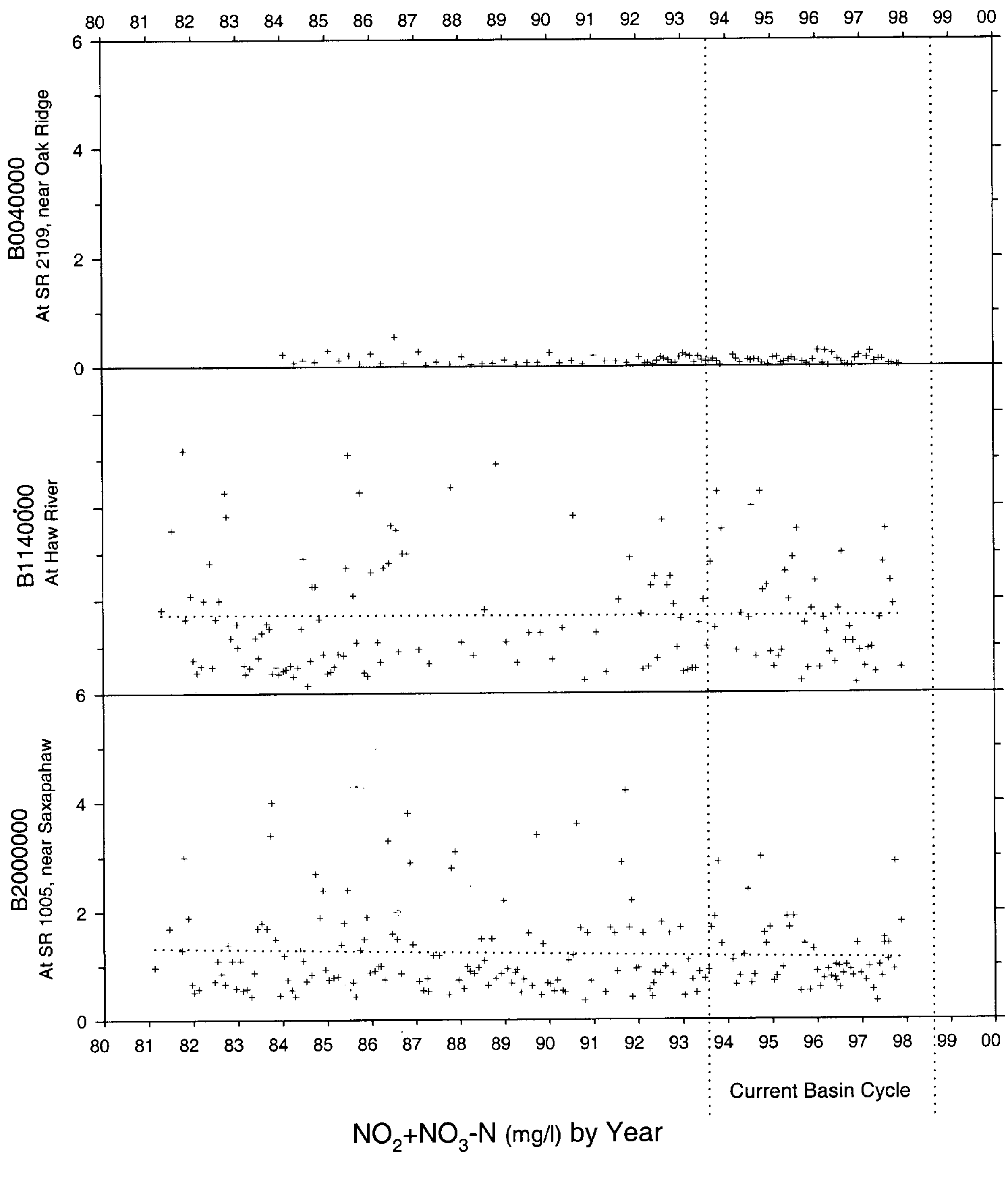


Figure A-29. Measurements of nitrite+nitrate-nitrogen (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

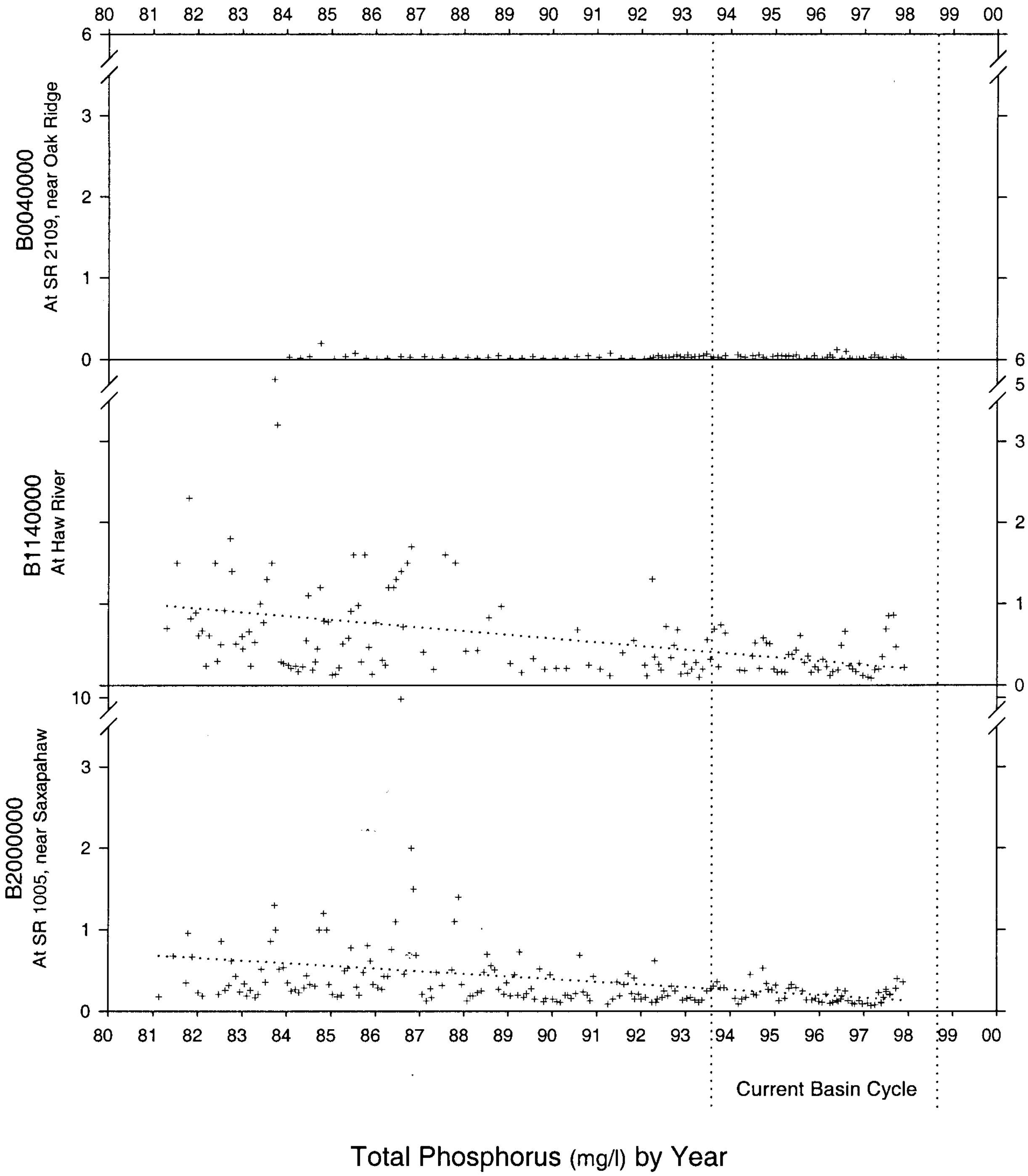


Figure A-30. Measurements of total phosphorus (y-axis) over time (x-axis) from three monitoring stations along the Haw River. Stations are arranged in an upstream (top) - downstream (bottom) pattern.

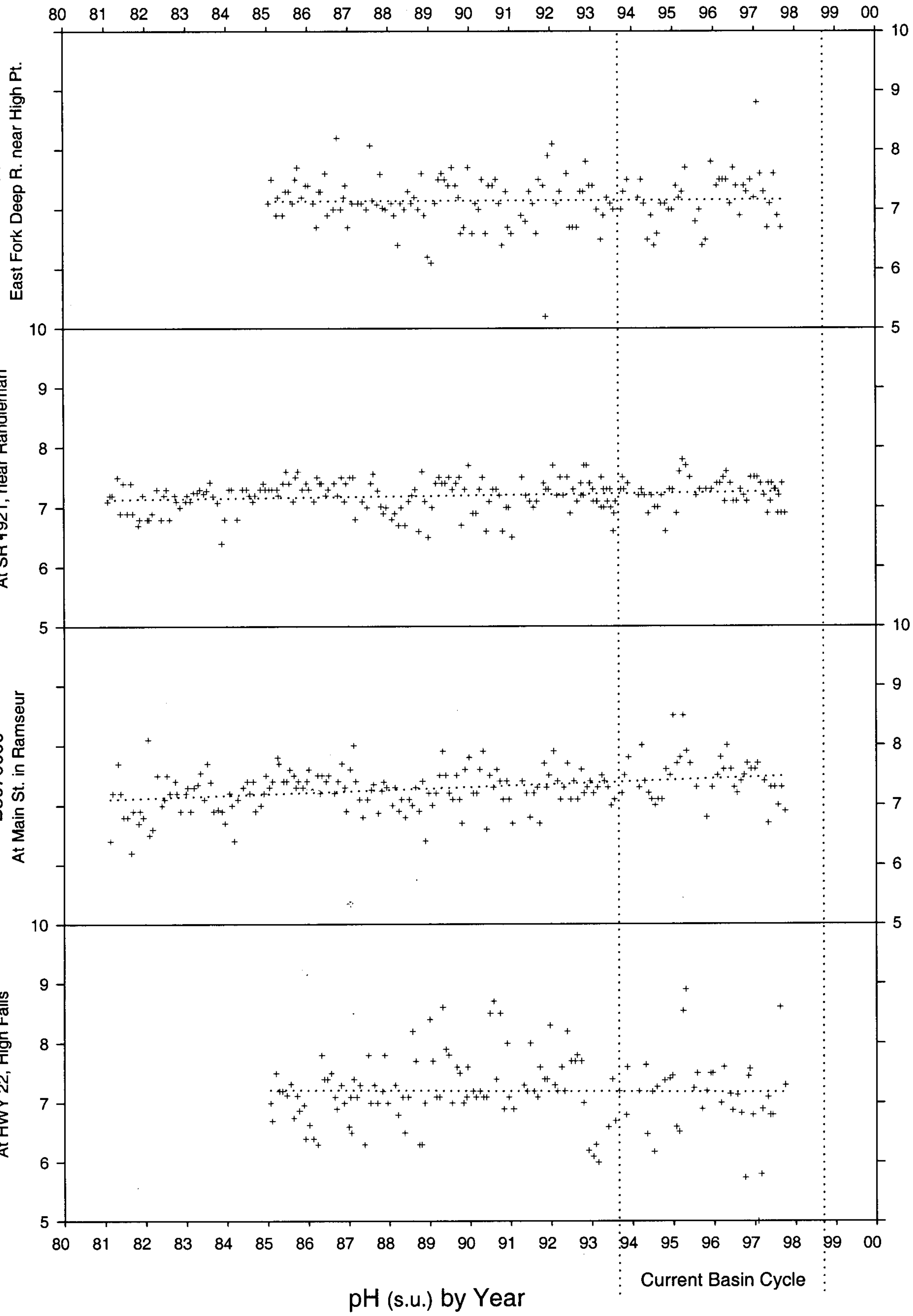


Figure A-31. Measurements of pH (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

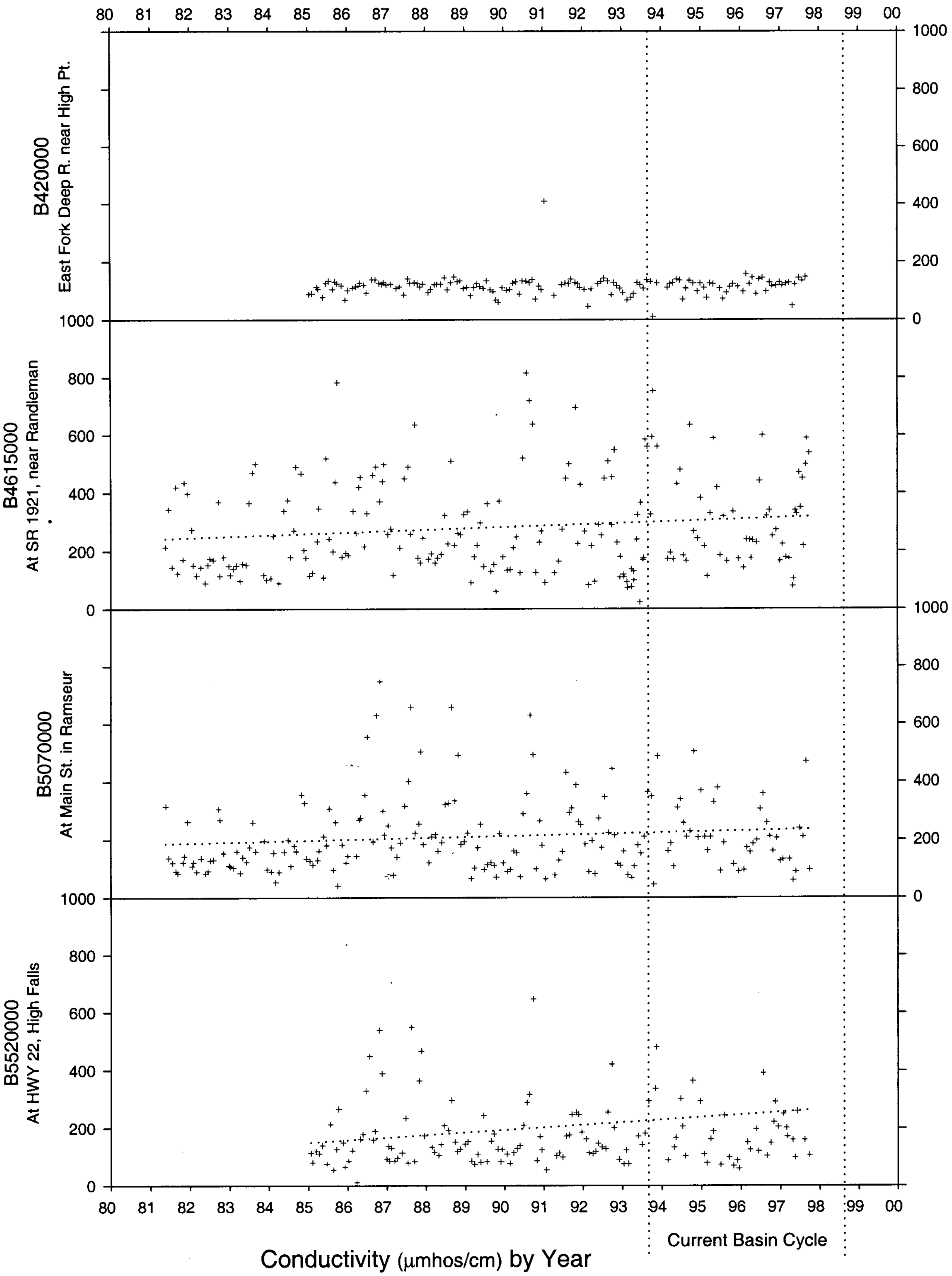


Figure A-32. Measurements of conductivity (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

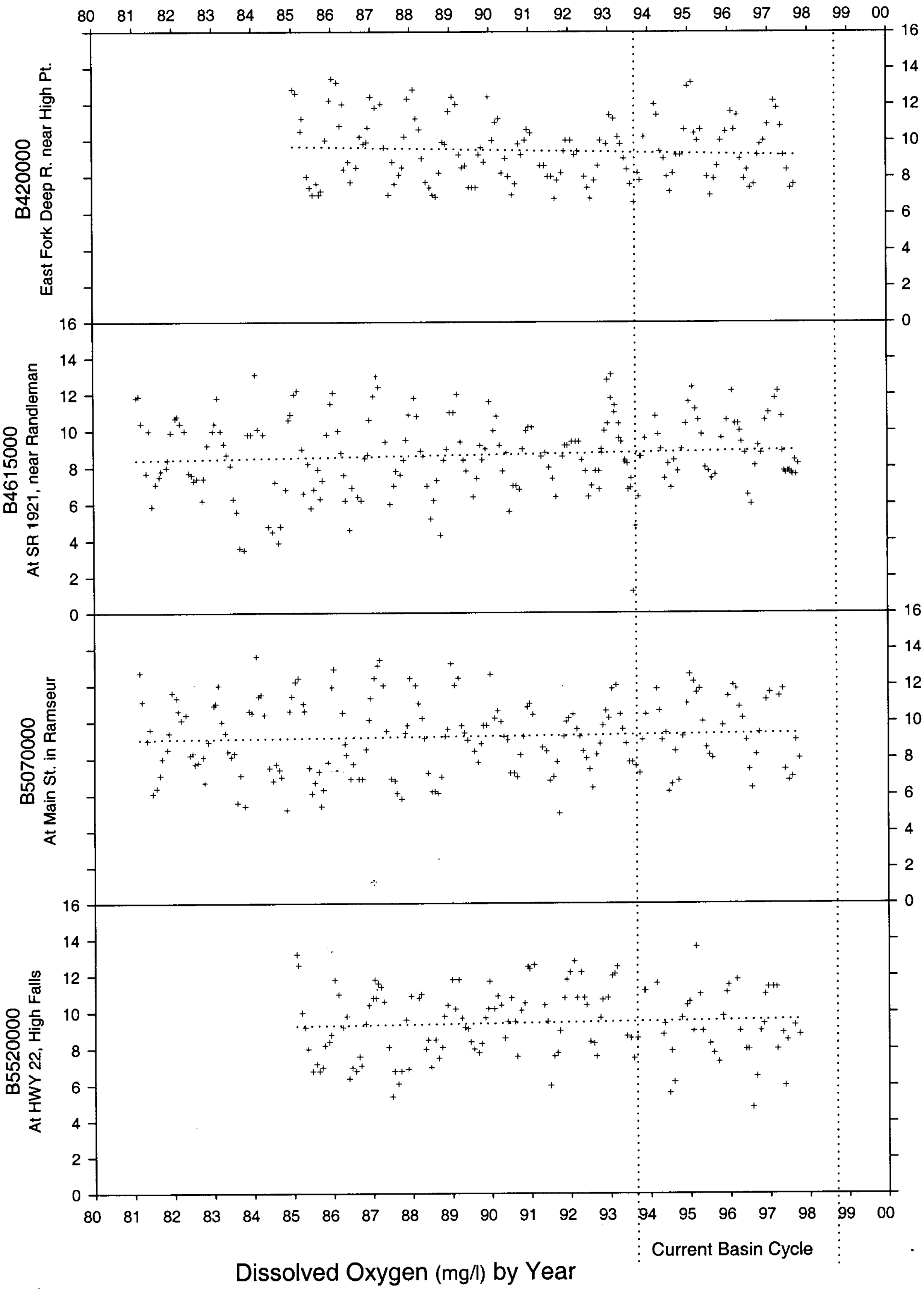


Figure A-33. Measurements of dissolved oxygen (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

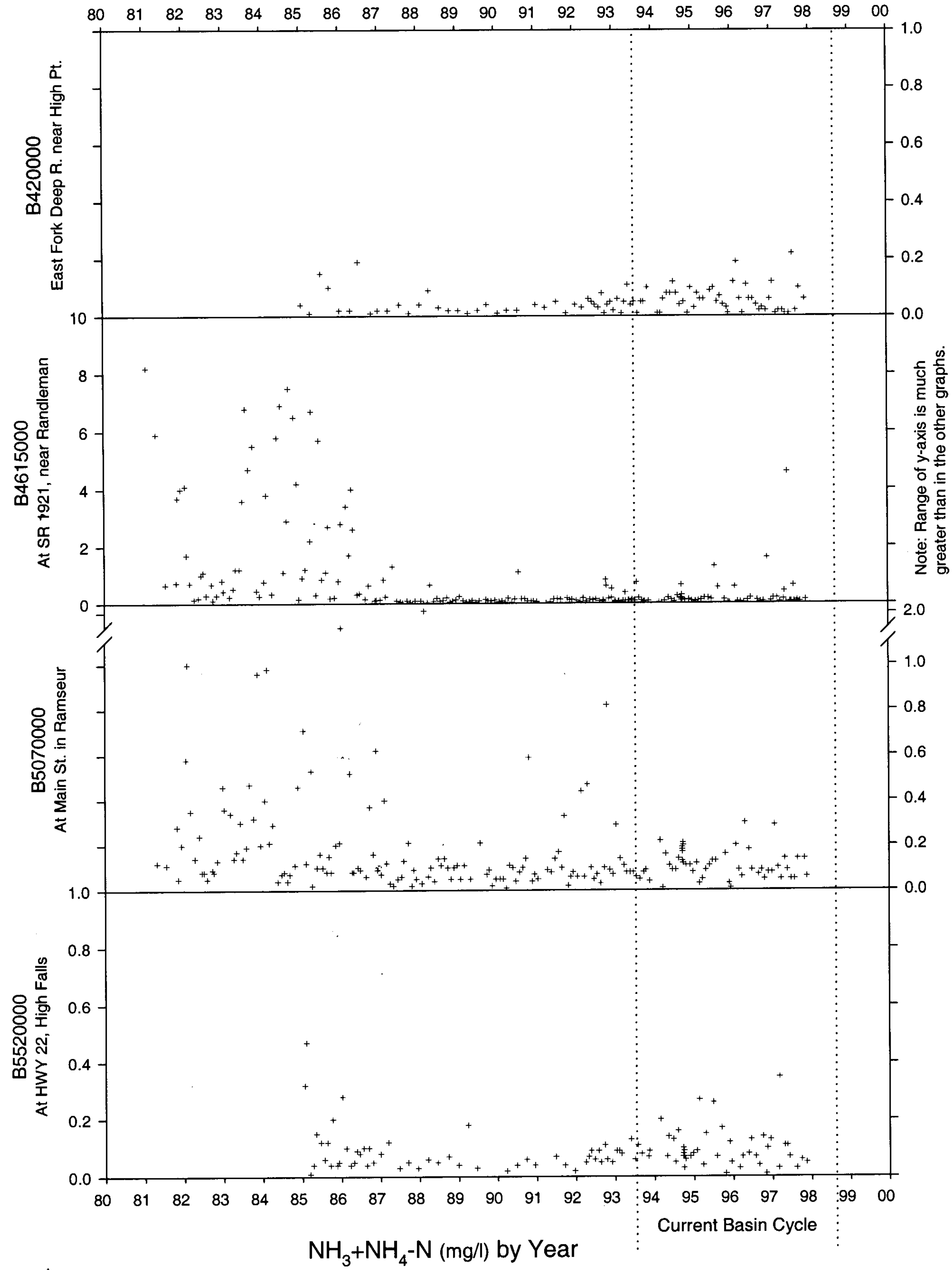


Figure A-34. Measurements of ammonia nitrogen (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

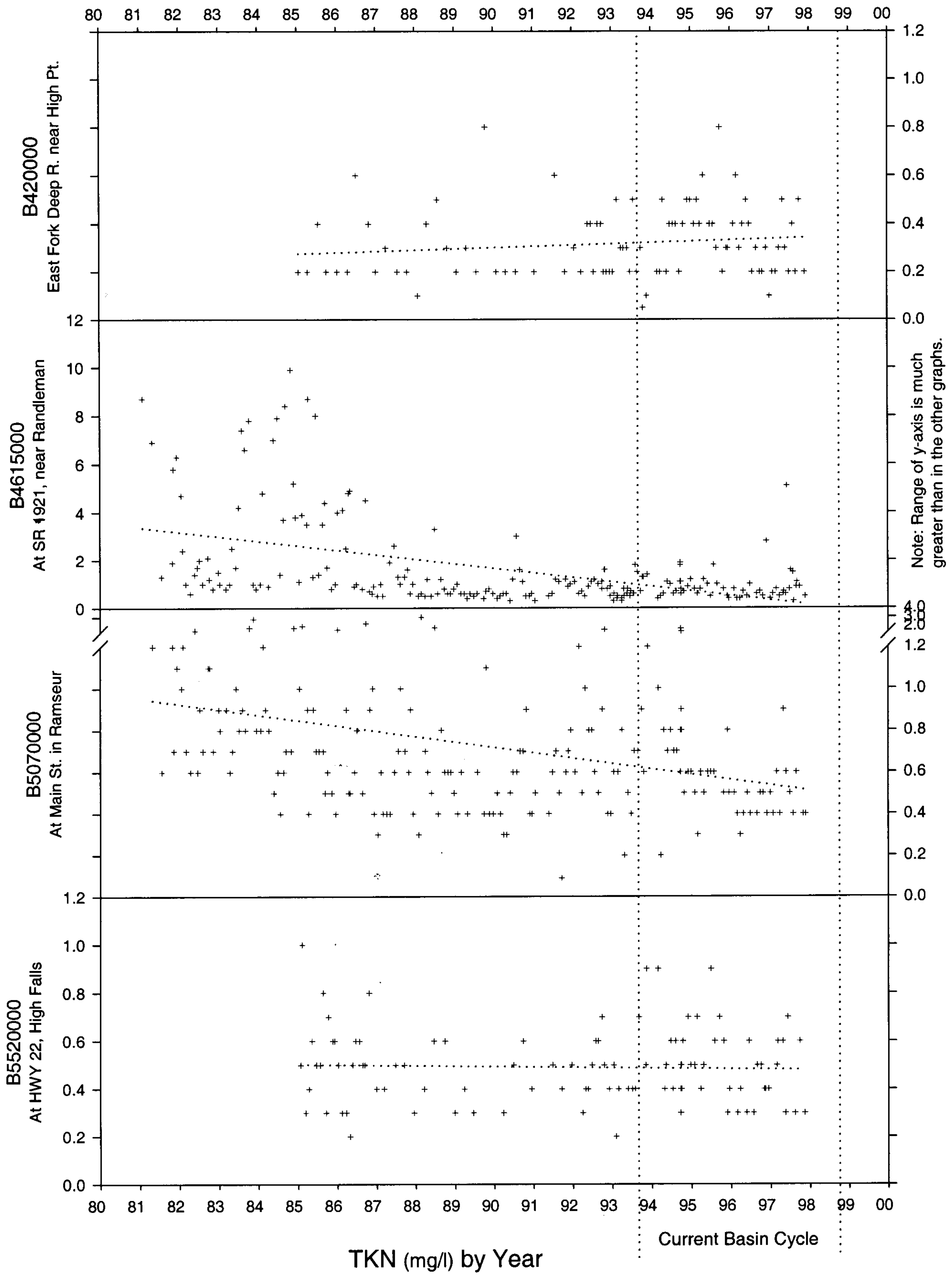


Figure A-35. Measurements of total Kjeldahl nitrogen (TKN; y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

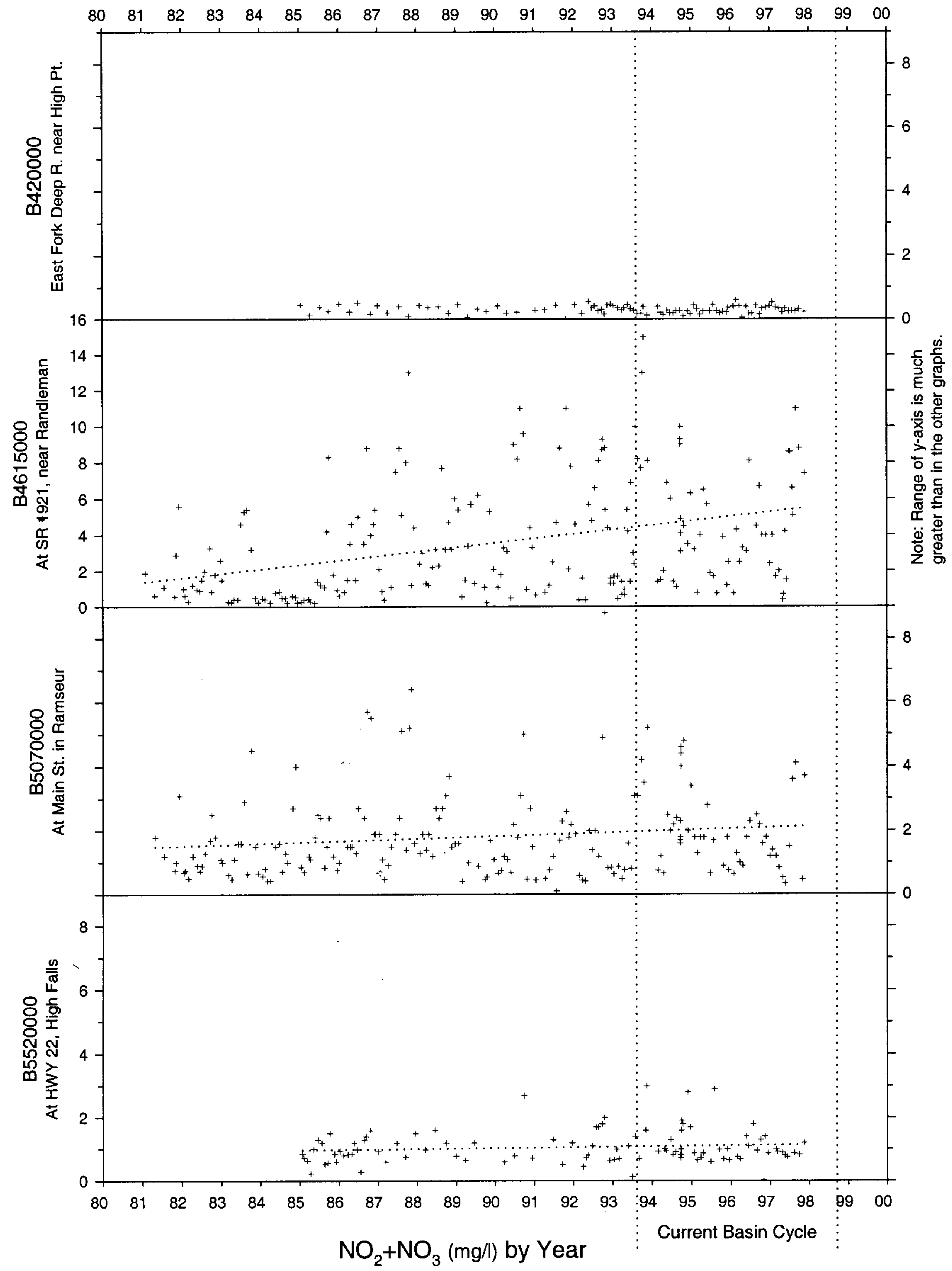


Figure A-36. Measurements of nitrite+nitrate-nitrogen (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

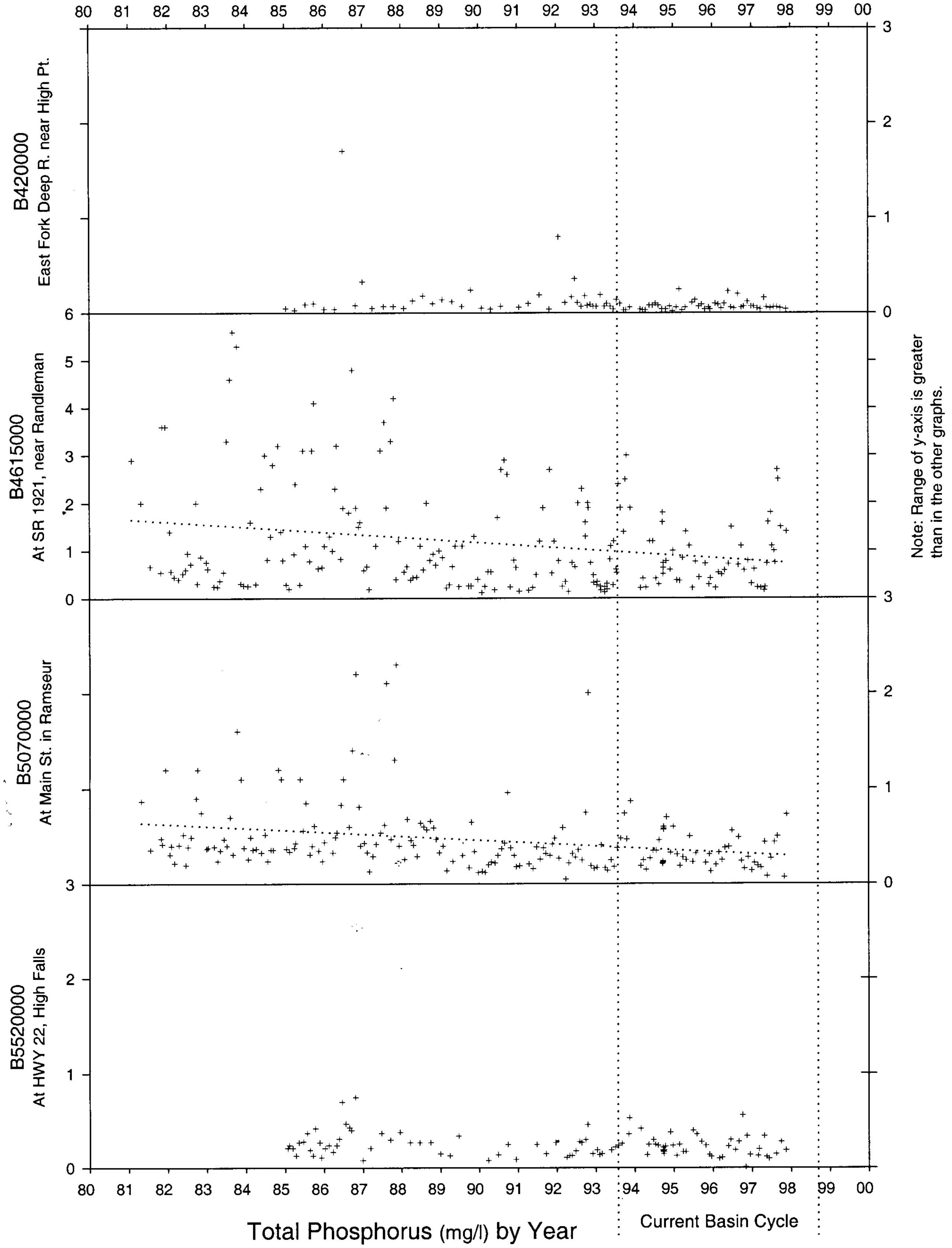


Figure A-37. Measurements of total phosphorus (y-axis) over time (x-axis) from four monitoring stations along the Deep River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

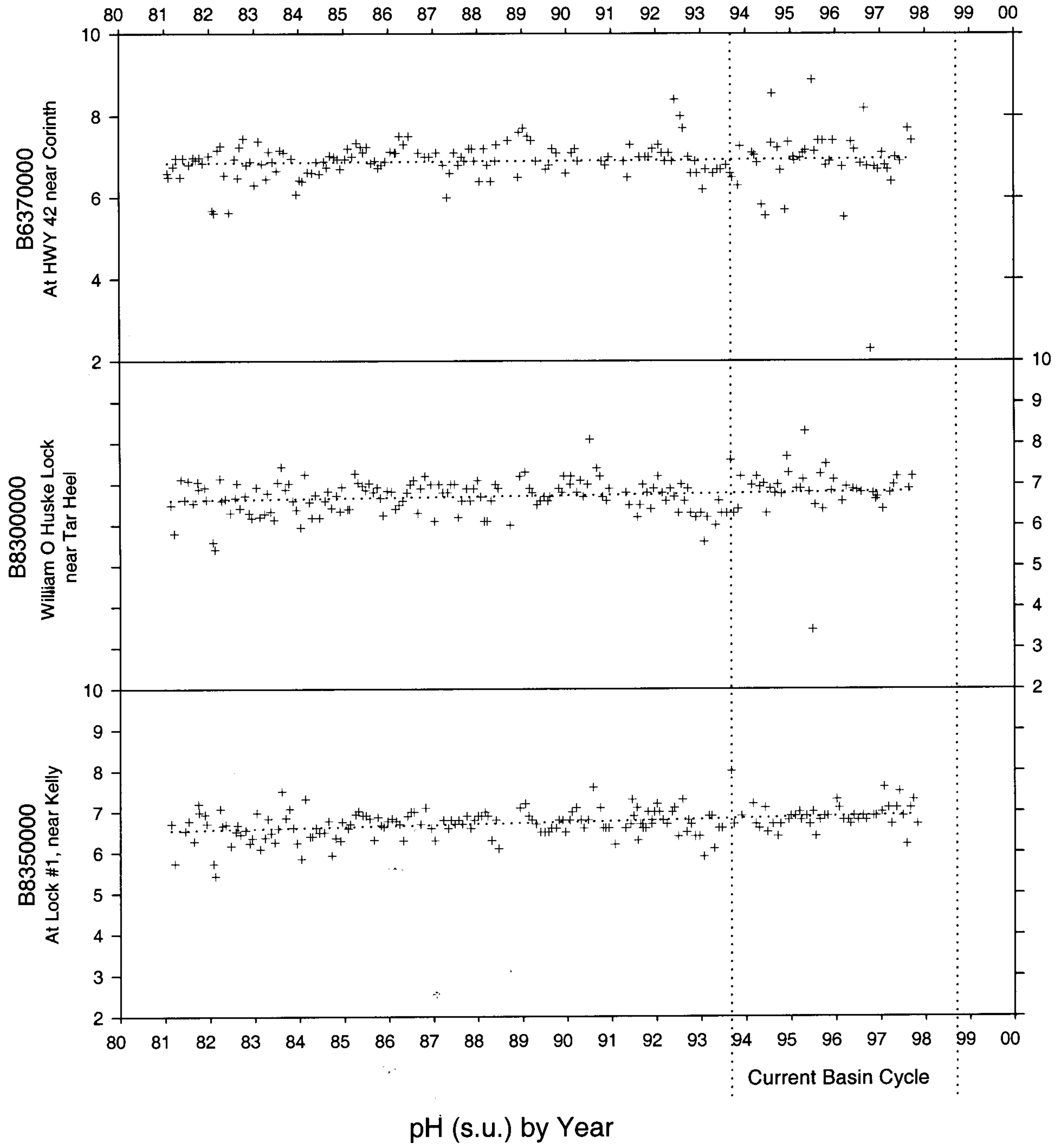
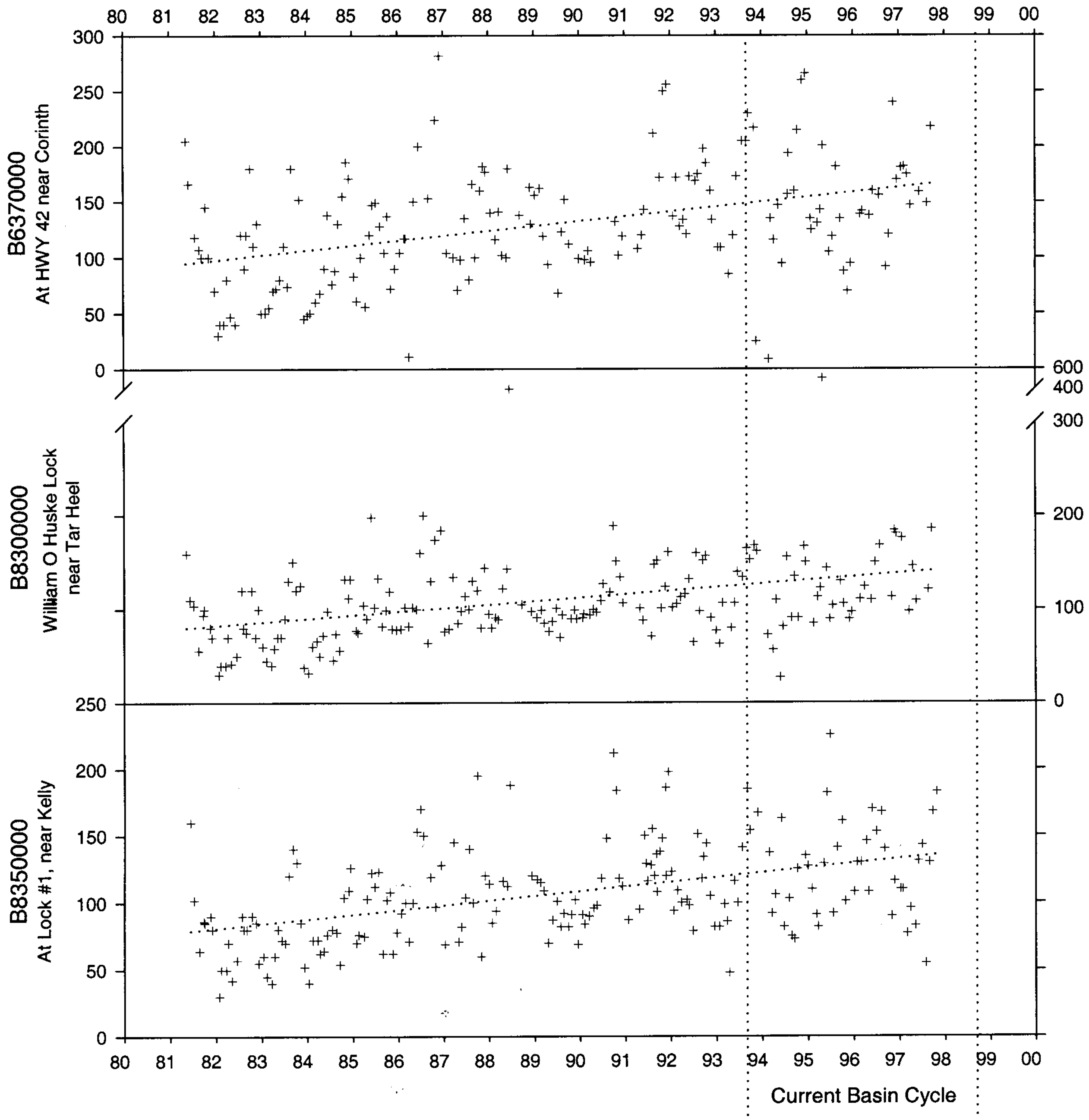


Figure A-38. Measurements of pH (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)



Conductivity (µmhos/cm) by Year

Figure A-39. Measurements of conductivity (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

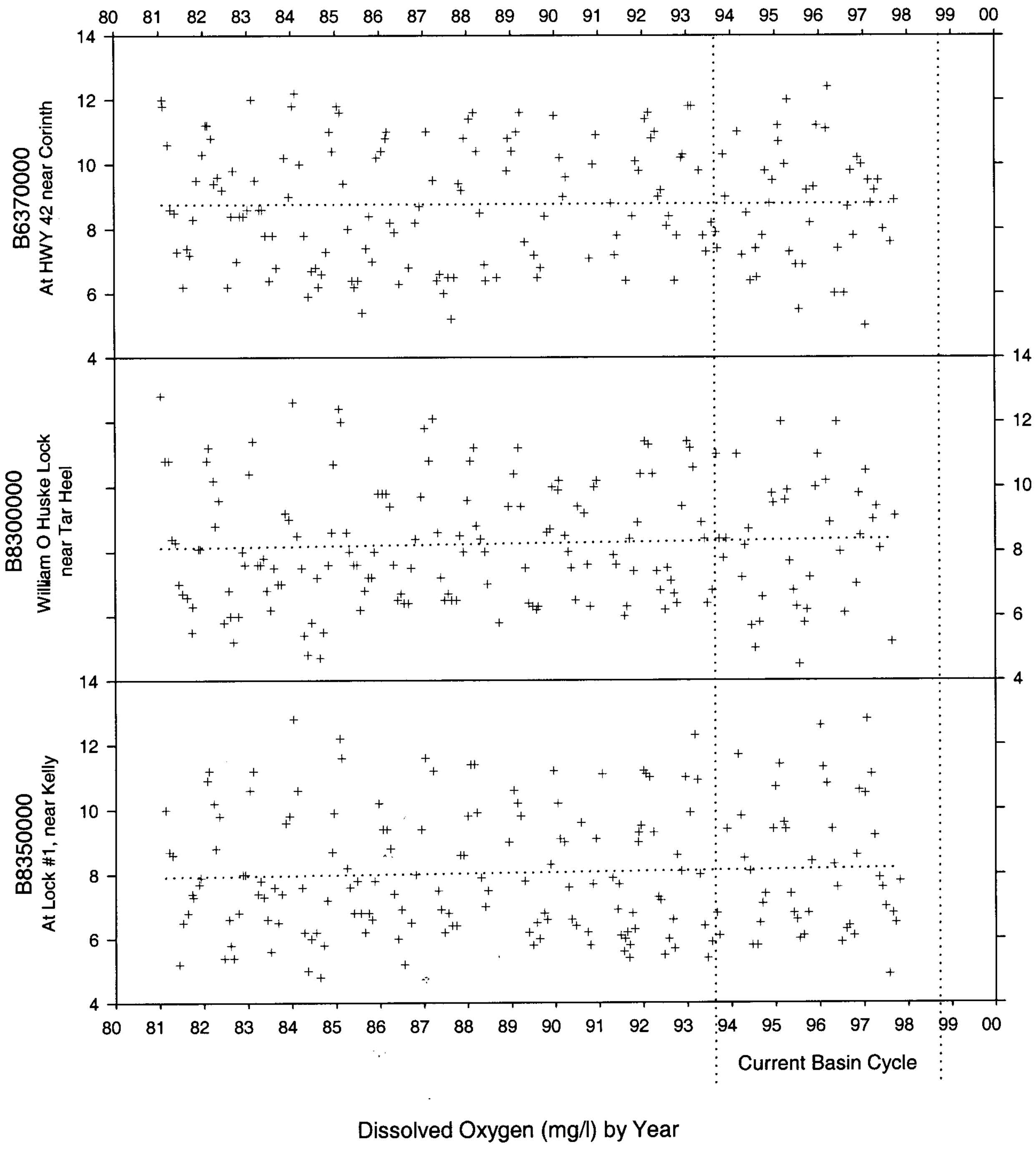


Figure A-40. Measurements of dissolved oxygen (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

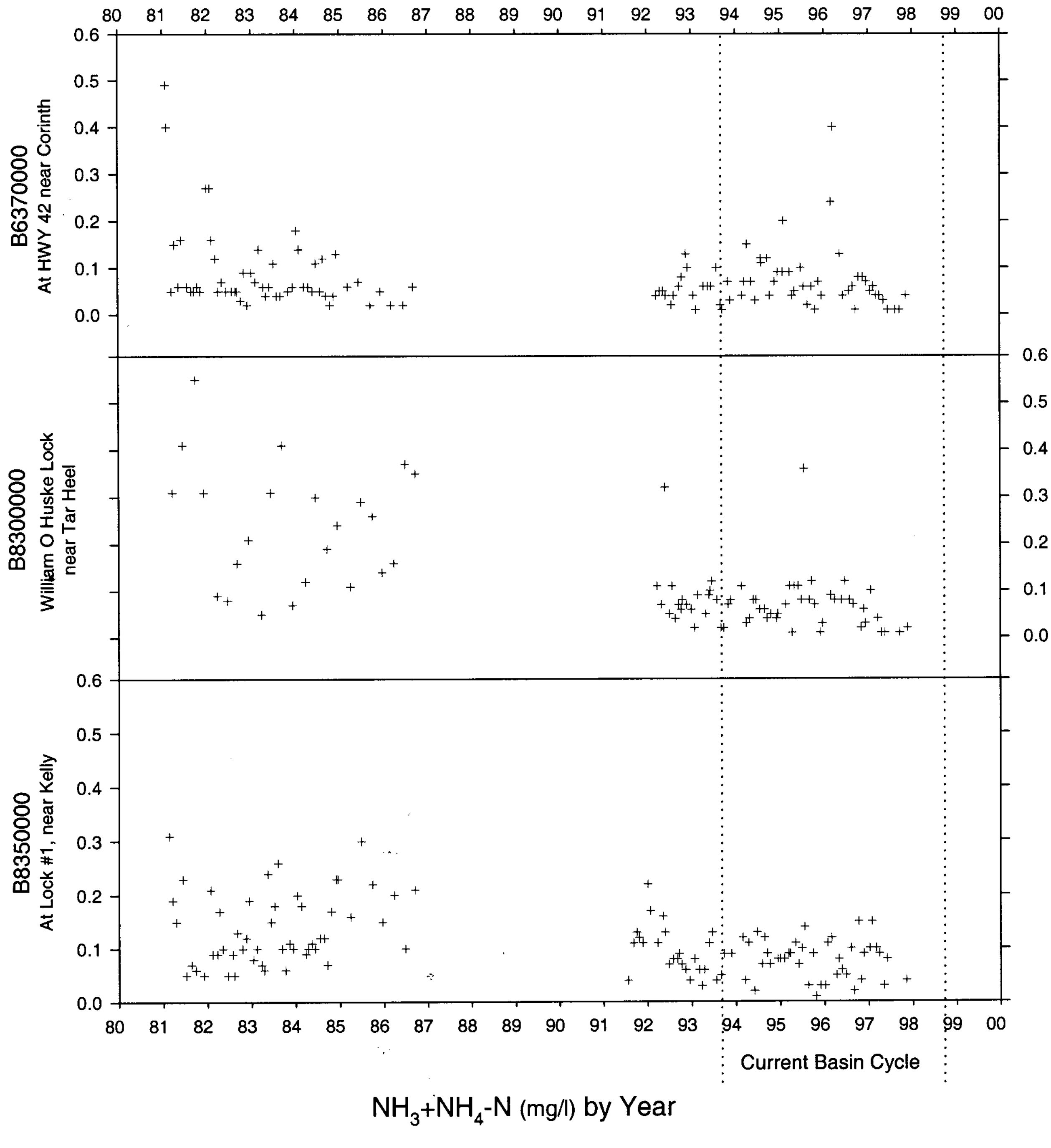


Figure A-41. Measurements of ammonia nitrogen (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

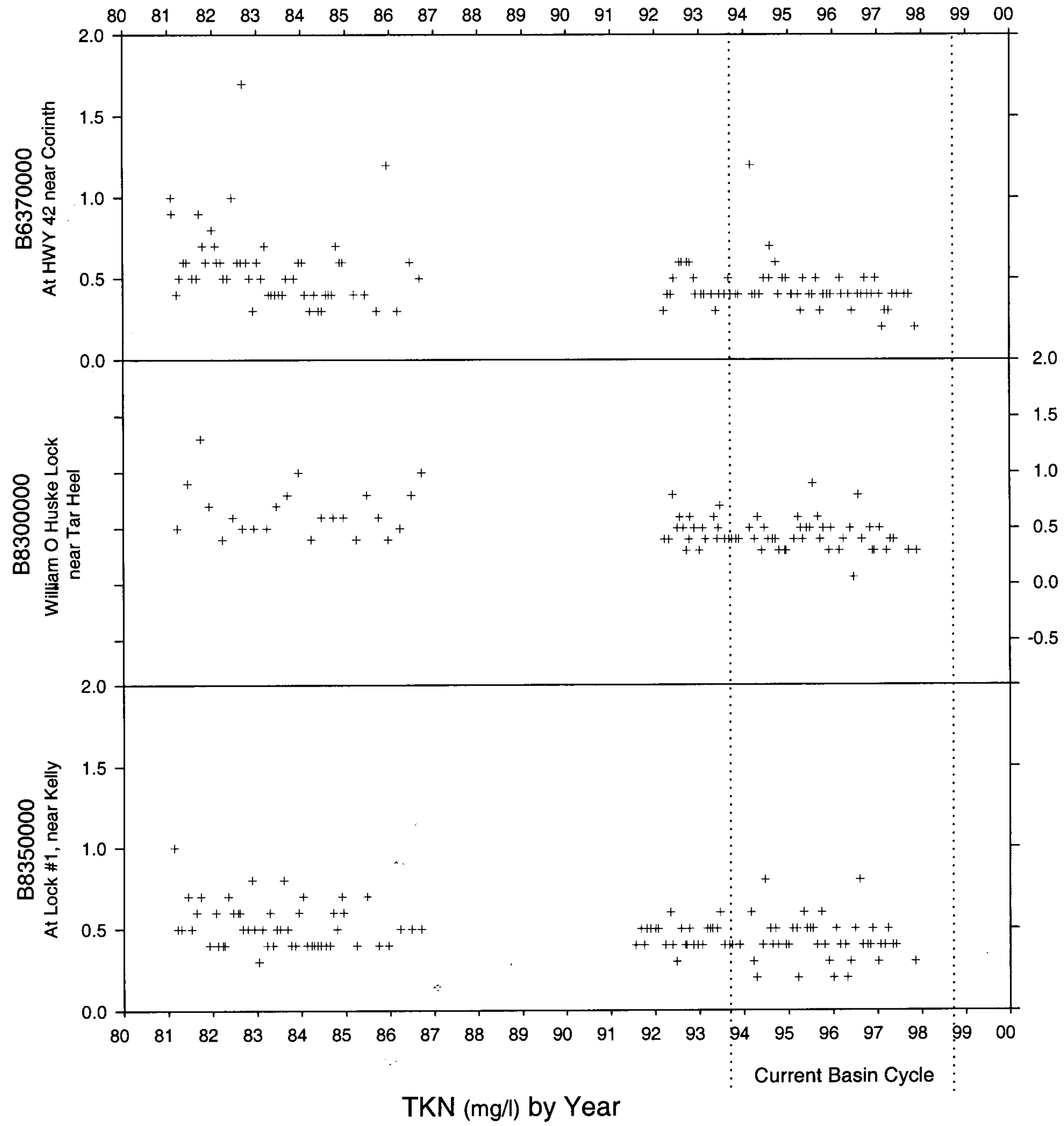
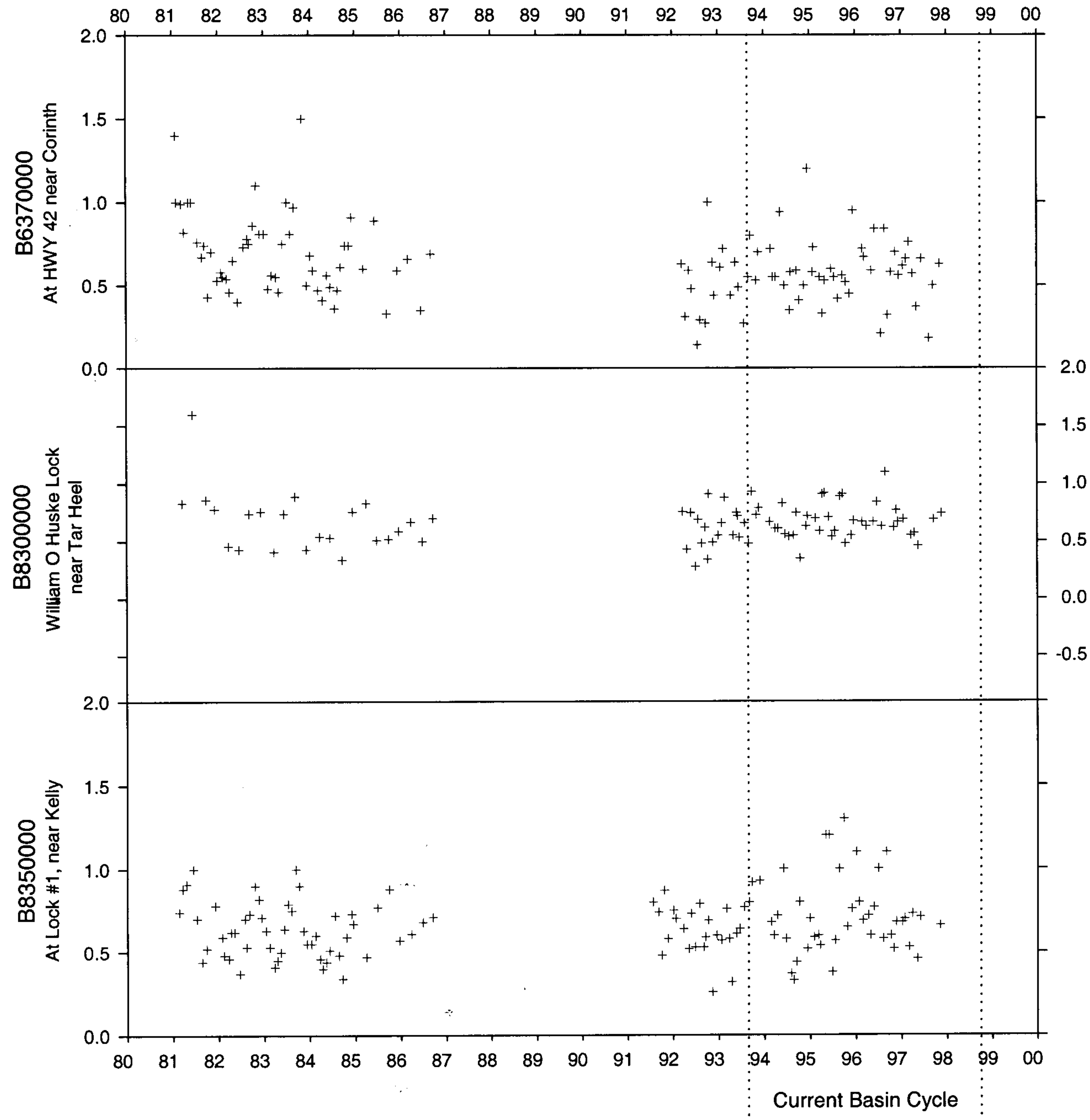


Figure A-42. Measurements of total Kjeldahl nitrogen (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)



NO_2+NO_3-N (mg/l) by Year

Figure A-43. Measurements of nitrite+nitrate-nitrogen (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

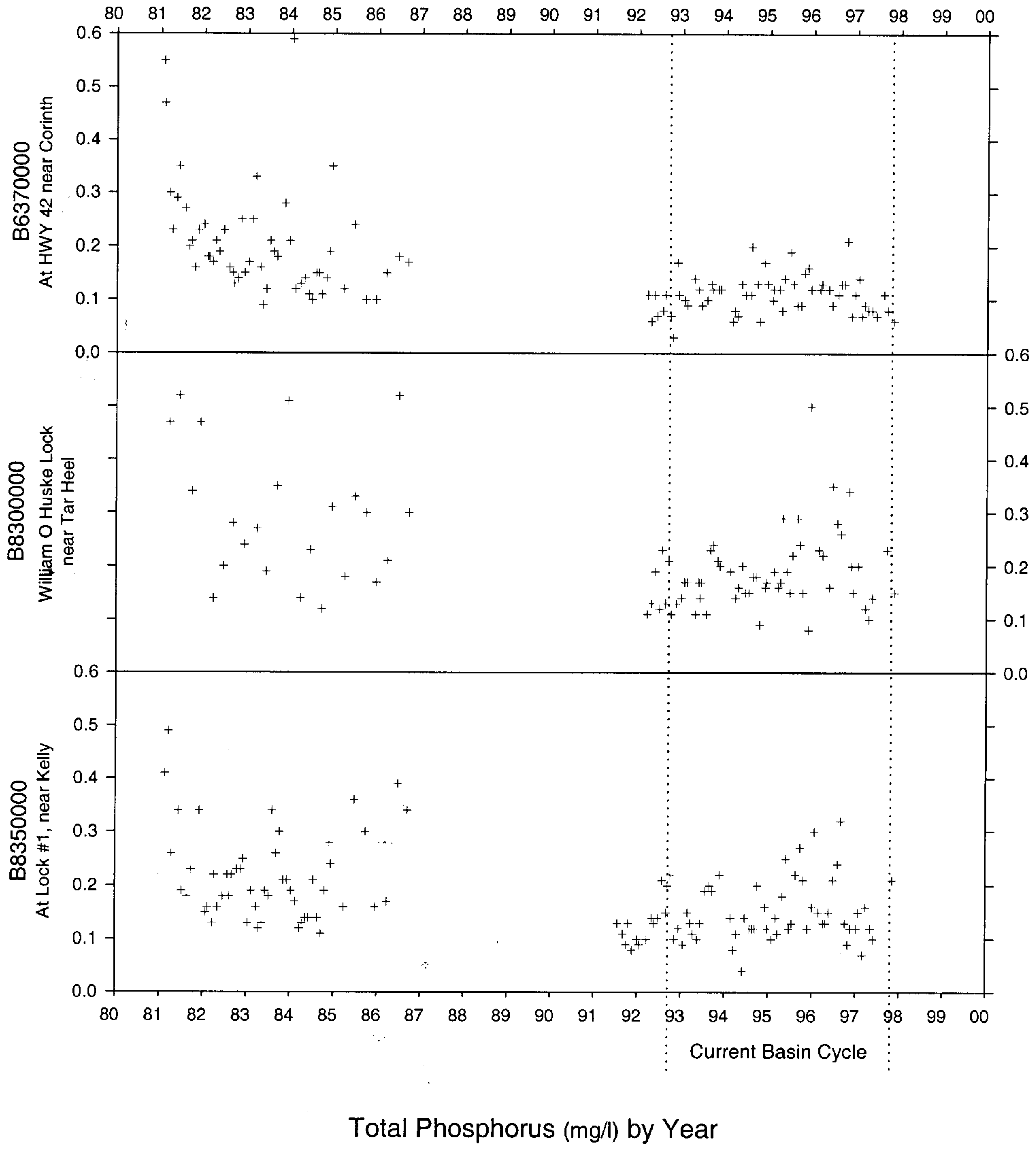


Figure A-44. Measurements of total phosphorus (y-axis) over time (x-axis) from three monitoring stations along the Cape Fear River. (Stations are arranged in an upstream (top) - downstream (bottom) pattern.)

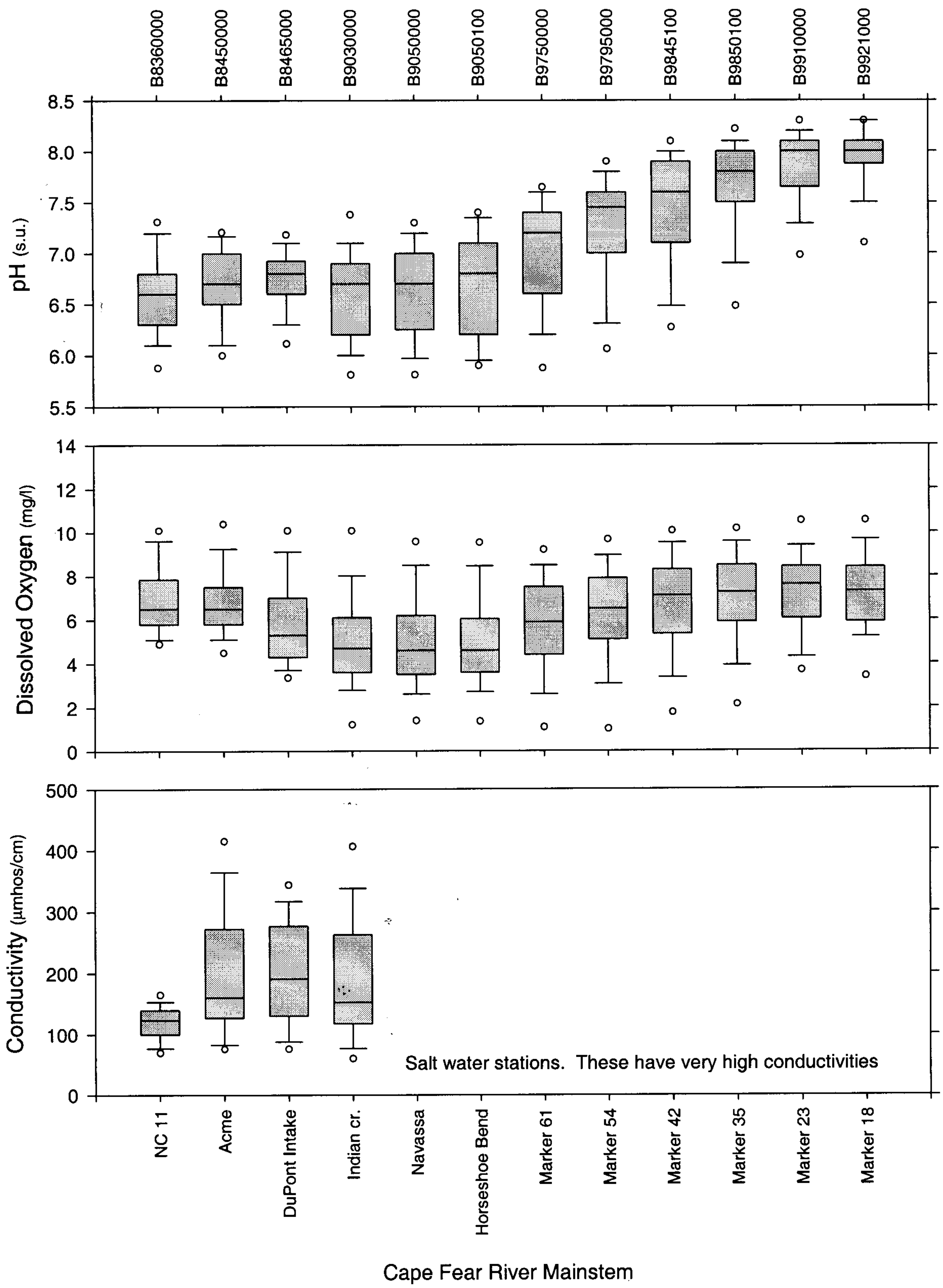


Figure A-45. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along the mainstem of the Cape Fear River (1996-1998). (Data were collected by the Lower Cape Fear River Program.)

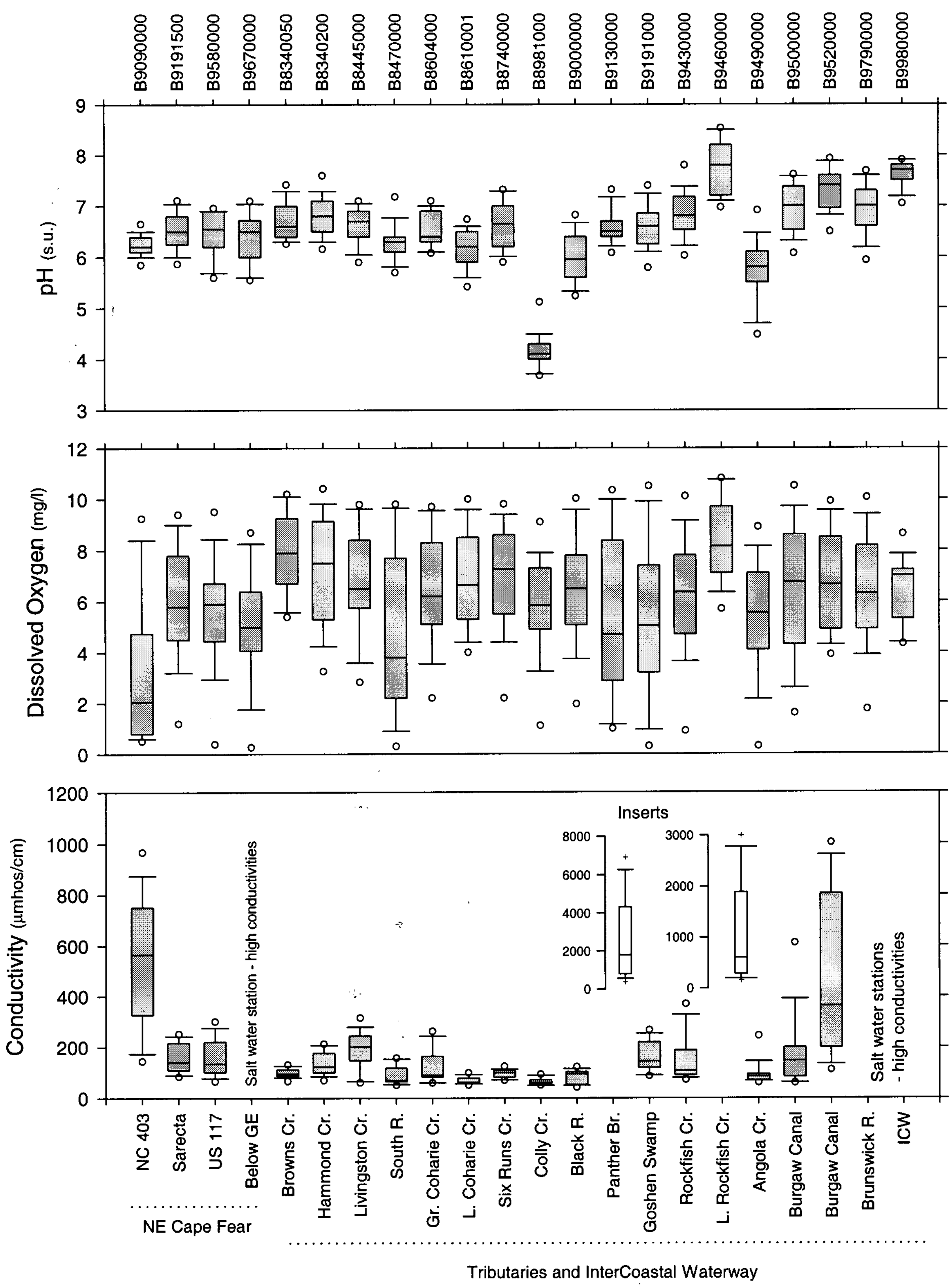


Figure A-46. Box plots for dissolved oxygen, pH and conductivity for the monitoring stations along tributaries of the Cape Fear River (1996-1998). (Data were collected by the Lower Cape Fear River Program.)

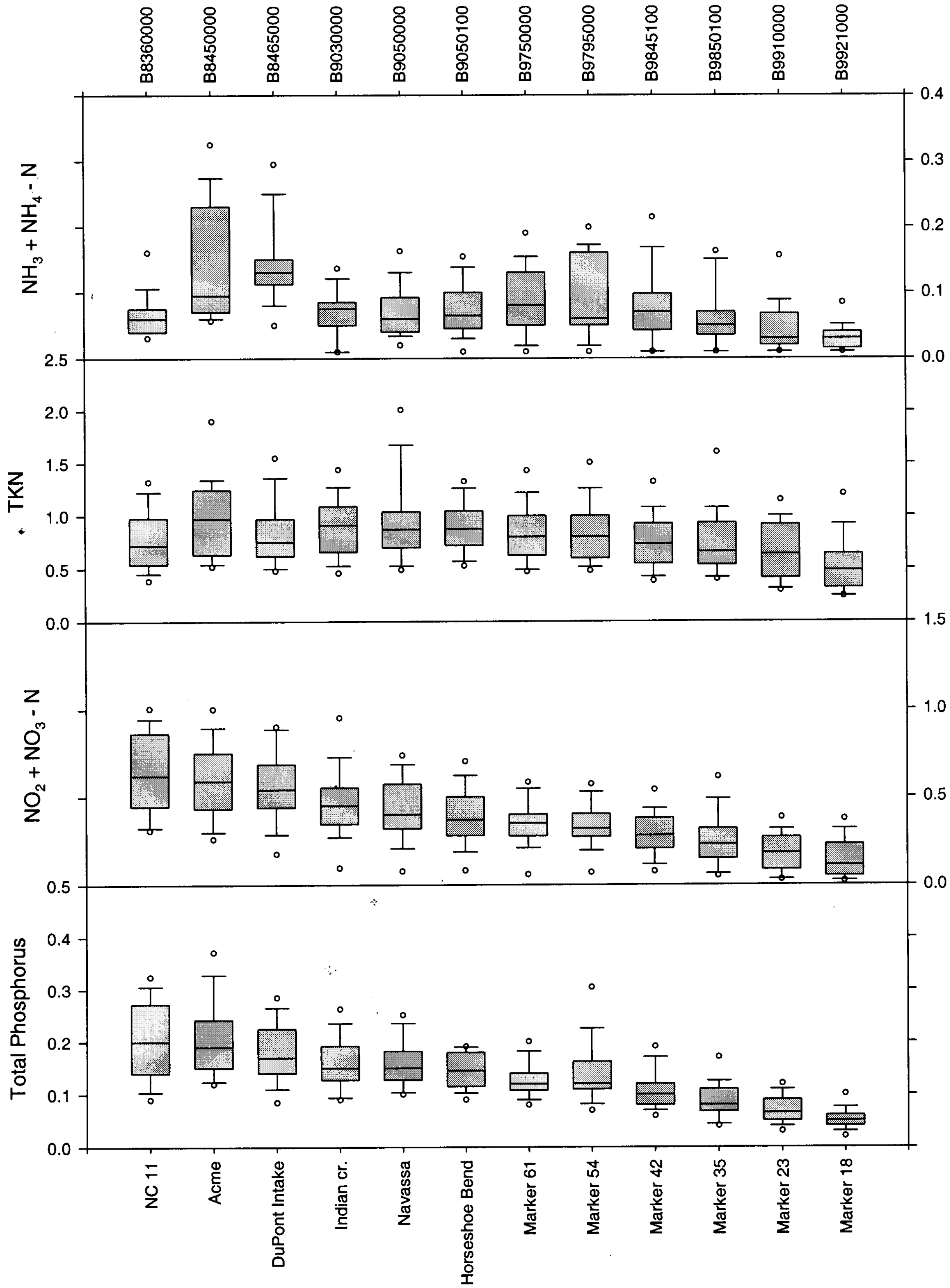


Figure A-47. Box plots for nutrients (mg/l) for the monitoring stations along the mainstem of the Cape Fear River. (Data were collected by the Lower Cape Fear River Program)

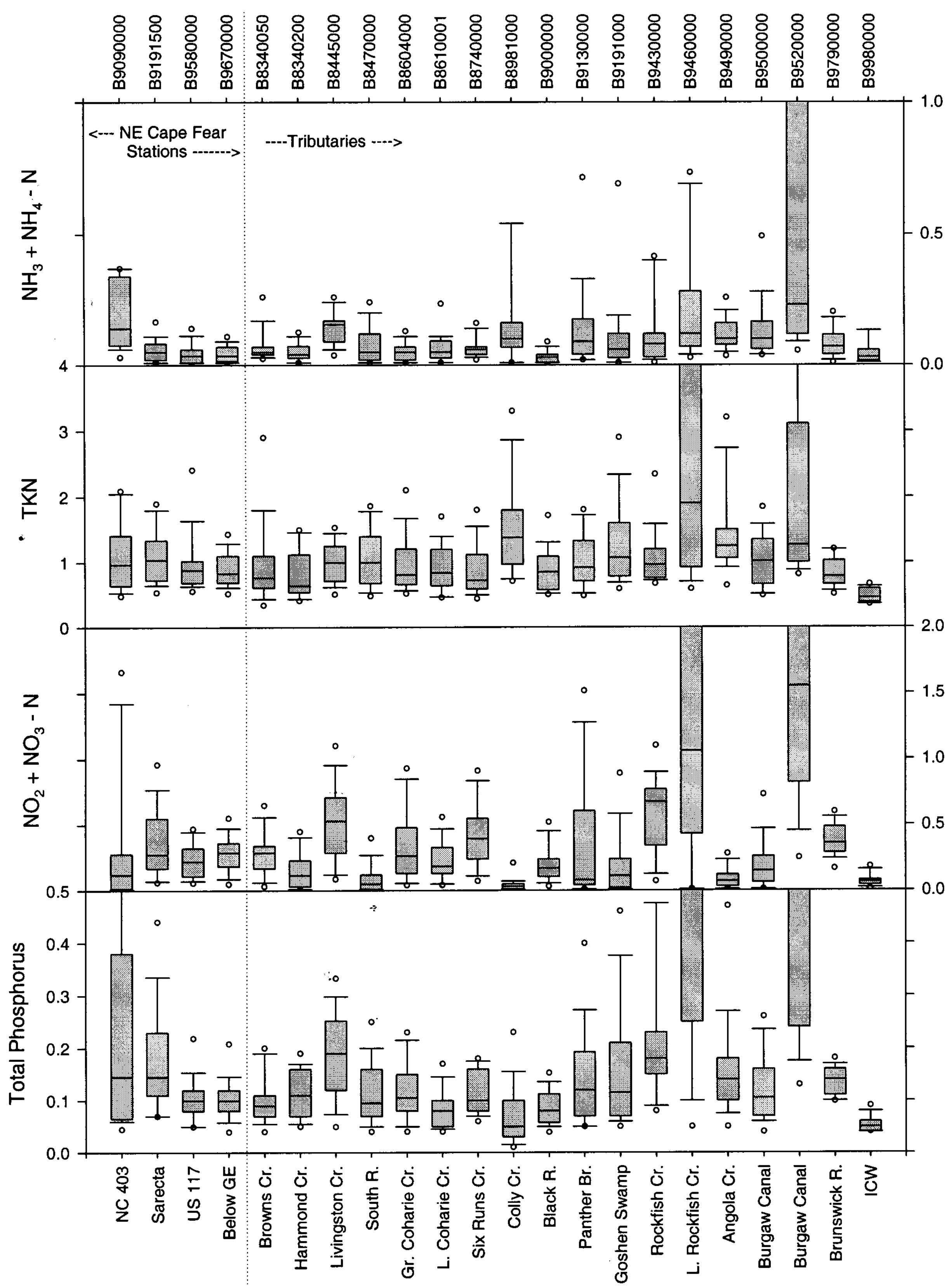


Figure -48. Box plots for nutrients (mg/l) for the monitoring stations along the tributaries of the Cape Fear River. (Data were collected by the Lower Cape Fear River Program)

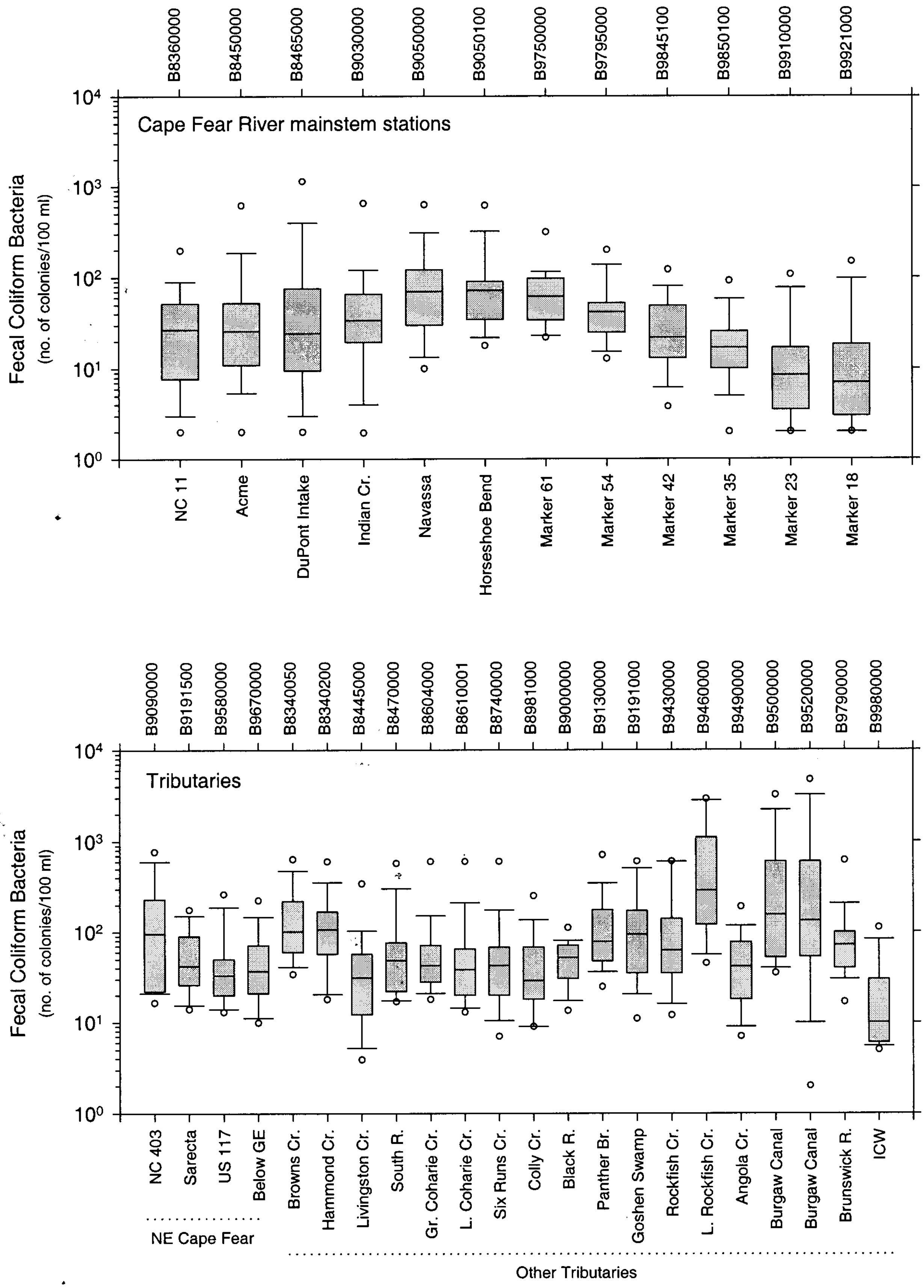


Figure A-49. Fecal Coliform measurements from stations along the Cape Fear River and tributaries (1996-1998). (Data were collected by the Lower Cape Fear River Program).

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GLOSSARY

Legend of Acronyms, List of Abbreviations

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.

AGPT-Algal Growth Potential Test.

AMS-Ambient Monitoring System.

BI(BIEPT)-Biotic Index, Biotic Index for EPT groups. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or NCBIEPT.

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.

BMAN-Biological Monitoring Ambient Network.

BODlt-Biochemical Oxygen Demand, long term.

cfs-Cubic feet per second, generally the unit in which stream flow is measured.

CHLA-Chlorophyll A.

ChV-Chronic Value. Of a toxicity test, defined as the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration.

DEM-Division of Environmental Management (became the Division of Water Quality on July 1, 1996)

D.O.-Dissolved Oxygen.

Ecoregion: An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include mountains, piedmont, coastal plain, sandhills and slate belt.

EHNR-N.C. Dept. of Environment, Health, and Natural Resources.

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

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.

JOC-Judicial Order by Consent- An administrative order issued by an administrative law judge which in some way modifies limitations of an NPDES permit by consent of both parties which provides interim limitations and conditions.

LC50- The concentration of a toxicant or percentage dilution of an effluent that is predicted to be lethal to 50% of a test population of organisms.

LOEC-In a toxicity test, the Lowest Observed Effect Concentration.

MGD-Million Gallons per Day, generally the unit in which effluent discharge flow is measured.

MSD-Metropolitan Sewerage District.

NPDES-National Pollutant Discharge Elimination System.

NCIBI-North Carolina Index of Biotic Integrity-a summary measure of the effects of factors influencing the fish community

NCTSI-North Carolina Trophic State Index.
NOEC-In a toxicity test, the No Observed Effect Concentration.
NSW-Nutrient Sensitive Waters.
NTU-Nephelometric Turbidity Unit.
ORW-Outstanding Resource Water.
Parameter-Independent measure of water quality. For example: Dissolved Oxygen, Turbidity are 2 parameters.
Parametric Coverage-A listing of parameters measured and reported.
PF-Permitted flow, of an NPDES permit.
POTW-Publicly Owned Treatment Works.
Secchi- a standard measure of water transparency as determined by lowering of a black and white Secchi disk to the depth that the disk is no longer visible.
Total S-the number of different taxa present in a benthic macroinvertebrate sample
UT-unnamed tributary
WTP-Water treatment plant
WWTP-Wastewater treatment plant

BENTHOS APPENDICES

Appendix B-1 BENTHIC MACROINVERTEBRATE SAMPLING AND CRITERIA

Freshwater Wadeable Flowing Waters

Benthic macroinvertebrates can be collected using two sampling procedures. The Division of Water Quality's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs. 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).

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

EPT taxa richness (EPT S) is used with DWQ criteria to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for Mountain/Piedmont/Coastal Plain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

Benthic macroinvertebrates can also be collected using the Division of Water Quality's EPT sampling procedure. Four composite samples are taken at each site instead of the 10 taken for the qualitative sample: 1 kick, 1 sweep, 1 leafpack and visual collections. Only intolerant EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

The expected EPT taxa richness values are lower in small high-quality mountain streams, <4 meters in width or with a drainage area < 3.5 square miles. For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria. Both EPT taxa richness and biotic index values also can be affected by seasonal changes. DWQ criteria for assigning bioclassification are based on summer sampling: June-September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal plain) within North Carolina.

Benthos Classification Criteria by Ecoregion*

EPT taxa richness values

	10-sample Qualitative Samples			4-sample EPT Samples		
	Mountains	Piedmont	Coastal	Mountains	Piedmont	Coastal
Excellent	>41	>31	>27	>35	>27	>23
Good	32-41	24-31	21-27	28-35	21-27	18-23
Good-Fair	22-31	16-23	14-20	19-27	14-20	12-17
Fair	12-21	8-15	7-13	11-18	7-13	6-11
Poor	0-11	0-7	0-6	0-10	0-6	0-5

Biotic Index Values (Range = 0-10) for 10-sample Qualitative Samples

	Mountains	Piedmont	Coastal
Excellent	<4.05	<5.19	<5.47
Good	4.06-4.88	5.19-5.78	5.47-6.05
Good-Fair	4.89-5.74	5.79-6.48	6.06-6.72
Fair	5.75-7.00	6.49-7.48	6.73-7.73
Poor	>7.00	>7.48	>7.73

*These criteria apply to flowing water systems only.

Swamp Streams

Recent extensive work on swamp streams suggested that different criteria should be used for slow flowing, swamp-like systems. Draft swamp stream rating criteria evaluate a stream based on benthic macroinvertebrate data collected in winter, fish community data, and a habitat score. Benthos data collected outside of the winter high flow period are not used to assign ratings. At least two of the data types must be collected to assign a rating. Each of these components is assigned a point value of 10 (Good), 5 (Fair) or 1 (Poor), and the points are averaged to assign an overall site rating (OSR): Good-Excellent (>7.5), Fair-Good (5.0-7.5), Fair (2.0-4.9), and Poor (<2.0). Ratings for the benthos are based entirely on the biotic index value: Good < 6.99, Fair 7.75-7.00, Poor >7.75. Deep (nonwadeable) coastal rivers with little or no visible current have different EPT criteria (Coastal B) that are being used on a provisional basis until more data can be gathered. Details of benthos sampling, criteria, and data analysis can be found in the Biological Monitoring SOP Manual (NCDEHNR, 1997).

The draft swamp criteria were developed after collecting data for over four years. That data appeared to indicate that the BI values could separate differences in impact, but only during winter high flow conditions. In the summer, all sites were too similar to provide meaningful data. However, even now, there has been insufficient sampling of reference swamp streams to use the ratings without reservation for such things as use support. It must be stressed that the criteria are draft and will remain so until we better evaluate such things as: year to year variation at reference swamp sites, variation among reference swamp sites, the effect of small changes in pH on the benthos community, whether the habitat evaluation can be improved, and the role fisheries data should play in the evaluation. In this light, the ratings should be used for comparative purposes only, and should not be used for use support.

Estuarine Sites

Draft criteria have been developed to evaluate the level of anthropogenic impact in estuarine waters greater than 8-10 parts per thousand salinity. Bioclassifications are based on the total number of taxa, the number of taxa from intolerant groups (amphipods and caridian shrimp) and the average sensitivity of all the taxa living at a site (Estuarine Biotic Index). Higher values of each of these metrics reflect better water quality. The ranges of metric values were found to be different in the mesohaline and polyhaline salinity regimes and criteria have been developed for each. The range of values for each metric was divided into five categories and each category was given a score of 1, 2, 3, 4 or 5 points. Metric scores that fell in the heavily impacted range received 1 point, metric scores in the unimpacted range received 5 points and scores from the moderately impacted range were given 2, 3, or 4 points depending on the severity of impact. The points scored from each metric were summed to give a final water quality rating.

STEP 1: Assign points for each of three metrics from a sweep sample.

Polyhaline (21 ppt to seawater)

Metrics/Points	5	4	3	2	1
EBI	> 2.40	2.33 - 2.40	1.99 - 2.32	1.91 - 1.98	≤ 1.90
Amphipods & Caridian Shrimp	≥ 21	18 - 20	13 - 17	10 - 12	< 10
Total Taxa	≥ 95	86 - 94	69 - 85	60 - 68	< 60

Mesohaline (10 ppt to 20 ppt)

Metrics/Points	5	4	3	2	1
EBI	≥ 2.20	2.15 - 2.19	1.95 - 2.14	1.90 - 1.94	< 1.90
Amphipods & Caridian Shrimp	≥ 8	7	5 - 6	4	< 4
Total Taxa	≥ 38	32 - 37	24 - 31	18 - 23	< 18

STEP 2: Sum points. This will yield a number between 3 and 15.

STEP 3: Check for Bonus Point conditions. Add 2 points to the score if one or more of the following conditions occurred: 1) Homogeneous habitat, 2) consistently high wave action, 3) very high salinity fluctuations. Homogeneous habitat is when only one habitat is available for sampling, while high wave action can be determined by the predominance of very coarse, almost gravel-sized, sand. High salinity fluctuations (> 26 ppt in the previous year) can only be determined at sites where water chemistry information is available which documents these fluctuations. A maximum of 2 points can be assigned even if more than one conditions occurs.

STEP 4: Assign Bioclassifications.

Bioclassification	Points
No Impact	13-15
Slight	11-12
Moderate Impact	8-10
Elevated	6-7
Heavy Impact	3-5

Appendix B-2. Benthic macroinvertebrate collections in the Cape Fear River Basin, 1983-1998.

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 01						
Haw R, SR 2109 at Oak Ridge, Guilford	B-1	16-(1)	7/98	-/11	-/5.30	Fair
			7/93	-/9	-/5.67	Fair
			5/85	59/11	6.52/4.85	Fair
Haw R, US 29 Bus, Rockingham	B-2	16-(1)	7/98	69/21	6.10/5.17	Good-Fair
			7/93	56/20	5.87/5.12	Good-Fair
Haw R, NC 150, Alamance	B-3	16-(1)	7/98	-/17	-/4.90	Good-Fair
Haw R, NC 87 nr Altamahaw, Alamance	B-4	16-(1)	7/98	57/17	6.69/5.98	Fair
			7/93	69/22	5.85/5.14	Good-Fair
			7/90	63/12	7.13/5.57	Fair
			7/87	65/14	6.41/5.93	Good-Fair
			5/85	65/23	6.50/4.91	Good-Fair
Brooks Lake Trib, Scout Camp, Guilford	B-5	16-4-1-(1)	6/90	53/15	4.30/2.39	Not Rated
			6/85	79/20	4.95/2.47	Not Rated
Candy Cr, SR 2700, Guilford	B-6	16-5	6/90	59/10	6.61/5.72	Not Rated
			6/85	69/11	6.96/6.17	Not Rated
Troublesome Cr, SR 2422, Rockingham	B-7	16-6-(0.7)	7/98	-/14	-/4.85	Good-Fair
			7/93	-/18	-/4.88	Good-Fair
L Troublesome Cr, ab Reidsville WWTP, Guilford	B-8	16-7	11/94	59/18	6.48/5.58	Fair
			1/92	42/8	6.74/5.63	Fair
			12/87	69/18	6.71/5.21	Fair
L Troublesome Cr, be Reidsville WWTP, Guilford	B-9	16-7	11/94	39/8	7.17/5.80	Fair
			1/92	33/7	6.83/5.15	Fair
			12/87	37/11	6.91/4.16	Fair
L Troublesome Cr, SR 2598, Rockingham	B-10	16-7	5/85	36/3	7.72/5.63	Poor
L Troublesome Cr, SR 2600, Rockingham	B-11	16-7	7/98	42/3	7.60/7.02	Poor
			7/93	42/3	7.22/7.22	Poor

CPF 02

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Haw R, NC 49 at Haw R, Alamance	B-1	16-(1)	5/85	58/10	6.85/5.76	Fair
			8/84	36/12	6.58/5.70	Fair
Haw R, NC 54 nr Graham, Alamance	B-2	16-(1)	7/98	73/21	6/01/4.69	Good-Fair
			7/93	64/19	6.11/5.20	Good-Fair
			8/89	58/14	6.15/5.55	Good-Fair
			8/87	-/13	-/5.43	Fair
			7/87	74/20	6.29/5.49	Good-Fair
			9/85	60/14	6.49/5.43	Fair
			5/84	66/16	6.96/5.44	Fair
			8/83	73/15	7.06/5.50	Fair
Haw R, ab Alamance Cr, Alamance	B-3	16-(1)	5/84	64/16	7.04/5.03	Fair
Haw R, be Alamance Cr, Alamance	B-4	16-(1)	5/84	68/20	7.12/4.61	Fair
Reedy Fk, SR 2128 nr Oak Ridge, Guilf.	B-5	16-11-(1)	7/98	-/19	-/4.06	Good-Fair
			7/93	-/19	-/4.87	Good-Fair
			7/88	69/22	5.55/4.44	Good
			4/86	77/24	5.50/4.48	Good
Brush Cr, SR 2136 (Fleming Rd), Guilford	B-6	16-11-4-(1)	9/98	72/15	6.83/5.00	Fair
Horsepen Cr, US 220, Guilford	B-7	16-11-5-(0.5)	7/98	-/7	-/6.45	Fair
			7/93	-/9	-/6.10	Fair
			4/86	82/22	6.48/5.13	Good-Fair
UT Horsepen Cr, Friendly Rd, Guilford	B-8	16-11-5-1-(2)	9/98	51/6	6.80/6.58	Not Rated
			9/92	43/4	7.58/7.04	Not Rated
Reedy Fk, SR 2728, Guilford	B-9	16-11-(9)	7/98	-/18	-/5.63	Good-Fair
			7/93	-/16	-/5.99	Good-Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 02						
Reedy Fk, NC 87 nr Ossippee, Alamance	B-10	16-11-(9)	7/98	53/11	7.11/6.15	Fair
			7/93	68/20	6.41/5.58	Good-Fair
			8/89	67/14	6.88/6.03	Fair
			7/86	59/10	6.75/6.02	Fair
			5/85	49/12	7.69/5.98	Fair
			8/83	52/13	7.65/6.69	Fair
N Buffalo Cr, ab Cone Mills, Guilford	B-11	16-11-14-1	7/97	43/5	7.49/6.99	Poor
N Buffalo Cr, be Cone Mills, Guilford	B-12	16-11-14-1	7/98	-/5	-/7.08	Poor
			7/97	50/4	7.81/6.49	Poor
N Buffalo Cr, ab WWTP, Guilford	B-13	16-11-14-1	7/97	50/3	7.75/7.00	Poor
			11/88	37/3	7.79/7.42	Poor
N Buffalo Cr, SR 2832 be WWTP, Guilf.	B-14	16-11-14-1	7/98	37/3	8.00/7.00	Poor
			7/93	40/4	8.11/6.68	Poor
			11/88	32/1	8.50/7.78	Poor
			5/85	28/2	8.66/6.05	Poor
S Buffalo Cr, McConnell Rd, Guilford	B-15	16-11-14-2	7/98	-/7	-/6.90	Fair
S Buffalo Cr, US 70 ab WWTP, Guilford	B-16	16-11-14-2	7/98	46/6	7.68/6.48	Poor
			7/93	59/8	7.41/4.89	Fair
			8/88	63/9	7.86/4.68	Poor
S Buffalo Cr, SR 2821 be WWTP, Guilf.	B-17	16-11-14-2	7/98	26/1	8.55/7.78	Poor
			7/93	50/2	8.23/-----	Poor
			8/88	34/1	7.61/7.78	Poor
			5/85	36/2	8.47/6.88	Poor
Mile Run Cr, SR 1400, Guilford	B-18	16-11-14-2-4	4/86	25/1	8.71/7.00	Poor
Stony Cr, SR 1100, Caswell	B-19	16-14-(1)	7/98	-/21	-/5.39	Good
			7/93	-/21	-/4.68	Good
			2/93	-/27	-/4.03	Good
Jordan Cr, SR 1002, Alamance	B-20	16-14-6-(0.5)	7/98	-/16	-/5.02	Good-Fair
			2/93	-/23	-/4.78	Good-Fair
Haw Cr, SR 2158, Alamance	B-21	16-20-(1)	7/98	-/22	-/4.80	Good
			2/93	-/19	-/4.76	Good-Fair

CPF 03

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
L Alamance Cr, SR 3056 ab Rock Cr, Guilford	B-1	16-19-3-(4.5)	2/93	69/24	5.48/4.72	Good
UT Rock Cr, SR 2808, Guilford	B-2	16-19-8-3.5-(1)	11/88	-/20	-/4.52	Not Rated
Big Alamance Cr, NC 49, Alamance	B-3	16-19-(4.5)	7/98	-/18	-/5.54	Good-Fair
			7/93	-/19	-/5.23	Good-Fair
			2/93	-/20	-/4.27	Good-Fair
Big Alamance Cr, SR 2309 nr Bellemont, Alam.	B-4	16-19-(4.5)	10/89	95/31	5.87/4.47	Good
			8/89	79/22	6.11/5.26	Good-Fair
			4/89	79/26	5.77/4.41	Good-Fair
			2/89	65/22	5.84/4.58	Good-Fair
			7/86	80/22	5.84/5.05	Good-Fair
UT Back Cr, off SR 1149, Alamance	B-5	16-19-5	4/95	70/28	4.84/3.95	Excellent
UT Back Cr, be Triangle Paving, Alamance	B-6	16-19-5	4/95	54/22	5.49/4.76	Good
Gum Cr, SR 1148, Alamance	B-7	16-19-7	4/86	67/14	7.52/5.98	Fair
Stinking Quarter Cr, SR 1136, Alamance	B-8	16-19-8	7/98	-/23	-/5.06	Good
			7/93	-/16	-/5.01	Good-Fair
			2/93	-/25	-/4.01	Good-Fair
			4/86	91/30	6.05/5.10	Good
Little Alamance Cr, SR 2309, Alamance	B-9	16-19-11	7/98	-/6	-/6.85	Poor
			7/85	45/8	7.33/6.62	Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 04						
Haw R, SR 2158 nr Saxapahaw, Alamance	B-1	16-(1)	8/83	54/7	6.90/5.63	Fair
Haw R, SR 1005 nr Saxapahaw, Alamance	B-2	16-(1)	11/98	47/15	5.68/4.49	Good-Fair
			7/98	65/20	6.17/4.76	Good-Fair
			7/93	60/18	5.91/5.27	Good-Fair
			7/90	71/20	6.11/5.01	Good-Fair
			8/89	60/18	6.23/5.42	Good-Fair
			7/88	71/21	5.90/5.15	Good-Fair
			7/87	71/21	6.11/5.27	Good-Fair
			7/87	-/21	-/5.05	Good
			7/86	67/19	6.18/5.07	Good-Fair
			9/85	64/23	5.63/5.20	Good
			5/85	73/24	6.30/5.01	Good-Fair
			9/84	61/13	6.53/5.17	Fair
			5/84	85/27	6.01/4.76	Good
Marys Cr, SR 2174, Alamance	B-3	16-26	2/98	-/17	-/3.88	Fair
Cane Cr, SR 1114, Orange	B-4	16-27-(2.5)	7/98	-/27	-/4.33	Good
			2/98	-/25	-/4.20	Good
			2/98	77/37	4.88/3.49	Excellent
			7/93	-/20	-/4.06	Good-Fair
			2/93	-/28	-/3.57	Good
			4/86	110/33	5.63/4.54	Good
Cane Cr, SR 1100, Orange	B-5	16-27-(2.5)	11/84	88/27	5.89/4.87	Good-Fair
Cane Cr, NC 54, Orange	B-6	16-27-(7)	4/94	91/28	5.86/4.17	Good-Fair
Cane Cr, SR 1958, Orange	B-7	16-27-(7)	4/94	110/37	5.85/4.69	Good
Cane Cr (west), SR 2351, Alamance	B-8	16-28	8/98	-/10	-/4.43	Not Rated
			12/86	-/12	-/5.75	Fair
Cane Cr (west), off SR 2351, Alamance	B-9	16-28	8/98	66/15	5.61/4.41	Good-Fair
Cane Cr (west), NC 87, Alamance	B-10	16-28	2/93	-/20	-/4.36	Good-Fair
			12/86	-/5	-/4.86	Poor
Collins Cr, SR 1539, Chatham	B-11	16-30-(1.5)	2/98	-/19	-/4.53	Good-Fair
			12/86	44/4	7.17/4.13	Poor
UT Collins Cr, ab WWTP, Orange	B-12	16-30-(1)	8/91	52/17	5.73/4.67	Good-Fair
UT Collins Cr, be WWTP, Orange	B-13	16-30-(1)	8/91	63/15	5.83/5.08	Good-Fair
Terrells Cr, NC 87, Chatham	B-14	16-31-(2.5)	7/98	-/15	-/4.53	Good-Fair
			2/93	-/30	-/3.32	Good
Terrells Cr, SR 1520, Chatham	B-15	16-31-(2.5)	12/86	-/13	-/5.07	Fair
Dry Cr, SR 1520, Chatham	B-16	16-34-(0.7)	2/98	-/21	-/3.98	Good-Fair
			2/93	-/31	-/4.63	Good
			12/86	-/5	-/6.02	Poor
Haw R, US 64 nr Pittsboro , Chatham	B-17	16-(36.7)	7/98	65/25	5.40/4.34	Good
			7/93	63/24	5.19/4.42	Good
			7/90	60/24	5.47/4.29	Good
			7/88	81/28	5.97/4.70	Good
			7/86	69/24	5.73/4.43	Good
			5/85	84/27	5.74/4.32	Good
			9/84	56/20	5.77/4.69	Good-Fair
			6/83	48/14	5.50/4.43	Good-Fair
			6/83	51/19	5.49/4.49	Good
			6/83	61/19	5.63/4.53	Good
Pokeberry Cr, SR 1711, Chatham	B-18	16-37	2/98	-/30	-/3.93	Good
			2/93	-/23	-/4.68	Good-Fair
			12/86	94/26	5.91/4.24	Good
			10/85	86/21	6.06/4.74	Good-Fair
Robeson Cr, US 15/501, Chatham	B-19	16-38-(3)	3/97	-/12	-/5.94	Fair
UT Robeson Cr, US 64, Chatham	B-20	-	3/97	24/3	7.62/4.03	Not Rated
Robeson Cr, ab Pittsboro WWTP, Chatham	B-21	16-38-(3)	3/97	52/7	6.44/6.26	Fair
			9/90	66/7	7.58/7.00	Poor

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 04						
Robeson Cr, be Pittsboro WWTP, Chatham	B-22	16-38-(3)	9/90	54/7	7.10/5.90	Fair
			4/86	82/11	7.26/5.89	Fair

CPF 05

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
New Hope Cr, SR 1734, Orange	B-1	16-41-1-(0.5)	3/93	94/29	5.03/3.85	Good
New Hope Cr, SR 2220, Durham	B-2	16-41-1-(11.5)	3/87	53/14	6.71/5.72	Fair
New Hope Cr, I-40, Durham	B-3	16-41-1-(11.5)	10/85	49/10	7.76/6.48	Fair
New Hope Cr, SR 1107, Durham	B-4	16-41-1-(11.5)	7/98	38/10	6.79/5.77	Fair
			10/85	32/5	7.59/6.69	Poor
Third Fork Cr, NC 751, Durham	B-5	16-41-1-12-(2)	2/93	39/8	7.63/6.65	Poor
			4/85	40/3	8.10/6.84	Poor
Northeast Cr, SR 1102, Durham	B-6	16-41-1-17-(0.7)	2/98	-/7	-/6.57	Not Rated
			2/93	58/9	6.82/6.05	Not Rated
			3/87	29/3	7.72/6.51	Not Rated
Northeast Cr, SR 1100, Durham	B-7	16-41-1-17-(0.7)	2/93	35/7	6.82/5.83	Not Rated
			3/87	27/0	7.97/-	Not Rated
			12/86	-/4	-/640	Not Rated
			4/85	62/7	7.38/6.09	Not Rated
Northeast Cr, SR 1731, Chatham	B-8	16-41-1-17-(0.7)	7/93	46/8	7.10/6.31	Fair
			12/86	-/8	-/5/95	Fair
Burdens Cr, SR 1945, Durham	B-9	16-41-1-17-1-(0.7) 4/86		60/10	6.96/5.41	Fair
Cub Cr, SR 1008, Chatham	B-10	16-41-2-10-(0.5)	12/86	-/14	-/5.44	Fair
Beartree Cr, SR 1716, Chatham	B-11	16-41-5-(2)	2/98	-/22	-/3.94	Not Rated
			7/93	-/10	-/6.30	Not Rated
			2/93	-/21	-/3.91	Not Rated
			4/86	79/29	4.95/3.78	Not Rated
White Oak Cr, SR 1603, Wake	B-12	16-41-6-(0.7)	2/98	-/10	-/5.17	Not Rated
White Oak Cr, NC 751, Chatham	B-13	16-41-6-(2)	2/93	-/13	-/4.82	Not Rated

CPF 06

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Little Cr, Pinehurst Dr, Orange	B-1	16-41-1-15-(0.5)	2/98	-/5	-/4.84	Poor
			2/93	37/7	7.13/4.70	Fair
Bolin Cr, SR 1777, Orange	B-2	16-41-1-15-1-(0.5)	3/98	-/23	-/4.23	Good
			4/93	-/24	-/4.46	Good
Bolin Cr, Village Rd, Orange	B-3	16-41-1-15-1-(0.5)	2/98	59/26	5.10/3.94	Good
			4/93	-/24	-/3.90	Good-Fair
Bolin Cr, E Franklin St, Orange	B-4	16-41-1-15-1-(4)	3/98	37/13	6.28/6.01	Fair
			2/98	-/4	-/6.66	Poor
			2/93	32/8	6.53/5.35	Fair
			4/86	89/28	6.08/4.35	Good-Fair
Booker Cr, Piney Mt. Rd, Orange	B-5	16-41-1-15-2-(1)	3/98	-/10	-/5.80	Fair
Morgan Cr, NC 54, Orange	B-6	16-41-2-(1)	2/98	-/31	-/3.64	Good
			2/98	80/33	4.38/3.29	Excellent
			10/96	64/22	5.03/4.12	Good
			7/93	61/21	4.93/3.49	Good
			2/93	90/36	4.48/3.23	Excellent
			4/85	109/32	5.72/4.69	Good
Morgan Cr, Botanical Trail, Orange	B-7	16-41-2-(5.5)	3/98	46/20	6.09/5.40	Good-Fair
			4/93	-/16	-/4.94	Fair
			2/93	71/26	6.00/4.64	Good-Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 06						
Morgan Cr, ab OWASA, Orange	B-8	16-41-2-(5.5)	9/94	58/9	7.27/6.27	Fair
			9/90	63/8	7.16/6.39	Fair
			7/88	82/13	6.94/6.35	Fair
Morgan Cr, be OWASA, Orange	B-9	16-41-2-(5.5)	3/98	44/11	6.67/5.69	Fair
			9/94	47/6	7.61/6.12	Poor
			2/93	42/7	7.21/4.93	Fair
			9/90	66/8	7.47/5.89	Poor
			7/88	52/4	7.80/7.11	Poor
Morgan Cr, SR 1726, Chatham	B-10	16-41-2-(5.5)	7/98	41/9	6.63/6.00	Fair
			7/93	38/7	6.88/6.54	Fair
			7/90	54/8	7.17/6.53	Fair
			7/87	35/6	6.82/6.30	Fair
			4/85	40/5	7.71/5.68	Poor
			8/84	50/10	7.06/5.90	Fair
Pritchards Mill Cr, Damascus Rd, Orange	B-11	16-41-2-3-(0.5)	4/93	-/22	-/4.31	Good-Fair
Meeting of Waters Cr, Laurel Hill Rd, Orange	B-12	16-41-2-7	3/98	-/3	-/7.37	Not Rated
			4/93	-/2	-/7.28	Not Rated

CPF 07

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Gulf Cr, nr SR 1924, Chatham	B-1	18-5-(1)	4/93	34/6	6.68/5.39	Not Rated
UT Gulf Cr, nr SR 1924, Chatham	B-2	18-5-(1)	4/93	19/4	6.63/4.50	Not Rated
Parkers Cr, SR 1450, Harnett	B-3	18-9	7/98	-/19	-/5.43	Good-Fair
			2/98	-/20	-/4.21	Good-Fair
			8/93	83/25	5.45/4.52	Good
			3/93	-/27	-/4.04	Good
Parkers Cr, off SR 1418, Harnett	B-4	18-9	11/88	-/28	-/3.42	Excellent
Avent Cr, SR 1418, Harnett	B-5	18-13	11/88	-/25	-/3.93	Excellent
Hector Cr, SR 1412, Harnett	B-6	18-15	11/88	100/29	5.20/3.83	Excellent
Neils (Neals) Cr, SR 1441, Harnett	B-7	18-16-(0.7)	2/98	-/19	-/5.10	Good-Fair
			3/93	-/18	-/4.66	Fair
Neils (Neals) Cr, SR 1403, Harnett	B-8	18-16-(0.7)	11/88	-/16	-/4.25	Good-Fair
Kenneth Cr, US 401, Wake	B-9	18-16-1-(2)	9/98	67/18	5.97/5.14	Not Rated
Kenneth Cr, nr SR 2772, be F-V, Wake	B-10	18-16-1-(2)	9/98	44/6	6.97/5.60	Not Rated
			9/90	47/3	7.53/6.51	Not Rated
Kenneth Cr, SR 1441,Harnett	B-11	18-16-1-(2)	2/98	-/5	-/6.22	Poor
			3/93	43/7	6.23/5.29	Poor
UT Kenneth Cr, off SR 1447, Harnett	B-12	18-16-1-(2)	8/81	50/16	4.14/2.37	Not Rated
Cape Fear R, US 401 nr Lillington, Harnett	B-13	18-(16.7)	7/98	75/32	5.99/4.84	Good
			8/93	76/28	5.79/4.71	Good
			9/90	107/36	6.10/4.73	Good
			7/88	93/30	5.95/4.72	Good
			7/86	89/29	6.09/4.82	Good
			8/85	91/29	6.20/5.04	Good
			9/84	94/25	6.01/4.98	Good-Fair
			7/83	72/30	5.28/4.54	Good
Cape Fear R, NC 217, Harnett	B-14	18-(20.7)	7/98	76/34	5.46/4.25	Excellent
			8/93	68/30	5.15/4.36	Excellent

CPF 08

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
E Fk Deep R, SR 1541, Guilford	B-1	17-2-(0.3)	7/98	-/13	-/6.01	Fair
			2/93	-/12	-/5.86	Fair
UT E Fk Deep R, I-40, Guilford	B-2	17-2-(0.3)	9/92	38/5	6.88/5.21	Not Rated

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 08						
W Fk Deep R, SR 1850, Guilford	B-3	17-3-(0.3)	9/98	46/11	5.59/4.57	Good-Fair
			7/98	-/12	-/4.35	Fair
			7/93	-/15	-/4.66	Good-Fair
			2/93	-/27	-/4.61	Good-Fair
W Fk Deep R, SR 1818, Guilford	B-4	17-3-(0.7)	8/83	71/12	-/-----	Fair
UT W Fk Deep R, ab LCP, Guilford	B-5	17-3-(0.3)	10/88	35/8	5.97/5.31	Not Rated
UT W Fk Deep R, be LCP, Guilford	B-6	17-3-(0.3)	10/88	6/0	8.41/----	Not Rated
Deep R, SR 1113, Guilford	B-7	17-(4)	9/98	55/12	6.62/6.00	Fair
			8/88	81/8	7.29/6.74	Fair
			8/87	90/17	7.04/6.12	Fair
			8/86	87/13	7.06/6.28	Fair
			7/85	67/14	6.72/6.45	Fair
			8/83	11/0	8.42/----	Poor
Deep R nr Randleman, SR 1921, Guilford	B-8	17-(4)	7/90	73/12	7.20/6.12	Fair
			7/89	66/16	7.03/6.01	Fair
			8/88	78/11	7.28/6.43	Fair
			7/88	80/18	7.03/6.42	Good-Fair
			8/87	78/16	6.99/5.86	Fair
			7/87	-/8	-/6.57	Fair
			8/86	56/10	7.67/6.70	Fair
			8/85	64/11	7.70/6.60	Fair
			8/84	39/7	7.40/6.63	Fair
			8/83	56/9	7.86/6.47	Poor
Deep R, US 220 Bus at Randleman, Randolph	B-9	17-(4)	7/98	77/20	5.98/5.10	Good-Fair
			7/93	74/20	6.07/5.39	Good-Fair
			08/88	63/12	6.64/6.22	Fair
			08/87	81/17	6.66/6.11	Fair
			08/86	74/10	7.14/6.22	Fair
			08/85	56/9	7.78/6.67	Poor
			08/83	60/9	7.22/6.46	Fair
Richland Cr, ab WWTP, Guilford	B-10	17-7	08/88	56/10	7.29/5.55	Fair
Richland Cr, SR 1145 be WWTP, Guilford	B-11	17-7	07/98	28/5	7.88/6.59	Poor
			07/93	53/13	7.09/5.56	Fair
			08/88	62/9	7.61/5.78	Poor
			08/87	61/9	7.60/6.11	Poor
			08/86	40/2	8.19/6.58	Poor
			07/85	30/5	8.42/6.81	Poor
			08/83	47/9	7.53/6.75	Fair
Hickory Cr, SR 1131, Guilford	B-12	17-8-3	07/98	-/12	-/5.31	Not Rated
			02/93	-/18	-/3.30	Fair
Muddy Cr, SR 1929, Randolph	B-13	17-9	07/98	-/13	-/6.06	Not Rated
			02/93	-/22	-/4.71	Good-Fair

CPF 09

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Deep R, SR 2122 at Worthville, Randolph	B-1	17-(4)	8/88	74/10	7.28/6.19	Fair
			8/87	57/9	7.14/5.97	Fair
			8/86	66/10	7.92/6.41	Fair
			7/85	47/5	8.22/6.80	Poor
			8/83	43/3	8.41/7.02	Poor
Deep R, SR 2226 at Cedar Falls, Randolph	B-2	17-(4)	8/88	61/16	6.34/5.29	Good-Fair
			8/87	70/17	6.90/5.88	Fair
			8/86	61/12	6.89/6.23	Fair
			7/85	65/9	7.78/6.70	Poor
			8/83	50/5	7.84/6.83	Poor

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 09						
Deep R, SR 2615 at Ramseur, Randolph	B-3	17-(4)	7/98	71/20	5.93/4.79	Good-Fair
			7/93	67/17	6.22/5.14	Good-Fair
			7/89	73/18	6.11/5.43	Good-Fair
			8/87	78/23	6.27/4.96	Good-Fair
			8/86	75/21	6.46/5.22	Good-Fair
			7/85	74/13	6.92/5.95	Fair
			8/83	62/15	7.15/5.92	Fair
Deep R, SR 2628 at Coleridge, Randolph	B-4	17-(4)	8/86	89/26	6.69/5.30	Good-Fair
			8/85	104/35	5.77/455	Good
			8/83	71/19	6.93/5.78	Good-Fair
Deep R, SR 1461 nr Jugtown, Moore	B-5	17-(4)	7/98	83/34	5.24/4.49	Excellent
			7/93	80/32	5.04/4.23	Excellent
			8/88	96/34	5.04/4.01	Excellent
			8/87	111/38	5.11/4.19	Excellent
			8/86	87/32	4.96/3.80	Excellent
			8/85	99/33	5.22/4.22	Excellent
			8/83	94/33	5.25/4.14	Good
Polecat Cr, US 220 Bus, Guilford	B-6	17-11-(1)	7/90	78/21	5.76/5.33	Good
Polecat Cr, SR 2113, Randolph	B-7	17-11-(1)	2/98	-/31	-/4.04	Good
			2/93	-/32	-/4.31	Good
Polecat Cr, SR 2116, Randolph	B-8	17-11-(1)	7/93	-/9	-/5.09	Fair
			8/83	77/22	6.27/5.69	Good-Fair
UT Polecat Cr, nr SR 3430, Guilford	B-9	17-11-2-(2)	7/90	33/1	8.87/7.42	Not Rated
L Polecat Cr, SR 2108, Randolph	B-10	17-11-3	2/98	-/14	-/4.23	Not Rated
L Polecat Cr, SR 2113, Randolph	B-11	17-11-3	2/93	83/32	4.63/3.44	Excellent
			8/86	91/20	5.14/4.21	Good
Hasketts Cr, SR 2149, Randolph	B-12	17-12	9/98	33/4	7.03/6.41	Poor
			2/87	58/12	7.01/5.46	Fair
Hasketts Cr, be SR 2149, Randolph	B-13	17-12	2/90	58/10	7.11/6.56	Fair
			8/88	66/12	7.64/6.63	Fair
Hasketts Cr, SR 2128, Randolph	B-14	17-12	9/98	27/5	7.79/6.86	Poor
			2/90	42/9	7.43/5.48	Poor
			8/88	35/4	7.92/7.02	Poor
			8/87	33/3	7.92/5.85	Poor
			2/87	29/3	8.34/5.80	Poor
Sandy Cr, SR 2261, Randolph	B-15	17-16-(1)	5/89	81/19	6.44/4.39	Good-Fair
			5/88	69/15	6.10/5.24	Good-Fair
Sandy Cr, SR 2481, Randolph	B-16	17-16-(1)	7/98	-/35	-/4.43	Excellent
			7/93	-/22	-/4.06	Good
			2/93	-/27	-/3.28	Good
			5/89	83/25	5.39/4/41	Good
			5/88	94/32	5.42/4.07	Good
UT Sandy Cr, SR 2261, Randolph	B-17	17-16-(1)	5/89	80/22	5.62/4.20	Good
			5/88	76/17	6.17/4.84	Good-Fair
Mt Pleasant Cr, SR 2442, Randolph	B-18	17-16-3	5/89	80/22	4.99/4.06	Good
Richland Cr, SR 2873, Randolph	B-19	17-22	7/98	-/29	-/3.92	Excellent
			7/93	-/26	-/3.89	Good
			2/93	-/23	-/3.60	Good
			5/88	81/27	5.30/3.93	Good
Brush Cr, SR 1102, Chatham	B-20	17-23	5/90	-/26	-/4.90	Good
Brush Cr, NC 22, Randolph	B-21	17-23	7/98	-/26	-/4.27	Good
			2/93	-/23	-/3.58	Good
			5/90	-/28	-/4.25	Excellent
			8/83	95/26	6.03/4.38	Good
UT Little Brush Cr, SR 1100, Chatham	B-22	17-23-2	5/90	-/23	-/5.02	Good
UT Little Brush Cr, SR 1005, Randolph	B-23	17-23-2	5/90	-/17	-/4.13	Good-Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 09						
Flat Cr, SR 2886, Randolph	B-24	17-24	2/98	-/22	-/4.72	Good-Fair
			2/93	-/17	-/5.07	Fair
Fork Cr, SR 2873, Randolph	B-25	17-25	2/98	-/28	-/3.75	Good
			2/93	-/22	-/3.38	Good

CPF 10

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Deep R, NC 22, Moore	B-1	17-(25.7)	7/89	69/24	5.58/4.83	Good
Wolf Cr, SR 1403, Moore	B-2	17-26-4	7/88	-/17	-/5.55	Good-Fair
			2/84	91/30	5.36/3.76	Good
Cabin Cr, SR 1400, Moore	B-3	17-26-5-(1)	3/98	-/29	-/4.20	Good
			2/93	-/27	-/3.62	Good
			9/92	-/14	-/4.50	Not Rated
Cabin Cr, private rd off SR 1002, Moore	B-4	17-26-5-(1)	9/92	61/11	6.37/3.71	Fair
Cabin Cr, SR 1275, Moore	B-5	17-26-5-(1)	9/92	91/27	5.50/3.73	Good
Cotton Cr, SR 1372, Montgomery	B-6	17-26-5-3	9/98	38/4	6.61/5.82	Poor
			9/92	35/4	6.20/4.19	Fair
			7/88	15/0	9.3/0	Poor
			2/84	18/2	8.79/6.53	Poor
Cotton Cr, SR 1370, Montgomery	B-7	17-26-5-3	9/98	49/11	6.07/4.39	Fair
			9/92	42/7	6.60/5.32	Fair
			2/84	33/10	7.16/4.76	Fair
Mill Cr, nr SR 1275, Moore	B-8	17-26-5-4	7/98	-/20	-/4.20	Good-Fair
			3/98	76/31	4.79/4.02	Good
			8/93	69/22	5.19/3.60	Good
			2/93	97/39	4.11/2.90	Excellent
Wet Cr, NC 24, Moore	B-9	17-26-5-5	3/98	-/24	-/3.26	Good
			2/93	-/34	-/3.95	Good
Bear Cr, NC 705, Moore	B-10	17-26-(6)	7/98	82/25	5.70/4.42	Good
			8/93	73/22	6.27/4.92	Good-Fair
Falls Cr, SR 1606, Moore	B-11	17-27	2/98	-/17	-/4.89	Not Rated
			2/93	-/18	-/4.61	Not Rated
Buffalo Cr, NC 22, Moore	B-12	17-28	2/98	-/27	-/3.93	Not Rated
			2/93	-/20	-/3.51	Not Rated
McLendons Cr, SR 1210, Moore	B-13	17-30	11/84	84/28	5.33/4.27	Not Rated
McLendons Cr, SR 1628, Moore	B-14	17-30	8/93	61/8	6.75/5.15	Not Rated
			2/93	-/13	-/5.59	Not Rated
Haystack Cr, off SR 1261, Moore	B-15	17-30-1-2	3/86	63/21	4.86/2.63	Good
			2/84	65/25	4.20/2.31	Good
Big Governors Cr, SR 1625, Moore	B-16	17-32	2/98	45/11	6.64/5.44	Not Rated
			2/93	49/10	6.26/4.48	Not Rated
Crawley Cr, nr SR 1625, Moore	B-17	17-32-2	2/98	-/10	-/5.47	Not Rated
Indian Cr, SR 2306, Chatham	B-2	17-35	3/93	-/10	-/5.18	Not Rated

CPF 11

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
UT Deep R, nr SR 2140, Chatham	B-1	17-(33.5)	9/87	64/13	6.50/5.28	Good-Fair
Deep R, SR 1007, Lee	B-3	17-(36.5)	7/98	61/23	5.93/4.65	Good-Fair
			8/93	74/25	5.78/4.90	Good
			9/87	99/32	5.76/4.23	Good
Little Pocket Cr, NC 42, Lee	B-4	11-37-4 (2)	2/98	-/14	-/4.57	Not Rated
			2/93	-/16	-/5.04	Not Rated
Cedar Cr, SR 2142, Chatham	B-5	17-39	2/98	-/16	-/5.09	Not Rated
			2/93	-/13	-/5.28	Not Rated
Big Buffalo Cr, SR 1403, Lee	B-6	17-40	8/93	-/4	-/6.12	Not Rated
			2/93	-/12	-/5.13	Not Rated
Georges Cr, SR 2142, Chatham	B-7	17-41	2/93	-/15	-/4.83	Not Rated

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 11						
Georges Cr, SR 2150, Chatham	B-8	17-41	2/98	-/4	-/4.25	Not Rated
Deep R, US 15/501-NC 87, Lee	B-9	17-(41.5)	7/98	72/21	6.39/4.96	Good-Fair
			8/93	77/27	5.97/4.65	Good
			9/87	88/25	6.09/4.62	Good-Fair
Little Buffalo Cr, SR 1420, Lee	B-10	17-42	2/93	-/5	-/7.09	Not Rated

CPF 12

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Rocky R, US 64, Chatham	B-1	17-43-(8)	7/98	78/16	6.40/4.60	Good-Fair
			6/97	77/20	6.74/5.08	Good-Fair
			7/93	69/12	6.97/5.65	Fair
			8/89	57/16	6.70/5.80	Fair
Rocky R, SR 2170, Chatham	B-2	17-43-(8)	7/98	69/19	6.24/4.97	Good-Fair
			6/97	80/19	6.47/5.29	Good-Fair
			7/93	66/19	6.54/5.38	Good-Fair
			8/89	56/11	6.77/6.12	Fair
Rocky R, NC 902, Chatham	B-3	17-43-(8)	6/97	-/22	-/4.76	Good
			8/89	73/24	5.84/4.77	Good-Fair
Rocky R, US 15/501, Chatham	B-4	17-43-(8)	7/98	77/26	5.26/3.99	Good
			7/93	85/30	5.41/4.22	Good
			7/90	98/30	5.54/4.51	Good
Loves Cr, nr SR 2203 ab WWTP, Chatham	B-5	17-43-10	6/97	55/8	7.25/6.61	Fair
			8/89	52/7	7.50/6.85	Fair
Loves Cr, be WWTP nr SR 2203, Chatham	B-6	17-43-10	6/97	36/4	7.41/6.06	Poor
			8/89	27/2	8.41/6.62	Poor
Tick Cr, US 421, Chatham	B-7	17-43-13	2/98	-/18	-/4.86	Good-Fair
			7/93	-/5	-/6.57	Poor
			8/85	80/19	6.54/5.40	Good-Fair
Tick Cr, SR 2120, Chatham	B-8	17-43-13	7/98	-/15	-/5.87	Good-Fair
Landrum Cr, NC 902, Chatham	B-9	17-43-14	7/90	-/19	-/3.53	Good-Fair
Harlands Cr, NC 902, Chatham	B-10	17-43-15	7/98	-/23	-/4.45	Good
			2/98	-/22	-/4.68	Good-Fair
			7/90	-/16	-/3.78	Good-Fair
Bear Cr, SR 2333, Chatham	B-11	17-43-16	8/91	73/16	6.78/5.56	Not Rated
Bear Cr, SR 2189, Chatham	B-12	17-43-16	8/91	69/15	6.51/5.58	Not Rated
Bear Cr, SR 2155, Chatham	B-13	17-43-16	7/90	-/15	-/4.83	Not Rated

CPF 13

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Juniper Cr, SR 1144, Lee	B-1	18-20-6-(1)	11/88	-/9	-/4.19	Fair
Upper Little R, SR 1222, Harnett	B-2	18-20-(8)	7/98	72/21	6.36/5.07	Good-Fair
			8/93	56/13	6.17/4.74	Good-Fair
			12/88	77/19	5.92/4.16	Good-Fair
Upper Little R, NC 27, Harnett	B-3	18-20-(8)	7/98	81/27	5.50/3.92	Good
			8/93	81/26	5.51/3.85	Good
Barbeque Cr, SR 1209, Harnett	B-4	18-20-13	7/98	-/20	-/3.67	Good
			8/93	-/14	-/3.61	Good-Fair
			11/88	-/19	-/4.09	Good-Fair
Upper Little R, nr SR 2016 ab Becker, Harnett	B-5	18-20-4	7/91	-/23	-/3.89	Good
Upper Little R, nr SR 2016 be Becker, Harnett	B-6	18-20-4	7/91	-/17	-/3.00	Good-Fair
Upper Little R, SR 2021 nr Erwin, Harnett	B-7	18-20-4	7/98	88/35	5.13/3.69	Excellent
			8/93	67/25	5.34/3.86	Good
			7/91	-/25	-/3.44	Excellent
			7/88	83/27	5.25/3.79	Excellent

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 14						
Nicks Cr, NC 22, Moore	B-1	18-23-3-(3)	7/98	-/24	-/3.92	Excellent
			8/93	-/20	-/3.27	Good
			11/88	-/22	-/2.99	Good
(Lower)Little R, SR 2023, Moore	B-2	18-23-(10.7)	7/98	75/31	4.69/3.55	Excellent
			8/93	70/33	4.54/3.23	Excellent
			4/90	-/35	-/3.94	Excellent
			12/88	85/35	4.37/2.63	Excellent
Mill Cr, SR 1853, Moore	B-3	18-23-11-(2)	7/98	68/30	4.86/3.69	Excellent
UT McDeeds Cr, bel HB/PS, Moore	B-4	18-23-11-4	7/93	15/0	8.46/0.00	Not Rated
James Cr, nr SR 2023, Hoke	B-5	18-23-13	4/90	-/24	-/3.93	Good
James Cr, at Little River, Moore	B-6	18-23-13	11/88	-/22	-/2.75	Good
James Cr, nr Weymouth Springs, Moore	B-7	18-23-13-1	3/86	49/11	5.01/2.99	Good
			2/84	55/16	4.46/2.63	Good
Horse Cr, Manchester Rd, Hoke	B-8	18-23-14	4/90	-/18	-/3.41	Good-Fair
Flat Cr, Manchester Rd, Hoke	B-9	18-23-15	4/90	-/21	-/3.52	Good
			12/84	74/24	4.98/3.97	Good
Mill Cr, Manchester Rd, Hoke	B-10	18-23-17-1	4/90	-/13	-/3.65	Good-Fair
UT in Sicily Drop Zone, Man. Rd, Hoke	B-11	18-23-17	4/90	-/2	-/2.37	Not Rated
Jumping Run Cr, Manchester Rd, Hoke	B-12	18-23-20	4/90	-/13	-/4.37	Good-Fair
McPherson Cr, Manchester Rd, Cumber.	B-13	18-23-23.7	4/90	-/12	-/4.70	Good-Fair
(Lower) Little R, NC 87/24 at Manchester,	B-14	18-23-(24)	7/98	83/40	4.79/3.71	Excellent
Cumberland			8/93	64/18	5.59/4.42	Good-Fair
			7/90	73/19	6.04/4.80	Good-Fair
			7/88	50/7	7.22/5.23	Fair
			6/86	57/8	6.74/3.03	Fair
			9/84	81/25	5.34/3.73	Good
(Lower) Little R, US 401, Cumberland	B-15	18-23-(24)	7/98	87/38	4.64/3.95	Excellent
			8/93	70/26	5.06/3.24	Excellent
Jumping Run Cr, NC 210, Cumberland	B-16	18-23-29	7/98	-/26	-/4.09	Excellent
			8/93	-/16	-/3.24	Good-Fair
Anderson Cr, SR 2031, Harnett	B-17	18-23-32	7/98	-/19	-/3.60	Good-Fair
			8/93	-/13	-/2.97	Good-Fair

CPF 15

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Cape Fear R, ab Cross Cr, Cumberland	B-1	18-(26)	1/86	77/32	5.58/4.13	Good
Cape Fear R, be Cross Cr WWTP, Cumber.	B-2	18-(26)	1/86	82/24	6.10/4.10	Good-Fair
Cape Fear R, Person Street, Cumberland	B-3	18-(26)	7/98	40/14	6.14/4.74	Not Rated
		18-(26)	8/93	48/19	5.38/4.05	Good-Fair
Cape Fear R, be Monsanto, Cumberland	B-4	18-(26)	1/86	78/28	5.78/4.46	Good
Cross Cr, ab UT, Cumberland	B-5	18-27-(1)	4/90	-/7	-/5.04	Not Rated
Cross Cr, be UT, Cumberland	B-6	18-27-(1)	4/90	-/10	-/5.12	Not Rated
Cross Cr, NC 87/210, Cumberland	B-7	18-27-(3)	8/93	-/10	-/6.01	Fair
Little Cross Cr, ab lake nr Bragg Blvd, Cumb.	B-8	18-27-4-(1)	9/98	48/12	5.98/4.58	Not Rated
			4/90	-/2	-/2.52	Not Rated
UT Little Cross Cr, ab Glenville Lake, Cumb.	B-9	18-27-4-(1)	9/98	-/8	-/2.93	Not Rated
Little Cross Cr, be Glenville Lake, Cumb.	B-10	18-27-4-2	3/98	37/7	6.93/6.10	Fair
Rockfish Cr, Plank Rd, Hoke	B-11	18-31-(1)	4/90	-/16	-/3.78	Good-Fair
Juniper Cr, Plank Rd, Hoke	B-12	18-31-10	4/90	-/19	-/3.85	Good
Pedler Br, NC 20, Hoke	B-13	18-31-16	2/90	36/2	8.29/6.33	Not Rated
Pedler Br, US 401, Hoke	B-14	18-31-16	2/90	16/0	8.46/-	Not Rated
Puppy Cr, Plank Rd, Hoke	B-15	18-31-19	4/90	-/15	-/4.35	Good-Fair
Rockfish Cr, SR 1300 (Vass Rd), Cumberland	B-16	18-31-(12)	5/94	66/25	5.10/3.94	Good

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 15						
Rockfish Cr, SR 1432, Hoke	B-17	18-31-(23)	7/98	61/26	5.33/3.91	Excellent
			5/94	-/24	-/3.68	Good
			8/93	61/25	4.81/3.48	Good
			6/90	-/16	-/4.24	Good-Fair
Rockfish Cr, SR 1115, Cumberland	B-18	18-31-(23)	5/94	76/23	5.40/3.80	Good
			6/90	-/17	-/4.53	Good-Fair
Rockfish Cr, US 301 Bus, Cumberland	B-19	18-31-(23)	7/83	60/25	5.03/4.11	Excellent
Rockfish Cr, I-95 nr Hope Mills, Cumberland	B-20	18-31-(23)	6/90	-/24	-/4.16	Excellent
			7/88	77/31	5.17/4.14	Excellent
Rockfish Cr, NC 87, Cumberland	B-21	18-31-(23)	7/98	68/32	4.56/3.82	Excellent
			8/93	60/23	4.95/3.65	Good
Little Rockfish Cr, Plank Rd, Hoke	B-22	18-31-24-(1)	4/90	-/12	-/3.50	Good-Fair
Bones Cr Trib, nr SR 1400, Cumberland	B-23	18-31-24-2	1/89	44/17	6.75/5.15	Not Rated
UT Bones Cr, be Sunset MHP, Cumberland	B-24	18-31-24-2	1/89	6/0	9.49/-	Not Rated
Little Rockfish Cr, NC 59, Cumberland	B-25	18-31-24-(4)	7/98	-/22	-/4.06	Good
			8/93	-/23	-/3.70	Good
Buckhead Cr, off Glenwick Rd, Cumberland	B-26	18-31-24-6	5/97	39/1	7.68/6.22	Not Rated
Little Rockfish Cr, SR 1131 be lake, Cumb.	B-27	18-31-24-(7)	6/90	-/13	-/4.78	Good-Fair

CPF 16

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Cape Fear R, SR 1355 nr Duarte, Bladen	B-1	18-(26)	8/98	48/16	6.74/5.82	Good-Fair
			8/93	50/10	6.37/4.69	Fair
Cape Fear R, ab Carolina Foods, Bladen	B-2	18-(26)	9/92	47/14	6.19/4.73	Good-Fair
Cape Fear R, be Carolina Foods, SR 1316,	B-3	18-(26)	9/92	45/11	6.56/4.77	Fair
nr Tar Heel, Cumberland			6/87	41/7	7.24/5.22	Fair
Cape Fear R, be Lock 2 nr Elizabethtown,	B-4	18-(26)	8/98	39/14	6.57/5.37	Good-Fair
Bladen			8/93	53/15	6.74/4.91	Good-Fair
Ellis Cr, NC 53, Bladen	B-5	18-44	8/98	-/16	-/3.95	Good-Fair
			8/93	-/16	-/3.88	Good-Fair
Harrison Cr, SR 1318, Bladen	B-6	18-42	8/98	-/17	-/3.39	Good-Fair
			8/93	-/11	-/3.61	Fair
Turnbull Cr, SR 1511, Bladen	B-7	18-46	8/98	-/18	-/3.93	Good
Cape Fear R, SR 1730 at Kelly, Bladen	B-8	18-(53.5)	8/98	49/15	6.72/4.82	Good-Fair
			8/93	48/11	6.51/4.62	Fair
			8/90	44/12	7.42/4.28	Fair
			7/88	69/12	7.14/6.35	Fair
			6/86	51/6	7.25/6.83	Fair
			8/84	52/7	7.20/5.66	Fair

CPF 17

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Cape Fear R, ab Federal Paper, Columbus	B-1	18-(59)	7/98	51/13	6.36/5.06	Excellent
			8/93	45/8	6.61/4.81	Good-Fair
Cape Fear R, be Federal Paper, Columbus	B-2	18-(63)	7/98	36/4	7.00/5.21	Fair
			8/93	32/5	7.21/5.34	Fair
Livingston Cr, NC 74, Columbus	B-3	18-64	7/98	83/20	6.30/5.31	Good-Fair
			8/93	68/9	7.31/5.60	Fair
Livingston Cr, SR1878, Columbus	B-4	18-64	8/90	39/4	7.65/4.22	Not Rated
			8/90	24/0	8.73/-	Not Rated
Hood Cr, US 74/76, Brunswick	B-5	18-66	9/98	-/13	-/4.75	Not Rated
			7/98	-/18	-/4.14	Not Rated
			3/98	69/20	5.86/4.70	Not Rated
Jumping Run Br, ab 17th St, New Hanover	B-6	18-76-1-3	5/95	43/9	6.25/4.08	Not Rated
			9/94	58/4	7.46/7.11	Not Rated
Jumping Run Br, be 17th St, New Hanover	B-7	18-76-1-3	5/95	28/1	7.73/4.10	Not Rated
			9/94	43/3	7.53/6.96	Not Rated

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 17						
Brunswick R, nr mouth, Brunswick	B-8	18-77	6/93	11/1	1.44/-	Not Rated
Barnards Cr, US 421, New Hanover	B-9	18-80	2/98	45/5	7.72/6.58	Not Rated
Town Cr, ab SR 1413, Brunswick	B-10	18-81	9/98	-/16	-/4.34	Not Rated
			7/98	-/15	-/5.02	Not Rated
			3/98	71/24	5.86/4.77	Not Rated
Lewis Swp, SR 1410, Brunswick	B-11	18-81-2	3/98	63/14	6.36/5.05	Not Rated

Estuarine

Site	Site #	Index #	Date	S/A&C S	EBI	Bioclass
Cape Fear R, Wilmington Main St, New Han.	B-12	18-72	7/83	8/0	2.08	Not Rated
Cape Fear R, Wilmington Docks, New Han.	B-13	18-72	6/98	22/0	1.24	Not Rated
			6/93	9/0	1.33	Not Rated
Cape Fear R, S. Side WWTP, New Hanover	B-14	18-72	6/98	30/4	1.66	Not Rated
			6/93	9/0	1.07	Not Rated
Cape Fear R, Mkr 56, New Hanover	B-15	18-72	6/98	31/6	2.08	Not Rated
Cape Fear R, Mkr 40, New Hanover	B-16	18-72	6/98	19/7	1.92	Not Rated
Cape Fear R, Mkr 35, Brunswick	B-17	18-72	6/98			Not Rated
Cape Fear R, at Snow's Marsh, Brunswick	B-18	18-(87.5)	6/98	75/12	2.06	Not Rated
			6/96	94/16	1.99	Not Rated
			6/93	62/8	1.95	Not Rated
			7/85	38/0	2.14	Not Rated
Cape Fear R, at Southport, Brunswick	B-19	18-88-3.5	10/98	57/6	2.50	Not Rated
			7/98	85/17	2.29	Not Rated
The Basin at Zeke's Island						
nr Wilmington, US421, New Hanover	B-20	18-88-8-1	7/85	61/0	2.52	Not Rated
at Rocks, New Hanover	B-21	18-88-8-1	7/98	42/4	2.09	Not Rated

CPF 18

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
South R, NC 13, Sampson	B-1	18-68-12(0.5)	10/89	-/5	-/5.78	Not Rated
South R, NC 242, Cumberland	B-2	18-68-12(0.5)	10/89	-/26	-/3.91	Excellent
South R, SR 1502, nr Parkersburg,	B-3	18-68-12(0.5)	8/98	68/25	5.91/4.46	Good
Sampson/Bladen County line			8/93	75/25	5.36/3.75	Good
			6/87	84/29	5.46/3.85	Excellent
			9/85	93/30	5.49/3.81	Excellent
			7/83	76/25	5.49/4.16	Good
Black R, US 421, Harnett	B-4	18-68-12-1	10/89	-/11	-/5.47	Not Rated
Black R, SR 1780, nr Dunn, Harnett	B-5	18-68-12-1	7/84	53/13	6.79/5.93	Fair
Mingo Swamp, NC 55, Sampson/Harnett	B-6	18-68-12-2	8/94	18/0	7.78/0	Poor
Mingo Swamp, US 421, Sampson/Harnett	B-7	18-68-12-2	8/94	50/10	7.28/6.33	Fair
Beaverdam Swamp, SR 1005, Sampson	B-8	18-68-12-2-4-1	6/98	-/6	-/5.22	Not Rated
Big Cr, SR 1851, Cumberland	B-9	18-68-12-5	6/98	-/12	4.78/4.69	Good-Fair
Big Swamp, SR 1246, Sampson	B-10	18-68-12-8	12/89	-/14	-/5.38	Good-Fair

CPF 19

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Great Coharie Cr, SR 1214, Sampson	B-1	18-68-1	8/98	39/12	5.88/4.06	Good-Fair
			8/93	77/26	5.51/4.23	Good
			10/89	-/19	-/4.53	Good
			9/88	69/20	5.89/4.47	Good
			7/83	62/19	5.53/3.66	Good-Fair
Little Coharie Cr, NC 24, Sampson	B-2	18-68-1-17	8/93	-/20	-/4.69	Good
Little Coharie Cr, SR 1214, Sampson	B-3	18-68-1-17)	8/98	-/16	-/4.41	Good-Fair
			8/93	-/17	-/4.08	Good-Fair
			10/89	-/23	-/3.86	Good
Little Coharie Cr, SR 1207	B-4	18-68-1-17	9/88	-/17	-/3.94	Good-Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 19						
Six Runs Cr, SR 1004, Sampson	B-5	18-68-2	11/96	-/9	-/5.43	Fair
			12/89	-/21	-/3.78	Good
Six Runs Cr, SR 1960, Sampson	B-6	18-68-2	9/98	-/13	-/5.49	Good-Fair
			8/98	-/23	-/4.78	Good
			8/93	-/28	-/3.39	Excellent
Six Runs Cr, SR 1130, Sampson	B-7	18-68-2	10/89	-/26	-/3.39	Excellent
Six Runs Cr, SR 1003, Sampson	B-8	18-68-2	9/88	-/25	-/4.07	Excellent
Tenmile Swp, SR 1740, Sampson	B-9	18-68-2-4	12/86	58/6	7.45/5.92	Fair
Stewarts Cr, SR 1973, Sampson	B-10	18-68-2-10	11/96	-/8	-/5.20	Fair
			12/89	-/17	-/4.73	Good-Fair
Crane Cr, SR 1004, Sampson	B-11	18-68-2-12	6/98	-/14	-/5.16	Good-Fair
Black R, NC 411 nr Tomahawk, Sampson	B-12	18-68	10/98	58/19	5.77/4.51	Good
			8/98	77/30	5.42/4.35	Excellent
			8/93	96/31	5.49/3.92	Excellent
			10/89	-/31	-/3.67	Excellent
			7/88	107/37	5.51/4.26	Excellent
			9/85	94/30	5.33/3.98	Excellent

CPF 20

Site	Site#	Index#	Date	S/EPTS	BI/BIEPT	Bioclass
Black R, at Turlington's (3 Sisters Area), Pend.	B-1	18-68	9/88	72/22	5.60/4.16	Good
Black R, NC 11 nr Atkinson , Bladen	B-2	18-68	7/98	90/28	5.86/4.46	Good
			8/93	73/28	5.53/4.39	Good
			9/91	100/28	5.79/4.23	Good
			8/90	48/18	6.19/4.59	Good-Fair
			10/89	-/28	-/3.89	Excellent
			6/86	78/23	6.18/4.82	Good
Moores Cr, NC 53, Pender	B-3	18-68-18	3/98	-/11	-/4.96	Good
White Oak Br, SR 1209, Pender	B-4	18-68-18-5	12/87	-/17	-/5.02	Good-Fair
Lyons Swamp Canal, NC 11, Bladen	B-5	18-68-22-1-1	3/98	-/5	-/6.24	Fair

CPF 21

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
NE Cape Fear R, SR 1937, Wayne	B-1	18-74-(1)	5/93	54/4	7.85/6.87	Not Rated
			6/86	13/0	8.08/-	Not Rated
NE Cape Fear R, NC 403, Duplin	B-2	18-74-(1)	5/93	68/13	6.96/5.27	Good-Fair
NE Cape Fear R, SR 1948, Wayne	B-3	18-74-(1)	5/93	67/15	6.16/4.88	Good-Fair
Barlow Br, Bell St in Faison, be Mt. Olive, Duplin	B-4	18-74-2	5/93	26/0	8.88/-	Not Rated
			6/86	8/0	9.63/-	Not Rated
Polly Run Cr, SR 1501, Duplin	B-5	18-74-5	7/86	67/11	6.70/5.52	Fair
Buck Marsh Br, NC 111, Duplin	B-6	18-74-8	8/93	-/16	-/3.84	Good-Fair
Grove Cr, SR 1301, ab Kenans. WWTP, Duplin	B-7	18-74-21	5/94	61/13	6.35/4.79	Not Rated
Grove Cr, NC 11, be Kenansv. WWTP, Duplin	B-8	18-74-21	5/94	63/9	6.99/5.05	Not Rated
Little Rockfish Cr, NC 11, Duplin	B-9	18-74-29-6	5/94	24/0	8.27/-	Poor

CPF 22

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
NE Cape Fear R, NC 11/903, Duplin	B-1	18-74-(1)	8/98	-/17	-/5.49	Good-Fair
			8/93	78/23	5.33/3.86	Excellent
			7/86	32/8	5.47/4.34	Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 22						
NE Cape Fear R, NC 41, nr Chinquapin, Duplin	B-2	18-74-(25.5)	9/98	40/3	7.00/4.48	Poor
			8/98	70/28	5.66/4.92	Good
			8/93	82/22	5.43/4.57	Good
			10/89	-/26	-/4.17	Excellent
			10/89	85/28	5.74/3.95	Good
			8/89	-/27	-/4.07	Excellent
			8/89	83/30	5.40/4.17	Excellent
			9/85	89/31	5.65/4.00	Excellent
Goshen Swp, SR 1302, Wayne	B-3	18-74-19	5/93	62/8	6.66/5.30	Not Rated
Goshen Swp, US 117, Duplin	B-4	18-74-19	5/93	51/11	6.68/5.44	Not Rated
Goshen Swp, NC 403, Duplin	B-5	18-74-19	5/93	56/10	6.67/5.57	Not Rated
Panther Br, NC 50, Duplin	B-6	18-74-19-3	12/86	64/11	6.59/5.10	Not Rated
Panther Br, be Faison UT, Duplin	B-7	18-74-19-3	5/93	35/1	8.26/6.22	Not Rated
			12/86	10/0	8.05/0	Not Rated
Halls Marsh Run, SR 1306, Duplin	B-8	18-74-19-11	9/96	-/4	-/5.51	Not Rated
			9/95	67/13	6.55/5.53	Not Rated
			9/94	76/9	6.82/5.23	Not Rated
			9/93	68/12	6.55/5.27	Not Rated
			9/92	69/9	6.36/4.98	Not Rated
			9/91	54/7	6.55/4.88	Not Rated
			9/90	68/11	6.56/4.92	Not Rated
UT Herrings Marsh Run, SR 1508, Duplin	B-9	18-74-19-16	9/93	-/8	-/4.89	Not Rated
			9/92	-/7	-/5.22	Not Rated
			9/91	-/2	-/5.68	Not Rated
Herrings Marsh Run, SR 1508, Duplin	B-10	18-74-19-16	9/93	0/0	0/0	Not Rated
			9/92	-/8	-/4.94	Not Rated
			9/91	-/14	-/4.43	Not Rated
Herrings Marsh Run, SR 1306, Duplin	B-11	18-74-19-16	9/96	48/4	7.03/6.68	Not Rated
			9/95	55/9	6.61/5.50	Not Rated
			9/94	69/8	7.32/5.77	Not Rated
			9/93	71/15	7.02/5.45	Not Rated
			9/92	72/13	6.58/5.13	Not Rated
			9/91	67/11	6.13/4.87	Not Rated
			9/90	74/10	6.79/5.44	Not Rated
			1/90	-/13	-/5.08	Not Rated
UT Grove (Maple) Cr, SR 1376, Duplin	B-12	18-74-21	9/90	62/15	6.29/4.61	Good-Fair
Limestone Cr, NC 111, Duplin	B-13	18-74-23	7/95	-/3	-/6.64	Not Rated
Limestone Cr, NC 24, Duplin	B-14	18-74-23	4/86	35/1	7.36/6.23	Poor
Limestone Cr, SR 1702, Duplin	B-15	18-74-23	8/98	-/14	-/4.85	Good-Fair
			7/95	-/4	-/5.48	Poor
			8/93	-/26	-/4.50	Excellent
Stockinghead Cr, SR 1953, Duplin	B-16	18-74-24	8/98	-/12	-/4.72	Good-Fair
			8/93	-/13	-/3.99	Good-Fair
Maxwell Cr, SR 1921, Duplin	B-17	18-74-24-1	6/85	55/5	6.89/5.52	Fair
UT Beaverdam Cr, SR 1916, Duplin	B-18	18-74-24-1-1	4/87	49/4	7.05/5.05	Not Rated
Cabin Br, SR 1911, Duplin	B-19	18-74-24-1-1-1	4/87	37/0	8.16/0	Poor
			6/85	48/2	8.72/8.94	Poor
Cabin Br, SR 1915, Duplin	B-20	18-74-24-1-1-1	4/87	20/0	9.11/0	Poor
			6/85	38/0	8.91/0	Poor
Muddy Cr, NC 41, Duplin	B-21	18-74-25	8/98	-/8	-/5.37	Fair
			8/93	-/4	-/5.59	Not Rated
Persimmon Br, ab Beulaville, Duplin	B-22	18-74-25-1	9/90	45/4	6.98/6.62	Not Rated
Persimmon Br, be Beulaville, Duplin	B-23	18-74-25-1	9/90	31/0	7.53/0	NR
Rockfish Cr, NC 41, at Wallace, Duplin	B-24	18-74-29	7/88	79/17	6.47/4.84	Good-Fair

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
CPF 22						
Rockfish Cr, SR 1165, Duplin	B-25	18-74-29	8/98	44/8	6.87/5.39	Fair
			8/93	81/14	6.31/4.79	Good-Fair
Rockfish Cr, I-40, Duplin	B-26	18-74-29	10/98	50/6	7.30/6.02	Fair
			8/98	62/16	6.97/5.85	Good-Fair
			8/93	64/12	6.83/5.26	Fair

CPF 23

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
NE Cape Fear R, nr Watha, Pender	B-1	18-74-(29.5)	7/83	44/5	7.30/4.84	Not Rated
NE Cape Fear R, NC 53 ab br, Pender	B-2	18-74-(29.5)	5/94	47/10	7.16/5.45	Not Rated
NE Cape Fear R, NC 53 be br, Pender	B-3	18-74-(29.5)	5/94	42/6	6.53/5.02	Not Rated
NE Cape Fear R, White Stocking Ramp, Pender	B-4	18-74-(29.5)	5/94	40/9	6.91/5.39	Not Rated
NE Cape Fear R at Castlehayne US117, New Hanover	B-5	18-74-(29.5)	7/98	44/9	6.40/5.26	Good
			8/93	38/7	6.93/4.84	Good-Fair
			6/90	45/7	6.51/5.26	Good-Fair
			6/87	41/6	7.32/5.34	Good-Fair
			7/85	42/5	7.05/3.97	Fair
Burgaw Cr, at old RR track, Pender	B-6	18-74-39	12/87	37/0	8.85/-	Not Rated
Burgaw Cr, US 117, Pender	B-7	18-74-39	12/87	14/0	9.44/-	Not Rated
Burgaw Cr, I-40, Pender	B-8	18-74-39	7/98	-/5	-/6.11	Poor
			3/98	34/5	7.12/6.46	Not Rated
Angola Cr, NC 53, Pender	B-9	18-74-33-3	7/98	-/9	-/6.06	Not Rated
			11/93	62/10	6.39/4.82	Not Rated
			11/93	56/9	6.33/4.70	Not Rated
			8/93	52/11	6.01/4.33	Not Rated
			5/93	68/17	6.23/4.93	Not Rated
			2/93	61/18	6.20/5.12	Not Rated
Long Cr, NC 53, Pender	B-10	18-74-55	3/98	-/2	-/7.00	Not Rated
Cypress Cr, NC 53, Pender	B-11	18-74-55-2	3/98	-/9	-/5.70	Not Rated
			3/93	-/9	-/5.88	Not Rated
Juniper Swp, NC 50, Onslow	B-12	18-74-33-4-2	3/98	22/2	6.66/6.25	Not Rated
			2/97	19/1	7.00/6.23	Not Rated
			11/93	30/2	6.90/6.30	Not Rated
			8/93	25/1	7.30/4.46	Not Rated
			5/93	34/2	7.07/5.90	Not Rated
			2/93	44/5	7.02/5.85	Not Rated
Lillington Cr, SR 1520, Pender	B-13	18-74-42	2/97	33/7	5.98/4.75	Not Rated
Merrick's Cr, NC 210, Pender	B-14	18-74-49-2	3/98	43/10	6.14/5.02	Not Rated
			2/97	43/12	6.00/4.58	Not Rated
			11/93	53/11	6.61/5.50	Not Rated
			11/93	52/11	6.38/5.50	Not Rated
			5/93	51/13	6.14/4.42	Not Rated
			2/93	52/16	6.24/5.21	Not Rated
Sandy Run Swp, NC 50, Onslow	B-15	18-74-33-2	11/93	36/2	7.27/6.34	Not Rated
			8/93	31/0	7.41/-	Not Rated
			6/93	42/5	6.59/4.89	Not Rated
			3/93	39/8	6.40/4.86	Not Rated
Shelter Swp, NC50, Onslow	B-16	18-74-33-2-2	3/98	28/3	6.74/5.93	Not Rated
Burnt Mill Cr, Metts Ave, New Hanover	B-17	18-74-63-2	7/98	-/4	-/5.00	Not Rated
			3/98	40/5	7.99/6.69	Not Rated

Appendix B-2 (continued).

Site	Site #	Index #	Date	S/A&C S	EBI	Bioclass
CPF 24						
Estuarine						
Everett Bay, nr point, Onslow	B-1	18-87-2	6/98	42/6	2.36	Not Rated
Spicer Bay, at neck, Onslow	B-2	18-87-4	6/98	54/8	2.24	Not Rated
Topsail Sd, docks nr Marker 5, Pender	B-7	18-87-10	6/93	46/3	1.95	Not Rated
Black Mud Ch, Pender	B-8	18-87-13	6/93	24/5	2.80	Not Rated
Howe Cr, nr bend, New Hanover	B-11	18-87-23	5/94	95/22	2.47	Not Rated
			2/94	108/17	2.39	Not Rated
			5/93	11/1	2.10	Not Rated
			3/93	28/1	2.71	Not Rated
ICWW, N of US 74, New Hanover	B-13	18-87-24	6/93	5/1	1.86	Not Rated
ICWW, Bridgetender Marina, New Hanover	B-14	18-87-24	6/93	17/1	1.21	Not Rated
Bradley Cr, US 76, New Hanover	B-15	18-87-24-4-(2)	6/98	59/8	1.74	Not Rated
			2/96	62/5	1.91	Not Rated
			2/96	67/5	1.70	Not Rated
			2/96	48/7	1.88	Not Rated
			1/96	73/8	1.87	Not Rated
			1/96	48/4	1.44	Not Rated
			1/96	48/7	1.84	Not Rated
			5/94	68/9	1.87	Not Rated
			2/94	60/7	1.84	Not Rated
			11/93	45/7	1.86	Not Rated
			2/93	36/2	1.63	Not Rated
Bradley Cr, off fuel dock, New Hanover	B-16	18-87-24-4-(2)	2/93	40/5	2.30	Not Rated
Bradley Cr, No Wake Sign, New Hanover	B-17	18-87-24-4-(2)	2/93	35/3	1.85	Not Rated
Hewletts Cr, at bend ab docks, New Hanover	B-21	18-87-26	6/98	80/10	2.16	Not Rated
			2/96	97/9	1.95	Not Rated
			2/96	90/10	1.97	Not Rated
			2/96	86/9	1.88	Not Rated
			1/96	91/9	2.15	Not Rated
			1/96	77/7	1.99	Not Rated
			1/96	89/6	1.66	Not Rated
			5/94	105/15	1.95	Not Rated
			2/94	91/8	2.20	Not Rated
			11/93	93/9	2.22	Not Rated
			5/93	42/3	2.20	Not Rated
			2/93	42/2	2.02	Not Rated
Masonboro Ch, Masonboro Is NERR, New H	B-22	18-87-27	6/98	123/25	2.55	Not Rated
Carolina Inlet Marina, in basin, New Hanover	B-24	18-87-(30.5)	6/93	27/0	1.53	Not Rated
ICWW, Marker 156, New Hanover	B-25	18-87-(30.5)	6/98	67/14	2.16	Not Rated
			6/93	21/2	1.94	Not Rated
ICWW spur, Marker 4, New Hanover	B-26	18-87-31.2	6/93	11/1	1.15	Not Rated

Freshwater

Site	Site #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
UT Hewletts Cr, ab pond, New Hanover	B-18	18-87-26	9/94	26/1	6.82/6.20	Not Rated
UT Hewletts Cr, Beasley Rd, New Hanover	B-19	18-87-26	9/94	37/1	7.23/6.20	Not Rated
Hewletts Cr, SR 1492, New Hanover	B-20	18-87-26	7/98	-/5	-/6.10	Not Rated
			2/98	41/6	7.11/5.95	Not Rated

FISH APPENDICES

Sampling Methods

At each sample site, a 200 meter section of stream was selected and measured. The fish in the delineated stretch of stream were then collected using two backpack electrofishing units and two persons netting the stunned fish.

After collection, all readily identifiable fish (usually sport fishes, catfishes, and suckers) were examined for sores, lesions, fin damage, and skeletal anomalies, measured (total length to the nearest 1 mm), and then released. The remaining fish (i.e., those fish that were not readily identifiable) were preserved in 10% formalin and returned to the laboratory for identification, examination, and total length measurement. Young-of-year fish were excluded from all analyses. The resulting data were then analyzed with the NCIBI.

NCIBI Analysis

The assessment of biological integrity using the NCIBI is provided by the cumulative assessment of 12 parameters or metrics (Appendices FC-1a and FC-1b). 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 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, as proposed by Karr (1981), of the stream from which the sample was collected (Table F-1).

Table F-1. Scores, integrity classes, and class attributes for evaluating a wadeable stream using the North Carolina Index of Biotic Integrity.

NCIBI Scores	Karr's Integrity Classes	Class Attributes[1]
58 or 60	Excellent	Comparable to the best situations without human disturbance. All regionally expected species for the habitat and stream size, including the most intolerant forms are present, along with a full array of size classes and a balanced trophic structure.
54 or 56	Good-Excellent	
48, 50, or 52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant species; some species are present with less than optimal abundances or size distributions; and the trophic structure shows some signs of stress.
46	Fair-Good	
40, 42, or 44	Fair	Signs of additional deterioration include the loss of intolerant species, fewer species, and a highly skewed trophic structure.
36 or 38	Poor-Fair	
28, 30, 32, or 34	Poor	Dominated by omnivores, tolerant species, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; and diseased fish often present.
24 or 26	Very Poor-Poor	
12, 14, 16, 18, 20, or 22	Very Poor	Few fish present, mostly introduced or tolerant species; and disease fin damage and other anomalies are regular.
-----	No fish	Repeated sampling finds no fish.

[1] Over-lapping classes share attributes with classes greater than and less than the respective NCIBI score.

The NCIBI has been revised since the initial Cape Fear River basinwide monitoring was conducted between 1992 and 1994 (NCDEHNR 1995). Recently, the focus of using and applying the NCIBI has been restricted to wadeable streams that can be sampled by a crew of four persons and strictly following the NCDWQ Standard Operating Procedures (NCDEHNR 1997). Also, further refinements have been made to the criteria of most of the 12 metrics such as developing criteria for the different ecoregions (Piedmont and Sandhills + Coastal Plain) within the basin (Appendices FC-1a and FC-1b).

In an effort to simplify and standardize the evaluation of a stream's ecological integrity and water quality bioclassification whether using a fish community or benthic invertebrate assessment, the fish community integrity classes were also modified (Table F-2).

Table F-2. Revised scores and classes for evaluating the fish community of a wadeable stream using the North Carolina Index of Biotic Integrity.

NCIBI Scores	NCIBI Classes
56-60	Excellent
50-54	Good
44-48	Good-Fair
38-42	Fair
≤ 36	Poor

These refinements in the metrics and classification scheme (in addition to the correction of errors which existed in the earlier database) resulted in substantial changes in the Cape Fear River Basin fish community assessments previously reported in NCDEHNR (1995). For example, for the 37 wadeable stream sites monitored in 1992-1994, the NCIBI scores decreased by 0-16 units. These numerical changes were reflected in 2 sites whose classification increased, 25 sites whose classification decreased, and 10 sites whose classification did not change (Table F-3).

Table F-3. Differences in how a stream's fish community was evaluated using the NCIBI as previously reported in NCDEHNR (1995) and how the stream's fish community is currently evaluated, Cape Fear River Basin.

	Old		New	
Stream	**NCIBI Score**	**Integrity Class**	**NCIBI Score**	**NCIBI Class**
Troublesome Creek	34	Poor	30	Poor
Reedy Fork	48	Good	42	Fair
North Buffalo	34	Poor	22	Poor
South Buffalo	42	Fair	26	Poor
South Buffalo	32	Poor	28	Poor
Stony Creek	54	Good-Excellent	48	Good-Fair
Jordan Creek	50	Good	46	Good-Fair
Big Alamance Creek	50	Good	40	Fair
Stinking Quarter Creek	54	Good-Excellent	44	Good-Fair
Rock Creek	48	Good	44	Good-Fair
Rock Creek	50	Good	50	Good
Little Alamance	46	Fair-Good	42	Fair
Cane Creek	46	Fair-Good	44	Good-Fair
Terrells Creek	46	Fair-Good	42	Fair
Third Fork Creek	38	Poor-Fair	26	Poor

Table F-3 (continued).

	Old		New	
Stream	**NCIBI Score**	**Integrity Class**	**NCIBI Score**	**NCIBI Class**
Northeast Creek	48	Good	42	Fair
Northeast Creek	36	Poor-Fair	32	Poor
Morgan Creek	44	Fair	42	Fair
Gulf Creek	44	Fair	42	Fair
Gulf Creek	38	Poor-Fair	34	Poor
Hector Creek	44	Fair	42	Fair
Kenneth Creek	34	Poor	32	Poor
Muddy Creek	46	Fair-Good	42	Fair
Sandy Creek	48	Good	44	Good-Fair
Bear Creek	54	Good-Excellent	42	Fair
Richland Creek	40	Fair	32	Poor
Cedar Creek	48	Good	38	Fair
Big Buffalo Creek	50	Good	38	Fair
Tick Creek	50	Good	48	Good-Fair
Lower Little River	52	Good	42	Fair
Crains Creek	44	Fair	30	Poor
Cross Creek	44	Fair	30	Poor
Harrison Creek	44	Fair	48	Good-Fair
Browns Creek	50	Good	36	Poor
Halls Marsh Run	42	Fair	34	Poor
Herrings Marsh Run	38	Poor-Fair	34	Poor
Grove Creek	54	Good-Excellent	52	Good

Appendix FC-1a. Scoring criteria for the NCIBI for wadeable streams in the Piedmont physiographic region of the Cape Fear River Basin with watershed drainage areas ranging between 3.1 and 242 mi^2.

No.	Metric	Score
1	**No. of species**[1]	
	where Y is the number of species in the sample and X is the stream's drainage area in mi^2:	
	$Y \geq 14.3*Log_{10}X$	5
	$7.2*Log_{10}X < Y < 14.3*Log_{10}X$	3
	$Y < 7.2*Log_{10}X$	1
2	**No. of fish**	
	where Y is the number of fish in the sample and X is the stream's drainage area in mi^2:	
	$Y \geq 313.3*Log_{10}X$	5
	$156.7*Log_{10}X < Y < 313.3*Log_{10}X$	3
	$Y < 156.7*Log_{10}X$	1
3	**No. of species of darters**[1]	
	where Y is the number of species in the sample and X is the stream's drainage area in mi^2:	
	$Y \geq 1.2*Log_{10}X$	5
	$0.6*Log_{10}X < Y < 1.2*Log_{10}X$	3
	$Y < 0.6*Log_{10}X$	1
4	**No. of species of sunfish**[1]	
	≥ 5 species	5
	3 or 4 species	3
	0- 2 species	1
5	**No. of species of suckers**[1]	
	where Y is the number of species in the sample and X is the stream's drainage area in mi^2:	
	$Y \geq 1.67*Log_{10}X$	5
	$0.83*Log_{10}X < Y < 1.67*Log_{10}X$	3
	$Y < 0.83*Log_{10}X$	1
6	**No. of intolerant species**[1]	
	Percina crassa or *Notropis mekistocholas* present	5
	Neither species present	1
7	**Tolerant individuals (%)**[1]	
	< 20%	5
	20-45%	3
	> 45%	1
8	**Omnivorous individuals**[1]	
	< 5-25%	5
	25-45%	3
	> 45%	1
	< 5%	1
9	**Insectivorous individuals (%)**[1]	
	< 75-95%	5
	60-75%	3
	< 60%	1
	> 95%	1
10	**Piscivorous individuals (%)**[1]	
	> 2%	5
	1-2%	3
	< 1%	1
11	**Diseased fish (%)**	
	< 2%	5
	2-5%	3
	> 5%	1
12	**Species with multiple age groups (%)**	
	> 60% of all species have multiple age groups	5
	40-60% of all species have multiple groups	3
	< 40% of all species have multiple age groups	1

[1]Refer to Appendix FC-2.

Appendix FC-1b. Scoring criteria for the NCIBI for wadeable streams in the Sandhills and Coastal Plain physiographic regions of the Cape Fear River Basin with watershed drainage areas ranging between 8.1 and 112 mi^2.

No.	Metric	Score
1	**No. of species**[1]	
	If the pH is ≥ 5.0: then Y is the number of species in the sample and X is the stream's drainage area in mi^2:	
	$Y \geq 14.3*Log_{10}X$	5
	$7.2*Log_{10}X < Y < 14.3*Log_{10}X$	3
	$Y < 7.2*Log_{10}X$	1
	If the pH is < 5.0:	
	≥ 5 species collected in the sample	5
	< 5 species collected in the sample	1
2	**No. of fish**	
	If the pH is ≥ 5.0: then Y is the number of fish in the samples and X is the stream's drainage area in mi^2:	
	$Y \geq 166.7*Log_{10}X$	5
	$83.3*Log_{10}X < Y < 166.7*Log_{10}X$	3
	$Y < 83.3*Log_{10}X$	1
	If the pH is < 5.0:	
	≥ 25 fish collected in the sample	5
	< 25 species collected in the sample	1
3	**No. of species of darters**[1]	
	≥ 2 species	5
	1 species	3
	0 species	1
4	**No. of species of sunfish**[1]	
	If the pH is ≥ 5.0:	
	≥ 5 species	5
	3 or 4 species	3
	0- 2 species	1
	If the pH is < 5.0:	
	≥ 2 species	5
	1 species	3
	0 species	1
5	**No. of species of suckers**[1]	
	If the drainage area is > 10 mi^2:	
	≥ 2 species	5
	1 species	3
	0 species	1
	If the drainage area is □□10 mi^2:	
	≥ 1 species	5
	0 species	1
6	**No. of intolerant species**[1]	
	If the pH is ≥ 5.0:	
	≥ 2 species	5
	1 species	3
	0 species	1
	If the pH is < 5.0:	
	≥ 1 species	5
	0 species	1
7	**Tolerant individuals (%)**[1]	
	< 20%	5
	20-45%	3
	> 45%	1
8	**Omnivorous individuals**[1]	
	If the pH is ≥ 6.0:	
	5-25%	5
	25-45%	3
	> 45%	1
	< 5%	1
	If the pH < 6.0:	
	< 20%	5
	20-40%	3
	> 40%	1
	< 2%	1

Appendix FC-1b (continued).

No.	Metric	Score
9	**Insectivorous individuals (%)**[1]	
	If the pH is ≥ 6.0:	
	75-95%	5
	60-75%	3
	< 60%	1
	> 95%	1
	If the pH < 6.0:	
	>40%	5
	20-40%	3
	> 20%	1
10	**Piscivorous individuals (%)**[1]	
	If the pH is ≥ 6.0:	
	> 15%	5
	5-15%	3
	< 5%	1
	If the pH < 6.0:	
	>20%	5
	10-20%	3
	< 10%	1
11	**Diseased fish (%)**	
	< 2%	5
	2-5%	3
	> 5%	1
12	**Species with multiple age groups (%)**	
	> 60% of all species have multiple age groups	5
	40-60% of all species have multiple groups	3
	< 40% of all species have multiple age groups	1

[1]Refer to Appendix FC-2.

A brief explanation of each of the NCIBI metrics specific for fish communities in wadeable streams in the Cape Fear River Basin following the NCDWQ Standard Operating Procedure collection methods (NCDEHNR 1997) is presented:

1. Number of Species: The total number of species supported by a stream of a given size in a given region decreases with environmental degradation. In addition, a stream with larger watershed can be expected to support a greater number of species than a stream with a smaller watershed. This metric is rated according to the river basin and ecoregion from which the sample was taken, the pH (for Sandhills and Coastal Plain streams), and the drainage area size at the sampling point. If the drainage area for a particular site is not listed in Meikle (1983), then the drainage area is delineated from USGS 7.5 minute series topographic maps.

   All fish should be identified to the species level. Exotics, but not hybrids, are included in this metric. The exotic species known from the Cape Fear River basin are: Dorosoma petenense, Ctenopharyngodon idella, Cyprinella lutrensis, Cyprinus carpio, Nocomis raneyi, Lythrurus ardens, Luxilus cerasinus, Notropis chiliticus, Ictalurus punctatus, I. furcatus, Pylodictis olivaris, Morone chrysops, Lepomis cyanellus, L. microlophus, Micropterus punctulatus, and Pomoxis annularis (Lee, et al. 1980, Hocutt and Wiley 1986, Menhinick 1991, Jenkins and Burkhead 1993).

   The metric is a count of all the species in the sample. The total number of species is compared against the number of species that can be expected to be collected using the same methods from other streams with the same size watershed in the Cape Fear River Basin (Appendices FC-1a and FC-1b).

   The revised metric criteria (replacing the criteria described in NCDEHNR 1997) are only applicable for rating the fish communities from streams whose watersheds are between 3.1 and 242 mi^2 in the Piedmont and whose watersheds are between 8.1 and 112 mi^2 in the Sandhills and Coastal Plain. The new criteria have also been adjusted for rating fish communities in Sandhill and Coastal Plain blackwater streams that have a pH < 5.0 because of the naturally limited fauna and productivity of these systems.

2. Number of Individuals: The total number of individuals (fish) supported by a stream of a given size in a given region decreases with environmental degradation. In addition, a stream with larger watershed can be expected to support a greater number of fish than a stream with a smaller watershed. This metric is rated according to the river basin and ecoregion from which the sample was taken, to the pH of the stream (for Sandhills and Coastal Plain streams), and to the drainage area size at the sampling point. If the drainage area for a particular site is not listed in Meikle (1983), then the drainage area is delineated from USGS 7.5 minute series topographic maps.

   The metric is a count of all the fish in the sample. The total number of fish is compared against the number of fish that can be expected to be collected using the same methods from other streams with the same size watershed in the Cape Fear River Basin (Appendices FC-1a and FC-1b). The metric criteria are only applicable for rating fish communities in streams whose watersheds in the Piedmont are between 3.1 and 242 mi^2 and whose watersheds in the Sandhills and Coastal Plain (if the pH ≥ 5.0 are between 8.1 and 112 mi^2. The criteria have also been adjusted for fish communities in blackwater streams that have a pH < 5.0 because of the limited fauna and productivity of these systems. (Appendix FC-1).

3. Number of Species of Darters: Darters are sensitive to environmental degradation particularly as a result of their specific reproductive and habitat requirements (e.g., Page 1983; Kuehne and Barbour 1983). Darter habitats are degraded as a result of channelization, siltation, and reduced oxygen levels. The collection of fewer then the expected number of species of darters can indicate that some degree of habitat degradation is occurring.

   The total number of species of darters supported by a stream of a given size in a given region decreases with environmental degradation. In addition, a stream with larger watershed can be expected to support a greater number of species than a stream with a smaller watershed. This metric with revised criteria (replacing the criteria described in NCDEHNR 1997) is rated according to the river basin and ecoregion from which the sample was taken and the drainage area size at the sampling point (Piedmont streams only). If the drainage area for a particular site is not listed in Meikle (1983), then the drainage area is delineated from USGS 7.5 minute series topographic maps.

   The metric is a count of all the species of Etheostoma and Percina in the sample. For fish communities from Piedmont streams, the total number of species is compared against the number of species that can be expected to be collected using the same methods from other streams with the same size watershed in the Piedmont portion of the Cape Fear River Basin (Appendices FC-1a and FC-1b). For fish communities in the Sandhills and Coastal Plain ecoregions, the total number of species, independent of drainage area size, is compared against the criteria listed in Appendix FC-1b.

4. Number of Species of Sunfish: The species diversity of sunfish is used because these species are particularly responsive to habitat degradation such as the filling in of pools by sedimentation and the loss of instream cover such as snags and deadfalls. In the Cape Fear River basin, this metric is a count of all the species of Acantharchus pomotis (Mud sunfish), Ambloplites cavifrons (Roanoke bass), Centrarchus macropterus (Flier), Enneacanthus spp. (Banded sunfish), and Lepomis spp. (Sunfish, exclusive of hybrids) in the sample (Appendix FC-2). This metric is rated according to the river basin and ecoregion from which the sample was taken and the pH (for Sandhills and Coastal Plain streams). The criteria have been adjusted for fish communities in blackwater streams that have a pH < 5.0 because of the limited fauna and productivity of these systems. The total number of species in a sample is compared against the number of species that can be expected to be collected using the same methods from other streams in the specific ecoregion in the Cape Fear River Basin (Appendices FC-1a and FC-1b).

5. Number of Species of Suckers: Many species of suckers are sensitive to habitat and chemical degradation. And, because they are long lived, provide a multiyear integrated perspective. Suckers also reflect the condition of the benthic community which may be harmed by sedimentation or by sediment contamination.

   The total number of species of suckers supported by a stream of a given size in a given region also decreases with environmental degradation. In addition, a stream with larger watershed can be expected to support a greater number of species than a stream with a smaller watershed. This metric is rated according to the river basin and ecoregion from which the sample was taken and the drainage area size at the sampling point. If the drainage area for a particular site is not listed in Meikle (1983), then the drainage area is delineated from USGS 7.5 minute series topographic maps.

   The metric is a count of all the species within the family Catostomidae in the sample (Appendix FC-2). For fish communities from Piedmont streams, the total number of species is compared against the number of species that can be expected to be collected using the same methods from other streams with the same size watershed in the Piedmont portion of the Cape Fear River Basin (Appendices FC-1a and FC-1b). For fish communities in the Sandhills and Coastal Plain ecoregions, the total number of species is compared against the partially drainage size-adjusted criteria listed in Appendix FC-1b.

6. Number of Intolerant Species: Intolerant species are those species which are most affected by environmental perturbations and therefore, should disappear, at least as viable populations, by the time a fish community is rated as "Fair". Many intolerant species also have limited zoogeographic distributions and are also listed as rare, endangered, or threatened on state or federal rare and endangered species lists. Intolerant species found in the Cape Fear River basin are Cyprinella zanema, Notropis chalybaeus, N. maculatus, N. mekistocholas, Semotilus lumbee, Noturus n. sp., Etheostoma serrifer, and Percina crassa (Appendix FC-2). Originally (NCDEHNR 1997), Cyprinella nivea, Lythrurus ardens, Notropis alborus, N. amoenus, N. hudsonius, and Menidia beryllina were considered to the “Intolerant”. The tolerance ranking of these species have subsequently been changed to “Intermediate”. Cyprinella zanema and Notropis mekistocholas were originally considered to be “Intermediate”. The tolerance ranking have subsequently been changed to “Intolerant”.

   This metric is a count of the number of intolerant species in the sample (Appendix FC-2). In the Piedmont, where there are only two intolerant species (of which one is rare), the criteria are based on the presence or absence of N. mekistocholas or P. crassa. In the Sandhills and Coastal Plain where six intolerant species are found, the criteria have also been adjusted for fish communities in blackwater streams that have a pH < 5.0 because of the limited fauna and productivity of these systems. For fish communities from either the Piedmont, Sandhills, or Coastal Plain streams, the total number of intolerant species is compared against the number of species that can be expected to be collected using the same methods from other streams in the Cape Fear River Basin (Appendices FC-1a and FC-1b).

7. Percentage of Tolerant Individuals: Tolerant species are those which are often present in a stream in low to moderate numbers but as the stream and water quality degrade, they may become dominant. The tolerant species found in the Cape Fear River basin are Lepisosteus osseus, Amia calva, Ctenopharyngodon idella, Cyprinella analostana, C. lutrensis, Cyprinus carpio, Notemigonus crysoleucas, Pimephales promelas, Semotilus atromaculatus, Catostomus commersoni, Ameiurus catus, A. natalis, A. nebulosus, A. platycephalus, Gambusia holbrooki, Lepomis auritus, L. cyanellus, and Lepomis sp. (Appendix FC-2). Originally (NCDEHNR 1997), Lepisosteus osseus, Amia calva, Cyprinella lutrensis, Notemigonus crysoleucas, Pimephales promelas, Semotilus atromaculatus, Catostomus commersoni, and Lepomis auritus were all considered to be "Intermediate". The tolerance ranking of these species has subsequently been changed to "Tolerant".

For each sample, the number of individuals of all the tolerant species is summed and divided by the total number of fish collected to obtain the percentage of tolerant fish. The resultant percentage is then compared against the percentage of tolerant fish that can be expected to be collected using the same methods from other streams in the Cape Fear River Basin (Appendices FC-1a and FC-1b).

8-10. Percentages of Omnivorous, Insectivorous, Piscivorous Individuals: The three trophic composition metrics--proportion of omnivores, insectivores, and piscivores--are used to measure the divergence from expected production and consumption patterns in the fish community that can result from environmental degradation. The main cause for a shift in the trophic composition of the fish community (a greater proportion of omnivores and lesser proportion of insectivores than what is to be expected) is nutrient enrichment. These three metrics are rated according to the river basin and ecoregion from which the sample was taken.

The trophic habitats of Anguilla rostrata, Dorosoma cepedianum, Lythrurus ardens, Semotilus atromaculatus, Ameiurus catus, A. natalis, A. nebulosus, and Ictalurus punctatus have been subsequently modified from their original designations (NCDEHNR 1997). Also, there were three criteria each for Metrics Nos. 8 and 9 (NCDEHNR 1997); there are now four criteria. The criteria for fish communities in the Piedmont have also been revised. In Sandhill and Coastal Plain streams, criteria for Metric Nos. 9 and 10 were also revised because of the abundance of insectivorous and piscivorous species in these streams and the criteria have also been adjusted for fish communities in streams where the pH < 6.0.

For each metric, the number of individuals in each trophic classes (Appendix FC-2) is summed and divided by the total number of fish collected in the sample to obtain the percentage by each specific trophic class. The resultant percentages for the three main trophic classes are then compared against the criteria in Appendices FC-1a and FC-1b.

11. The Percentage of Diseased Fish: The percentage of fish with disease, tumors, fin erosion and damage, and skeletal anomalies increases as the water quality is degraded. To rate this metric, the number of fish in the sample which have externally evident open

sores, tumors, lesions, skeletal anomalies or diseased, damaged, or eroded fins are summed and divided by total number of fish collected to obtain the percentage of diseased fish. Fin or other external damage as a result of spawning are not counted. Fish are considered to be in spawning condition when tubercles or breeding colors are evident.

12. The Percentage of Species with Multiple Age Groups (Length Distribution): For each species, the total length distribution data are used to determine the presence of different age groups and thus, the amount of reproductive success by that species in a particular stream. This metric is calculated by first counting the total number of species present in the sample. Then, the total lengths of all the fish of each species are examined to determine whether or not all the fish of that species are of one or multiple age groups. Finally, the percentage of species with multiple age groups is determined by dividing the number of species with multiple age groups by the total number of species collected in the sample. Although some species are rare and some species have fewer age groups than others, at least three individuals per species must have been collected to determine the presence of multiple age groups within the population. In some instances, professional judgment may also be used to determine the reproductive success of a particular species. Publications such as Carlander (1969 and 1977), Kuehne and Barbour (1983), Page (1983), Manooch (1984), Etnier and Starnes (1993), Jenkins and Burkhead (1993), and Rohde, et al. (1994) may also be consulted to determine length-age class relationships. Sunfish hybrids and other species group hybrids are not included in this metric.

    Originally the scoring criteria for this metric were > 40% = 5, 20-40% = 3, and < 20% = 1 (NCDEHNR 1997). The scoring criteria have been subsequently modified to provide greater separation of the sites based upon reproductive success of the fish populations.

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Appendix FC-2. Tolerance ratings and adult trophic guild assignments for the fishes of the Cape Fear River Basin.

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Petromyzontidae	**Lampreys**		
Petromyzon marinus	Sea Lamprey	Intermediate	Parasitic
Acipenseridae	**Sturgeons**		
Acipenser brevirostrum	Shortnose Sturgeon	Intermediate	Insectivore
A. oxyrhynchus	Atlantic Sturgeon	Intermediate	Insectivore
Lepisosteidae	**Gars**		
Lepisosteus osseus	Longnose Gar	Tolerant	Piscivore
Amiidae	**Bowfins**		
*Amia calva**	Bowfin	Tolerant	Piscivore
Anguillidae	**Eels**		
*Anguilla rostrata**	American Eel	Intermediate	Piscivore
Clupeidae	**Herrings and Shads**		
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[1]	Threadfin Shad	Intermediate	Planktivore
Umbridae	**Mudminows**		
*Umbra pygmaea**	Eastern Mudminnow	Intermediate	Insectivore
Esocidae	**Pikes**		
*Esox americanus**	Redfin Pickerel	Intermediate	Piscivore
*E. niger**	Chain Pickerel	Intermediate	Piscivore
Cyprinidae	**Minnows**		
*Clinostomus funduloides**	Rosyside Dace	Intermediate	Specialized Insectivore
Ctenopharyngodon idella[1]	Grass Carp	Tolerant	Herbivore
*Cyprinella analostana**	Satinfin Shiner	Tolerant	Insectivore
*C. lutrensis**[1]	Red Shiner	Tolerant	Insectivore
*C. nivea**	Whitefin Shiner	Intermediate	Insectivore
C. zanema	Thinlip Chub form	Intolerant	Insectivore
*Cyprinus carpio**[1]	Common Carp	Tolerant	Omnivore
*Hybognathus regius**	Silvery Minnow	Intermediate	Herbivore
*Luxilus albeolus**	White Shiner	Intermediate	Insectivore
*L. cerasinus**[1]	Crescent Shiner	Intermediate	Insectivore
*Lythrurus ardens**[1]	Rosefin Shiner	Intermediate	Specialized Insectivore
*Nocomis leptocephalus **	Bluehead Chub	Intermediate	Omnivore
N. raneyi[1]	Bull Chub	Intermediate	Omnivore
*Notemigonus crysoleucas**	Golden Shiner	Tolerant	Omnivore
*Notropis alborus**	Whitemouth Shiner	Intermediate	Specialized Insectivore
*N. altipinnis**	Highfin Shiner	Intermediate	Specialized Insectivore

Appendix FC-2 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
*N. amoenus**	Comely Shiner	Intermediate	Specialized Insectivore
*N. chalybaeus**	Ironcolor Shiner	Intolerant	Specialized Insectivore
*N. chiliticus**[1]	Redlip Shiner	Intermediate	Specialized Insectivore
*N. cummingsae**	Dusky Shiner	Intermediate	Specialized Insectivore
*N. hudsonius**	Spottail Shiner	Intermediate	Omnivore
N. maculatus	Taillight Shiner	Intolerant	Specialized Insectivore
*N. mekistocholas**	Cape Fear Shiner	Intolerant	Omnivore
*N. petersoni**	Coastal Shiner	Intermediate	Specialized Insectivore
*N. procne**	Swallowtail Shiner	Intermediate	Specialized Insectivore
*N. scepticus**	Sandbar Shiner	Intermediate	Specialized Insectivore
*Phoxinus oreas**	Mountain Redbelly Dace	Intermediate	Herbivore
*Pimephales promelas**	Fathead Minnow	Tolerant	Omnivore
*Semotilus atromaculatus**	Creek Chub	Tolerant	Insectivore
*S. lumbee**	Sandhills Chub	Intolerant	Insectivore
Catostomidae	**Suckers**		
Carpiodes velifer	Highfin Carpsucker	Intermediate	Insectivore
*Catostomus commersoni**	White Sucker	Tolerant	Omnivore
*Erimyzon oblongus**	Creek Chubsucker	Intermediate	Omnivore
E. sucetta	Lake Chubsucker	Intermediate	Insectivore
*Minytrema melanops**	Spotted Sucker	Intermediate	Insectivore
*Moxostoma anisurum**	Silver Redhorse	Intermediate	Insectivore
M. macrolepidotum	Shorthead Redhorse	Intermediate	Insectivore
M. pappillosum	Suckermouth Redhorse	Intermediate	Insectivore
Moxostoma n. sp.*	"Carolina" Redhorse	Intermediate	Insectivore
Scartomyzon n. sp.*	"Brassy" Jumprock	Intermediate	Insectivore
Ictaluridae	**Catfishes**		
*Ameiurus brunneus**	Snail Bullhead	Intermediate	Insectivore
*A. catus**	White catfish	Tolerant	Omnivore
*A. natalis**	Yellow Bullhead	Tolerant	Omnivore
*A. nebulosus**	Brown Bullhead	Tolerant	Omnivore
*A. platycephalus**	Flat Bullhead	Tolerant	Insectivore
Ictalurus furcatus[1]	Blue Catfish	Intermediate	Piscivore
*I. punctatus**[1]	Channel Catfish	Intermediate	Omnivore
*Noturus gyrinus**	Tadpole Madtom	Intermediate	Insectivore
*N. insignis**	Margined Madtom	Intermediate	Insectivore
N. n. sp.	"Broadtail" Madtom	Intolerant	Insectivore
Pylodictis olivaris[1]	Flathead Catfish	Intermediate	Piscivore
Amblyopsidae	**Cavefishes**		
*Chologaster cornuta**	Swampfish	Intermediate	Insectivore
Aphredoderidae	**Pirate Perches**		
*Aphredoderus sayanus**	Pirate Perch	Intermediate	Insectivore
Fundulidae	**Topminnows**		
Fundulus diaphanus	Banded Killifish	Intermediate	Insectivore
F. lineolatus	Lined Topminnow	Intermediate	Insectivore
*F. rathbuni**	Speckled Killifish	Intermediate	Insectivore

Appendix FC-2 (continued).

Family/Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Poeciliidae	**Livebearers**		
*Gambusia holbrooki**	Eastern Mosquitofish	Tolerant	Insectivore
Atherinidae	**Silversides**		
Menidia beryllina	Inland Silverside	Intermediate	Insectivore
Moronidae	**Temperate Basses**		
Morone americana	White Perch	Intermediate	Piscivore
M. chrysops[1]	White Bass	Intermediate	Piscivore
M. saxatilis	Striped Bass	Intermediate	Piscivore
Centrarchidae	**Sunfishes**		
*Acantharchus pomotis**	Mud Sunfish	Intermediate	Insectivore
Ambloplites cavifrons[1]	Roanoke Bass	Intermediate	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**[1]	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**[1]	Redear Sunfish	Intermediate	Insectivore
*L. punctatus**	Spotted Sunfish	Intermediate	Insectivore
L. sp.	Hybrid Sunfish	Tolerant	Insectivore
*Micropterus punctulatus**[1]	Spotted bass	Intermediate	Piscivore
*M. salmoides**	Largemouth Bass	Intermediate	Piscivore
Pomoxis annularis[1]	White Crappie	Intermediate	Piscivore
*P. nigromaculatus**	Black Crappie	Intermediate	Piscivore
Elassomatidae	**Pygmy Sunfishes**		
Elassoma evergladei	Everglades Pygmy Sunfish	Intermediate	Insectivore
E. zonatum	Banded Pygmy Sunfish	Intermediate	Insectivore
Percidae	**Perches**		
*Etheostoma collis**	Carolina Darter	Intermediate	Specialized Insectivore
*E. flabellare**	Fantail Darter	Intermediate	Specialized Insectivore
E. fusiforme	Swamp Darter	Intermediate	Specialized Insectivore
*E. olmstedi**	Tessellated Darter	Intermediate	Specialized Insectivore
*E. serrifer**	Sawcheek Darter	Intolerant	Specialized Insectivore
*Perca flavescens**	Yellow Perch	Intermediate	Piscivore
*Percina crassa**	Piedmont Darter	Intolerant	Specialized Insectivore

* = Species collected during the 1998 basinwide monitoring program.
[1] Species not native to the Cape Fear River Basin.

Appendix FC-3. Ecoregion classification, 1996 Use Support Rating, and water quality data from the fish community assessments in the 1998 Cape Fear River basinwide monitoring program.

Subbasin/ Waterbody	Station	County	Date	Use Support Rating[1]	Eco-region[2]	Temp. (°C)	Specific Conductance (µmhos/cm)	Dissolved Oxygen (mg/L)	pH
030301									
Haw R	SR 2109	Guilford	04/06/98	PS	P	18.2	67	8.2	6.8
Haw R	SR 2426	Rockingham	04/06/98	ST	P	14.6	72	9.7	6.8
Haw R	SR 2426	Rockingham	10/12/98	ST	P	14.0	93	8.0	7.3
Troublesome Cr	SR 1001	Rockingham	04/06/98	PS	P	12.0	28	8.1	6.6
L. Troublesome Cr	SR 2600	Rockingham	04/06/98	PS	P	10.6	236	8.2	6.9
L. Troublesome Cr	SR 2600	Rockingham	10/12/98	PS	P	15.4	549	7.1	7.3
030302									
Reedy Fork	SR 2728	Guilford	04/07/98	S	P	15.2	80	10.1	7.4
Reedy Fork	SR 2728	Guilford	10/12/98	S	P	16.3	107	7.7	7.2
N Buffalo Cr	SR 2770	Guilford	04/07/98	NS	P	15.3	342	7.3	7.2
S Buffalo Cr	US 70	Guilford	04/07/98	NS	P	11.8	200	8.2	7.1
S Buffalo Cr	SR 2821	Guilford	04/07/98	NS	P	15.8	426	7.5	7.4
030303									
Big Alamance Cr	SR 3088	Guilford	04/08/98	ST	P	18.3	99	9.0	7.4
L. Alamance Cr	SR 3039	Guilford	04/22/98	PS	P	14.0	123	8.5	7.0
Stinking Quarter Cr	SR 1136	Alamance	04/08/98	S	P	15.8	88	8.5	7.3
L. Alamance Cr	SR 2309	Alamance	04/08/98	PS	P	15.4	171	7.8	7.2
030304									
Collins Cr	SR 1539	Chatham	04/21/98	NS	P	13.9	71	8.3	6.7
Terrells Cr	NC 87	Chatham	04/21/98	PS	P	13.8	80	8.7	7.0
Ferrells Cr	SR 1525	Chatham	04/21/98	PS	P	15.0	83	8.2	6.7
030305									
New Hope Cr	SR 2220	Durham	05/18/98	PS	P	20.0	116	6.5	6.6
030306									
Bolin Cr	off SR 1750	Orange	05/18/98	PS	P	22.0	153	8.0	7.4
Morgan Cr	SR 1900	Orange	05/18/98	PS	P	22.0	320	6.5	6.8
030307									
Avents Cr	SR 1418	Harnett	09/21/98	S	P	21.3	47	7.2	6.9
Hector Cr	SR 1412	Harnett	05/06/98	ST	P	15.0	48	8.8	6.5
Kenneth Cr	SR 1441	Harnett	05/06/98	PS	P	16.0	83	7.2	6.2
030308									
Richland Cr	SR 1154	Guilford	04/22/98	PS	P	13.8	158	8.8	7.1
Muddy Cr	SR 1929	Randolph	04/22/98	ST	P	14.4	100	8.8	7.0
030309									
Sandy Cr	SR 2481	Randolph	05/04/98	S	P	16.0	94	8.8	7.3
030310									
Bear Cr	SR 1405	Moore	9/21/98	S	P	23.1	108	8.0	7.3
Cabin Cr	SR 1275	Moore	05/05/98	S	P	16.0	94	8.0	7.1
Falls Cr	SR 1606	Moore	05/05/98	PS	P	15.0	114	7.2	6.8
McLendon's Cr	SR 1210	Moore	05/05/98	S	SH	16.0	22	8.7	6.1
Richland Cr	SR 1640	Moore	04/24/98	PS	SH	13.0	52	8.5	6.6
Indian Cr	SR 2306	Chatham	04/23/98	NS	P	13.7	91	8.1	6.8
030311									
Big Buffalo Cr	SR 1403	Lee	04/24/98	NS	P	12.9	86	8.3	6.5
030312									
Rocky R	SR 1300	Chatham	05/04/98	S	P	19.0	81	8.5	7.1
Loves Cr	SR 2229	Chatham	05/04/98	NS	P	18.0	132	6.9	7.2
Bear Cr	SR 2187	Chatham	04/23/98	ST	P	13.6	91	7.0	7.0
030314									
Crains Cr	US 1	Moore	05/07/98	S	SH	16.0	41	8.0	6.4
Buffalo Cr	SR 1001	Moore	05/07/98	PS	SH	16.0	21	7.5	4.5
Anderson Cr	SR 2031	Harnett	05/06/98	PS	SH	17.0	35	7.6	5.6
030315									
Big Cross Cr	NC 87/210/24	Cumberland	05/21/98	PS	SH	23.0	54	6.7	6.4
Puppy Cr	SR 1406	Hoke	05/21/98	ST	SH	22.0	18	6.9	4.9
030316									
Harrison Cr	SR 1318	Bladen	05/20/98	PS	CA	22.0	64	6.0	4.1
Browns Cr	NC 87	Bladen	05/20/98	PS	CA	22.0	86	6.7	6.2
Turnbull Cr	NC 242	Bladen	05/20/98	PS	CA	21.0	58	4.4	3.9
Whites Cr	SR 1704	Bladen	05/20/98	PS	CA	22.0	73	6.9	6.4

Appendix FC-3 (continued).

Subbasin/ Waterbody	Station	County	Date	Use Support Rating[1]	Eco-region[2]	Temp. (°C)	Specific Conductance (µmhos/cm)	Dissolved Oxygen (mg/L)	pH
030320									
Colly Cr	US 701	Bladen	05/19/98	ST	CA	20.0	78	5.0	3.5
White Oak Br	SR 1206	Pender	05/19/98	PS	CA	24.0	43	4.6	5.0
030321									
Mathews Cr	NC 111/NC 903	Duplin	05/22/98	S	CA	22.0	99	4.6	6.3
030322									
Grove Cr	NC 11/903	Duplin	05/22/98	PS	CA	22.0	99	4.7	6.6
Duff Cr	SR 1170	Duplin	05/22/98	PS	CA	25.0	133	5.7	6.6
030323									
Burgaw Cr	US 117	Pender	05/19/98	NS	CA	22.0	434	4.2	7.1

[1] Use Support Ratings are S = Supporting, ST = Support Threatened, PS = Partially Supporting, and NS = Not Supporting.
[2] Ecoregion are P = Piedmont, SH = Sandhills, and CA = Coastal Plain.

Appendix FC-4. Metric values and scores from the fish community assessments in the 1998 Cape Fear River basinwide monitoring program.

Metric Values

Waterbody (by subbasin by index number)	Drainage Area (mi^2)	Eco-region	No. of Species	No. of Individuals	No. of Species of Darters	No. of Species of Sunfish	No. of Species of Suckers	No. of Intolerant Species	% Tolerants	% Omnivores	% Insectivores	% Piscivores	% Diseased Individuals	% Species with Multiple Age Groups
Haw R	14.1	P	12	68	2	3	1	0	9	34	65	1.5	1.5	33
Haw R	62.1	P	15	166	2	4	0	1	22	26	67	4	0	53
Haw R	62.1	P	9	39	1	3	0	0	46	33	64	3	0	33
Troublesome Cr	25.6	P	9	43	1	1	1	0	9	53	44	2	0	44
L. Troublesome Cr	12.1	P	9	50	0	4	0	0	38	52	48	0	0	22
L. Troublesome Cr	12.1	P	11	43	0	4	0	0	26	19	70	5	7	36
Reedy Fork	125	P	22	568	3	5	0	1	11	22	77	0.2	0	64
Reedy Fork	125	P	16	452	3	3	1	1	21	38	62	0	0	88
N Buffalo Cr	43.7	P	6	59	0	4	0	0	75	15	85	0	0	66
S Buffalo Cr	39.5	P	6	428	0	3	0	0	100	0	100	0	0	67
S Buffalo Cr	43.5	P	7	63	0	2	0	0	97	0	98	1.6	43	57
Big Alamance Cr	30.5	P	20	364	2	5	3	1	15	3	94	3	0.3	50
L. Alamance Cr	10.1	P	14	154	1	5	0	0	19	24	75	1.3	0	64
Stinking Quarter Cr	83	P	20	229	3	3	1	1	24	22	77	0.9	0.9	45
L. Alamance Cr	14.8	P	10	137	1	4	1	0	20	52	47	0.7	0	70
Collins Cr	19.4	P	12	211	1	2	1	0	11	31	68	0.9	0	50
Terrells Cr	20.9	P	17	227	2	4	2	1	14	45	55	0	0	59
Ferrells Cr	15.7	P	19	576	1	5	2	0	20	6	93	1.2	0	58
New Hope Cr	52.2	P	17	124	1	6	0	0	66	18	80	2	1.6	47
Bolin Cr	11.8	P	12	436	1	3	0	0	19	47	52	1.1	0	75
Morgan Cr	41	P	19	301	1	4	1	0	67	7	91	2	0	32
Avents Cr	14.2	P	14	424	1	5	0	0	9	32	66	2	0	57
Hector Cr	17.4	P	20	214	1	5	1	0	16	38	58	4	0	50
Kenneth Cr	15.2	P	14	250	1	4	0	0	19	27	72	0.8	0	43
Richland Cr	12.5	P	9	190	0	3	1	0	67	5	95	0.5	0	44
Muddy Cr	16.8	P	13	195	1	3	2	0	38	37	63	0	0	62
Sandy Cr	45.1	P	19	436	2	4	2	1	12	28	70	2	1.6	63
Bear Cr	25.2	P	20	518	2	3	2	1	9	28	72	0.6	1.3	60
Cabin Cr	46.9	P	25	273	3	5	2	1	16	29	68	2	0	44
Falls Cr	14.4	P	26	639	2	5	3	2	15	26	74	0	1.6	46

Appendix FC-4 (continued).

Waterbody (by subbasin by index number)	Drainage Area (mi^2)	Eco-region	No. of Species	No. of Individuals	No. of Species of Darters	No. of Species of Sunfish	No. of Species of Suckers	No. of Intolerant Species	% Tolerants	% Omnivores	% Insectivores	% Piscivores	% Diseased Individuals	% Species with Multiple Age Groups
McLendon's Cr	14.5	SH	16	110	3	3	1	2	17	23	75	1.8	0	44
Richland Cr	24.9	SH	19	64	1	4	1	0	38	16	80	5	0	26
Indian Cr	25.4	P	22	280	2	5	1	1	18	18	80	1.8	2.5	59
Big Buffalo Cr	19.7	P	13	110	1	5	0	0	36	2	98	0	0	31
Rocky R	7.4	P	15	672	1	5	1	0	22	48	51	1.3	0	60
Loves Cr	7.9	P	20	470	1	6	2	1	58	27	72	0.6	0.2	55
Bear Cr	42.4	P	19	398	3	5	1	1	11	6	93	1.5	0	63
Crains Cr	32.7	SH	17	176	1	5	1	0	12	4	91	5	0.6	59
Buffalo Cr	18.3	SH	6	28	1	1	1	1	0	4	36	61	0	33
Anderson Cr	34.7	SH	12	74	2	3	0	2	9	1	86	12	0	50
Big Cross Cr	25.2	SH	6	134	1	3	0	0	84	0	96	4	0	33
Puppy Cr	26	SH	8	35	1	0	1	0	3	3	86	11	0	50
Harrison Cr	48.3	CA	9	26	0	2	1	0	4	15	54	31	3.8	44
Browns Cr	15	CA	11	43	1	2	1	0	9	0	47	53	2.3	55
Turnbull Cr	36.6	CA	6	33	0	2	0	0	3	3	21	76	0	33
Whites Cr	10.3	CA	19	144	2	6	2	1	10	6	71	24	0	53
Colly Cr	16.6	CA	7	51	0	2	0	0	2	2	45	53	0	72
White Oak Branch	17	CA	14	304	1	5	1	1	45	38	36	26	0	43
Mathews Cr	8.1	CA	20	400	1	7	1	0	33	9	76	15	0.5	60
Duff Cr	21.8	CA	20	312	1	6	2	1	60	7	78	15	0	50
Grove Cr	22.6	CA	20	604	1	6	2	2	26	2	67	31	0	60
Burgaw Cr	8.6	CA	11	224	0	4	1	0	76	5	79	16	0.4	27

P = Piedmont, SH = Sandhills, and CA = Coastal Plain.

Appendix FC-4 (continued).

Metric Scores

Waterbody (by subbasin by index number)	NCIBI Score	NCIBI Class	No. of Species	No. of Individuals	No. of Species of Darters	No. of Species of Sunfish	No. of Species of Suckers	No. of Intolerant Species	% Tolerants	% Omnivores	% Insectivores	% Piscivores	% Diseased Individuals	% Species with Multiple Age Groups
Haw R	36	Poor	3	1	5	3	3	1	5	3	3	3	5	1
Haw R	38	Fair	3	1	3	3	1	5	3	3	3	5	5	3
Haw R	26	Poor	1	1	1	3	1	1	1	3	3	5	5	1
Troublesome Cr	28	Poor	1	1	3	1	1	1	5	1	1	5	5	3
L. Troublesome Cr	22	Poor	3	1	1	3	1	1	3	1	1	1	5	1
L. Troublesome Cr	28	Poor	3	1	1	3	1	1	3	5	3	5	1	1
Reedy Fork	48	Good-Fair	3	3	5	5	1	5	5	5	5	1	5	5
Reedy Fork	40	Fair	3	3	5	3	1	5	3	3	3	1	5	5
N Buffalo Cr	30	Poor	1	1	1	3	1	1	1	5	5	1	5	5
S Buffalo Cr	24	Poor	1	3	1	3	1	1	1	1	1	1	5	5
S Buffalo Cr	16	Poor	1	1	1	1	1	1	1	1	1	3	1	3
Big Alamance Cr	50	Good	3	3	5	5	5	5	5	1	5	5	5	3
L. Alamance Cr	42	Fair	5	1	3	5	1	1	5	5	3	3	5	5
Stinking Quarter Cr	40	Fair	3	1	5	3	1	5	3	5	5	1	5	3
L. Alamance Cr	30	Poor	3	1	3	3	3	1	3	1	1	1	5	5
Collins Cr	32	Poor	3	3	3	1	1	1	5	3	3	1	5	3
Terrells Cr	40	Fair	3	3	5	3	3	5	5	3	1	1	5	3
Ferrells Cr	48	Good-Fair	5	5	3	5	5	1	3	5	5	3	5	3
New Hope Cr	36	Poor	3	1	1	5	1	1	1	5	5	5	5	3
Bolin Cr	36	Poor	3	5	3	3	1	1	5	1	1	3	5	5
Morgan Cr	34	Poor	3	3	3	3	1	1	1	5	5	3	5	1
Avents Cr	42	Fair	3	5	3	5	1	1	5	3	3	5	5	3
Hector Cr	40	Fair	5	3	3	5	1	1	5	3	1	5	5	3
Kenneth Cr	34	Poor	3	3	3	3	1	1	5	3	3	1	5	3
Richland Cr	30	Poor	3	3	1	3	3	1	1	1	5	1	5	3
Muddy Cr	36	Poor	3	3	3	3	3	1	3	3	3	1	5	5
Sandy Cr	48	Good-Fair	3	3	5	3	3	5	5	3	3	5	5	5
Bear Cr	46	Good-Fair	5	5	5	3	3	5	5	3	3	1	5	3
Cabin Cr	50	Good	5	3	5	5	3	5	5	3	3	5	5	3
Falls Cr	50	Good	5	5	5	5	5	5	5	3	3	1	5	3

Appendix FC-4 (continued).

Waterbody (by subbasin by index number)	NCIBI Score	NCIBI Class	No. of Species	No. of Individuals	No. of Species of Darters	No. of Species of Sunfish	No. of Species of Suckers	No. of Intolerant Species	% Tolerants	% Omnivores	% Insectivores	% Piscivores	% Diseased Individuals	% Species with Multiple Age Groups
McLendon's Cr	46	Good-Fair	3	3	5	3	3	5	5	5	5	1	5	3
Richland Cr	34	Poor	3	1	3	3	3	1	3	5	5	1	5	1
Indian Cr	48	Good-Fair	5	3	5	5	1	5	5	5	5	3	3	3
Big Buffalo Cr	26	Poor	3	1	3	5	1	1	3	1	1	1	5	1
Rocky R	38	Fair	5	5	3	5	3	1	3	1	1	3	5	3
Loves Cr	44	Good-Fair	5	5	3	5	5	5	1	3	3	1	5	3
Bear Cr	50	Good	3	3	5	5	1	5	5	5	5	3	5	5
Crains Cr	40	Fair	3	3	3	5	3	1	5	1	5	3	5	3
Buffalo Cr	48	Good-Fair	5	5	3	3	3	5	5	5	3	5	5	1
Anderson Cr	40	Fair	3	1	5	3	1	5	5	1	5	3	5	3
Big Cross Cr	22	Poor	1	3	3	3	1	1	1	1	1	1	5	1
Puppy Cr	44	Good-Fair	5	5	3	1	3	1	5	5	5	3	5	3
Harrison Cr	46	Good-Fair	5	5	1	5	3	1	5	5	5	5	3	3
Browns Cr	30	Poor	3	1	3	1	3	1	5	1	1	5	3	3
Turnbull Cr	42	Fair	5	5	1	5	1	1	5	5	3	5	5	1
Whites Cr	52	Good	5	3	5	5	5	3	5	5	3	5	5	3
Colly Cr	48	Good-Fair	5	5	1	5	1	1	5	5	5	5	5	5
White Oak Branch	44	Good-Fair	3	5	3	5	3	3	3	3	3	5	5	3
Mathews Cr	48	Good-Fair	5	5	3	5	5	1	3	5	5	5	5	3
Duff Cr	50	Good	5	5	3	5	5	3	1	5	5	5	5	3
Grove Cr	48	Good-Fair	5	5	3	5	5	5	3	1	3	5	5	3
Burgaw Cr	40	Fair	3	5	1	3	5	1	1	5	5	5	5	1

P = Piedmont, SH = Sandhills, and CP = Coastal Plain.

Appendix FC-5. Fish community assessments in the Cape Fear River Basin, 1992-1998.

Subbasin/Stream	Road	County	Map F#	Index #	D.A. (mi^2)	Date	NCIBI Score	NCIBI Class[1]
030301								
Haw R	SR 2109	Guilford	F-1	16-(1)	14.1	04/06/98	36	P
Haw R	SR 2426	Rockingham	F-2	16-(1)	62.1	10/12/98	38	F
						04/06/98	26	P
Troublesome Cr	SR 1001	Rockingham	F-3	16-6-(0.3)	25.6	04/06/98	28	P
						11/03/93	30	P
L Troublesome Cr	SR 2600	Rockingham	F-4	16-7	12.1	10/12/98	22	P
						04/06/98	28	P
030602								
Reedy Fork	SR 2728	Guilford	F-1	16-11-(9)	125	10/12/98	48	G-F
						04/07/98	40	F
						11/03/93	42	F
N Buffalo Cr	SR 2770	Guilford	F-2	16-11-14-1	43.7	04/07/98	30	P
						05/10/94	22	P
S Buffalo Cr	US 70	Guilford	F-3	16-11-14-2	39.5	04/07/98	24	P
						05/10/94	26	P
S Buffalo Cr	SR 2821	Guilford	F-4	16-11-14-2	43.5	04/07/98	16	P
						05/10/94	28	P
Stony Cr	SR 1104	Caswell	F-5	16-14-(1)	12.4	05/19/94	48	G-F
Jordan Cr	SR 1002	Alamance	F-6	16-14-6-(0.5)	13.8	11/04/93	46	G-F
030603								
Big Alamance Cr	SR 3088	Guilford	F-1	16-19-(1)	30.5	04/08/98	50	G
L Alamance Cr	SR 3039	Guilford	F-2	16-19-3-(0.5)	10.1	04/22/98	42	F
Big Alamance Cr	SR 2309	Alamance	F-3	16-19-(4.5)	242	11/14/93	40	F
Stinking Quarter Cr	SR 1136	Alamance	F-4	16-19-8	83	04/08/98	40	F
						05/19/94	44	G-F
Rock Cr	off SR 2409	Alamance	F-5	16-19-8-3	11	07/30/92	44	G-F
Rock Cr	off SR 2409	Alamance	F-6	16-19-8-3	11	07/30/92	50	G
L Alamance Cr	SR 2309	Alamance	F-7	16-19-11	14.8	04/08/98	30	P
						11/04/93	42	F
030604								
Cane Cr	SR 1114	Orange	F-1	16-27-(2.5)	7.5	03/24/94	44	G-F
Collins Cr	SR 1539	Chatham	F-2	16-30-(1.5)	19.4	04/21/98	32	P
Terrells Cr	NC 87	Chatham	F-3	16-31-(2.5)	20.9	04/21/98	40	F
						04/19/94	42	F
Ferrells Cr	SR 1525	Chatham	F-4	16-32	15.7	04/21/98	48	G-F
030605								
New Hope Cr	SR 2220	Durham	F-1	16-41-1-(11.5)	52.2	05/18/98	36	P
Third Fork Cr	NC 751	Durham	F-2	16-41-1-12-(2)	16.5	06/16/93	26	P
Northeast Cr	SR 1102	Durham	F-3	16-41-1-17-(0.7)	13	06/16/93	42	F
Northeast Cr	SR 1100	Durham	F-4	16-41-1-17-(0.7)	18.2	06/16/93	32	P

Appendix FC-5 (continued).

Subbasin/Stream	Road	County	Map F#	Index #	D.A. (mi^2)	Date	NCIBI Score	NCIBI Class[1]
030606								
Bolin Cr	off SR 1750	Orange	F-1	16-41-1-15-1-(4)	11.8	05/18/98	36	P
Morgan Cr	NC 54	Orange	F-2	16-41-2-(1)	8.4	03/24/94	42	F
Morgan Cr	SR 1900	Orange	F-3	16-41-2-(5.5)	41	05/18/98	34	P
030607								
Gulf Cr	off SR 1924	Chatham	F-1	18-5-(1)	3.1	04/22/93	42	F
Gulf Cr	off SR 1916	Chatham	F-2	18-5-(1)	4.6	04/22/93	34	P
Avents Cr	SR 1418	Harnett	F-3	18-13	14.2	09/21/98	42	F
Hector Cr	SR 1403	Harnett	F-4	18-15	11.2	02/09/94	42	F
Hector Cr	SR 1412	Harnett	F-5	18-15	17.4	05/06/98	40	F
Kenneth Cr	SR 1441	Harnett	F-6	18-16-1-(2)	15.2	05/06/98	34	P
						02/09/94	32	P
030608								
Richland Cr	SR 1154	Guilford	F-1	17-7	12.5	04/22/98	30	P
Muddy Cr	SR 1929	Randolph	F-2	17-9	16.8	04/22/98	36	P
						03/22/94	42	F
030609								
Sandy Cr	SR 2481	Randolph	F-1	17-16-(1)	45.1	05/04/98	48	G-F
						03/22/94	44	G-F
030610								
Bear Cr	SR 1405	Moore	F-1	17-26-(1)	25.2	09/21/98	46	G-F
Cabin Cr	SR 1275	Moore	F-2	17-26-5-(1)	46.9	05/05/98	50	G
Bear Cr	NC 705	Moore	F-3	17-26-(6)	137	05/20/94	42	F
Falls Cr	SR 1606	Moore	F-4	17-27	14.4	05/05/98	50	G
McLendon's Cr	SR 1210	Moore	F-5	17-30-(0.5)	14.5	05/05/98	46	G-F
Richland Cr	SR 1640	Moore	F-6	17-30-5-(2)	24.9	04/24/98	34	P
						05/20/94	32	P
Indian Cr	SR 2306	Chatham	F-7	17-35	25.4	04/23/98	48	G-F
030611								
Cedar Cr	SR 2145	Chatham	F-1	17-39	13	04/11/94	38	F
Big Buffalo Cr	SR 1403	Lee	F-2	17-40	19.7	04/24/98	26	P
						04/11/94	38	F
030612								
Rocky R	SR 1300	Chatham	F-1	17-43-(1)	7.4	05/04/98	38	F
Loves Cr	SR 2229	Chatham	F-2	17-43-10	7.9	05/04/98	44	G-F
Tick Cr	US 421	Chatham	F-3	17-43-13	15.5	04/19/94	48	G-F
Bear Cr	SR 2187	Chatham	F-4	17-43-16	42.4	04/23/98	50	G
030614								
Nicks Cr	NC 22	Moore	F-1	18-23-3-(3)	26.8	05/31/96	40	F
Lower Little R	SR 2023	Moore	F-2	18-23-(10.7)	112	04/20/94	42	F
Crains Cr	US 1	Moore	F-3	18-23-16	32.7	05/07/98	40	F
Crains Cr	SR 1001	Moore	F-4	18-23-16	94.6	04/20/94	30	P
Buffalo Cr	SR 1001	Moore	F-5	18-23-18	18.3	05/07/98	48	G-F
Anderson Cr	SR 2031	Harnett	F-6	18-23-32	34.7	05/06/98	40	F

Appendix FC-5 (continued).

Subbasin/Stream	Road	County	Map F#	Index #	D.A. (mi^2)	Date	NCIBI Score	NCIBI Class[1]
030615								
Cross Cr	NC 87/ 210	Cumberland	F-1	18-27-(3)	15.4	05/03/94	30	P
Big Cross Cr	NC 87/ 210/24	Cumberland	F-2	18-27-(3)	25.2	05/21/98	22	P
Puppy Cr	SR 1406	Hoke	F-3	18-31-19	26	05/21/98	44	G-F
030616								
Harrison Cr	SR 1318	Bladen	F-1	18-42	48.3	05/20/98	46	G-F
						05/03/94	48	G-F
Browns Cr	NC 87	Bladen	F-2	18-45	15	05/20/98	30	P
						08/11/92	36	P
Turnbull Cr	NC 242	Bladen	F-3	18-46	36.6	05/20/98	42	F
Whites Cr	SR 1704	Bladen	F-4	18-50-5	10.3	05/20/98	52	G
030620								
Colly Cr	US 701	Bladen	F-1	18-68-17	16.6	05/19/98	48	G-F
White Oak Br	SR 1206	Pender	F-2	18-68-18-5	17	05/19/98	44	G-F
030621								
Mathews Cr	NC 111/ 903	Duplin	F-1	18-17-13	8.1	05/22/98	50	G
030622								
Halls Marsh Run	SR 1306	Duplin	F-1	18-74-19-11	8.5	11/18/92	34	P
Herrings Marsh Run	SR 1306	Duplin	F-2	18-74-19-16	8.8	11/18/92	34	P
Grove Cr	NC 11/ 903	Duplin	F-3	18-74-21	22.6	05/22/98	48	G-F
						06/01/94	52	G
Duff Cr	SR 1170	Duplin	F-4	18-74-29-2-(2)	21.8	05/22/98	50	G
030623								
Burgaw Cr	US 117	Pender	F-1	18-74-39	8.6	05/19/98	40	F

[1] The NCIBI Classifications are: G = Good, G-F = Good-Fair, F = Fair, and P = Poor.

APPENDIX FT-1

Fish Tissue Criteria

In evaluating fish tissue analysis results, several different types of criteria are used. Human health concerns related to fish consumption are screened by comparing results with Federal Food and Drug Administration (FDA) action levels, U. S. Environmental Protection Agency (EPA) recommended screening values, and criteria adopted by the North Carolina State Health Director.

The FDA levels were developed to protect humans from the chronic effects of toxic substances consumed in foodstuffs and thus employ a "safe level" approach to fish tissue consumption. A list of fish tissue analytes accompanied by their FDA criteria are presented below (USFDA, 1980). At present, the FDA has only developed metals criteria for mercury. Individual parameters which appear to be of potential human health concern are evaluated by the N.C. Division of Occupational and Environmental Epidemiology by request of the Water Quality Section.

In the guidance document, Fish Sampling and Analysis: Volume 1 (USEPA, 1993), EPA has recommended screening values for target analytes which are formulated from a risk assessment procedure. These are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DWQ compares fish tissue results with EPA screening values to evaluate the need for further intensive site specific monitoring. A list of target analytes and EPA recommended screening values for the general adult population is presented below.

The North Carolina State Health Director has adopted a selenium limit of 5 ppm for issuing fish consumption advisories. Total DDT includes the sum of all its isomers and metabolites (i.e. p,p DDT, o,p DDT, DDE, and DDD). Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane. Although the EPA has suggested a screening value of 7.0×10^{-7} ppm for dioxins, the State of North Carolina currently uses a value of 3.0 ppt (3×10^{-3}) in issuing fish consumption advisories.

Food and Drug Administration (FDA) Action Levels

Metals

Mercury	1.0 ppm

Organics

Aldrin	0.3 ppm	p,p DDE	5.0 ppm
Dieldrin	0.3 ppm	o,p DDT	5.0 ppm
Endrin	0.3 ppm	p,p DDT	5.0 ppm
o,p DDD	5.0 ppm	PCB-1254	2.0 ppm
p,p DDD	5.0 ppm	cis-chlordane	0.3 ppm
o,p DDE	5.0 ppm	trans-chlordane	0.3 ppm

Environmental Protection Agency (EPA) Screening Values

Metals

Cadmium	10.0 ppm
Mercury	0.6 ppm
Selenium	50.0 ppm

Organics

Chlorpyrifos	30.0 ppm	Heptachlor epoxide	0.01 ppm
Total chlordane	0.08 ppm	Hexachlorobenzene	0.07 ppm
Total DDT	0.3 ppm	Lindane	0.08 ppm
Dieldrin	0.007 ppm	Mirex	2.0 ppm
Dioxins	7.0×10^{-7} ppm	Total PCB's	0.01 ppm
Endosulfan (I and II)	20.0 ppm	Toxaphene	0.1 ppm
Endrin	3.0 ppm		

**Total DDT includes the sum of all its isomers and metabolites (i.e. p,p DDT, o,p DDT, DDE, and DDD). Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane.*

APPENDIX L1-LAKES ASSESSMENT PROGRAM

NCTSI Methodology

Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD, 1982). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/L), total organic nitrogen (TON in mg/L), Secchi depth (SD in inches), and chlorophyll *a* (CHL in µg/L). Lakewide means for these parameters are used to produce a NCTSI score for each lake, using the following equations:

$$\mathrm{TON}_{\mathrm{Score}} = \frac{\mathrm{Log(TON)} + 0.45}{0.24} \times 0.90$$

$$\mathrm{TP}_{\mathrm{Score}} = \frac{\mathrm{Log(TP)} + 1.55}{0.35} \times 0.92$$

$$\mathrm{SD}_{\mathrm{Score}} = \frac{\mathrm{Log(SD)} - 1.73}{0.35} \times -0.82$$

$$\mathrm{CHL}_{\mathrm{Score}} = \frac{\mathrm{Log(CHL)} - 1.00}{0.48} \times 0.83$$

$$\mathrm{NCTSI} = \mathrm{TON}_{\mathrm{Score}} + \mathrm{TP}_{\mathrm{Score}} + \mathrm{SD}_{\mathrm{Score}} + \mathrm{CHL}_{\mathrm{Score}}$$

In general, NCTSI scores relate to trophic classifications as follows: less than -2.0 is oligotrophic, -2.0 to 0.0 is mesotrophic, 0.0 to 5.0 is eutrophic, and greater than 5.0 is hypereutrophic. When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state of a lake between years is not unusual due to the potential variability of data collections which usually involve sampling on a limited number of times during the growing season.

Lakes are classified for their “best usage” and are subject to the state’s water quality standards. Primary classifications are C (suited for aquatic life propagation/protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses). Lakes with a CA designation represent water supplies with watersheds that are considered to be Critical Areas (i.e., an area within 1/2 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 1/2 mile and draining to a river intake). Supplemental classifications may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

Lakes, before 1998, were sometimes sampled for their potential of supporting algal blooms with the Algal Growth Potential Test (AGPT). The objective of the Algal Growth Potential Test is to assess a waterbody's potential for supporting algal biomass and to determine whether algal growth is limited by nitrogen, by phosphorus, or co-limited by both nutrients. When a waterbody supports algal growth at bloom levels without additional increases in nitrogen and/or phosphorus, the system may be subject to frequent nuisance algal blooms. The test exposes a standard alga, Selenastrum capricornutum, to the test water (this constitutes the control). Additional test samples are enriched with nitrogen or phosphorus. When one of these nutrients is added to a water sample which is growth limiting to that nutrient, the resulting mean standing crop (MSC) will generally reflect the level of added nutrient. In some cases, the bioavailable nitrogen and phosphorus in a sample may approach their optimum ratio for growth of the test alga and the addition of nutrients may not clearly identify the limiting nutrient. A waterbody may be protected from nuisance algal blooms if an AGPT value is consistently less than or equal to 5 mg/L.

Appendix L2 lists values for total phosphorus (TP in mg/L), total organic nitrogen (TON in mg/L), chlorophyll *a* (CHLA in µg/L), and Secchi depth, and other measurements made of water quality.

Median values for selected parameters from freshwater ambient monitoring stations 1994 through Sept. 15, 1997.

STORET No	Station Name	1994 TP	1994 NH3	1994 TSS	1995 TP	1995 NH3	1995 TSS	1996 TP	1996 NH3	1996 TSS	1997 TP	1997 NH3	1997 TSS
Haw R Watershed													
B0040000	Haw R nr Oak Ridge	.03	.01	6	.04	.07	10	.02	.06	4	.03	.01	4
B0050000	Haw R, US 29a	.03	.04	8	.04	.13	8	.03	.09	5	.02	.01	6
B0210000	Haw R,nr Altamahaw	.08	.06	6	.09	.07	7	.07	.07	6	.09	.04	9
B1140000	Haw R, Haw R	.36	.07	9	.26	.09	10	.22	.06	7	.35	.10	12
B2000000	Haw R, SR 1005	.35	.08	4	.24	.08	11	.17	.08	11	.21	.08	8
B2100000	Haw R, US 15-501, nr Bynum	.21	.05	4	.16	.09	6	.13	.06	6	.20	.02	7
B4050000	Haw R below Jordan Dam	.10	.12	10	.10	.16	11	.09	.09	9	.07	.05	9
B0160000	L Troublesome Cr, SR 2600	.64	.06	10	.40	.09	12	.20	.09	8	.21	.05	11
B0540000	North Buffalo Cr, nr Greensboro	1.0	.31	6	1.0	1.4	9	.77	1.7	9	1.0	3.5	9
B0750000	South Buffalo Cr, McLeansville	.88	.14	7	1.2	.66	6	.46	.17	6	.44	.42	7
B0840000	Reedy Fork, NC 87	.61	.12	6	.45	.23	5	.31	.11	6	.54	.38	8
B1090000	Jordan Cr, SR 1002	.05	.06	5	.05	.05	6	.05	.07	6	.04	.07	16
B1260000	Town Branch, SR 2109	.05	.05	6	.06	.06	4	.06	.05	3	.09	.04	12
B1960000	Alamance Cr, SR 2116	.39	.15	6	.19	.11	12	.10	.08	8	.11	.07	12
B2450000	Robeson Cr, SR 1939	.14	.05	14	.15	.1	10	.12	.05	7	.14	.04	13
B3040000	New Hope Cr, SR 1107	.37	.2	28	.22	.07	29	.25	.08	30	.15	.04	23
B3660000	Northeast Cr, SR 1100	.41	.44	21	.58	.22	17	.30	.11	23	.46	.13	23
B3900000	Morgan Cr, SR 1726	.19	.11	8	.16	.09	9	.16	.12	8	.12	.05	24
Deep R Watershed													
B4240000	East Fork Deep R, SR 1541	.04	.06	8	.06	.06	17	.08	.06	11	.06	.02	10
B4615000	Deep R, SR 1921 nr Randleman	.76	.13	8	.44	.13	11	.59	.08	13	.88	.09	7
B4800000	Deep R, SR 2128 at Worthville	.50	.17	9	.34	.10	12	.43	.17	9	.41	.05	7
B5070000	Deep R, Main St, Ramseur	.33	.14	5	.27	.10	8	.28	.09	6	.25	.10	7
B5190000	Deep R, SR 1456	.20	.06	5	.22	.05	7	.21	.09	8	.18	.05	17
B5520000	Deep R, NC 22, High Falls	.19	.07	6	.23	.09	9	.21	.08	8	.15	.08	9
B5575000	Deep R, NC 42, Carbonton	.18	.11	8	.17	.08	8	.16	.07	9	.13	.04	11
B5820000	Deep R, US 15-501 nr Sanford	.21	.09	8	.19	.09	7	.16	.08	7	.16	.04	8
B6050000	Deep R, CSX RR Bridge	.17	.07	6	.16	.05	5	.14	.06	5	.11	.03	8
B4410000	Richland Cr, SR 1145	2.35	.10	6	1.5	.21	6	1.7	.10	7	1.8	.10	8
B4890000	Hasketts Cr, SR 2128	1.0	.13	7	.93	.10	11	.90	.13	9	.95	.05	8
B5480000	Bear Cr, NC 705 at Robbins	.25	.08	4	.13	.05	6	.08	.08	6	.11	.01	4
B6010000	Rocky R, US 15-501	.11	.05	2	.10	.06	4	.07	.05	3	.07	.01	6
Cape Fear Mainstem													
B6160000	Cape Fear R, NC 42 Nr Corinth	.12	.07	8	.13	.08	11	.11	.07	15	.09	.03	10
B6370000	Cape Fear R, US 401, Lillington	.11	.07	18	.12	.06	16	.12	.08	30	.08	.04	17
B6840000	Cape Fear R, NC 217	.10	.06	11	.13	.06	14	.14	.07	14	.09	.05	14
B7600000	Cape Fear R, NC 24, Fayetteville	.11	.06	14	.15	.08	12	.14	.06	13	.09	.04	11
B8300000	Cape Fear R, W. O. Hoske Lock	.16	.05	16	.19	.08	44	.23	.08	32	.17	.03	34
B8305000	Cape Fear R, SR 1316 nr Tarheel,	.18	.07	9	.26	.11	29	.18	.08	15	.18	.04	23
B8340000	Cape Fear R, Lock & Dam #2	.20	.06	10	.20	.09	37	.26	.10	27	.19	.04	10
B8350000	Cape Fear R, Lock #1 Nr Kelly	.12	.08	7	.14	.09	8	.15	.07	7	.15	.10	12
B8360000	Cape Fear R, NC 11 Nr Kelly,	.13	.08	7	.13	.08	12	.14	.08	6	.15	.09	12
B8450000	Cape Fear R nr Acme	.13	.11	6	.14	.10	8	.14	.11	7	.16	.12	15
B9020000	Cape Fear R nr Phoenix	.11	.11	7	.13	.08	7	.13	.11	7	.12	.10	10
B9050000	Cape Fear R, Navassa	.12	.10	8	.11	.08	10	.14	.10	12	.13	.08	10
Cape Fear Tributaries													
B6830000	Upper Little R, SR 2021	.03	.05	4	.03	.05	4	.03	.05	5	.03	.03	3
B7280000	Little R[Lower], NC 87&24	.07	.05	6	.04	.06	7	.07	.05	3	.04	.04	5
B7245000	Lower Little R, SR 2023	.03	.04	3	.03	.04	5	.03	.04	4	.02	.03	3
B7700000	Rockfish Cr, SR 1432	.09	.08	4	.10	.05	6	.10	.09	3	.12	.29	6
B8220000	Rockfish Cr, US 301	.07	.07	8	.08	.05	6	.06	.06	6	.07	.06	6
B8445000	Livingston Cr, Mouth	.13	.18	7	.16	.17	8	.06	.24	6	.09	.13	5
Black R Watershed													
B8750000	Black R, NC 411	.10	.08	3	.14	.05	3	.16	.08	3	.10	.03	2
B9013000	Black R below Raccoon Is.	.06	.07	4	.08	.06	4	.09	.08	2	.10	.05	5
B8919000	South R, SR 1503	.05	.05	3	.10	.05	2	.08	.07	1	.08	.04	4
B8540000	Little Coharie Cr, NC 24	.07	.10	3	.18	.07	2	.10	.05	2	.07	.03	3
B8725000	Six Runs, SR 1960	.11	.08	3	.16	.09	2	.11	.09	1	.08	.05	2
Northeast Cape Fear River Watershed													
B9290000	Northeast Cape Fear R, NC 41	.15	.09	2	.19	.05	1	.15	.13	2	no data from '97		
B9580000	Northeast Cape Fear R, US 117	.12	.04	3	.09	.04	3	.11	.06	1	.09	.03	3
B9740000	Northeast Cape Fear R, US 421	.11	.08	13	.09	.10	11	.12	.11	9	.10	.11	16
B9090000	Northeast Cape Fear R, NC 403							.16	.22	3	.09	.06	2
B9470000	Rockfish Cr, I-40	.52	.10	4	.24	.08	2	.29	.13	1	.21	.09	3

Median values for selected parameters from freshwater ambient monitoring stations 1994 through Sept. 15, 1997.

		1994			1995			1996			1997		
STORET No	Station Name	DO	Cond	pH	DO	Cond	pH	DO	Cond	pH	DO	Cond	pH
Haw R Watershed													
B0040000	Haw R nr Oak Ridge	7.4	74	6.8	7.8	74	6.9	8.9	61	7.1	8.0	67	6.6
B0050000	Haw R, US 29a	8.2	73	7.0	8.0	67	7.1	9.8	57	7.2	9.4	62	7.0
B0210000	Haw R, nr Altamahaw	9.6	118	7.2	8.8	103	7.4	10.5	78	7.3	9.2	101	7.2
B1140000	Haw R, Haw R	9.2	255	7.5	9.4	228	7.6	10.7	200	7.7	9.0	242	7.4
B2000000	Haw R, SR 1005	8.6	367	7.3	8.6	202	7.3	9.6	201	7.4	9.2	220	7.2
B2100000	Haw R, US 15-501	9.4	173	7.5	9.5	219	7.4	8.9	140	7.5	9.0	200	7.8
B4050000	Haw R below Jordan Dam	8.8	168	7.1	9.5	153	7.0	8.9	110	7.1	8.8	103	7.3
B0160000	L Troublesome Cr, SR 2600	8.2	354	7.1	9.7	316	7.2	8.5	336	7.4	8.6	289	7.1
B0540000	North Buffalo Cr, nr Greensboro	6.4	588	7.1	7.0	583	7.4	6.8	462	7.2	6.4	415	6.9
B0750000	South Buffalo Cr, McLeansville	6.8	600	7.2	6.4	605	7.4	7.7	503	7.4	6.2	494	7.2
B0840000	Reedy Fork, NC 87	9.6	484	7.4	8.8	394	7.7	9.8	316	7.5	8.7	307	7.2
B1090000	Jordan Cr, SR 1002	9.2	122	7.2	8.1	100	7.3	10.1	85	7.2	8.6	101	7.0
B1260000	Town Branch, SR 2109	8.0	216	7.3	8.7	197	7.6	10.9	252	7.4	8.2	222	7.1
B1960000	Alamance Cr, SR 2116	7.1	491	7.0	7.7	156	7.3	9.1	169	7.3	8.2	185	6.9
B2450000	Robeson Cr, SR 1939	11	201	7.7	11	152	7.2	9.9	100	7.5	8.9	151	7.8
B3040000	New Hope Cr, SR 1107	6.3	271	7.1	7.4	200	7.1	6.6	216	7.0	8.0	193	7.2
B3660000	Northeast Cr, SR 1100	5.7	448	6.9	6.9	458	6.8	6.5	190	6.9	6.3	471	7.1
B3900000	Morgan Cr, SR 1726	6.4	329	7.1	7.3	268	7.2	8.0	227	7.3	7.2	249	7.3
Deep R Watershed													
B4240000	East Fork Deep R, SR 1541	9.2	126	7.0	10.0	113	7.2	9.5	127	7.4	8.8	125	7.1
B4615000	Deep R, SR 1921 nr Randleman	9.0	243	7.2	9.7	269	7.3	9.4	240	7.4	7.8	335	7.3
B4800000	Deep R, SR 2128 nr Worthville	9.2	240	7.3	10.0	153	7.7	10.0	202	7.6	9.1	220	7.3
B5070000	Deep R, Main St, Ramseur	9.2	230	7.3	10.0	191	7.7	10.2	194	7.6	8.5	134	7.3
B5190000	Deep R, SR 1456	9.2	190	7.4	9.0	138	7.3	8.4	183	6.9	9.0	192	6.8
B5520000	Deep R, NC 22, High Falls	9.5	188	7.3	9.0	106	7.4	9.0	175	7.1	8.9	166	6.9
B5575000	Deep R, NC 42, Carbonton	6.8	110	7.0	7.3	103	7.0	8.3	93	7.1	7.8	85	7.3
B5820000	Deep R, US 15-501	6.9	127	6.9	6.7	90	7.1	6.9	96	6.9	6.7	87	7.2
B6050000	Deep R, CSX RR Bridge	8.2	163	7.1	8.6	114	7.1	7.8	99	7.0	8.3	90	7.3
B4410000	Richland Cr, SR 1145	8.8	528	7.0	9.1	587	7.2	9.3	554	7.1	8.0	494	6.9
B4890000	Hasketts Cr, SR 2128	9.0	918	7.5	10.2	696	7.5	9.6	754	7.5	9.1	610	7.4
B5480000	Bear Cr, NC 705	7.9	85	6.7	8.7	66	6.8	6.8	117	6.5	8.9	99	6.7
B6010000	Rocky R, US 15-501	9.9	125	7.2	9.2	101	7.2	9.4	90	7.3	10.0	82	7.5
Cape Fear Mainstem													
B6160000	Cape Fear R, NC 42 Nr Corinth	10.4	150	7.1	9.5	124	7.1	8.9	100	7.2	9.4	125	7.5
B6370000	Cape Fear R, US 401, Lillington	8.2	157	7.1	9.3	128	7.1	9.3	149	6.8	8.9	175	7.0
B6840000	Cape Fear R, NC 217 Nr Erwin	8.0	153	7.3	8.6	114	7.3	8.9	160	7.0	8.4	149	7.2
B7600000	Cape Fear R, NC 24, Fayetteville	7.9	135	7.0	8.0	120	6.8	7.6	146	7.1	8.6	107	6.5
B8300000	Cape Fear R, W. O. Hoske Lock	7.7	91	7.0	7.5	106	6.9	8.7	137	6.8	9.1	134	7.0
B8305000	Cape Fear R, SR 1316 nr Tarheel	7.9	102	6.9	7.4	104	6.9	7.9	133	6.5	7.4	123	7.0
B8340000	Cape Fear R, Lock And Dam #2	7.1	124	6.8	8.2	109	6.8	8.2	151	6.7	9.0	137	6.4
B8350000	Cape Fear R, Lock #1 Nr Kelly	8.1	106	6.7	7.1	120	6.9	8.5	130	6.9	7.8	107	7.0
B8360000	Cape Fear R, NC 11	7.7	108	6.7	7.3	105	6.9	8.1	141	6.9	7.7	117	7.0
B8450000	Cape Fear R nr Acme	7.4	137	6.7	6.6	142	6.8	8.1	153	6.9	7.1	119	7.0
B9020000	Cape Fear R nr Phoenix	5.6	151	6.7	5.2	135	6.6	6.3	156	6.6	7.3	126	6.9
B9050000	Cape Fear R, Navassa	6.9	165	6.7	5.4	140	6.7	6.4	166	6.8	6.5	124	6.9
Cape Fear Tributaries													
B6830000	Upper Little R, SR 2021	8.9	48	6.4	8.0	42	6.2	8.7	67	6.2	8.6	68	6.5
B7280000	Little R[Lower], NC 87&24	8.0	49	6.3	8.1	36	6.3	9.2	48	6.2	9.3	55	6.5
B7245000	Lower Little R, SR 2023	7.5	33	5.9	8.0	30	6.0	8.2	40	5.7	7.6	47	6.2
B7700000	Rockfish Cr, SR 1432	7.9	35	6.1	8.2	30	6.0	7.6	37	5.5	7.2	46	6.2
B8220000	Rockfish Cr, US 301	8.3	43	6.6	8.4	41	6.6	8.1	46	5.1	8.7	44	6.8
B8445000	Livingston Cr, Mouth	6.7	115	6.7	6.5	157	6.8	6.5	144	6.9	6.9	126	6.8
Black R Watershed													
B8750000	Black R, NC 411	7.5	96	6.4	7.9	91	6.3	6.5	96	6.3	8.2	101	6.5
B9013000	Black R at Raccoon Island	5.0	97	6.4	4.8	96	6.3	4.8	98	6.3	4.6	112	6.7
B8919000	South R, SR 1503	5.9	68	5.5	6.5	55	5.8	6.4	75	5.2	6.9	67	6.4
B8540000	Little Coharie Cr, NC 24	6.8	73	6.3	6.7	71	6.4	5.7	86	5.9	7.4	74	6.4
B8725000	Six Runs, SR 1960	7.2	112	6.8	6.6	98	7.0	6.4	122	6.4	6.8	112	6.5
Northeast Cape Fear River Watershed													
B9290000	Northeast Cape Fear R, NC 41	7.2	183	6.8	7.8	162	6.9	8.1	167	6.9	no data from "97		
B9580000	Northeast Cape Fear R, US 117	5.5	140	6.6	5.7	113	6.6	4.6	147	6.6	6.3	151	6.9
B9090000	Northeast Cape Fear R, NC 403				new station			2.9	438	6.5	7.3	320	6..5
B9740000	Northeast Cape Fear R, US 421	5.3	1155	6.6	5.7	671	6.8	6.5	190	6.7	6.1	5180	6.8
B9470000	Rockfish Cr, I-40	6.2	254	7.1	8.0	144	7.0	8.9	226	6.9	8.8	212	6.9