

# **Summary of Water Quality Monitoring Results in South Hominy Creek and its Tributaries, French Broad River Basin**

Prepared by the Division of Water Quality, North Carolina Department of Environment and Natural Resources

Prepared for the North Carolina Ecosystem Enhancement Program

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From December 2003 to January 2005, the Division of Water Quality (DWQ) conducted ambient water monitoring in South Hominy Creek and several of its tributaries (DWQ Subbasin 04-03-02) to support the North Carolina Ecosystem Enhancement Program's planning efforts in this area. This summary documents the nature of these monitoring activities and briefly describes the major water quality patterns observed during this study. Major findings and notable differences in water chemistry among the sampling sites and between stormflow and baseflow are discussed. Comparisons are made to existing water standards and criteria, and summary tables are provided for all monitoring sites.

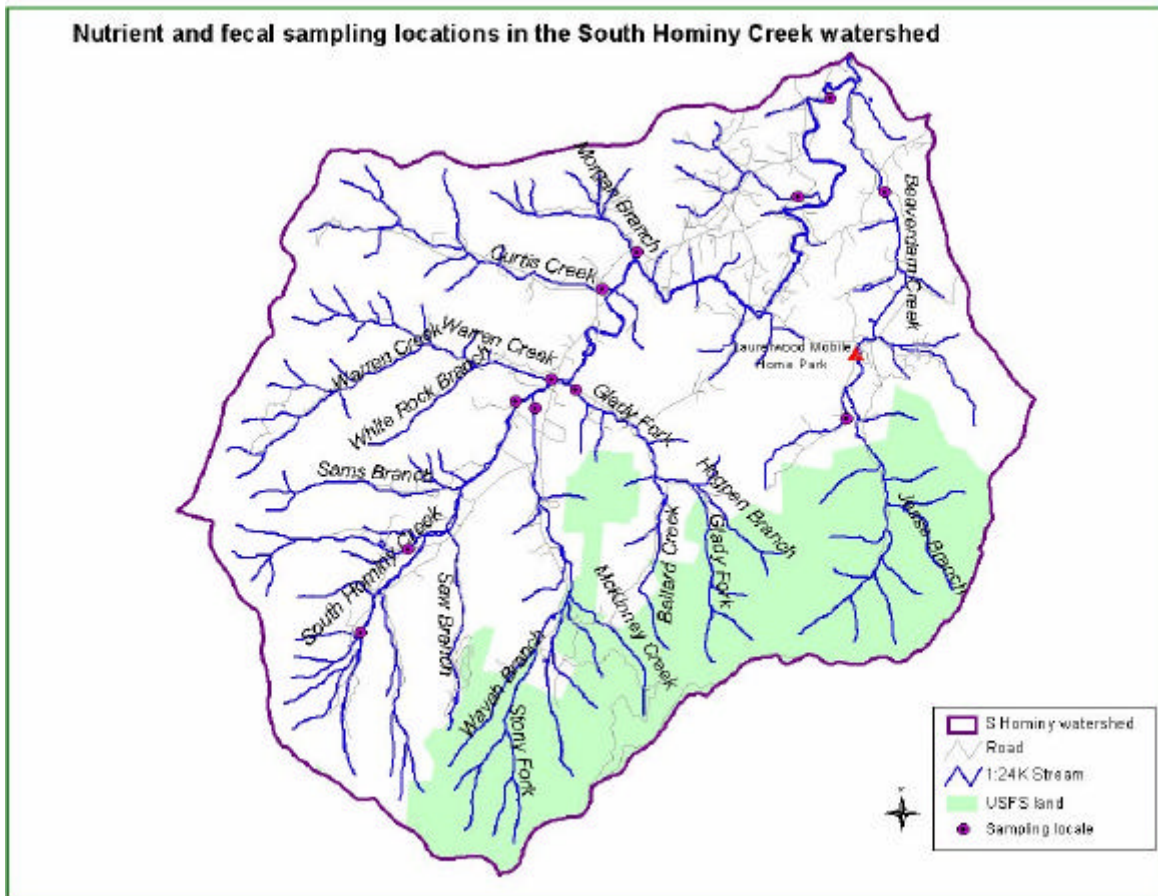
## **I. DESCRIPTION OF STUDY PLAN**

The Ecosystem Enhancement Program (EEP) Hydrological Unit 06010105060020 planning area is the South Hominy Creek watershed, an approximately 38 square mile area located southwest of Asheville and entirely within Buncombe County (Figure 1). South Hominy Creek is a major tributary to Hominy Creek. The main tributaries to South Hominy Creek are Stony Fork, Beaverdam Creek, Glady Fork and Warren Creek. The majority of the watershed's underlying geology is characterized by Muscovite-Biotite Gneiss, though Biotite Gneiss characterizes a small section along the western boundary. Ten of the twenty-nine soil series within the watershed represent approximately 85 percent of the area, and all are well-draining soils. Wetlands are primarily present in the Upper and Middle South Hominy Creek drainage areas, though a few wetlands occur in the Beaverdam Creek drainage. There are few to no wetlands present in the lower South Hominy drainage. The watershed contains several significant and/or rare ecological communities and species, specifically on Mt. Pisgah, Ben's Ridge and Coves, Spring Mountain, and the high elevations of HWY 151 (see Technical Memorandum 1, 2004)

There are no hazardous material sites and one minor NPDES permitted point source discharge within the study area. Laurelwood Mobile Home Park has a domestic subsurface sandfilter wastewater treatment facility (2000 gallons per day) which discharges into Beaverdam Creek.

### **A. Water Sampling**

To provide supplemental information to support the Local Watershed Plan being developed for this area by EEP, DWQ conducted chemical-physical monitoring at thirteen sites (Figure 1). Detailed information about the types of data collected and the location of each site is provided in Table 1.



**Figure 1:** Sampling sites in the South Hominy Creek Watershed.

Site # (See Figure 1)	Location [ID #]	Benthos July 2004	Fish	Water Quality
1	South Hominy @ Old Hwy 151 [FRB02_B001]			
2	South Hominy Cr @ SR 3451 / Hominy Creek Rd [FRB02_B002]		x	x
3	Youngs Cove @ SR 3452 / Bailey Rd [FRB02_B003]	x		x
4	Morgan Branch @ NC 151 [FRB02_B004]			x
5	Curtis Cr @ NC 151 [FRB02_B005]	x		x
6	Warren Cr @ NC 151 [FRB02_B006]	x		
7	Glady Fork @ SR 3452/Upper Glady Rd [FRB02_B007]	x	x	x
8	South Hominy Cr @ SR 1109/Pisgah View Rd [FRB02_B008]	x	x	x
9	Stony Fork @ SR 1109/Pisgah View Rd [FRB02_B009]		x	x
10	Pisgah View Cr @Pisgah View Ranch Rd [FRB02_B010]		x	
11	South Hominy Cr @ Pisgah View Ranch campground off SR 1105 [FRB02_B011]	x		x
12	Smith Cove @ SR 3449/Beaverdam Loop [FRB02_B012]	x		x
13	Beaverdam Cr @ Beaverdam Rd [FRB02_B013]		x	x

**Table 1:** Locations and monitoring conducted at each sampling site in the South Hominy Creek watershed.

Three sites are located on the mainstem of South Hominy Creek and ten are positioned on smaller tributary creeks. Periodic samples were collected under both baseflow and stormflow conditions at one site on the main stem of South Hominy Creek from December 2003 through January 2005. The additional twelve sites were sampled on three separate dates during baseflow conditions. Baseflow conditions were defined as those that occurred at least 48 hours after measurable precipitation was recorded. Stormflow conditions were those that occurred within 48 hours of measureable precipitation, and all stormflow samples were collected during rising stream stage. All samples were grab samples, collected at surface depth (0.15 meters). Chemical and physical monitoring were conducted according to the procedures described in the Intensive Survey Unit's Standard Operating Procedures (SOP) manual (NCDWQ, 2003) and the DWQ Laboratory Section's sample submission guidance (NCDWQ, 2002).

Stream temperature, dissolved oxygen concentration, oxygen saturation, pH, and specific conductance were measured in the field. For all other parameters, samples were collected in the field and sent to the DWQ laboratory for analysis. Standard parameters included: suspended residue, turbidity, fecal coliforms, metals, and nutrients. The sample preservation procedures that were followed are available on the DWQ Laboratory Section website. DWQ Lab Methods and Practical Quantitation Limits (PQLs) for all parameters are provided in Table 2.

Parameter	EPA Method <sup>1</sup>	APHA Method <sup>2</sup>	Other Method	PQL	Revision Date
<b>Coliform, MF fecal</b>	600/8-78-017	9222D		1 colony/100mL	3/13/01
<b>Susp. residue</b>	160.2	2540D		2 mg/L	3/13/01
<b>Susp. fixed residue</b>	160.4			2 mg/L	3/13/01
<b>Susp. volatile res.</b>	160.4			2 mg/L	3/13/01
<b>Turbidity</b>	180.1	2130B		1 NTU	3/13/01
<b>NH<sub>3</sub> as N</b>	350.1 and 350.2		QUIK CHEM 10-107-06-1-J	0.01 mg/L	7/24/01
<b>TKN as N</b>	350.1 and 351.2		QUIK CHEM 10-107-06-2-H	0.20 mg/L	7/24/01
<b>NO<sub>2</sub>+ NO<sub>3</sub> as N</b>	353.2		QUIK CHEM 10-107-04-1-C	0.01 mg/L	7/24/01
<b>P total as P</b>	365.1		QUIK CHEM 10-115-01-1-EF	0.02 mg/L	7/24/01
<b>Copper (Cu)</b>	200.8/220.2			2.0 µg/L	3/13/01
<b>Nickel (Ni)</b>	200.8/200.7			10 µg/L	3/13/01
<b>Lead (Pb)</b>	200.8/239.2			10 µg/L	3/13/01
<b>Zinc (Zn)</b>	200.8/200.7			10 µg/L	3/13/01
<b>Aluminum (Al)</b>	200.7			50 µg/L	3/13/01
<b>Iron (Fe)</b>	200.7			50 µg/L	3/13/01
<b>Manganese (Mn)</b>	200.8/200.7			10 µg/L	3/13/01
<b>Sodium (Na)</b>	200.7			0.10 mg/L	7/24/01
<b>Calcium (Ca)</b>	200.7			0.10 mg/L	3/13/01
<b>Magnesium (Mg)</b>	200.7			0.10 mg/L	3/13/01
<b>Arsenic (As)</b>	200.8/206.2			10 µg/L	3/13/01
<b>Mercury (Hg)</b>	245.1			0.02 µg/L	3/13/01
<b>Silver (Ag)</b>	200.8/272.2			5 µg/L	3/13/01
<b>Chromium (Cr)</b>	200.8/200.7			25 µg/L	3/13/01
<b>Cadmium (Cd)</b>	200.8/213.2			2.0 µg/L	3/13/01

1. Information on EPA methods is available at <http://h2o.enr.state.nc.us/lab/qa/pqclinorg.htm>.

2. APHA reference: Standard Methods for the Examination of Water and Wastewater, 18th ed.

**Table 2:** DWQ Laboratory Section Methods and Practical Quantitation Limits (PQL).

## II. Summary of Results

This section provides a synopsis of water quality patterns observed at the thirteen sampling sites. Complete site summaries are provided in Section III.

A robust sampling plan was implemented at South Hominy Creek at Old Hwy 151, the furthest downstream site sampled in this study, while a more limited sampling scheme was conducted at the remaining twelve sites. The following parameters were measured exclusively at South Hominy Creek at Old Hwy 151: trace metals (aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc), major cations (calcium, sodium, and magnesium), residue (suspended, fixed, and volatile), and turbidity. Sampling at South Hominy Creek at Old Hwy 151 was conducted on sixteen dates between December 2, 2003 and December 22, 2004.

### A. Metals

Of the twelve metals analyzed, all but arsenic (As), cadmium (Cd), and silver (Ag) were found at analytically reportable concentrations (Figure 3). For each element, benchmark values have been established to provide an estimate of the highest concentration of a pollutant to which an aquatic community can be exposed indefinitely (chronic limit) without resulting in an unacceptable effect (US EPA Water Quality Standards Database 2004). Aluminum (Al) exceeded benchmark concentrations in all but one of the sixteen samples, while Iron (Fe) exceeded the benchmark concentrations in seven samples. Both of these elements are major constituents of the native soils of this area and were the only metals to exceed benchmark concentrations in baseflow samples (Reid, 1993).

Manganese (Mn) concentrations were higher than the benchmark concentration in three storm samples, while copper (Cu) and lead (Pb) each surpassed the benchmarks in two storm samples. Chromium (Cr), copper (Cu), lead (Pb), and nickel (Ni) were only detectable in stormflow samples, and both nickel and chromium were found at concentrations above their respective analytical reporting limits (10 and 25 micrograms per liter) only in the stormflow sample taken during Hurricane Frances.

Metals (total, mg/L)		Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ag	Zn
<b>Benchmarks</b>		<b>87</b>	<b>150</b>	<b>0.25</b>	<b>11</b>	<b>9.0</b>	<b>1000</b>	<b>2.5</b>	<b>120</b>	<b>0.77</b>	<b>52</b>	<b>0.36</b>	<b>120</b>
<i>Detection levels</i>			10	2*	25*	2		10*		0.2	10	5*	10
12/2/2003	Base flow	<b>130</b>	U	U	U	U	210	U	17	U	U	U	U
12/10/2003	Storm flow	<b>6100</b>	U	U	U	8.8	<b>7600</b>	U	<b>180</b>	U	U	U	33
1/21/2004	Base flow	73	U	U	U	U	140	U	13	U	U	U	U
3/2/2004	Base flow	<b>160</b>	U	U	U	U	250	U	15		U	U	U
3/18/2004	Storm flow	<b>470</b>	U	U	U	U	680	U	28	U	U	U	U
3/25/2004	Base flow	<b>170</b>	U	U	U	U	270	U	14		U	U	U
4/20/2004	Base flow	<b>340</b>	U	U	U	U	490	U	20		U	U	U
4/26/2004	Storm flow	<b>1800</b>	U	U	U	3.5	<b>2500</b>	U	91		U	U	16
5/13/2004	Storm flow	<b>740</b>	U	U	U	U	<b>1100</b>	U	41		U	U	U
5/25/2004	Base flow	<b>920</b>	U	U	U	U	<b>1200</b>	U	34		U	U	13
6/15/2004	Storm flow	<b>1100</b>	U	U	U	14.0	<b>15,000</b>	11	<b>340</b>		U	U	60
9/7/2004	Storm flow Hurricane Frances	<b>31,000</b>	U	U	33	34.0	<b>40,000</b>	31	<b>1200</b>		17	U	<b>180</b>
9/22/2004	Base flow	<b>580</b>	U	U	U	U	840	U	61		U	U	U
10/19/2004	Storm flow	<b>660</b>	U	U	U	U	<b>1100</b>	U	80		U	U	U
12/2/2004	Base flow	<b>130</b>	U	U	U	U	270	U	43		U	U	U
12/22/2004	Base flow	<b>98</b>	U	U	U	U	200	U	36	U	U	U	U

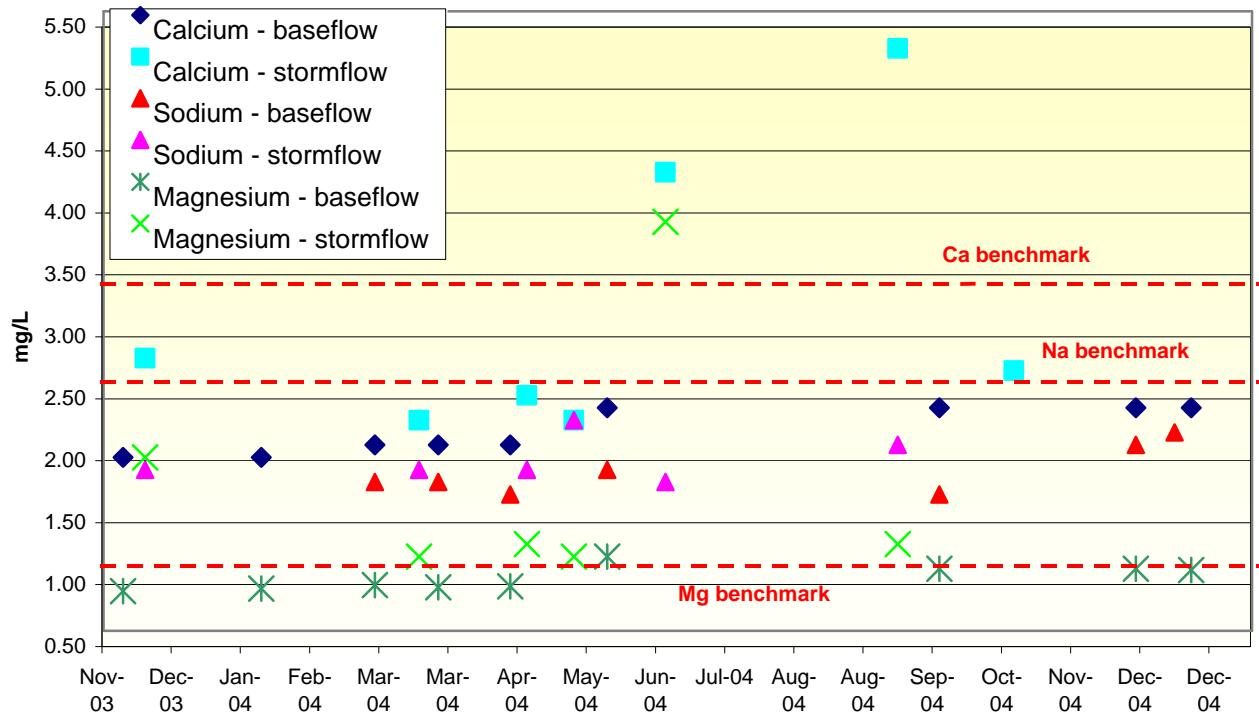
**Table 3:** Metals Concentrations (µg/L) at South Hominy Creek at Old Hwy 151. Values exceeding benchmark concentrations in Table 4 are in **bold** font. Asterisks indicate that detection levels are higher than benchmark values. A “U” indicates that concentrations were below detection levels. Mercury (Hg) was only sampled on five dates.

Sources in order of priority:				
Element	EPA National Water Quality Standards Database, 2004	EPA National Recommended Water Quality Criteria, 1999	Risk Assessment Information System (RAIS)	USGS Paper, LI Briel, 1997
Aluminum		87.00		
Arsenic	150.00			
Cadmium	0.25			
Chromium	11.00			
Copper	9.00			
Iron		1000.00		
Lead	2.50			
Manganese			120	
Mercury	0.77			
Nickel	52.00			
Potassium				0.80
Silver			0.36	
Zinc	120.00			

**Table 4:** Benchmark concentration ranges for metals (µg/L).

## B. Major Cations

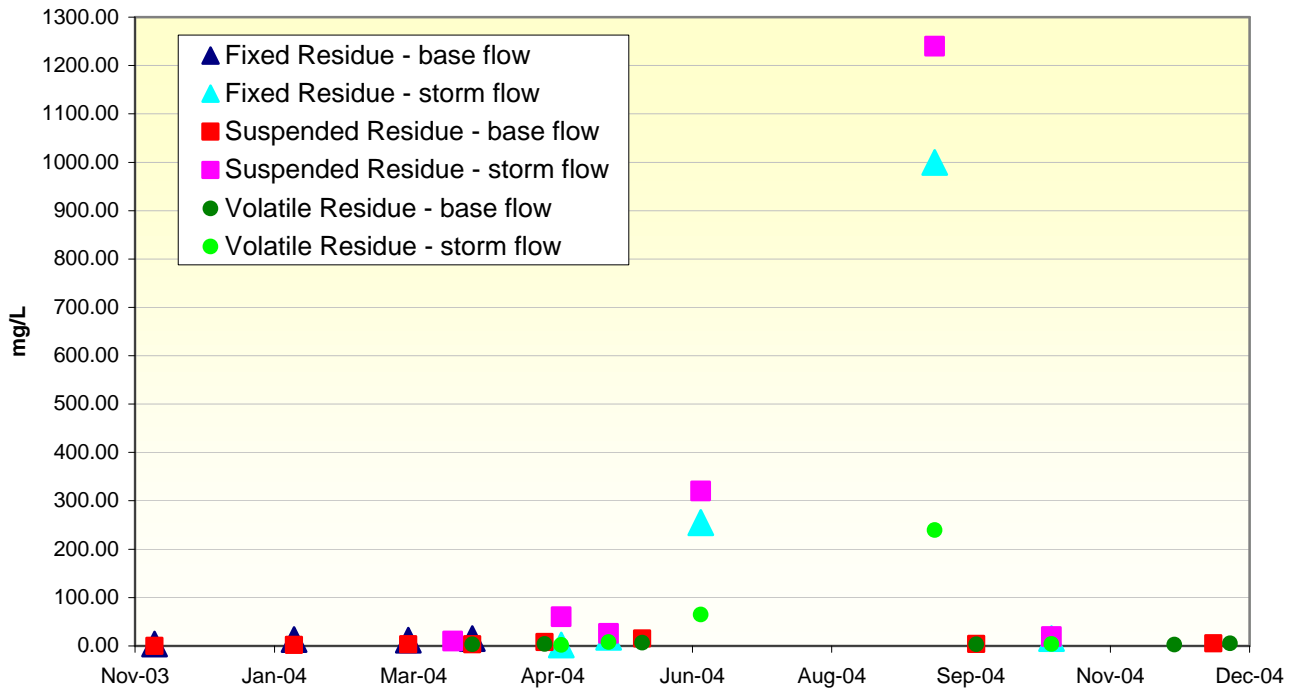
Magnesium (Mg) was highly influenced by flow. Magnesium was recorded at concentrations below the benchmark concentration of 1.1 mg/L in every baseflow sample, but exceeded benchmark concentrations in all but one of the seven storm samples (Figure 2). Baseflow calcium (Ca) concentrations ranged from 1.5 to 2.5 mg/L. With the exception of two stormflow samples, which exceeded the benchmark value of 3.4 mg/L, stormflow concentrations were only slightly higher than baseflow concentrations, ranging from 2.0 to 3.0 mg/L. Sodium (Na) concentrations exhibited minimal fluctuation between baseflow and stormflow events. All sodium concentrations varied from 1.6 to 2.2 mg/L and were below the benchmark value of 2.6 mg/L.



**Figure 2:** Concentrations of major cations (calcium, sodium, and magnesium) at baseflow and stormflow.

### C. Residue

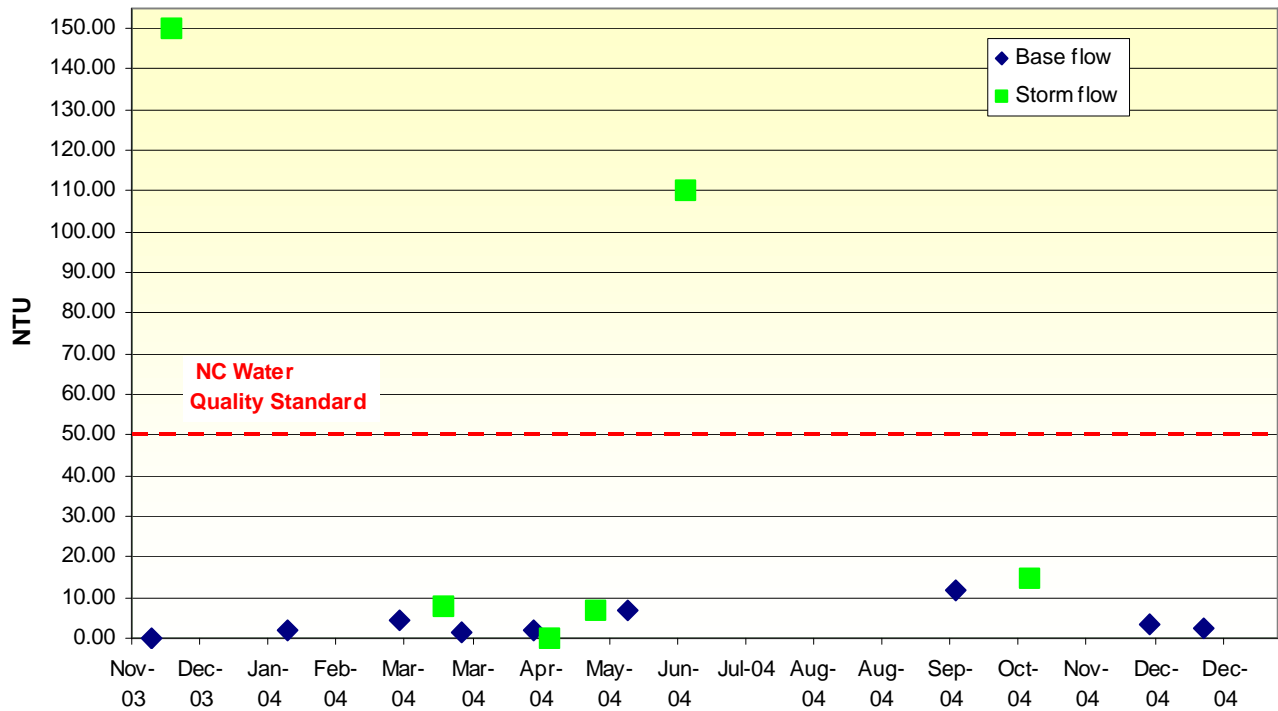
Suspended, volatile, and fixed residue concentrations were at or below 15 mg/L in all baseflow samples (Figure 3). Stormflow suspended residue concentrations were more variable. The median stormflow suspended residue concentration (43 mg/L) was almost 1,000% higher than the median baseflow concentration (4.5 mg/L). During extreme storm events, suspended residue increased to concentrations as high as 1,240 mg/L.



**Figure 3:** Suspended, fixed, and volatile residue concentrations at South Hominy Creek at Old Hwy 151.

### D. Turbidity

Stormflow turbidity exceeded the state standard of 50 NTU in fifty percent of sampling events (Figure 4). All baseflow turbidity measurements were below 12 NTU with the exception of a turbidity recording of 500 NTU taken downstream of a direct discharge into the stream on 10/28/04. As observed in metals concentrations, turbidity was highest (550 NTU) in a sample taken during Hurricane Frances on 9/7/04.

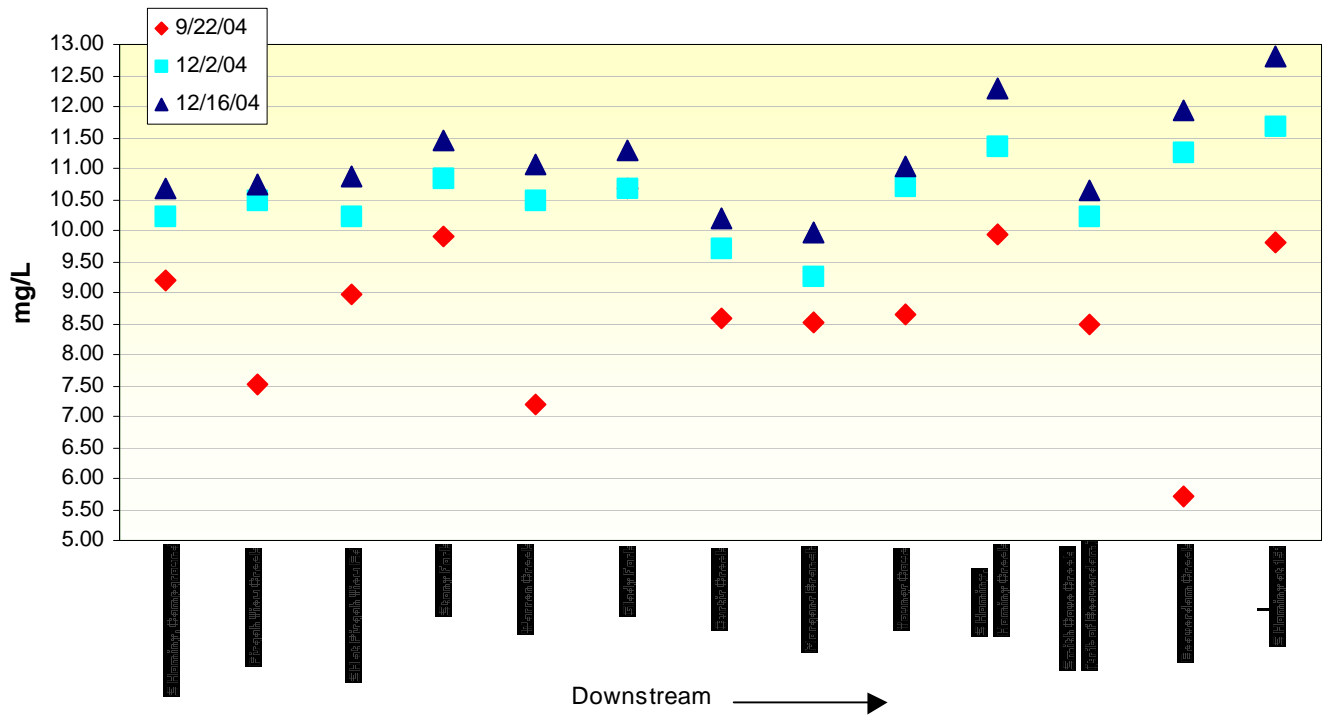


**Figure 4:** Turbidity recordings at South Hominy Creek at Old Hwy 151.

### E. Field Parameters

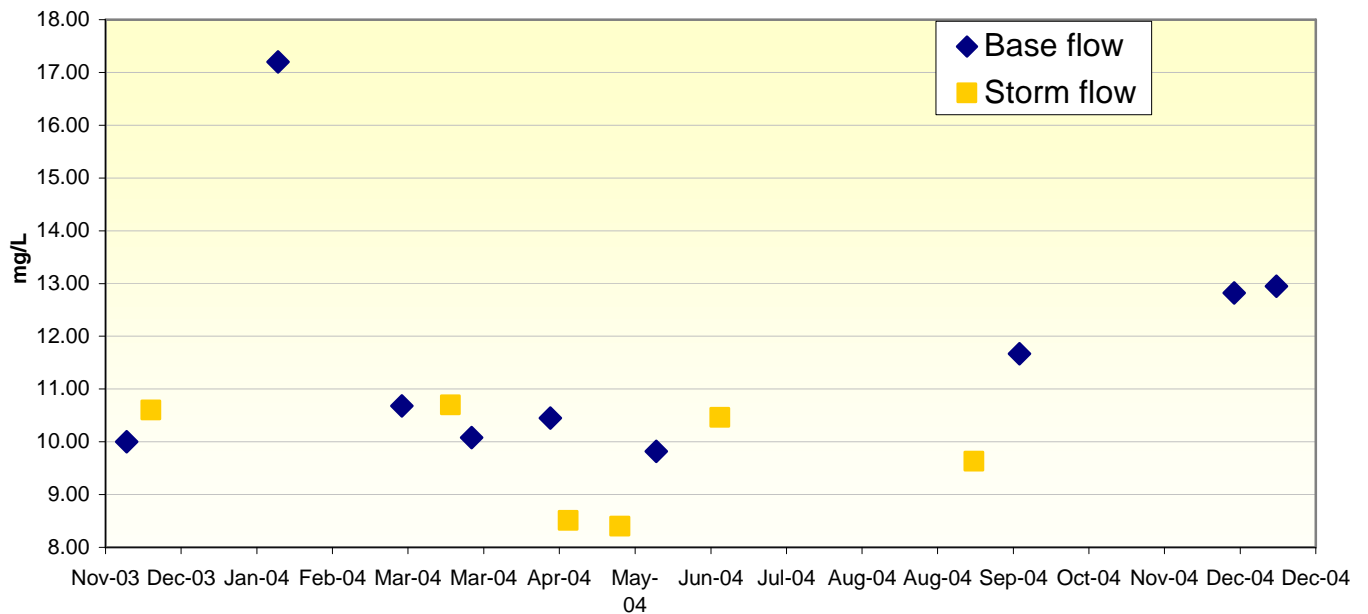
Field parameters (including dissolved oxygen and specific conductance), fecal coliform bacteria, and nutrients (ammonia nitrogen, nitrate plus nitrite nitrogen, total Kjeldahl nitrogen (TKN), and total phosphorus) were measured at thirteen sites in the South Hominy watershed on 9/22/04, 12/2/04, and 12/16/04.

Dissolved oxygen concentrations followed a similar trend on 12/2/04 and 12/16/04. On both dates, DO remained fairly constant at the six most upstream sites, decreased over the next several sites, and gradually increased at the most downstream sites in the watershed (Figure 5). This pattern was not repeated on 9/22/04, when greater variability in DO concentrations was exhibited.



**Figure 5:** Dissolved oxygen concentrations at all sites at baseflow.

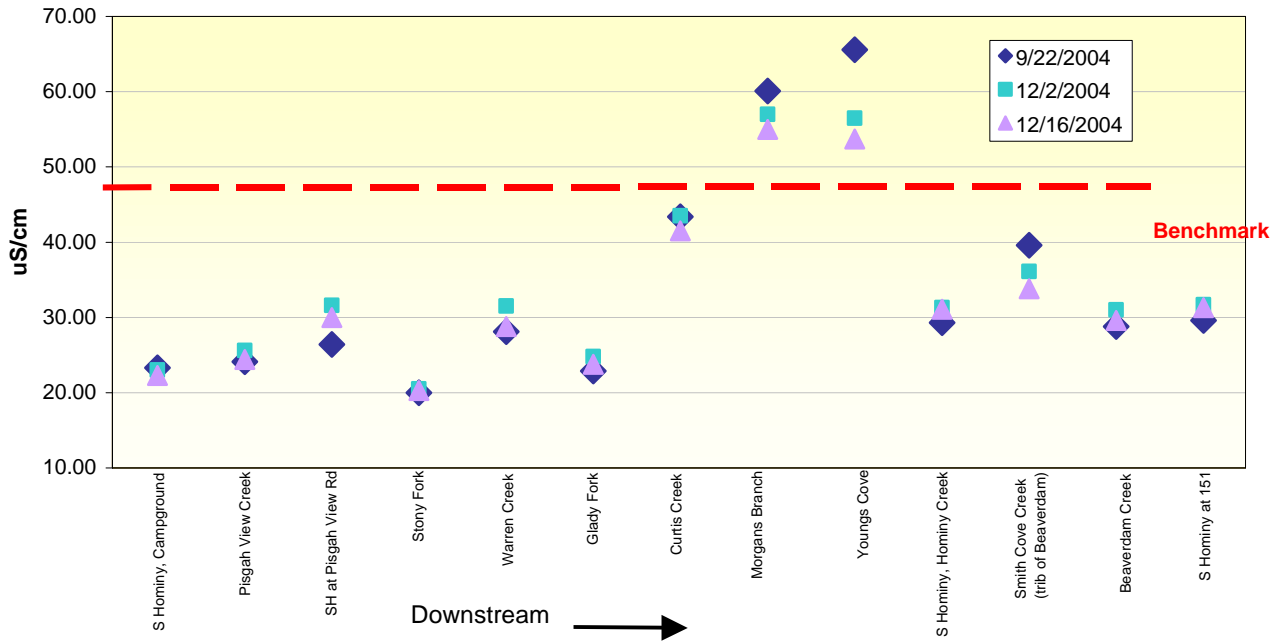
Comparisons of dissolved oxygen concentrations at baseflow and stormflow at South Hominy Creek at Old Hwy 151 indicate that DO decreased slightly in stormflow samples (Figure 6). While variation in both baseflow and stormflow samples was observed, the median baseflow concentration (10.57 mg/L) was only slightly higher than the median stormflow concentration (10.05 mg/L).



**Figure 6:** Stormflow and baseflow dissolved oxygen concentrations at the South Hominy at Route 151 site.

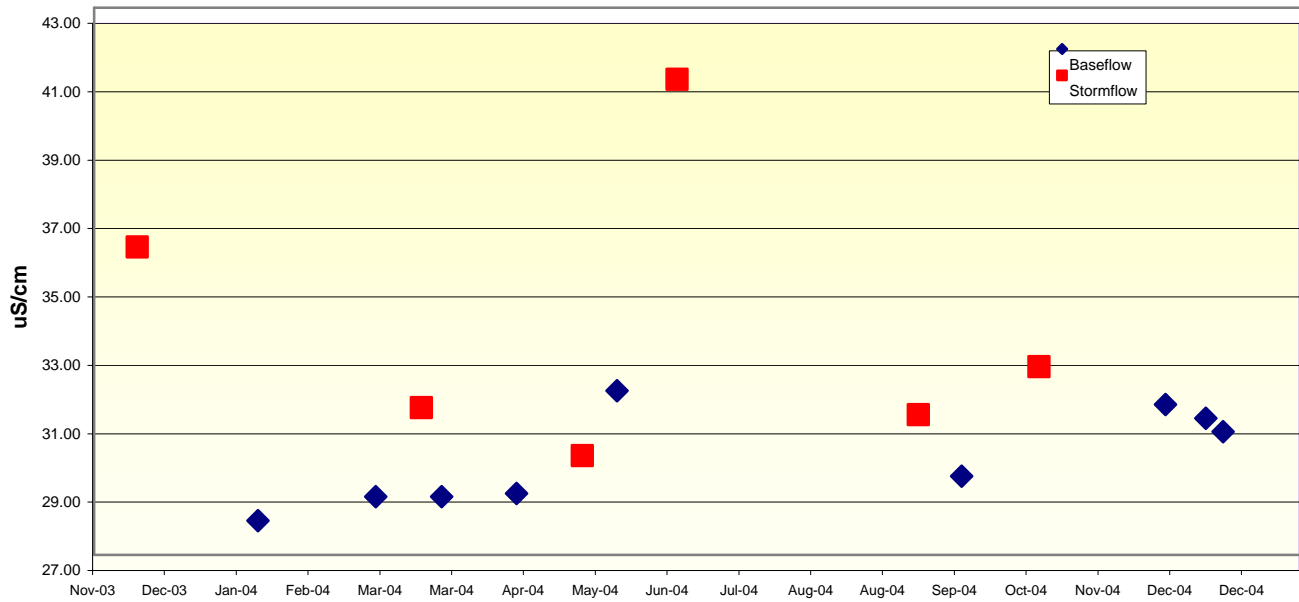
Specific conductance exceeded the benchmark value of 45  $\mu\text{g/L}$  in all three samples taken at Morgans Branch and at Youngs Cove (Figure 7). All samples at the other eleven sites had specific conductance concentrations

below the benchmark value. Excluding Morgans Branch and Youngs Cove, there is a gradual increase in specific conductance from the upstream to the downstream sites.



**Figure 7:** Specific conductance at all sites at baseflow.

Both stormflow and baseflow specific conductance remained below the benchmark value at South Hominy Creek at Old Hwy 151 (Figure 8). Baseflow specific conductance ranged from 28  $\mu\text{g/L}$  to 32  $\mu\text{g/L}$ , while stormflow specific conductance demonstrated much greater variability, extending from a low of 29  $\mu\text{g/L}$  to a high of 41  $\mu\text{g/L}$ .



**Figure 8:** Stormflow and baseflow specific conductance at South Hominy Creek at Old Hwy 151.

Water temperatures follow the same trend in all three samples. Temperatures remain relatively constant in the six most upstream sites in the watershed, increase in the middle of the watershed, and generally decline in the downstream section of the watershed (Figure 9).

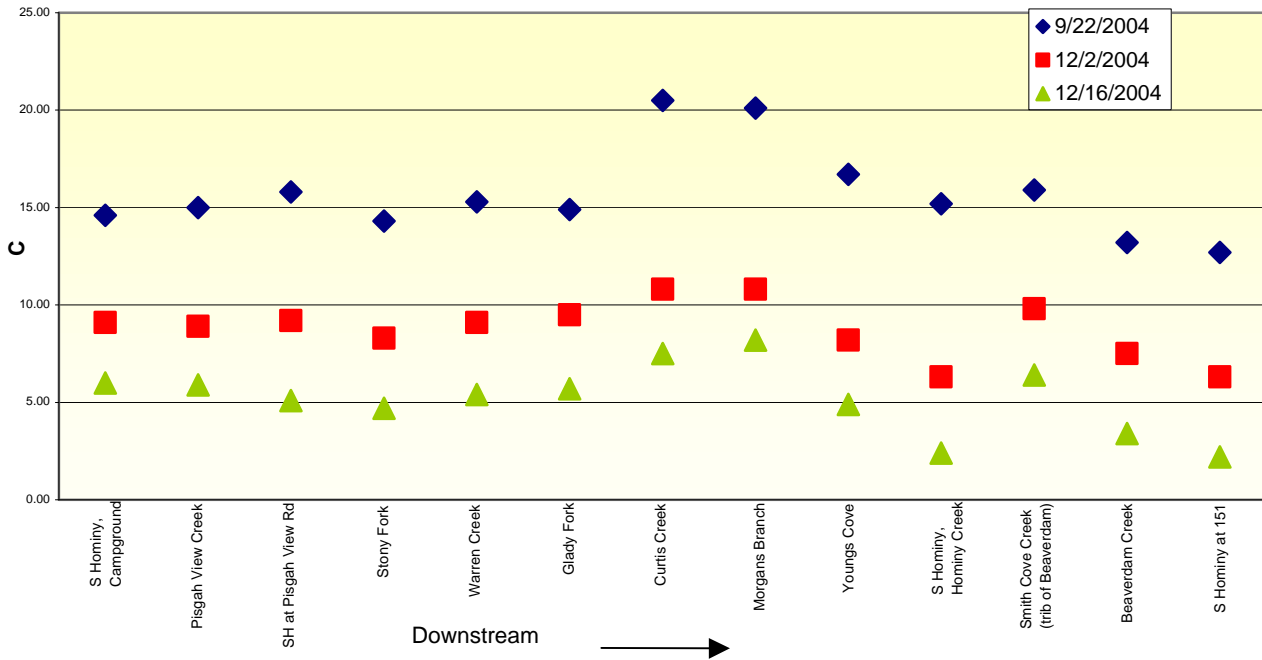


Figure 9: Water temperature at all sites at baseflow.

### F. Fecal Coliform Bacteria

Four sites, Warren Creek, Morgans Branch, Youngs Cove, and Beaverdam Creek, exceeded the NC Water Quality Standard for fecal coliform of 200 colonies/100ml as a geometric mean (Figure 10). Stormflow samples taken at the South Hominy Creek at Old Hwy 151 site exhibited an extremely high geometric mean concentration of 3,543 colonies per 100 mL.

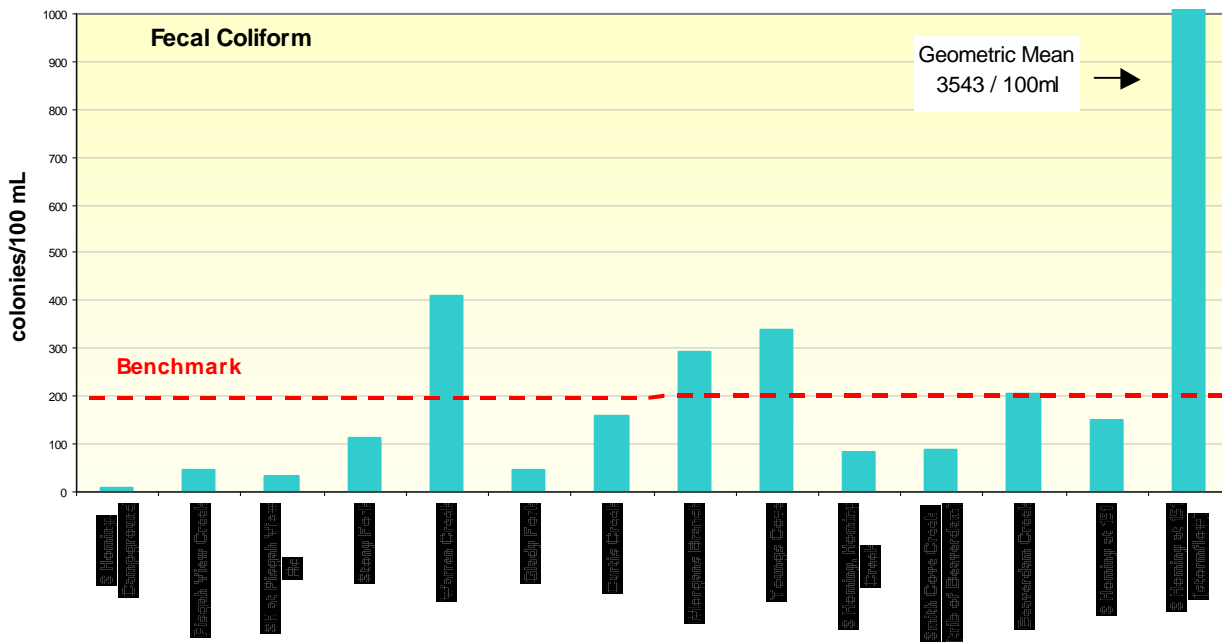
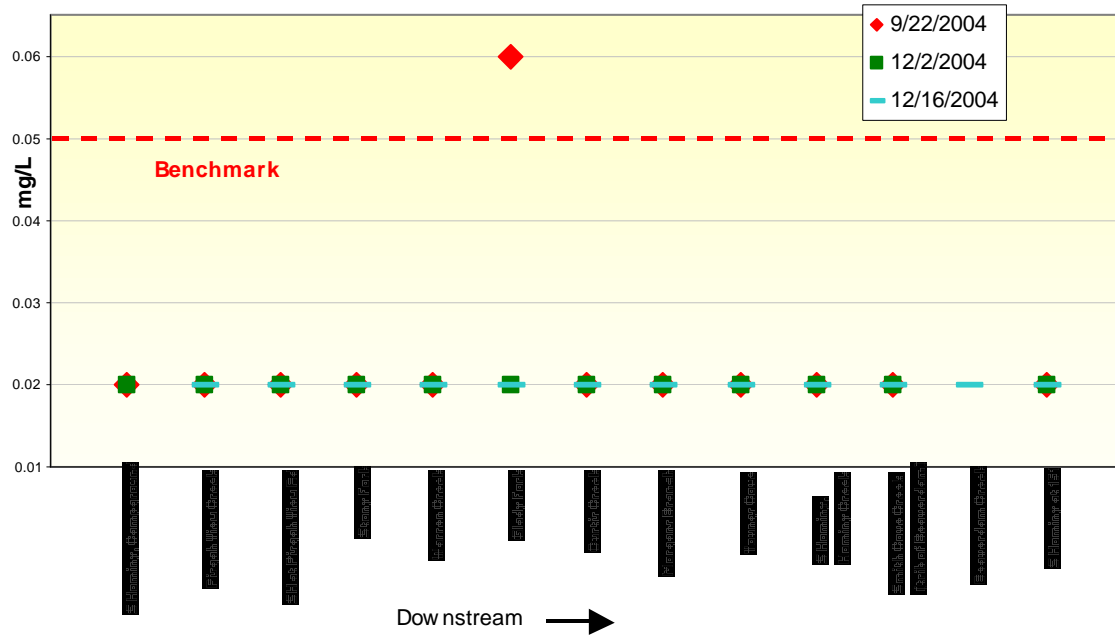


Figure 10: Fecal coliform geometric means for all sites.

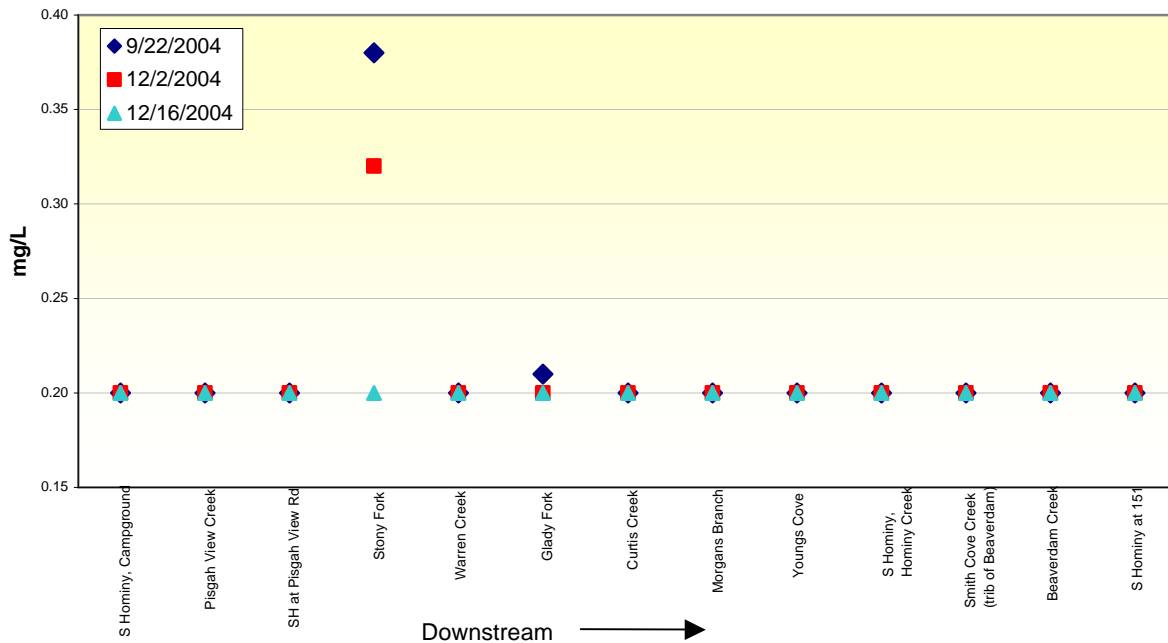
## G. Nutrients

Ammonia nitrogen concentrations were below detection levels in all but one sample (Figure 11). The sample taken at Glady Fork on 9/22/04 recorded a concentration of ammonia (0.06 mg/L) above the benchmark value of 0.05 mg/L.



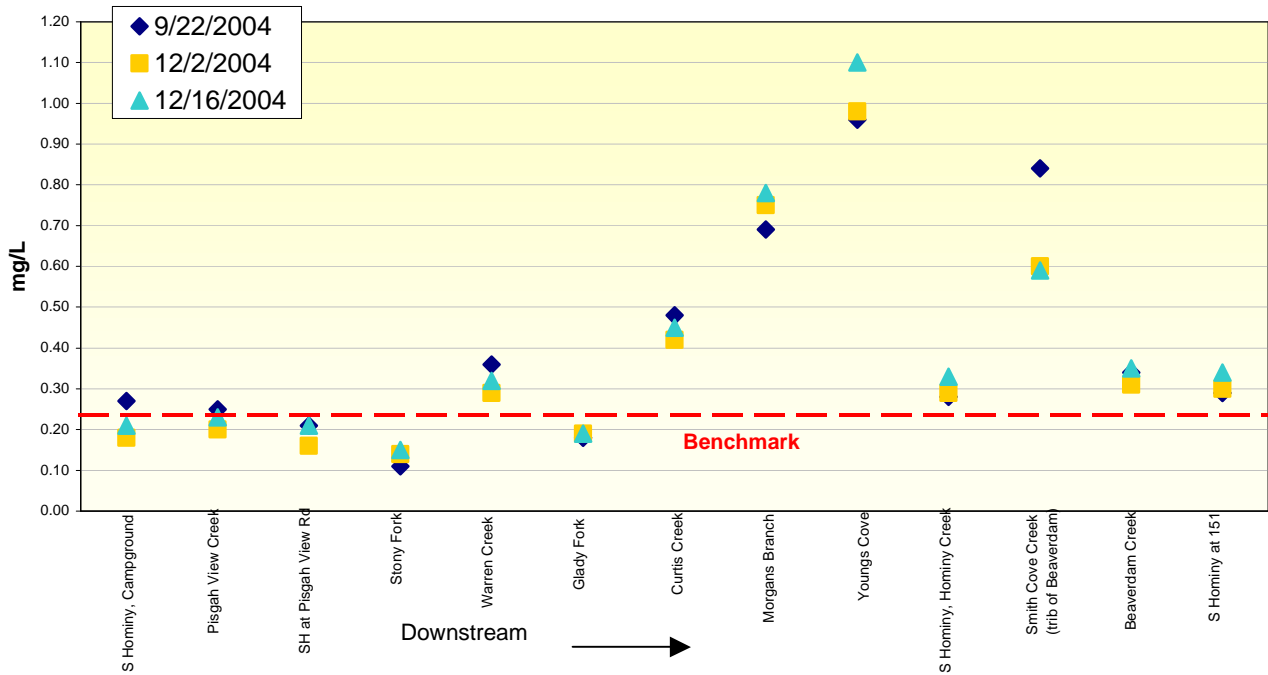
**Figure 11:** Ammonia concentrations at all sites at baseflow.

TKN concentrations were below the detection level of 0.02 mg/L in most samples (Figure 12). Only three samples had detectable concentrations of TKN at baseflow; one at Glady Fork on 9/22/04 and two at Stony Fork on 9/22/04 and 12/2/04.



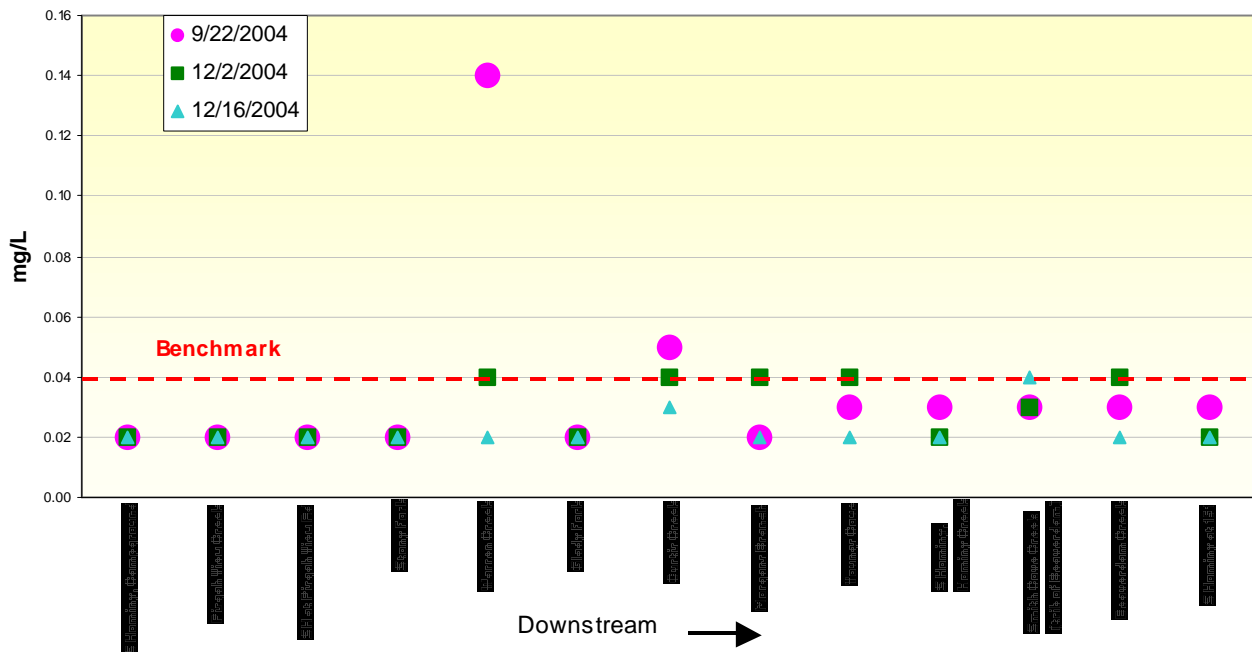
**Figure 12:** TKN concentrations at all sites at baseflow. Concentrations recorded as 0.2 mg/L were below detection levels.

Nitrate plus nitrite nitrogen concentrations exceeded the benchmark value of 0.23 mg/L on all three sampling dates at eight of the thirteen sites (Figure 13). Only three sites, South Hominy at Pisgah View Road, Stony Fork, and Glady Fork, had nitrate plus nitrite concentrations below the benchmark value in all samples.



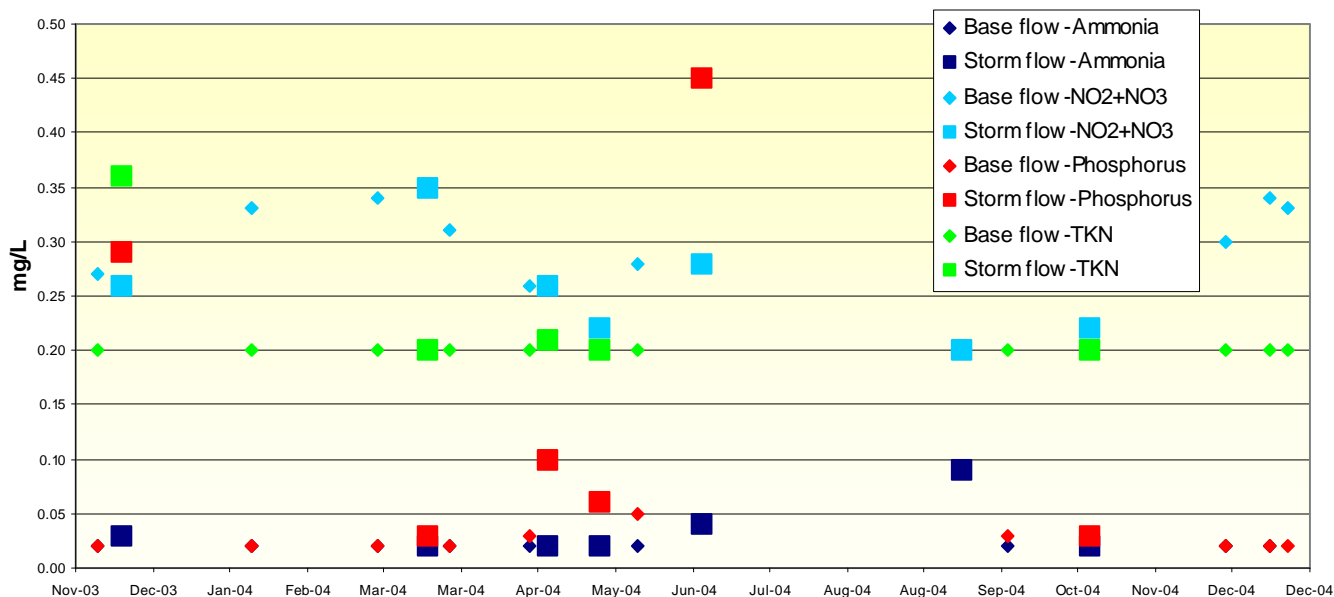
**Figure 13:** Nitrate plus nitrite nitrogen concentrations at all sites at baseflow.

Phosphorus was undetected at the four most upstream sites in the South Hominy watershed (Figure 14). The highest phosphorus concentration (0.14 mg/L) was observed at Warren Creek. Curtis Creek and Smith Cove Creek were the only sites at which phosphorus was detected on all three sampling dates. Phosphorus concentrations were recorded at or above the benchmark value of 0.04 mg/L in at least one sample at Warren Creek, Curtis Creek, Morgans Branch, Youngs Cove, Smith Cove Creek, and Beaverdam Creek (Briel, 1997).



**Figure 14:** Phosphorus concentrations at all sites at baseflow.

Ammonia concentrations increased slightly during stormflow events (Figure 15). As with many other parameters, the highest ammonia concentration was observed following Hurricane Frances in the 9/7/04 sample. Nitrate plus nitrite nitrogen concentrations followed similar patterns during baseflow and stormflow samples. The baseflow median for Nitrate plus nitrite nitrogen (0.31 mg/L) was slightly higher than the stormflow median (0.26 mg/L). TKN were undetectable or just above the detection level of 0.2 mg/L for half of the stormflow and all of the baseflow samples. Stormflow concentrations above detection levels were recorded on 12/10/03 (0.36 mg/L), 4/26/04 (0.21 mg/L), and 9/7/04 (5.0 mg/L). All baseflow phosphorus concentrations were recorded at or below 0.05 mg/L. Stormflow phosphorus concentrations ranged widely, from below detection levels to 1.0 mg/L.



**Figure 15:** Nutrient concentrations at South Hominy Creek at Old Hwy 151. Note that neither the TKN concentration (5 mg/L) nor the phosphorus concentration (1.0 mg/L) recorded on 9/7/04 is visible on the chart.

### Discussion of water quality results and trends

Stormflow samples had much higher concentrations for many parameters than baseflow samples. For the following parameters, stormflow concentrations were consistently higher than baseflow values at South Hominy Creek at Old Hwy 151: fecal coliform bacteria, turbidity, residue (suspended, volatile, and fixed), total phosphorus, total Kjeldahl nitrogen (TKN), copper, zinc, manganese, iron and aluminum. Stormflow values were usually lower than baseflow values for pH and for nitrate plus nitrite nitrogen. Levels of mercury, nickel, sodium and ammonia were relatively consistent at storm and base flows, except during the extreme storm event caused by Hurricane Frances in early September 2004.

Many parameters were reported at exceptionally high concentrations in the 9/7/04 stormflow samples taken during Hurricane Frances. The TKN concentration was over ten times higher in the 9/7/04 sample (5 mg/L) than in the next-highest stormflow sample. Fecal coliform bacteria, residue, phosphorus, and turbidity were also at their highest values in the 9/7/04 sample.

Baseflow concentrations of most trace metals measured at South Hominy Creek at Old Hwy 151 were well within accepted limits. Aluminum was the main exceptions to this rule, but its presence in suspended clay, rather than in the toxic dissolved form, would argue against likely toxic effects. It should be noted that the analytical reporting limits for several of the trace metals were higher than the chronic criteria; with more sensitive analyses, additional metals may have exceeded benchmark concentrations.

The data indicate that Curtis Creek, Morgans Branch, and Youngs Cove, which are situated in the northern part of the South Hominy Creek watershed, are the most impaired sites in the study area. These sites had the lowest

DO concentrations and the highest specific conductance concentrations of all thirteen sites, and comprise three of the four sites with the highest nitrate plus nitrite nitrogen concentrations. Two of the sites, Morgans Branch and Youngs Cove, not only were the sole sites to exceed the specific conductance benchmark value, but also surpassed the benchmark in all three samples. Both of these sites also exceeded the fecal coliform benchmark of 200 colonies/100ml as a geometric mean.

After Curtis Creek, Morgans Branch, and Youngs Cove, Beaverdam Creek and its tributary, Smith Cove Creek, appear to be the most impaired sites in the watershed. Beaverdam Creek, into which the watershed's one NPDES permitted point source is discharged, exceeds the fecal coliform benchmark of 200 colonies/100ml as a geometric mean and has the lowest DO concentration in the watershed, 5.72 mg/L. However, unlike Curtis Creek, Morgans Branch, and Youngs Cove, Beaverdam Creek does not have high specific conductance. Both Beaverdam Creek and Smith Cove Creek exceeded the phosphorus concentration benchmark in one sample, and have phosphorus levels at or above those recorded at Curtis Creek, Morgans Branch, and Youngs Cove. Smith Cove Creek's nitrate plus nitrite nitrogen concentrations are the third highest in the watershed.

There is an observable trend in water quality degradation from the upstream to the downstream sections of the watershed. In general, indicators of impairment remain relatively constant in the six most upstream sites in the watershed, increase in severity in the middle of the watershed, and lessen in severity in the downstream sites to levels similar to those recorded in the most upstream sites. This pattern can be observed in many of the parameters measured in this study.

Specific conductance and fecal coliform bacteria concentrations are fairly stable in the upstream portion of the watershed, increase substantially between Curtis Creek and Morgans Branch and again from Morgans Branch to Youngs Cove, and then decrease in the downstream portion of the watershed. Continuing this trend, DO concentrations from 12/2/04 and 12/16/04 decrease in the middle of the watershed (particularly in Curtis Creek and Morgans Branch) before increasing in the downstream sites to levels slightly higher than those found at the most upstream sites. This pattern is also observed, with slight deviations, in the nitrate plus nitrite nitrogen, phosphorus, and water temperature data. Nitrate plus nitrite nitrogen concentrations follow the same trend as fecal coliform concentrations and specific conductance but also increase at Smith Cove Creek and Beaverdam Creek, the third and second most downstream sites, respectively. Phosphorus concentrations are below detection levels in all samples at the four most upstream sites. They increase to detectable concentrations in the middle of the watershed from Warren Creek to Youngs Creek, except at Glady Fork, where phosphorus was undetected on all three sampling dates. Following the trend of nitrate plus nitrite nitrogen concentrations, phosphorus concentrations decrease to undetectable levels at the South Hominy at Hominy Creek site, increase at Smith Cove Creek and Beaverdam Creek, and decrease again at the most downstream site in the watershed. Finally, water temperatures rise at Curtis Creek, Morgans Branch, and Youngs Cove, and decrease in the downstream section of the watershed, except for a slight rise in temperature at Smith Cove Creek.

A final area of concern is Warren Creek. Warren Creek had the highest fecal coliform geometric mean, 409.84 colonies per 100 mL, of any of the sites at baseflow. It also had the highest concentration of phosphorus at baseflow.

The sites that appear to be least severely impacted by pollution are the three most upstream sites in the watershed, South Hominy Creek at the campground, Pisgah View Creek, South Hominy Creek at Pisgah View Road, as well as two downstream sites, South Hominy Creek at Hominy Creek and South Hominy Creek at Old Hwy 151. All five sites were below benchmark values for specific conductance and fecal coliform bacteria concentrations. The highest DO concentrations were recorded at South Hominy Creek at Hominy Creek and South Hominy Creek at Old Hwy 151.

Considering that the South Hominy Creek at Old Hwy 151 stormflow concentrations of many metals, two of the three major cations, turbidity, and fecal coliform bacteria were above benchmark values, and that at baseflow, South Hominy Creek at Old Hwy 151 was one of the least impaired sites, it can be hypothesized that the more impaired sites in the watershed would also exceed benchmark values for these parameters at stormflow.

It is important to keep in mind that analytical methods used for all metals data collected in this study yield “total recoverable” concentrations rather than “dissolved” concentrations, which are the basis for NAWQC benchmark values in Table 4. It is not known what fraction of the metals concentrations reported here are indeed dissolved and therefore directly comparable to the benchmark values, but as a general rule, the dissolved fraction decreases at higher suspended residue concentrations.

### III. SITE SUMMARIES

The tables below summarize the physical and chemical data collected at sampling sites described in the main text. All tables cover sampling that was conducted between December 2003 and January 2004. Column headings for these tables are given below:

N        number of samples or measurements  
 Max     maximum value  
 Min     minimum value  
 Med     median  
 Mean    mean (geometric mean was calculated for fecal coliform)  
 BM      benchmark values (Additional information is provided in Table 5.)

<b>Table 5: BENCHMARKS</b>		
<b>Parameter</b>	<b>Benchmark</b>	<b>Source</b>
<b>Field parameters</b>		
<b>Air Temperature</b>		
<b>Water Temperature</b>		
<b>Dissolved Oxygen (mg/L)</b>	<b>9.6</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>DO%</b>		
<b>Specific Conductance (uS/cm)</b>	<b>45</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>pH</b>	<b>6.8</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Nutrients (mg/L)</b>		
<b>Ammonia</b>	<b>0.05</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>TKN</b>		
<b>NO<sub>2</sub>+NO<sub>3</sub></b>	<b>0.23</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Phosphorus</b>	<b>0.04</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Other (mg/L)</b>		
<b>Turbidity</b>	<b>50</b>	<b>NC Water Quality Standard</b>
<b>Suspended Residue</b>		
<b>Volatile Residue</b>		
<b>Fixed Residue</b>		
<b>Major cations (mg/L)</b>		
<b>Calcium</b>	<b>3.40</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Magnesium</b>	<b>1.10</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Sodium</b>	<b>2.60</b>	<b>USGS Professional Paper, Briel, 1999</b>
<b>Trace metals (mg/L)</b>		
<b>Silver</b>	<b>0.36</b>	<b>Risk Assessment Information System</b>
<b>Aluminum</b>	<b>87.00</b>	<b>EPA National Recommended Water Quality Criteria, 1999</b>
<b>Arsenic</b>	<b>150.00</b>	<b>EPA National Water Quality Standards Database, 2004</b>
<b>Cadmium</b>	<b>0.25</b>	<b>EPA National Water Quality Standards Database, 2004</b>
<b>Chromium</b>	<b>11.00</b>	<b>EPA National Water Quality Standards Database, 2004</b>
<b>Copper</b>	<b>9.00</b>	<b>EPA National Water Quality Standards Database, 2004</b>
<b>Iron</b>	<b>1000.00</b>	<b>EPA National Recommended Water Quality Criteria, 1999</b>
<b>Mercury</b>	<b>0.77</b>	<b>EPA National Water Quality Standards Database, 2004</b>
<b>Manganese</b>	<b>120.00</b>	<b>Risk Assessment Information System</b>
<b>Nickel</b>	<b>52.00</b>	<b>EPA National Water Quality Standards Database, 2004</b>

Lead	2.50	EPA National Water Quality Standards Database, 2004
Zinc	120.00	EPA National Water Quality Standards Database, 2004
Fecal Coliform (col/100mL)	Geo mean	Geo mean
	200	NC Water Quality Standard

In calculating means, values below the practical quantitation limit (PQL) (coded as <) were assumed to be equal to the PQL. The PQL is about five times the calculated Method Detection Limit (MDL) and represents a practical and routinely available detection level with a relatively good certainty that any reported value is reliable. Additional laboratory information is available on the DWQ Laboratory Section web site at <http://www.esb.enr.state.nc.us/lab/qa.htm>.

Reported metals concentration data are total recoverable (not dissolved).

South Hominy Cr @ Pisgah View Ranch campground off SR 1105 [FRB02_B011]						
Parameter	Base flow					
	N	Max	Min	Med	Mean	BM
<b>Field Parameters</b>						
Air Temperature	3	23.00	10.00	12.00	15.00	
Water Temperature	3	14.60	6.00	9.10	9.90	
Dissolved Oxygen	3	10.69	9.18	10.21	10.03	<b>9.6</b>
DO%	3	90.20	85.90	88.40	88.17	
Specific Conductance	3	23.00	22.00	22.70	22.57	<b>45.00</b>
pH	3	7.05	6.42	6.50	6.66	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	2	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	0					
NO2+NO3	3	0.27	0.18	0.21	0.22	<b>0.23</b>
Phosphorus	3	0.02	0.02	0.02	0.02	<b>0.04</b>
Fecal Coliform Bacteria (col/100mL)					Geo Mean	
	3	27.00	2.00	6.00	6.87	<b>200.00</b>

Pisgah View Cr @ Pisgah View Ranch Rd [FRB02_B010]						
Parameter	Base flow					
	N	Max	Min	Med	Mean	BM
<b>Field Parameters</b>						
Air Temperature	3	25.00	9.00	16.00	16.67	
Water Temperature	3	15.00	5.90	8.90	9.93	
Dissolved Oxygen	3	10.73	7.53	10.50	9.59	<b>9.6</b>
DO%	3	90.60	74.30	85.90	83.60	
Specific Conductance	3	25.30	23.80	24.10	24.40	<b>45.00</b>
pH	3	6.64	6.45	6.54	6.54	<b>6.5-9.0</b>
<b>Nutrients</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.25	0.20	0.23	0.23	<b>0.23</b>

Phosphorus	3	0.02	0.02	0.02	0.02	<b>0.04</b>
Fecal Coliform Bacteria (col/100mL)					Geo mean	
	3	100.00	26.00	35.00	44.98	<b>200.00</b>

South Hominy Cr @ SR 1109/Pisgah View Rd [FRB02_B008]						
Base flow						
Parameter	N	Max	Min	Med	Mean	BM
Field Parameters						
Air Temperature	2	15.00	12.00	13.50	13.50	
Water Temperature	3	15.80	5.10	9.20	10.03	
Dissolved Oxygen	3	10.88	8.98	10.23	10.03	<b>9.6</b>
DO%	3	90.60	85.40	88.90	88.30	
Specific Conductance	3	31.30	26.10	29.70	29.03	<b>45.00</b>
pH	3	7.03	6.49	6.71	6.74	<b>6.5-9.0</b>
Nutrients						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.21	0.16	0.21	0.19	<b>0.23</b>
Phosphorus	3	0.02	0.02	0.02	0.02	<b>0.04</b>
Fecal Coliform Bacteria (col/100mL)					Geo mean	
	3	54.00	28.00	29.00	35.26	<b>200.00</b>

Stony Fork @ SR 1109/Pisgah View Rd [FRB02_B009]						
Base flow						
Parameter	N	Max	Min	Med	Mean	BM
Field Parameters						
Air Temperature	3	26.00	9.00	13.00	16.00	
Water Temperature	3	14.30	4.70	8.30	9.10	
Dissolved Oxygen	3	11.46	9.90	10.84	10.73	<b>9.6</b>
DO%	3	97.10	88.60	92.10	92.60	
Specific Conductance	3	20.20	19.70	20.00	19.97	<b>45.00</b>
pH	3	6.82	6.45	6.77	6.68	<b>6.5-9.0</b>
Nutrients (mg/L)						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.15	0.11	0.14	0.13	<b>0.23</b>
Phosphorus	3	0.02	0.02	0.02	0.02	<b>0.04</b>
Fecal Coliform Bacteria (col/100mL)					Geo mean	
	3	870.00	30.00	56.00	113.49	<b>200.00</b>

Warren Cr @ NC 151 [FRB02_B006]						
Base flow						
Parameter	N	Max	Min	Med	Mean	BM
<b>B. Field Parameters</b>						
Air Temperature	3	26.00	9.00	14.00	16.33	
Water Temperature	3	15.30	5.40	9.10	9.93	

Dissolved Oxygen	3	11.06	7.19	10.49	<b>9.58</b>	<b>9.6</b>
DO%	3	91.10	71.50	87.30	83.30	
Specific Conductance	3	31.20	27.80	28.50	29.17	<b>45.00</b>
pH	3	6.99	6.58	6.88	6.82	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.38	0.20	0.32	0.30	
NO2+NO3	3	0.36	0.29	0.32	<b>0.32</b>	<b>0.23</b>
Phosphorus	3	0.14	0.02	0.04	<b>0.07</b>	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	730.00	230.00	410.00	<b>409.84</b>	<b>200.00</b>

<b>Glady Fork @ SR 3452/Upper Glady Rd [FRB02_B007]</b>						
Parameter	Base flow					BM
	N	Max	Min	Med	Mean	
<b>Field Parameters</b>						
Air Temperature	3	26.00	11.00	16.00	17.67	
Water Temperature	3	14.90	5.70	9.50	10.03	
Dissolved Oxygen	3	11.29	10.67	10.69	10.88	<b>9.6</b>
DO%	3	108.50	90.00	93.30	97.27	
Specific Conductance	3	24.50	22.60	23.50	23.53	<b>45.00</b>
pH	3	6.70	6.40	6.67	6.59	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.06	0.02	0.02	0.03	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.19	0.18	0.19	0.19	<b>0.23</b>
Phosphorus	3	0.02	0.02	0.02	0.02	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	92.00	19.00	50.00	44.38	<b>200.00</b>

<b>Curtis Cr @ NC 151 [FRB02_B005]</b>						
Parameter	Base flow					BM
	N	Max	Min	Med	Mean	
<b>Field Parameters</b>						
Air Temperature	2	13.00	12.00	12.50	12.50	
Water Temperature	3	20.50	7.50	10.80	12.93	
Dissolved Oxygen	3	10.19	8.59	9.71	<b>9.50</b>	<b>9.6</b>
DO%	3	95.10	85.00	87.80	89.30	
Specific Conductance	3	43.20	41.20	43.10	42.50	<b>45.00</b>
pH	3	7.01	6.35	6.70	6.69	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.21	0.20	0.20	0.20	
NO2+NO3	3	0.48	0.42	0.45	<b>0.45</b>	<b>0.23</b>
Phosphorus	3	0.05	0.03	0.04	0.04	<b>0.04</b>

Fecal Coliform Bacteria (col/100mL)					Geo mean	
	3	230.00	100.00	180.00	160.57	<b>200.00</b>

<b>Morgan Branch @ NC 151 [FRB02_B004]</b>						
	<b>Base flow</b>					
<b>Parameter</b>	<b>N</b>	<b>Max</b>	<b>Min</b>	<b>Med</b>	<b>Mean</b>	<b>BM</b>
<b>C. Field Parameters</b>						
Air Temperature	2	15.00	13.00	14.00	14.00	
Water Temperature	3	20.10	8.20	10.80	13.03	
Dissolved Oxygen	3	9.97	8.52	9.25	<b>9.25</b>	<b>9.6</b>
DO%	3	93.00	83.90	84.50	87.13	
Specific Conductance	3	59.80	54.70	56.70	<b>57.07</b>	<b>45.00</b>
pH	3	6.95	6.39	6.80	6.71	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.78	0.69	0.75	<b>0.74</b>	<b>0.23</b>
Phosphorus	3	0.04	0.02	0.02	0.03	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	420.00	160.00	370.00	<b>291.87</b>	<b>200.00</b>

<b>Youngs Cove @ SR 3452 / Bailey Rd [FRB02_B003]</b>						
	<b>Base flow</b>					
<b>Parameter</b>	<b>N</b>	<b>Max</b>	<b>Min</b>	<b>Med</b>	<b>Mean</b>	<b>BM</b>
<b>Field Parameters</b>						
Air Temperature	3	29.00	12.00	13.00	18.00	
Water Temperature	3	49.00	8.20	16.70	24.63	
Dissolved Oxygen	3	11.02	8.65	10.72	10.13	<b>9.6</b>
DO%	3	90.80	85.80	88.90	88.50	
Specific Conductance	3	65.30	53.40	56.20	<b>58.30</b>	<b>45.00</b>
pH	3	7.18	6.68	6.69	6.85	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	1.10	0.96	0.98	<b>1.01</b>	<b>0.23</b>
Phosphorus	3	0.04	0.02	0.03	0.03	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	1100.00	70.00	500.00	<b>337.67</b>	<b>200.00</b>

<b>South Hominy Cr @ SR 3451 / Hominy Creek Rd [FRB02_B002]</b>						
	<b>Base flow</b>					
<b>Parameter</b>	<b>N</b>	<b>Max</b>	<b>Min</b>	<b>Med</b>	<b>Mean</b>	<b>BM</b>
<b>Field Parameters</b>						
Air Temperature	2	11.00	8.00	9.50	9.50	
Water Temperature	3	15.20	2.40	6.30	7.97	
Dissolved Oxygen	3	12.28	9.94	11.37	11.20	<b>9.6</b>

DO%	3	99.00	90.20	92.20	93.80	
Specific Conductance	3	31.00	29.00	30.80	30.27	<b>45.00</b>
pH	3	7.17	6.53	7.00	6.90	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.33	0.28	0.29	<b>0.30</b>	<b>0.23</b>
Phosphorus	3	0.03	0.02	0.02	0.02	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	140.00	53.00	77.00	82.98	<b>200.00</b>

<b>Smith Cove @ SR 3449/Beaverdam Loop [FRB02_B012]</b>						
Parameter	Base flow					BM
	N	Max	Min	Med	Mean	
<b>Field Parameters</b>						
Air Temperature	3	24.00	13.00	14.00	17.00	
Water Temperature	3	15.90	6.40	9.80	10.70	
Dissolved Oxygen	3	10.64	8.48	10.24	9.79	<b>9.6</b>
DO%	3	90.30	84.30	86.40	87.00	
Specific Conductance	3	39.30	33.50	35.80	36.20	<b>45.00</b>
pH	3	7.16	6.49	6.74	6.80	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	3	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	2	0.84	0.59	0.72	<b>0.72</b>	<b>0.23</b>
Phosphorus	3	0.04	0.03	0.03	0.03	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	148.00	54.00	80.00	86.15	<b>200.00</b>

<b>Beaverdam Cr @ Beaverdam Rd [FRB02_B013]</b>						
Parameter	Base flow					BM
	N	Max	Min	Med	Mean	
<b>Field Parameters</b>						
Air Temperature	3	22.00	9.00	10.00	13.67	
Water Temperature	3	13.20	3.40	7.50	8.03	
Dissolved Oxygen	3	11.95	5.72	11.25	9.64	<b>9.6</b>
DO%	3	93.80	54.10	89.80	79.23	
Specific Conductance	3	30.70	28.50	29.30	29.50	<b>45.00</b>
pH	3	7.26	6.22	6.91	6.80	<b>6.5-9.0</b>
<b>Nutrients (mg/L)</b>						
Ammonia Nitrogen	1	0.02	0.02	0.02	0.02	<b>0.05</b>
TKN	3	0.20	0.20	0.20	0.20	
NO2+NO3	3	0.35	0.31	0.34	<b>0.33</b>	<b>0.23</b>
Phosphorus	3	0.04	0.02	0.03	0.03	<b>0.04</b>
<b>Fecal Coliform Bacteria (col/100mL)</b>					<b>Geo mean</b>	
	3	700.00	84.00	150	<b>206.61</b>	<b>200.00</b>

South Hominy @ Old Hwy 151 [FRB02_B001]												
	Baseflow						Stormflow					
Parameter	N	Max	Min	Med	Mean	BM	N	Max	Min	Med	Mean	
<b>Field parameters</b>												
Air Temperature	9.00	27.00	6.00	16.00	14.91		5.00	22.00	10.00	21.00	19.20	
Water Temperature	10.00	16.80	2.20	7.70	8.68		6.00	18.70	7.50	15.35	13.90	
Dissolved Oxygen	10.00	17.20	8.52	10.57	11.42	<b>9.6</b>	6.00	10.70	8.40	10.05	9.72	
DO%	6.00	97.20	87.80	94.10	93.52		6.00	111.30	86.00	92.10	95.53	
Specific Conductance	9.00	31.80	28.00	29.30	29.81	<b>45</b>	6.00	40.90	29.90	31.90	33.62	
pH	10.00	7.11	6.43	6.89	6.87	<b>6.5-9.0</b>	6.00	7.06	6.43	6.78	6.76	
<b>Nutrients (mg/L)</b>												
Ammonia	9.00	0.02	0.02	0.02	0.02	<b>0.05</b>	7.00	0.09	0.02	0.02	0.03	
TKN	10.00	0.20	0.20	0.20	0.20		7.00	5.00	0.20	0.21	1.07	
NO2+NO3	10.00	0.34	0.26	0.31	<b>0.31</b>	<b>0.23</b>	7.00	0.35	0.20	0.26	<b>0.26</b>	
Phosphorus	10.00	0.05	0.02	0.02	0.03	<b>0.04</b>	7.00	1.00	0.03	0.10	0.28	
<b>Other (mg/L)</b>												
Turbidity	9.00	500.00	1.70	3.30	<b>59.39</b>	<b>50</b>	7.00	550.00	0.00	7.70	<b>98.54</b>	
Suspended Residue	8.00	20.00	2.10	4.50	7.64		6.00	1240.00	10.00	43.00	279.17	
Volatile Residue	6.00	6.60	2.50	3.70	4.08		6.00	240.00	0.00	6.05	53.18	
Fixed Residue	6.00	13.40	0.40	4.40	6.18		6.00	1000.00	0.00	16.45	214.98	
<b>Major cations (mg/L)</b>												
Calcium	9.00	2.30	1.90	2.00	2.11	<b>3.40</b>	6.00	5.20	2.20	2.65	3.22	
Magnesium	9.00	1.10	0.82	0.87	0.93	<b>1.10</b>	7.00	8.30	1.10	1.20	<b>2.66</b>	
Sodium	8.00	2.10	0.00	1.70	1.56	<b>2.60</b>	7.00	2.20	0.00	1.80	1.61	
<b>Trace metals (mg/L)</b>												
Silver	9.00	U	U	U	U	<b>0.36</b>	7.00	U	U	U	U	
Aluminum	9.00	920.00	73.00	160.00	<b>289</b>	<b>87.00</b>	7.00	31000.00	470.00	1100.00	<b>5981.43</b>	
Arsenic	9.00	U	U	U	U	<b>150.00</b>	7.00	U	U	U	U	
Cadmium	9.00	U	U	U	U	<b>0.25</b>	7.00	U	U	U	U	
Chromium	9.00	U	U	U	U	<b>11.00</b>	7.00	33.00	U	U	<b>33.00</b>	
Copper	9.00	U	U	U	U	<b>9.00</b>	7.00	34.00	U	3.50	<b>9.47</b>	
Iron	9.00	1200.00	140.00	270.00	430	<b>1000.00</b>	7.00	40000.00	680.00	2500.00	<b>9711.43</b>	
Mercury	3.00	U	U	U	U	<b>0.77</b>	2.00	U	U	U	U	
Manganese	9.00	61.00	13.00	20.00	28.11	<b>120.00</b>	7.00	1200.00	28.00	91.00	<b>280.00</b>	
Nickel	9.00	U	U	U	U	<b>52.00</b>	7.00	17.00	U	U	11.00	
Lead	8.00	U	U	U	U	<b>2.50</b>	7.00	31.00	U	U	<b>13.14</b>	
Zinc	9.00	13.00	U	U	10.33	<b>120.00</b>	7.00	180.00	U	16.00	45.57	
<b>Fecal Coliform (col/100mL)</b>					<b>Geo mean</b>							<b>Geo mean</b>
	10.00	540.00	43.00	135.50	151.38	<b>200</b>	6.00	15000.00	600.00	4075.00	<b>3543.93</b>	

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