

Water Quality in the Mountains:
Henderson County Volunteer Water Information Network
Year Seventeen Report

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Acknowledgments

We wish to thank the Henderson County Board of Commissioners, the Chuck McGrady Family, private donors, and the Town of Lake Lure for their continued support of this work. Their support has enabled Henderson County to develop a comprehensive water quality database that will assist greatly with planning future development in the county. Continued monitoring will provide additional information on changes taking place as the county continues to grow. The Henderson County program also provides essential information to complete the assessment of water quality in the French Broad River and Broad River watersheds. Every county in these watersheds should be clearly aware of the part they play in the overall water quality of the region.

Volunteers continue to be the key to the success of any VWIN program. Without volunteers, a water monitoring program would be prohibitively expensive. Volunteers who have been responsible for collecting samples monthly over the past year include Dick Black, Dave and Betty Bucher, Peter Colburn, Richard and Brenda Cross, Karen and Phil Cutright, Paula and Ron Bakule, Richard Freudenberger, Beth and Dave Harris, Lee Johnson, Bill Moore, Doreen Blue, Bill Rylands, Denise and Danny Sherrill, Betty Shevick, Jim and Sharon Spicer, Colette Summitt, J. R. Mason, and Marilyn Westphal. All of the time and effort these volunteers put into this project are greatly appreciated. They are making an important contribution to the preservation of clean water in Henderson County.

Special thanks also go to Michelle Skeele who has graciously allowed the program to use her porch as a kit storage area, and to the county coordinators Jim and Sharon Spicer who have consistently ensured that all samples were collected each month. Thanks also to Mr. Pete's Market VIII, and VanWingerden International for providing cold storage space for water monitoring kits. Much credit for the continued success of water monitoring also goes to the Environmental and Conservation Organization for their administrative support of the program. ECO continues to be a driving force in the prevention of water quality degradation in Henderson County.

I. Introduction

VWIN's History

The Volunteer Water Information Network (VWIN) is a partnership of groups and individuals dedicated to preserving water quality in western North Carolina. Organizations such as the Environmental and Conservation Organization, the Pacolet Area Conservancy, the Town of Lake Lure, the Lake James Environmental Association, and many others provide administrative support. The UNC Asheville Environmental Quality Institute (EQI) provides technical assistance through laboratory analysis of water samples, statistical analysis of water quality results, and written interpretation of the data.

An accurate and on-going water quality database, as provided by VWIN, is essential for good environmental planning. The data gathered by the volunteers provides an increasingly accurate picture of water quality conditions and changes in these conditions over time. Communities and governmental agencies can use this data to identify streams of high water quality that need to be preserved, as well as streams which cannot support further development without significant water quality degradation. In addition, the information allows planners to assess the impacts of increased development and measures to control pollution. In other words, this program provides water quality data for evaluation of current management efforts and can help guide decisions affecting future management actions. The VWIN program also encourages involvement of citizens in the awareness, ownership and protection of their water resources.

In February of 1990, volunteers began monthly sampling of 27 stream sites in Buncombe County. The program was expanded to 45 sites by November of 1990. In July 2009, most VWIN sampling was halted when UNC Asheville closed EQI due to state budget cuts. Laboratory services are expected to resume in the summer of 2010, when EQI reopens as a nonprofit organization. Since 1990, most of the other counties in Western North Carolina have established sites to bring the total number of sites to over 200. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Catawba, Tuckasegee, Hiawasse, and Watauga River watersheds in Western North Carolina.

The Henderson County VWIN Program

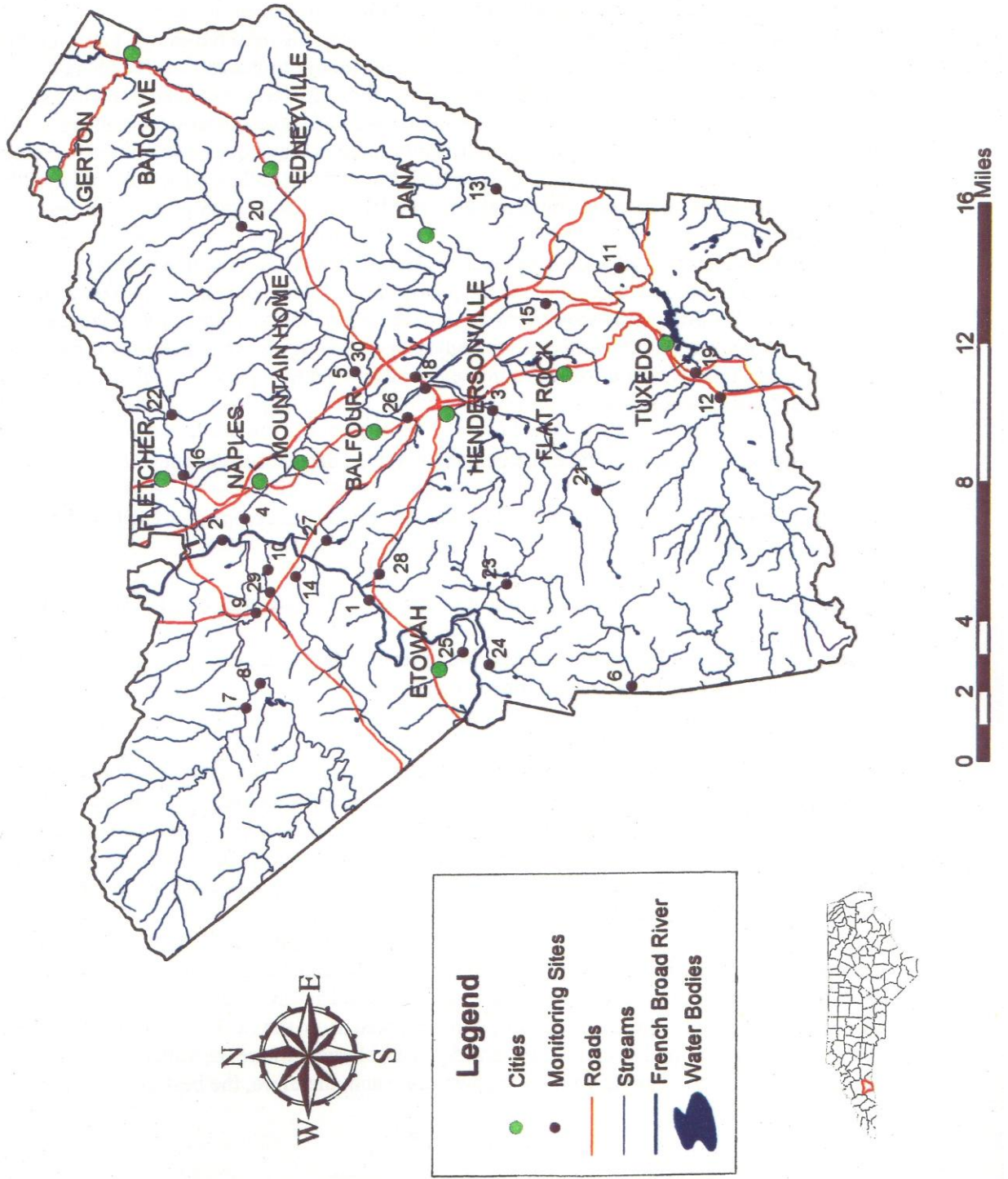
In July of 1992, members of the Volunteer Water Information Network began monthly sampling of 18 selected streams in Henderson County in order to provide an accurate picture of water quality conditions. Since that time many other sites in the county have been established. Sample sites were chosen to cover a variety of watershed drainage areas. The approximate locations of the monitoring sites in Henderson County are shown in Figure 1. The stream names associated with each site number are listed in Table 1. Some sites were chosen to monitor potential drinking water supplies. Several sites were selected as control sites to provide comparison between undeveloped and developed subwatersheds.

Under the administration of the Environmental and Conservation Organization, this program has gathered over 17 years of water quality data. This annual report represents statistical analyses and interpretation of seventeen years of data gathered from August 1992 through July 2009 for the currently monitored sites in the county.

Table 1: Location of Henderson Co. VWIN sites

<u>Site#</u>	<u>Approximate Stream Location</u>
1	French Broad River at Banner Farm Road in Horseshoe
2	French Broad River at Butler Bridge Road
3	Mud Creek at Erkwood Road
4	Mud Creek at North Rugby Road
5	Clear Creek at Nix Road
6	Crab Creek at Staton Road (discontinued in 2002)
7	North Fork of Mills River on LL Moore Road
8	South Fork of Mills River on South Mills River Road
9	Mills River at Hwy 191 (Davenport Bridge)
10	Mills River at Hooper Lane
11	Green River below Lake Summit
12	Green River at Terry's Creek Road
13	Big Hungry River below dam
14	Boylston Creek at Ladson Road
15	Bat Fork Creek at Tabor Road
16	Cane Creek at Hoopers Creek/Howard Gap Road
17	Lower Cane Creek at Hwy 25 (discontinued)
18	Mud Creek at 7th Avenue East
19	Green River at Old Hwy 25 S
20	Clear Creek at Apple Valley Road
21	Mud Creek at Berea Church Road
22	Hoopers Creek at Jackson Road
23	Big Willow Creek at Patterson Road
24	Little Willow Creek at River Road
25	Gash Creek at Etowah School Road
26	Brittain Creek at Patton Park
27	Mill Pond Creek at South Rugby Road
28	Shaw Creek at Hunters Glen
29	Brandy Branch at Mills River Village on NC 191
30	Devil's Fork at Dana Road
LL1	Reedypatch Creek at Bat Cave
LL2	Hickory Creek at Bat Cave
LL3	Broad River at Bat Cave

Figure 1: Henderson County WWIN Monitoring Sites



II. Methodology

Chemical Monitoring

Volunteers are provided with instructions about sample collection procedures prior to their first sample collection day. Instruction is provided through hands-on experience by a VWIN coordinator, and a training manual is given to each volunteer to read.

Henderson County stream samples are collected on the third Saturday of each month. Collecting coincident samples from all the sites in the monitoring area greatly reduces meteorological variability between sites. Therefore, the volunteers are asked to collect samples from the assigned site as close to noon as possible. Water samples are collected in six 250 mL polyethylene bottles. In order to assure consistent sampling techniques, each bottle is labeled with the site number and the parameter for which the water from that particular bottle will be analyzed. Information recorded by the volunteer (chain-of-custody form) can be found in Appendix A.

After collection, the volunteer takes the samples and data sheet to a designated drop point where the samples are refrigerated. It is the job of the volunteer coordinator to pick up the samples from the drop point and deliver them to the EQI laboratory for analysis Monday morning. A description of the laboratory analysis methodology is contained in Appendix B. After analysis, the empty bottles are cleaned in the laboratory and then packed together with a blank data sheet for use next month.

Various statistical analyses are performed on the data and are intended to:

- 1) Characterize the water quality of each stream site relative to accepted or established water quality standards;
- 2) Compare water quality of each stream site relative to all other sites in the VWIN program;
- 3) Identify effects of precipitation, stream water level, and seasonality and temporal trends on water quality, after sufficient data has been collected.

III. Results and Discussion

This discussion is based on seventeen years of data gathered between August 1992 and July 2009. However, monitoring at sites 21 through 30 began in July 1998. With each additional year of continuous stream monitoring, trends in water quality become more evident, and a clearer picture of actual conditions existing in various streams and watersheds is available. Continuing water quality data collection over time provides updated information on changing conditions. With this information, financial resources and policies can be focused on areas of greatest concern.

A discussion of the stream sites relative to specific water quality parameters follows. To better understand the parameters, explanations, standards and sources of contamination, some definitions of units and terms have been provided. The amount of a substance in water is referred to in units of concentration. Parts per million (ppm) is equivalent to mg/L. This means that if a substance is reported to have a concentration of 1 ppm, then there is one milligram of the substance in each liter (1000 grams) of water. The parameter total suspended solids (TSS) illustrates the weight/volume concept of concentration. According to the statistical summary data for Henderson County (Appendix E), site 1 had a median TSS concentration of 8.2 mg/L over the past three years, which is equivalent to 8.2 ppm. Thus if you filter one liter of water from site 1 on average you will collect sediments that weigh 9.6 mg. The same conversion applies for parts per billion (ppb), which is equivalent to micrograms per liter (ug/L). Concentrations of the VWIN parameters in water samples are compared to normal ambient levels. Ambient levels are estimates of the naturally occurring concentration ranges of a substance. For instance, the ambient level of copper in most streams is less than 1 ug/L (1 ppb). Ambient water quality standards, on the other hand, are used to judge acceptable concentrations. The ambient water quality standard for Ammonia-nitrogen to protect trout populations is 1.0 mg/L, but the normal ambient level for most trout waters is about 0.1 mg/L.

A classification grade was assigned to each site based on the results of analysis. This report shows site-specific grades for each parameter for the three-year period from August 2006 through July 2009 (Table 2). Using only the past three years of data allows streams to show the most current water quality status. Thus, streams that may show improved water quality as a result of newly implemented management practices will reflect improvement in their grade. Likewise, streams where water quality has been deteriorating will show lower grades than past years. The grades are designed to characterize the water quality at each site with regard to individual parameters. Water quality standards were used where applicable to assess the possible impacts these levels could have on human health and organisms in the aquatic environment. For example, the 7 ppb water quality standard for copper was used to determine grades for the sites. A grade of "A" would be assigned to a site if, over the last three years, no samples had a concentration that exceeded this standard. In contrast, due to the detrimental effects decreases in pH can have on the organisms that live in streams, a site could receive an "A" if minimum pH value was never lower than 6.0. Appendix C describes the criteria used for the grading system for each parameter.

Appendix D is a list of all VWIN stream sites monitored in Western North Carolina indexed and ranked using the grading system previously discussed and shown in Table 2. This

Table 2: Classification Grades Based on Parameters and Ranges

Site	Description	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho P	Ammonia-N	Nitrate/nitrite-N
1	French Broad River/Banner Farm Rd	A	D	C	C	A	A	A	A	B	A	A
2	French Broad River/Butler Br Rd	A	C	C	B	B	B	A	B	C	A	B
3	Mud Creek/Erkwood Rd	A	C	B	A	B	A	B	B	A	A	B
4	Mud Creek/N Rugby Rd	A	B	C	B	D	A	A	B	D	A	C
5	Clear Creek/Nix Rd	A	B	B	A	C	A	A	A	B	A	C
7	North Fork Mills River	A	D	A	A	A	A	A	A	A	A	A
8	South Fork Mills River	A	D	B	A	B	A	A	B	A	D	A
9	Mills River/Hwy 191	A	D	A	A	A	A	A	A	A	A	A
10	Mills River/Hooper Lane	A	D	A	A	A	B	A	B	A	A	A
11	Green River/down L Summit	A	D	A	A	A	A	A	A	A	A	A
12	Green River/Terry's Ck Rd	A	D	A	A	A	A	A	A	A	A	A
13	Big Hungry River below dam	A	B	B	A	B	A	A	A	A	A	B
14	Boylston Creek/Ladson Rd	A	B	C	B	B	A	A	A	A	A	B
15	Bat Fork Creek/Tabor Rd	A	B	B	A	C	A	A	A	A	A	C
16	Cane Creek/Howard Gap Rd	A	B	D	B	C	B	B	B	B	C	B
18	Mud Creek/7th Ave	A	B	C	B	C	A	B	B	A	A	B
19	Green River/Old 25	A	D	B	A	A	A	A	A	A	A	A
20	Clear Creek/Apple Valley Rd	A	C	C	A	B	B	A	B	B	A	B
21	Mud Creek/Berea Church Rd	A	B	B	A	B	A	A	A	B	A	B
22	Hoopers Creek/Jackson Rd	A	B	B	A	C	A	B	B	B	A	B
23	Big Willow Creek/Patterson Rd	A	C	B	A	B	A	A	B	B	A	A
25	Gash Creek/Etowah School Rd	A	A	C	A	C	A	A	B	C	C	B
26	Brittain Creek/Patton Park	A	B	B	A	C	A	A	A	A	A	B
27	Mill Pond Creek/S Rugby Rd	A	A	C	A	D	A	A	A	C	A	B
28	Shaw Creek/Hunters Glen	A	B	C	A	C	A	A	A	B	A	B
29	Brandy Branch/Mills R Village	A	C	A	A	C	A	A	B	B	A	C
30	Devil's Fork/Dana Rd	A	A	C	A	C	A	A	B	B	A	C
LL1	Reedypatch Creek at Bat Cave	A	B	C	A	C	A	A	A	B	A	B
LL2	Hickory Creek at Bat Cave	A	C	B	A	B	A	A	A	B	A	A
LL3	Broad River at Bat Cave	A	C	B	A	B	A	A	A	B	A	A

indexing system was developed to facilitate comparisons of specific problem areas such as sediment, nutrients, or chemical and heavy metal pollutants. Parameters were grouped into these three categories and number grades were assigned to each parameter (A=100, B=75, C=50, D=25). The numbers were added and the total divided by the number of parameters in the dimension. For example, a site with a B in turbidity and a C in total suspended solids would receive a sediment index of $(75 + 50)/2 = 62.5$ (rounded to 63). Index ratings for each of the three groupings were added and the total divided by 3 to determine the overall index rating for each site. A maximum score of 100 and a minimum of 25 are possible.

It is important and useful to compare sites within the mountain area to understand how water quality from each stream ranks, not only within the county, but also within the region. With this information local governments, organizations, and individuals can compare areas with similar problems or successes and share information or even develop regional plans. It will also be helpful to note changes in ranking over time as stream water quality improves or deteriorates relative to the many other mountain streams tested in the VWIN program. Many factors such as population density, industrial development, topography, and land use patterns can affect water quality. All of these factors must be taken into consideration when comparing stream water quality.

Appendix E contains summarized statistical data collected over the course of this study. It is a list of minimum, maximum, and median concentrations or values over the past three years and also includes the median values for each site over the entire period of the study. With this expanded information, changes in median values over time can be seen.

The data from over 200 sites throughout Western North Carolina in the VWIN program are used in this report to compare water quality from the stream sites in Henderson County with water quality from the mountain region in general. Some of the graphs in this discussion section include averages of median values for all sites analyzed throughout the region. The averages for sites in mainly forested watersheds are included to show typical water quality in streams that are relatively unaffected by human disturbance. With most parameters, sites that show median values closer to the forested stream median levels exhibit better water quality. In the case of pH and alkalinity, however, the differences may be also related to elevation and rainfall because streams in lower elevation watersheds and those receiving less rainfall naturally exhibit higher pH and alkalinity. Most of the more pristine VWIN sites are currently located in the southern edge of the mountains and/or in relatively high elevation watersheds.

It should be noted that, although there are always some sites in each county that are relatively unaffected by human activities, most VWIN sites are generally chosen to measure the effects of human activities on stream water quality. For this reason, forest streams are under-represented and the averages in all areas are weighted somewhat toward streams that experience various degrees of pollution.

A statistical analysis of the effects of stream water level, temporal changes, and seasonality on the water quality parameters at individual sites has also been included in this discussion. This analysis is used to determine if changes in concentrations or levels of a parameter relate to changes in water levels, (i.e. flow), increases or decreases over time (i.e. temporal change), and changes of the seasons in Western North Carolina (i.e. seasonality). Trends are considered significant if the p-value is less than 0.05. The p-value is the probability of obtaining as much trend as observed in the data if, in fact, there was no true underlying trend.

Trends related to flow are determined using flow measurements from nearby US Geological Survey gauging stations. Although this method may also present some problems as gauging stations can only truly represent the streams on which they are located, the method has been found to be the most effective for the least cost. With this method the control for flow allows for more precise examination of the effects of other factors. The USGS gauging stations on the French Broad River at Blantyre (03443000) and on the Mills River (03446000) were utilized to estimate relative flow for the sites in Henderson County. Each site was matched to the gauge station nearest that site. The logarithm of the ratio of the measured flow to the long-term average flow for each date was used as the predictor variable for flow. Corresponding flow data were found for all sample collection dates from the beginning of the Henderson County monitoring program in 1992 to present.

Appendix F is a summary of trends related to flow, Appendix G shows trends related to time, and Appendix H shows trends related to season.

A. Acidity (pH) and Alkalinity: pH is used to measure acidity. The pH is a measure of the concentration of hydrogen ions in a solution. If the value of the measurement is less than 7.0, the solution is acidic. If the value is greater than 7.0, the solution is alkaline (more commonly referred to as basic). The ambient water quality standard is between 6.0 and 9.0. Natural pH in area streams should be in the range of 6.5 - 7.2. Values below 6.5 may indicate the effects of acid rain or other acidic inputs, and values above 7.5 may be indicative of an industrial discharge.

Because organisms in aquatic environments have adapted to the pH conditions of natural waters, even small pH fluctuations can interfere with the reproduction of those organisms or can even kill them outright. The pH is an important water quality parameter because it has the potential to seriously affect aquatic ecosystems. It can also be a useful indicator of specific types of discharges.

Alkalinity is the measure of the acid neutralizing capacity of a water or soil. Waters with high alkalinity are considered protected (well buffered) against acidic inputs. Streams that are supplied with a buffer are able to absorb and neutralize hydrogen ions introduced by acidic sources such as acid rain, decomposing organic matter and industrial effluent. For example, water can leach calcium carbonate (a natural buffer) from limestone soils or bedrock and then move into a stream, providing that stream with a buffer. As a result, pH levels in the stream are held constant despite acidic inputs. Unfortunately, natural buffering materials can become depleted due to excessive acidic precipitation over time. In that case, further acidic precipitation can cause severe decreases in stream pH. Potential future stream acidification problems can be anticipated by alkalinity measurement. There is no legal standard for alkalinity, but waters with an alkalinity below 30 mg/l are considered to have low alkalinity. Western NC streams tend to have low alkalinity because of generally thin soils and because the underlying granitic bedrock does not contain many acid-neutralizing compounds such as calcium carbonate.

Figures 2 and 3 show median pH and alkalinity levels for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

Figure 2: Median pH levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas

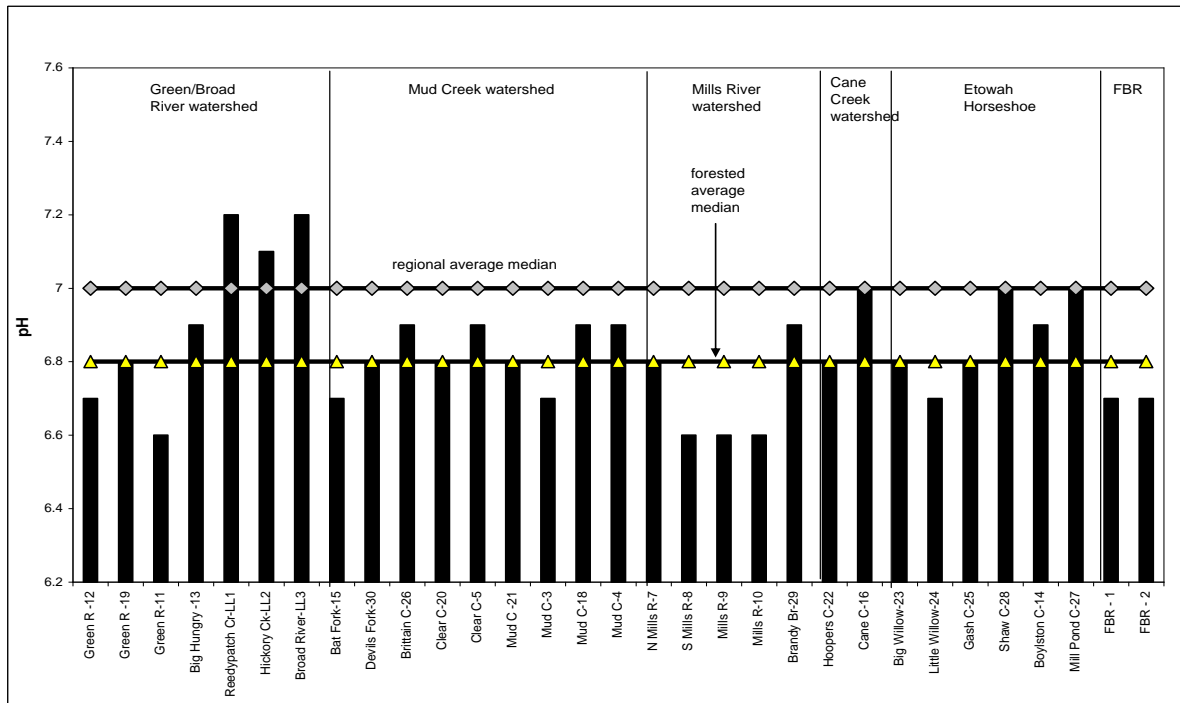
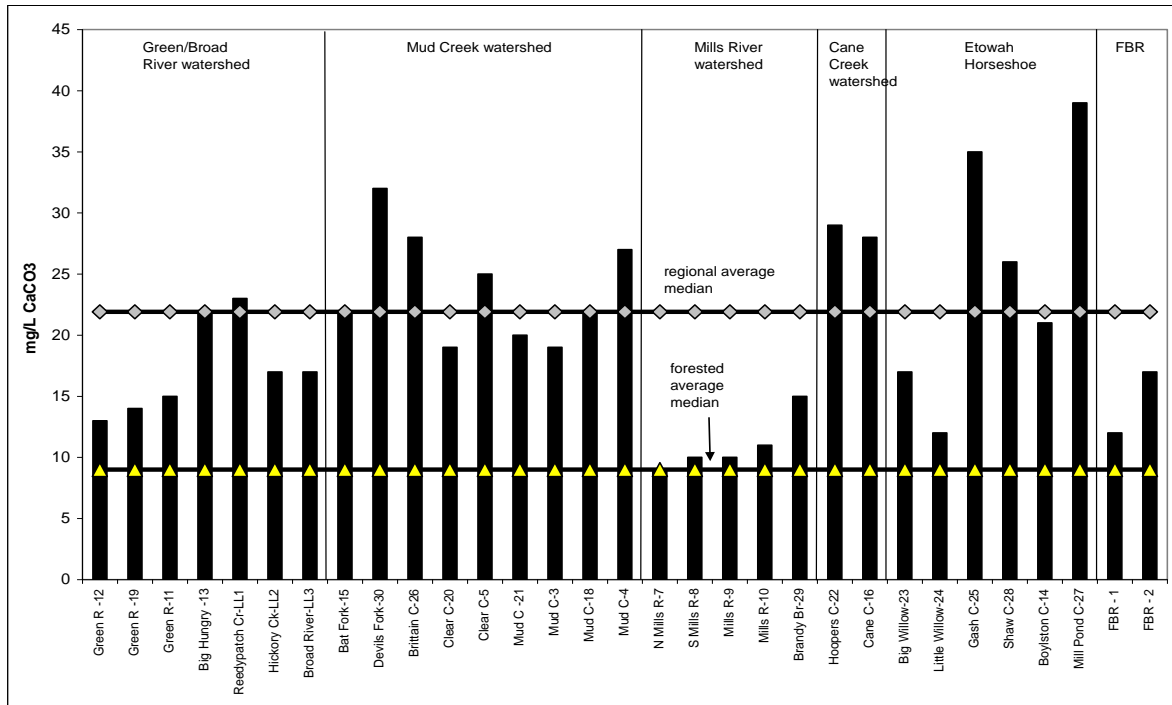


Figure 3: Median alkalinity levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



B. Turbidity and Total Suspended Solids (TSS): Turbidity is a measurement of the visual clarity of a water sample and indicates the presence of fine suspended particulate matter. The unit used to measure turbidity is NTU (nephelometric turbidity units), which measures the absorption and reflection of light when it is passed through a sample of water. Because particles can have a wide variety of sizes, shapes and densities, there is only an approximate relationship between the turbidity of a sample and the concentration (i.e. weight) of the particulate matter present. This is why there are separate tests for NTU turbidity and suspended solids.

Turbidity is an important parameter for assessing the viability of a stream for trout propagation. Trout eggs can withstand only small amounts of silt before hatching success is greatly reduced. Fish that are dependent on sight for locating food are also at a great disadvantage when water clarity declines. For this reason, the standard for trout-designated waters is 10 NTU while the standard to protect other aquatic life is 50 NTU.

Mountain streams in undisturbed forested areas remain clear even after a moderately heavy rainfall event, but streams in areas with disturbed soil may become highly turbid after even a relatively light rainfall. Deposition of silt into a stream bottom can bury and destroy the complex bottom habitat. Consequently, the habitat for most species of aquatic insects, snails, and crustaceans is destroyed by stream siltation. The absence of these species reduces the diversity of the ecosystem. In addition, small amounts of bottom-deposited sediment can severely reduce the hatch rate of trout eggs. There is no legal standard for TSS, but values below 30.0 mg/l are generally considered low, and values above 100 mg/l are considered high. TSS quantifies solids by weight and is heavily influenced by the combination stream flow and land disturbing activities. A good measure of the upstream land use conditions is how much TSS rises after a heavy rainfall.

Land use and degree of slope are important factors contributing to potential erosion and runoff. Cleared land on steep slopes will generally produce the greatest erosion rates. Henderson County has lower average slope than most other monitored counties in Western North Carolina, but it also has a high percentage of deforested land. Although the lower slopes result in lower erosion rates, some watersheds experience greater erosion rates because of extensive deforestation. Figures 4 and 5 show median turbidity levels and total suspended solids concentrations for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

C. Conductivity and Heavy Metals (Copper, Lead, and Zinc): Conductivity is measured in micromhos per centimeter (umho/cm) and is used to measure the ability of a water sample to conduct an electrical current. Pure water will not conduct an electrical current. However, samples containing dissolved solids and salts will form positively and negatively charged ions that will conduct an electrical current. The concentration of dissolved ions in a sample determines conductivity. Inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum affect conductivity levels. Geology of an area can affect conductivity levels. Streams that run through areas with granitic bedrock tend to have lower conductivity because granitic rock is composed of materials that do not ionize in water. Streams that receive large amounts of runoff containing clay particles generally have higher conductivity because of the presence of materials in clay that ionize more readily in water.

Figure 4: Median turbidity levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas

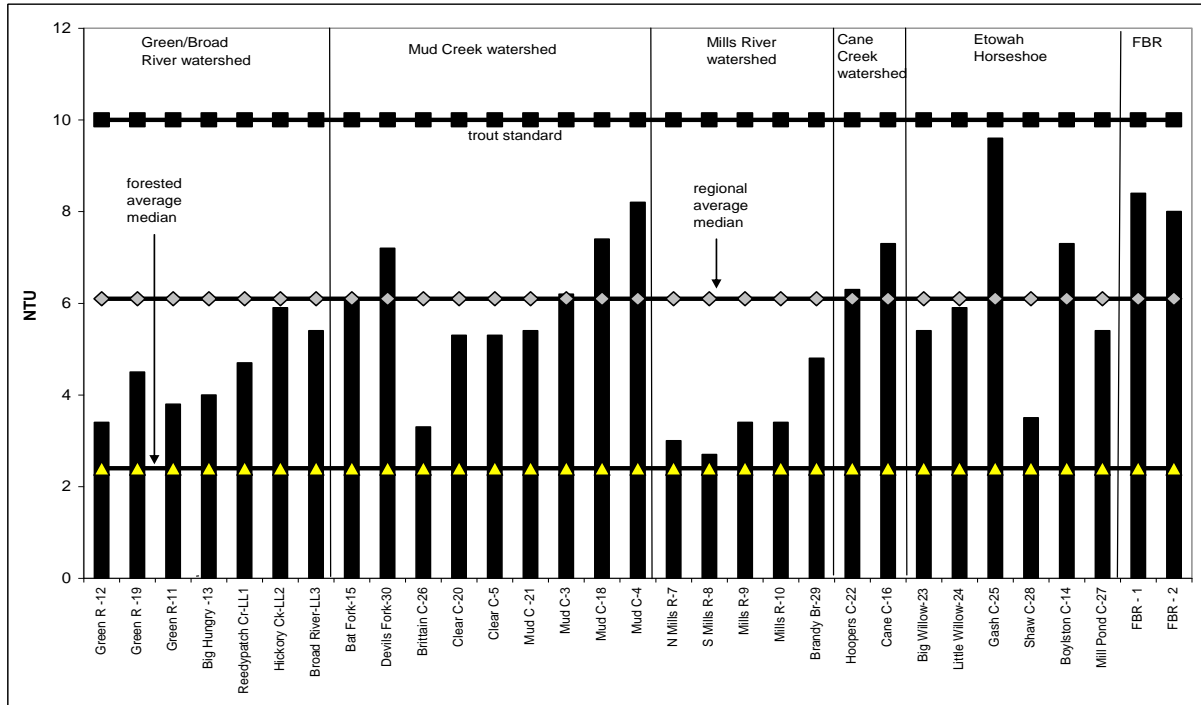
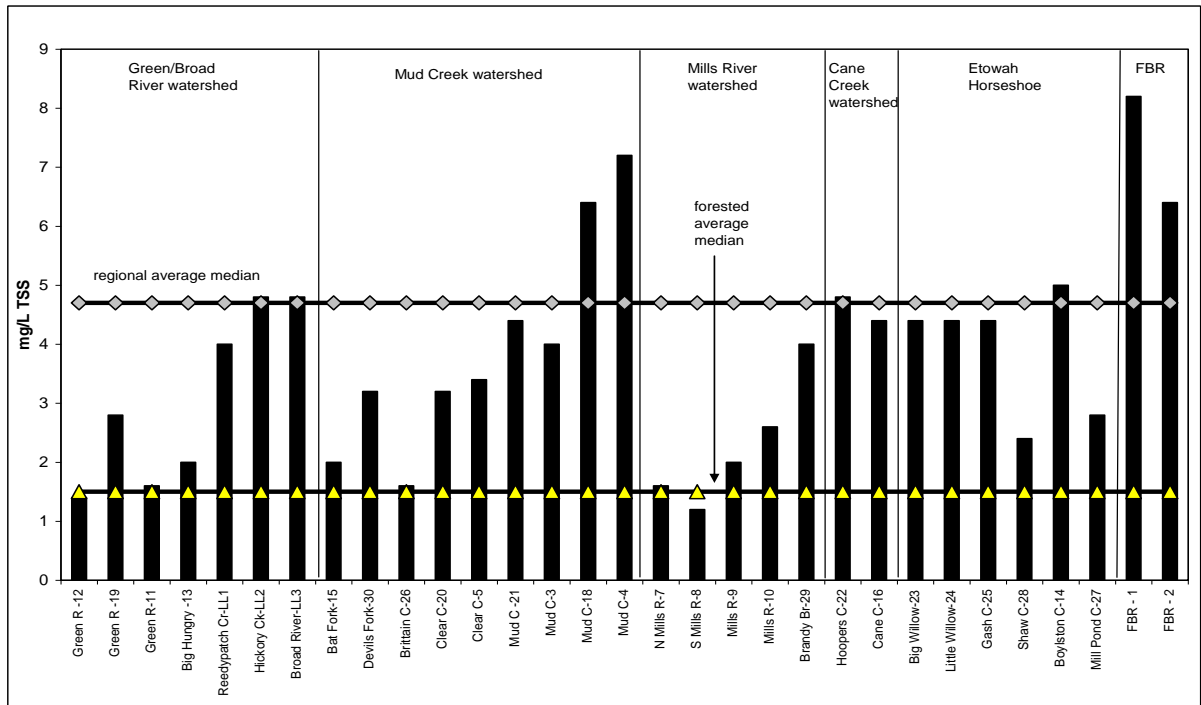


Figure 5: Median total suspended solids concentrations for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



Metals are naturally occurring in surface waters in minute quantities as a result of chemical weathering and soil leaching. However, concentrations greater than those occurring naturally can be toxic to human and aquatic organisms. Elevated levels are often indicative of industrial pollution, wastewater discharge, and urban runoff, especially from areas with high concentrations of automobiles. Airborne contaminants from coal-fired power plants may also contribute metals to the atmosphere, which are then carried to land by precipitation and dry fallout. Because metals sorb readily to many sediment types, they may easily enter streams in areas with high sediment runoff. Another source of heavy metals can be runoff from agricultural fields using sewage sludge as fertilizer, which sometimes is permitted to contain up to 1500 mg metal/1 kg fertilizer.

Copper: The standard of 7.0 ug/l has been established to protect aquatic life. In most areas, ambient levels are usually below 1.0 ug/l. Wear of brake linings has been shown to contribute concentrations of copper, lead, and zinc. Copper has a relatively high content in brake linings. Copper is also present in leaded, unleaded, and diesel fuel emissions.

Lead: A standard of 25.0 ug/l has been established to protect aquatic life, while the normal ambient level is usually below 1.0 ug/l. Lead may be present in industrial wastewater and was once common in road runoff from the use of leaded gasoline. Roadside soils still generally contain high lead levels, resulting in elevated stream concentrations if these soils are subject to erosion.

Zinc: The surface water standard is 50.0 ug/l. Typical ambient levels of zinc are approximately 5.0 ug/l. Zinc is a major metal component of tire rubber, brake linings, and galvanized crash barriers. Studies have been conducted linking this to zinc contamination from urban runoff. Because zinc is a by-product of the auto tire vulcanization process as well as the galvanization of iron, its presence in water may also result from industrial or domestic wastewater.

Elevated levels of conductivity and heavy metals are most often seen in streams receiving industrial or domestic wastewater or urban runoff. These substances also occur naturally in soils and may show higher levels in streams where severe erosion and runoff are occurring.

Figure 6 shows median conductivity levels for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas. Figure 7 shows median zinc concentrations for each monitoring site compared to median concentrations for all sites in Western North Carolina and to sites in relatively undisturbed areas. Table 3 shows the number of times each site has exceeded water quality standards for copper, lead, and zinc in the past three years.

Figure 6: Median conductivity levels at each VWIN monitoring sites compared with the median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas

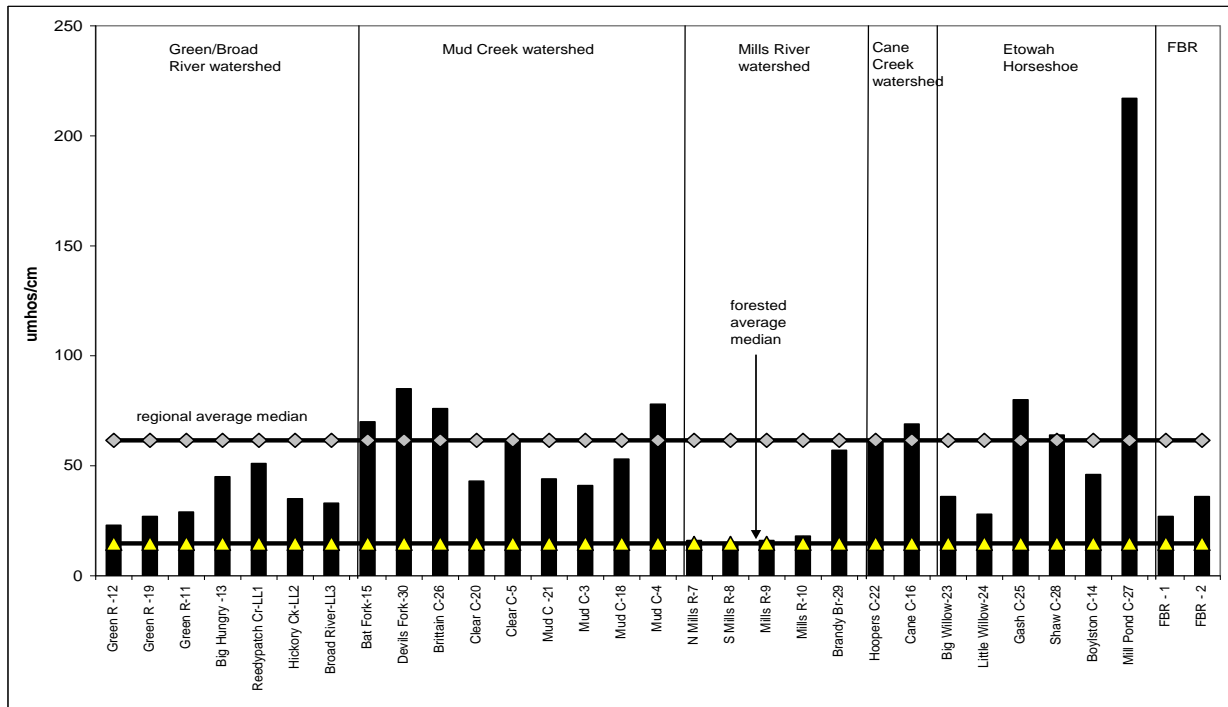


Figure 7: Median zinc concentrations at each VWIN monitoring sites compared with the median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas

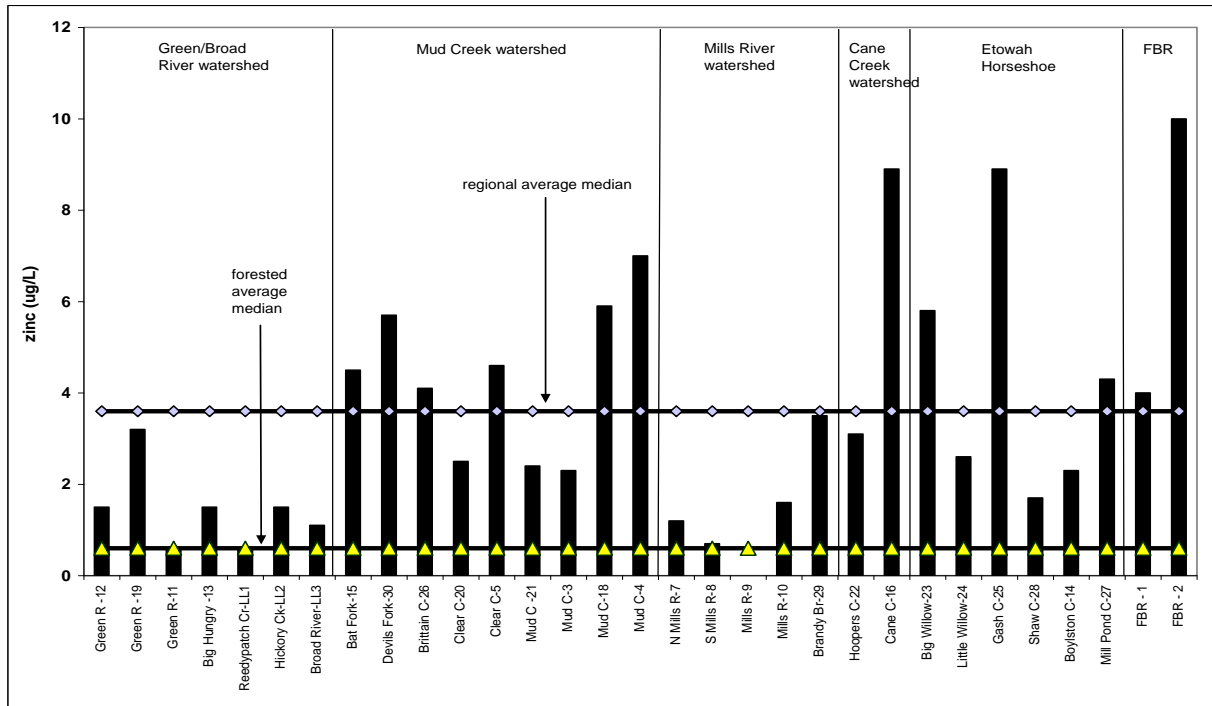


Table 3: The number of times each site has exceeded water quality standards for copper, lead, and zinc in the past three years

		copper	lead	zinc
site	Green River/Broad River Watershed			
12	Green River at Terry's Creek Road	0	0	0
19	Green River upstream Lake Summit	0	0	0
11	Green River dwnstrm Lake Summit	0	0	0
13	Big Hungry River downstream	0	0	0
LL1	Reedypatch Creek	0	0	0
LL2	Hickory Creek	0	0	0
LL3	Broad River at Bat Cave	0	0	0
	Mud Creek Watershed			
21	Mud Creek at Berea Church Road	0	0	0
3	Mud Creek at Erkwood Road	0	1	1
18	Mud Creek at 7th Avenue	0	0	0
15	Bat Fork Creek	0	0	0
30	Devil's Fork	0	0	0
26	Brittain Creek	0	0	0
20	Clear Creek at Bearwallow	1	0	1
5	Clear Creek at Nix Road	0	0	0
4	Mud Creek at N Rugby Rd	0	0	0
	Mills River Watershed			
7	North Fork Mills River	0	0	0
8	South Fork Mills River	0	0	1
9	Mills River at Davenport Bridge	0	0	0
29	Brandy Branch	0	0	1
10	Mills River at Hooper Lane	1	0	1
	Cane Creek watershed			
22	Hoopers Creek	0	1	1
16	Cane Creek at Howard Gap Rd	3	0	2
	Etowah/Horseshoe			
23	Big Willow Creek	0	0	3
25	Gash Creek	0	0	0
28	Shaw Creek	0	0	0
27	Mill Pond Creek	0	0	0
14	Boylston Creek	0	0	0
	French Broad River			
1	French Broad River/Horseshoe	0	0	0
2	French Broad River/Mt Home	3	0	3

D. Nutrients (Orthophosphate (PO_4^{3-}), Ammonia-Nitrogen ($\text{NH}_4^+/\text{NH}_3$), and Nitrate/Nitrite-Nitrogen ($\text{NO}_3^-/\text{NO}_2^-$): Phosphorus is an essential nutrient for aquatic plants and algae. It occurs naturally in water and is in fact, usually the limiting nutrient in most aquatic systems. In other words, plant growth is restricted by the availability of phosphorus in the system. Excessive phosphorus inputs stimulate the growth of algae and diatoms on rocks in a stream and cause periodic algal blooms in reservoirs downstream. Slippery green mats of algae in a stream, or blooms of algae in a lake are usually the result of an introduction of excessive phosphorus into

the system that has caused algae or aquatic plants to grow at abnormally high rates. Eutrophication is the term used to describe this growth of algae due to an over abundance of a limiting nutrient. Sources of phosphorus include soil, disturbed land, wastewater treatment plants, failing septic systems, runoff from fertilized crops and lawns, and livestock waste storage areas. Phosphates have an attraction for soil particles, and phosphorus concentrations can increase greatly during rains where surface runoff is a problem. **In this report orthophosphate is reported in the form of orthophosphate (PO_4^{3-}). To isolate phosphorus (P) from the measurement, divide the reported amount by 3.07.**

Orthophosphate: This is a measure of the dissolved phosphorus that is immediately available to plants or algae. Orthophosphate is also referred to as phosphorus in solution. There is no legal water quality standard, but generally levels must be below 0.05 mg/l to prevent downstream eutrophication.

Ammonia-Nitrogen ($\text{NH}_4^+/\text{NH}_3$) is contained in the remains of decaying wastes of plants and animals. Some species of bacteria and fungi decompose these wastes and NH_3 is formed. The normal ambient level is approximately 0.10 mg/l, and elevated levels of NH_3 can be toxic to fish. Although the actual toxicity depends on the pH of the water, the proposed ambient standard to protect trout waters is 1.0 mg/l in summer and 2.0 mg/l in winter. The most probable sources of ammonia nitrogen are agricultural runoff, livestock farming, septic drainage and sewage treatment plant discharges. In Western North Carolina, streams with extensive trout farming may also show elevated ammonia-nitrogen concentrations.

Like phosphorus, **nitrate/nitrite-nitrogen ($\text{NO}_3^-/\text{NO}_2^-$)** serves as an algal nutrient contributing to excessive stream and reservoir algal growth. In addition, nitrate is highly toxic to infants and the unborn causing inhibition of oxygen transfer in the blood stream at high doses. This condition is known as "blue-baby" disease. This is the basis for the 10 mg/L national drinking water standard. The ambient standard to protect aquatic ecosystems is 10 mg/L as well. The most probable sources are septic drainage and fertilizer runoff from agricultural land and domestic lawns. Nitrates from land sources end up in streams more quickly than other nutrients such as phosphorus because they dissolve in water more readily and can travel with ground water into streams. Consequently, nitrates are a good indicator of the possibility of sources of pollution from sewage or animal waste during dry weather. Figures 8, 9, and 10 show median orthophosphate, ammonia-nitrogen, and nitrate-nitrite-nitrogen concentrations for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

Figure 8: Median orthophosphate concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas

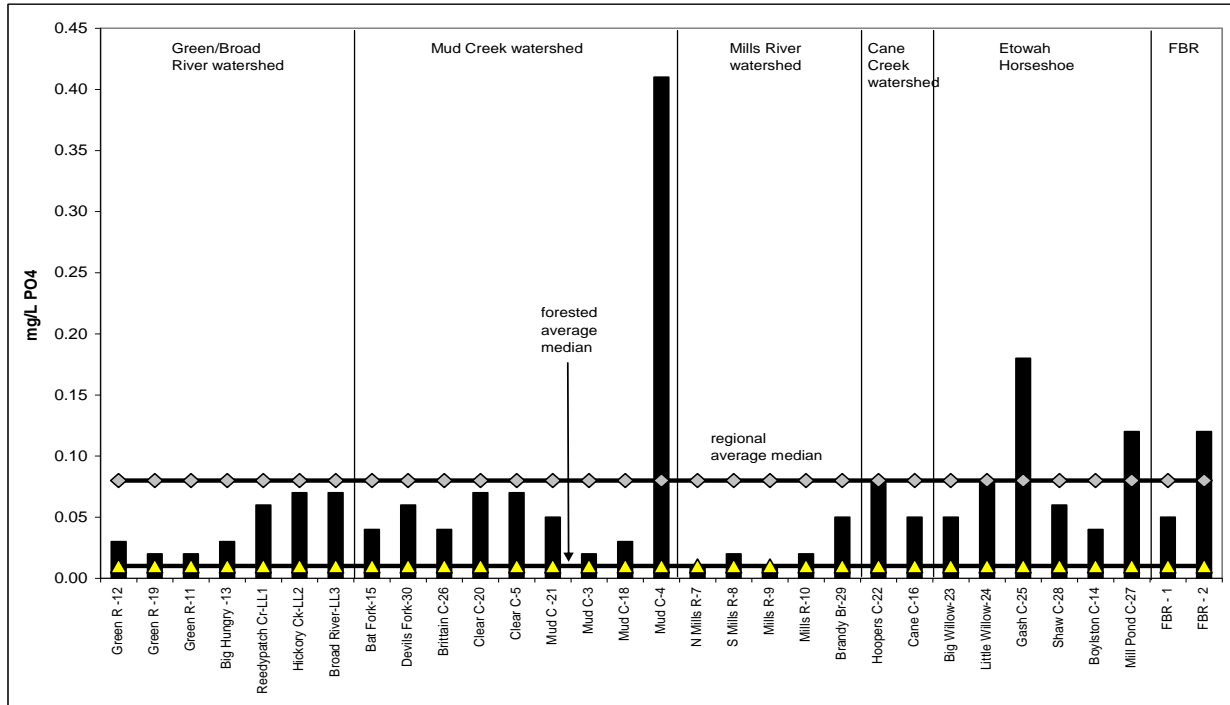


Figure 9: Median ammonia-nitrogen concentrations for each VWIN monitoring site compared to the average median for all VWIN monitoring sites in WNC and to the average median for sites in relatively undisturbed forested areas

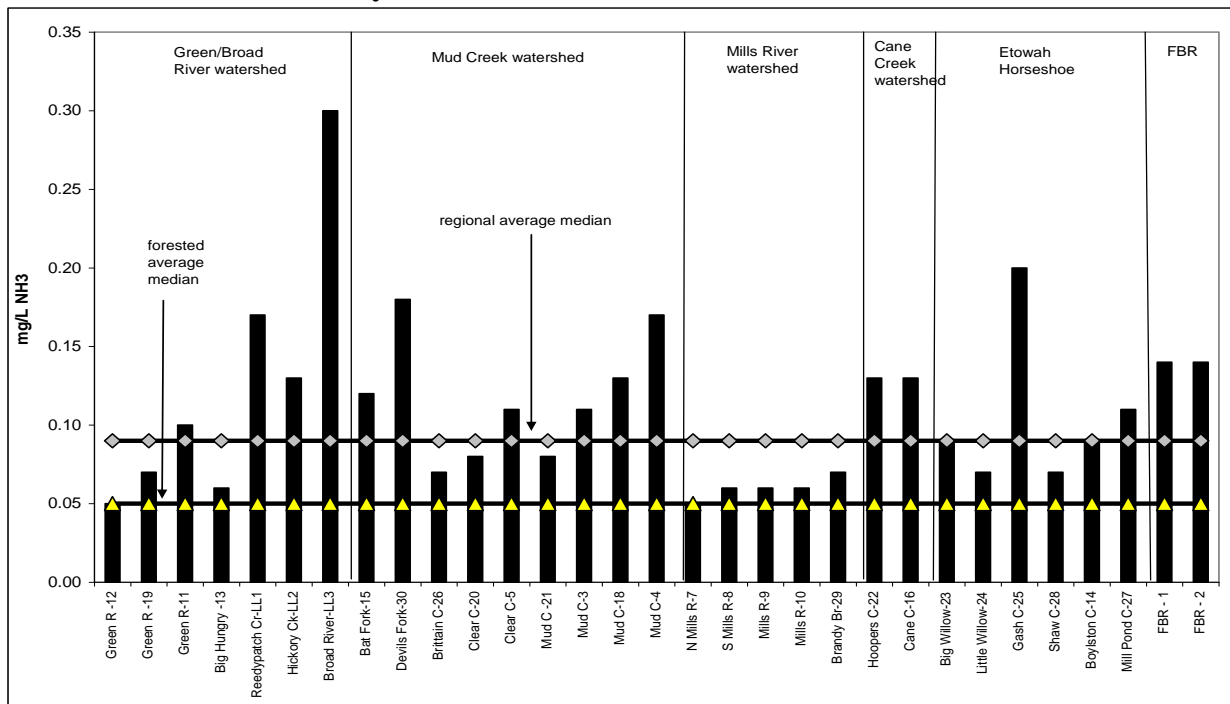
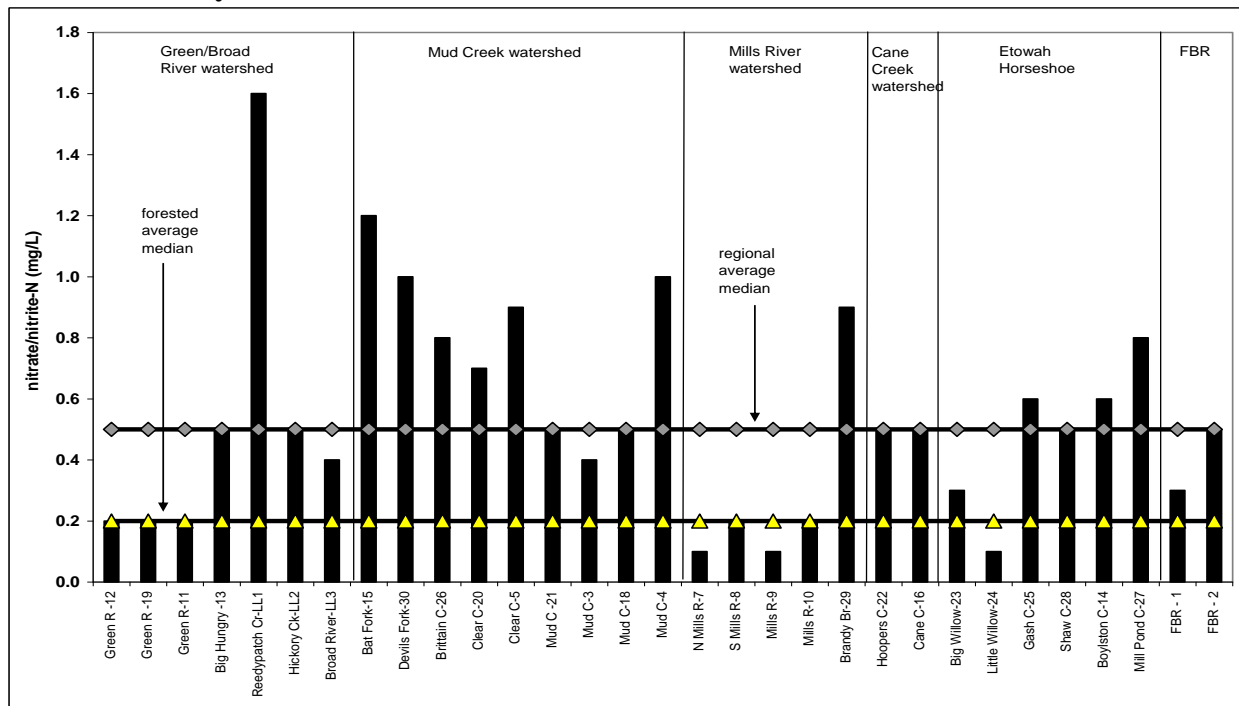


Figure 10: Median nitrate/nitrite-nitrogen concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas



IV. Summary

Chemical analysis of samples collected at Henderson County sites are intended to characterize the water quality relative to the parameters established by the Volunteer Water Information Network program. Concerned groups and individuals can use the information from the program to help identify problems and evaluate solutions. Characterizing the water quality of the county is a complex task, and interpretation of the data can be difficult due to many factors. With continued long term monitoring, however, various trends become more evident. Until July 2009, the VWIN program was monitoring over 200 sites throughout Western North Carolina. A comparison of Henderson County stream sites with all other sites in the program is presented in Appendix D. These comparisons are based on the most recent three years of analysis to ensure that only current water quality is being rated. Appendix E shows the data summary for each parameter and site for the past three years. Summaries of trends related to flow, time, and season are presented in Appendices F, G, and H. Data from all seventeen years of monitoring are used to determine trends.

As discussed in Section 3 of the report, the ranking system allows grouping by parameters into categories. This system permits comparison of specific water quality problems such as stream sedimentation, urban runoff of chemicals and heavy metals, and nutrient loading. Table 4 is a summary of ranking of Henderson County sites by water quality issues and by watershed. With this information it is easier to focus on specific areas with related water quality problems. To obtain a more complete picture of water quality trends, it is useful to group streams

geographically and by watershed. In this way problem areas can be more easily illustrated, and it may help focus limited resources on areas that require the greatest attention.

Table 4: Stream ranking index for Henderson County monitoring sites

site #	site name	sediment	metals	nutrients	overall	chemical rating
	VWIN - WNC Regional Average	74	86	85	82	
	Green River/Broad River Watershed					
12	Green River at Terry's Creek Road	100	100	100	100	excellent
19	Green River upstream from Lake Summit	88	100	100	96	excellent
11	Green River downstream from Lake Summit	100	100	100	100	excellent
13	Big Hungry River downstream	88	94	92	91	excellent
LL1	Reedypatch Creek	75	88	83	82	good
LL2	Hickory Creek	88	94	92	91	excellent
LL3	Broad River at Bat Cave	88	94	92	91	excellent
	Average for this grouping	90	96	94	93	
	percent sites below regional average	0%	0%	14%	0%	

	Mud Creek Watershed					
21	Mud Creek at Berea Church Road	88	94	83	88	good
3	Mud Creek at Erkwood Road	88	81	92	87	good
18	Mud Creek at 7th Avenue	63	75	92	76	average
15	Bat Fork Creek	88	88	83	86	good
30	Devil's Fork	75	81	75	77	average
26	Brittain Creek	88	88	92	89	good
20	Clear Creek at Bearwallow	75	81	83	80	good
5	Clear Creek at Nix Road	88	88	75	83	good
4	Mud Creek at N Rugby Rd	63	75	58	65	below average
	Average for this grouping	80	83	81	81	
	percent sites below regional average	22%	56%	67%	44%	

	Mills River Watershed					
7	North Fork Mills River	100	100	100	100	excellent
8	South Fork Mills River	88	88	75	83	good
9	Mills River at Davenport Bridge	100	100	100	100	excellent
29	Brandy Branch	100	81	75	85	good
10	Mills River at Hooper Lane	100	88	100	96	excellent
	Average for this grouping	98	91	90	93	
	percent sites below regional average	0%	20%	40%	0%	

	Cane Creek watershed					
22	Hoopers Creek	88	75	83	82	good
16	Cane Creek at Howard Gap Rd	50	69	67	62	below average
	Average for this grouping	69	72	75	72	
	percent sites below regional average	50%	100%	100%	50%	

Table 4: Stream ranking index for Henderson County monitoring sites – continued

site #	site name	sediment	metals	nutrients	overall	chemical rating
	VWIN - WNC Regional Average	74	86	85	82	
	Etowah/Horseshoe					
23	Big Willow Creek	88	88	92	89	good
24	Little Willow Creek	88	100	92	93	excellent
25	Gash Creek	75	81	58	72	average
28	Shaw Creek	75	88	83	82	good
27	Mill Pond Creek	75	81	75	77	average
14	Boylston Creek	63	94	92	83	good
	Average for this grouping	77	89	82	83	
	percent sites below regional average	17%	33%	50%	33%	
	French Broad River					
1	French Broad River/Horseshoe	50	100	92	81	good
2	French Broad River/Mt Home	63	81	75	73	average
	Average for this grouping	57	91	84	77	
	percent sites below regional average	100%	50%	50%	100%	
	Overall County Rating					
	Average for All Sites	82	88	85	85	
	percent sites below regional average	21%	39%	54%	32%	

Overall, Henderson County has better water quality than the rest of the region. This is especially true for the Green River Watershed and the Mills River Watershed, both of which have almost all of their sites with an overall quality rating that is well above the regional average (Table 4). Nutrient levels for Henderson County sites are also improving with time overall. For example, orthophosphate concentrations have declined significantly over the past 10 years at almost all of the sites in Henderson County and nitrate levels have declined significantly at about half the sites (Appendix G). The statistical analysis examining trends attempts to adjust for different flows but because the adjustment is not perfect it is possible that these trends are at least partially an artifact of the unusual weather patterns over the past 10 years. The only sites that have more parameters that are increasing with time than decreasing is site 16 (Cane Creek/Howard Gap Rd) and site 18 (Mud Creek at 7th Avenue) which have had significant increases in all the metal concentrations over the past 10 years. Site 16 in particular shows water quality degradation, with metal and nutrient ranks below average and a poor sediment ranking. The other site listed as below average is site 4 (Mud Creek at N Rugby Rd), which exhibits unusually high nutrient levels from upstream contributions in the watershed.

Table 5 shows median levels of parameters at all VWIN sites along the French Broad River, which allows comparison of water quality as the river travels through the three counties. This includes data from two sites in Henderson County, five sites in Buncombe County, and two sites in Madison County. As in the past, the downstream site in Henderson County shows a large increase in orthophosphate attributed to inflow from Mud Creek. The river also continues to show increases in sediment and nutrients at the Buncombe County location downstream of Asheville at Ledges Park.

Table 5: Median levels of parameters analyzed at each site on the French Broad River from Horseshoe in Henderson County to Hot Springs in Madison County

site #	location	Turbidity	TSS	Cond	Zinc	Copper	Ortho-P	Ammonia-N	Nitrate-N
		NTU	mg/L	umhos/cm	ug/L	ug/L	mg/L	mg/L	mg/L
H-1	at Horseshoe	8.4	8.2	27	4.0	1.0	0.05	0.14	0.3
H-2	at Mountain Home	8.0	6.4	36	10.0	2.2	0.12	0.14	0.5
B-13	at Corcoran Park	9.3	8.8	39	7.8	1.9	0.16	0.13	0.5
B-12B	at Bent Creek	6.6	4.0	39	3.6	1.1	0.12	0.12	0.5
B-23	at Jean Webb Park	6.8	4.0	58	4.0	1.1	0.09	0.12	0.5
B-6A	at Ledges Park	8.5	6.1	62	4.1	1.8	0.36	0.29	0.8
B-32	at Walnut Island Park	9.5	4.9	65	3.8	1.7	0.31	0.22	0.8
M-2	at Barnard Bridge	8.7	6.0	63	4.0	1.7	0.27	0.16	0.8
M-3	at Hot Springs	8.4	6.2	67	3.0	1.5	0.23	0.15	0.8

Appendix A: Chain of Custody form
Volunteer Water Information Network
Henderson County

- 1) Sample Site Number _____.
- 2) Sample Site Name _____.
- 3) Collection Date _____ Day _____.
- 4) Time Collected _____.
- 5) Temperature at drop-off site (in cooler) _____.
- 6) Volunteer's Name _____.
- 7) Volunteer's Phone# &/or Email: _____.
 _____ (please provide current mailing address if there has been a change)
- 8) Water Flow Rate (please circle one) Very High High Normal Low
- 9) Type of Rain in past 3 days (please circle one) Heavy Medium Light Dry
- 10) General Observations (turbidity, waste matter, dead animals upstream, anything out of the ordinary) _____.
 _____.
 _____.

Parameter Results (For Lab Use Only)

Parameter and Result	Date of Analysis
NH3	mg/L
NO3	mg/L
Po	mg/L
Turb	NTU
TSS	mg/L
Cond	umhos/cm
Alk	mg/L
pH	

Appendix B: Laboratory Analysis

Samples are kept refrigerated until they are delivered to the EQI laboratory on the Monday morning following Saturday collections. Methods follow EPA or Standard Methods for the Examination of Water and Wastewater-18th-20th Edition techniques and the EQI laboratory is certified by the State of North Carolina for water and wastewater analysis of orthophosphate, total phosphorus, ammonia-nitrogen, turbidity, total suspended solids, pH, conductivity, copper, lead, and zinc. All samples are kept refrigerated until the time of analysis. Shipped samples are sent on ice. Analysis for nitrogen, phosphorus, pH, turbidity, and conductivity are completed within 48 hours of the collection time. As pH cannot be tested on site, the holding time for pH is exceeded. When immediate analysis does not occur, such as for total phosphorus and heavy metals, the samples are preserved by acidification.

Explanations about the procedures and instruments used in the EQI lab are quite technical in nature and will be omitted from this report. Detailed information is available on request. The reporting limits for each parameter have been provided.

Approximate Analytical Reporting Limits for VWIN Water Quality Parameters.

<u>PARAMETER</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Ammonia Nitrogen	0.02	mg/L
Nitrate/nitrite Nitrogen	0.1	mg/L
Total Phosphorus (as PO ₄ ³⁻)	0.02	mg/L
Orthophosphate (as PO ₄ ³⁻)	0.02	mg/L
Alkalinity	1.0	mg/L
Total Suspended Solids	4.0	mg/L
Conductivity	10.0	umhos/cm
Turbidity	1.0	NTU
Copper	2.0	ug/L
Zinc	20.0	ug/L
Lead	2.0	ug/L
pH	n/a	n/a

Appendix C: Parameters and Ranges for Stream Quality Classifications

pH -

- Grade A= never less than 6.0
- Grade B= below 6.0 in less than 10% of samples, never below 5.0
- Grade C= never less than 5.0
- Grade D= at least one sample was less 5.0.

Alkalinity -

- Grade A= median greater than 30 mg/L (indicates little vulnerability to acidic inputs)
- Grade B= median 20-30 mg/L (indicates moderate vulnerability to acidic inputs)
- Grade C= median less than 20 mg/L (considered to be vulnerable to acidic inputs).
- Grade D= median less than 15 mg/L (very vulnerable to acidic inputs)

Turbidity -

- Grade A= median less than 5 NTU and exceeded the standard for trout waters of 10 NTU in less than 10% of samples, but never exceeded 50 NTU
- Grade B= median less than 7.5 NTU and never exceeded the 50 NTU standard
- Grade C= median less than 10 NTU and exceeded 50 NTU in less than 10% of samples
- Grade D= median greater than 10 NTU or exceeded 50 NTU in more than 10% of samples.

Total Suspended Solids -

- Grade A= median less than 5 mg/L and maximum less than 100 mg/L - not measurably disturbed by human activities
- Grade B= median less than 7.5 mg/L and exceeded 100 mg/L in less than 10% of samples - low to moderate disturbance
- Grade C= median less than 10 mg/L and exceeded 100 mg/L in less than 10% of samples - moderate to high disturbance.
- Grade D= median greater than 10 mg/L or maximum exceeded 100 mg/L in more than 10% of samples - high level of land disturbance

Conductivity -

- Grade A= median less than 30 umhos/cm, never exceeded 100 umhos/cm
- Grade B= median less than 50 umhos/cm, exceeded 100 umhos/cm in less than 10% of samples
- Grade C= median greater than 50 umhos/cm, exceeded 100 umhos/cm in less than 10% of samples
- Grade D= exceeded 100 umhos/cm in more than 10% of samples.

Total Copper -

- Grade A= never exceeded water quality standard of 7 ug/L
- Grade B= exceeded 7 ug/L in less than 10% of samples
- Grade C= exceeded 7 ug/L in 10 to 20% of samples
- Grade D= exceeded 7 ug/L in more than 20% of samples

Appendix C (continued)

Total Lead -

- Grade A= never exceeded water quality standard of 10ug/L
- Grade B= exceeded 10 ug/L in less than 10% of samples
- Grade C= exceeded 10 ug/L in 10 to 20% of samples
- Grade D= exceeded 10 ug/L in more than 20% of samples

Total Zinc -

- Grade A= median less than 5 ug/L, never exceeded water quality standard of 50 ppb
- Grade B= median less than 10 ug/L, exceeded 50 ppb in less than 10% of samples
- Grade C= median less than 10 ug/L, exceeded 50 ppb in 10 - 20% of samples.
- Grade D= Median greater than 10 ug/L or concentration exceeded 50 ppb in more than 20% of samples

Total Phosphorous (as P)-

- Grade A= median not above 0.03 mg/L
- Grade B= median greater than 0.03 mg/L but less than 0.07 mg/L.
- Grade C= median greater than 0.07 mg/L but less than 0.10 mg/L
- Grade D= median greater then 0.10 mg/L

Orthophosphate (as PO_4^{3-}) -

- Grade A= median less than ambient level of 0.05 mg/L
- Grade B= median between 0.05 mg/L but less than 0.10 mg/L
- Grade C= median greater than 0.10 mg/L but less than 0.20 mg/L
- Grade D= median greater then 0.20 mg/L.

Ammonia Nitrogen -

- Grade A= never exceeded 0.50 mg/L
- Grade B= never exceeded the proposed ambient standard for trout waters in the summer of 1 mg/L
- Grade C= exceeded 1 mg/L in less than 10% of samples, but never exceeded 2mg/L
- Grade D= exceeded 1 mg/L in more than 10% of samples, or at least one sample had a concentration greater than the proposed ambient standard for trout waters in the winter of 2.0 mg/L.

Nitrate Nitrogen -

- Grade A= median does not exceed 0.3 mg/L, no sample exceeded 1.0 mg/L
- Grade B= less than 10% of samples exceeded 1.0 mg/L, none exceeded 5 mg/L
- Grade C= no samples exceeded 5 mg/L
- Grade D= at least one sample exceeded 5 mg/L

Appendix D: Stream Ranking Index

Excellent	Median and maximum pollutant levels in all parameters show little effect from human disturbances
Good	One or more parameters show minor or only occasional increases in pollutant levels from human disturbances
Average	Exhibits constant low levels of one or more pollutants or sudden significant, but short term increases
Below Ave	Median pollutant levels are abnormally high in one or more parameters, or exhibits very high pollutant levels during certain weather conditions
Poor	Pollutant levels are consistently higher than average in several parameters and/or show extreme levels during certain weather conditions

B = Buncombe County

H = Henderson County

HW = Hiwassee River Watershed

HY = Haywood County

J = Jackson/Lake Glenville

LJ = Lake James

LL = Lake Lure

M = Madison County

NOT=Nottely River Watershed

P = Polk County

TOE = Toe River Watershed

TU = Tuckasegee River watershed

	site #	site description	Excellent
1	B28	Bent Creek below Lake Powhatan	100
2	H11	Green River below Lake Summit	100
3	H12	Green River at Terry's Creek Rd	100
4	H7	North Fork Mills River	100
5	H9	Mills River at SR 191 (Davenport Bridge)	100
6	HW1	Upper Hiwassee River	100
7	HW11	Hog Creek	100
8	HW2	Martin's Creek	100
9	HW3	Hightower Creek	100
10	HW8	Lower Shooting Creek	100
11	HY1	West Fork Pigeon River/Bethel	100
12	HY2	East Fork Pigeon River/Bethel	100
13	J1	Hurricane Creek/Norton Br Rd (Tuckasegee R wtrshd)	100
14	J2	Norton Creek at Norton Rd br (Tuckasegee R wtrshd)	100
15	J5	Cedar Creek at Beetree Rd (Tuckasegee R wtrshd)	100
16	J7	Norton Creek/up Grassy Cmp (Tuckasegee R wtrshd)	100
17	NOT5	Coosa Creek	100
18	Toe3	South Toe River	100
19	TU1	East Fork Tuckasegee River	100
20	B9A	Beetree Creek (Swannanoa River watershed)	98
21	HW7	Upper Shooting Creek	98
22	HY13	Allens Creek (Richland Creek watershed)	98
23	LL6	Pool Creek (Broad River watershed)	98
24	B22	Ivy Creek at Dillingham Road	97
25	J3	Mill Creek/dnstrm Norton br (Tuckasegee R wtrshd)	97
26	NOT9	Conley Creek	97
27	B31	Swannanoa River at Grassy Branch confluence	96

Appendix D: Stream Ranking Index - continued

28	H10	Mills River at Hooper Lane	96
29	H19	Green River at Old Hwy 25 S	96
30	HW4	Scataway Creek	96
31	HW9	Upper Bell Creek	96
32	HY3	East Fork Pigeon River/Cruso	96
33	NOT3	Nottely River	96
34	NOT8	Ivy Log Creek	96
35	B12A	Bent Creek at SR 191	95
36	HW12	Woods Creek	95
37	J6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	95
38	B24	Swannanoa River at confluence with North Fork	94
39	LJ5	Linville River at Hwy 126	94
40	NOT1	Nottely River upstream	94
41	H24	Little Willow Creek at River Road	93
42	HW5	Geisky Creek	93
43	LL10	Fairfield Mts Creek (Broad River watershed)	93
44	LL9	Buffalo Creek (Broad River watershed)	93
45	NOT7	Young Cane Creek	93
46	B17A	Swannanoa River at NC 81	92
47	B33	North Fork Swannanoa River at Grovestone Quarry	92
48	LJ1	Catawba River at SR 1501	92
49	P13	Green River at Hwy 9	92
50	P6	Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)	92
51	TU3	Caney Fork (Tuckasegee River watershed)	92
52	B20	Ivy Creek at Buckner Branch Road	91
53	B5B	Reems Creek at Ox Creek	91
54	H13	Big Hungry River below dam (Green River watershed)	91
55	HY10	Richland Creek at West Waynesville	91
56	LL2	Hickory Creek at Bat Cave (Broad River watershed)	91
57	LL3	Broad River at Bat Cave	91
			Good
58	H23	Big Willow Creek at Patterson Rd	89
59	H26	Brittain Creek at Patton Park (Mud Creek watershed)	89
60	B38	Swannanoa River at Bull Creek	88
61	H21	Mud Creek at Berea Church Road	88
62	LJ2	Catawba River at US 221A	88
63	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	88
64	NOT2	Arkaqua Creek	88
65	P1	White Oak Creek at SR 1137/Houston Road	88
66	Toe1	Cane Creek at Bakersville	88
67	Toe5	Cane River at MH High Sch	88
68	TU10	Barker's Creek (Tuckasegee River watershed)	88
69	TU14	Deep Creek (Tuckasegee River watershed)	88
70	TU5	Tuckasegee River upstream from Scott's Creek	88
71	B1A	Big Ivy Creek at Forks of Ivy	87
72	B43	Ross Creek at Swannanoa River (Swannanoa R wtrshd)	87
73	H3	Mud Creek at Erkwood Road	87
74	LL5	Broad River at Lake Lure	87
75	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	87
76	B16A	Cane Creek at Mills Gap Road	86
77	H15	Bat Fork Creek at Tabor Road (Mud Creek watershed)	86
78	TU4	Cullowhee Creek (Tuckasegee River watershed)	86

Appendix D: Stream Ranking Index - continued

79	B30	Grassy Branch (Swannanoa River watershed)	85
80	B5A	Ox Creek at Reems Creek (Reems Creek watershed)	85
81	H29	Brandy Branch at Mills River Village (Mills River watershed)	85
82	J4	Pine Creek/Pine Creek Rd br (Tuckasegee R wtrshd)	85
83	LJ12	North Fork of the Catawba River below Limekiln Creek	85
84	LL15	Buffalo Creek at Bald Mtn Lake (Broad R watershed)	85
85	P5	Horse Creek at SR 1516 (River Road) N Pacolet R wtrshd)	85
86	TU2	West Fork Tuckasegee River	85
87	Toe2	Cane Creek at Loafer's Glory	84
88	H14	Boylston Creek at Ladson Road	83
89	H5	Clear Creek at Nix Road (Mud Creek watershed)	83
90	H8	South Fork Mills River	83
91	HY11	Richland Creek at Lake Junaluska	83
92	HY9	Plott Creek in Hazelwood (Richland Crk watershed)	83
93	LJ4	Catawba River at Resistoflex	83
94	LL4	Broad River at Chimney Rock	83
95	NOT6	Anderson Creek	83
96	P15	North Pacolet River at Melrose	83
97	P16	North Pacolet River at Rte 108	83
98	TU11	Connelley Creek (Tuckasegee River watershed)	83
99	TU12	Tuckasegee River downstream from Bryson City	83
100	TU9	Tuckasegee River at Barker's Creek	83
101	B15A	Cane Creek at Hwy 74 (FBR watershed)	82
102	B23	French Broad River at Jean Webb Park - Asheville	82
103	H22	Hoopers Creek at Jackson Rd (Cane Creek watershed)	82
104	H28	Shaw Creek at Hunters Glen	82
105	HY31	Beaverdam Creek just downstream from I-40	82
106	LL1	Reedypatch Creek at Bat Cave (Broad River watershed)	82
107	P9	Joels Creek upstream (N. Pacolet Rvr watershed)	82
108	TU15	Oconoluftee River (Tuckasegee River watershed)	82
109	B21	Paint Fork at Barnardsville (Ivy River watershed)	81
110	H1	French Broad River at Banner Farm Road in Horseshoe	81
111	HY12	Jonathan Creek near confluence with Pigeon River	81
112	HY27	Jonathan Creek at Maggie Valley	81
113	P7	North Pacolet River at SR 1516 (S River Rd)	81
114	TU7	Savannah Creek (Tuckasegee River watershed)	81
115	B40	Ross Creek at Lower Chunns Cove Rd(Swannanoa R wtrshd)	80
116	B41	Ross Creek at Tunnel Road (Swannanoa River watershed)	80
117	H20	Clear Creek at Apple Valley Rd (Mud Crk watershed)	80
118	LJ3	North Fork of the Catawba River at SR 1552	80

			<u>Average</u>
119	B15B	Ashworth Creek at Hwy 74 & Cane Crk Rd (Cane Ck wtrshd)	79
120	M4	East Fork Bull Creek (Ivy River watershed)	79
121	TU13	Kirkland Creek (Tuckasegee River watershed)	79
122	TU8	Green's Creek (Tuckasegee River watershed)	79
123	B10	Bull Creek at Swannanoa River (Swannanoa R wtrshd)	78
124	B35	Smith Mill Creek at Louisiana Blvd.	78
125	B6B	Reems Creek at French Broad River	78
126	HY6	Rush Fork at Crabtree (Crabtree Creek watershed)	78
127	P4	White Oak Creek at SR 1322 (Moore Road)	78
128	P8	Demannu Creek at SR 1140 and Hwy 9 (Green River wtrshd)	78
129	B27	Flat Creek at NC 19/23	77

Appendix D: Stream Ranking Index - continued

130	H27	Mill Pond Creek at South Rugby Road	77
131	H30	Devils Fork at Dana Road (Mud Creek watershed)	77
132	HY25	Raccoon Creek downstream (Richland Creek watershed)	77
133	M11	Bull Creek (Ivy River watershed)	77
134	P2	White Oak Creek at SR 1531 (Fox Mt Rd)	77
135	B12B	French Broad River at Bent Creek	76
136	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	76
137	B2	Lower Sandymush Creek	76
138	B34	Lower Hominy Creek at NC 191	76
139	B9B	Swannanoa River at Beetree Creek	76
140	H18	Mud Creek at 7th Avenue	76
141	HY24	Raccoon Creek upstream (Richland Creek watershed)	75
142	HY26	Crabtree Creek at Crabtree Rd	75
143	B47	Reed Creek at entrance to UNCA	74
144	B7A	Reed Creek at UNCA Botanical Gardens	74
145	B8	Beaverdam Creek at Beaver Lake	74
146	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	74
147	LJ13	North Fork of the Catawba River at Old Linville Rd	74
148	B25	South Turkey Creek (Sandymush Creek watershed)	73
149	H2	French Broad River at Butler Bridge Road	73
150	M15	Paint Fork at Beech Glen (Ivy River watershed)	73
151	P14	White Oak Creek at Briar Hill Farm	73
152	P18	Camp Creek (Green River watershed)	73
153	B26	North Turkey Creek (Sandymush Creek watershed)	72
154	H25	Gash Creek at Etowah School Road	72
155	HY32	Beaverdam Creek upstream	72
156	HY4	Pigeon River downstream from Canton	72
157	M13	California Creek at Beech Glen (Ivy River watershed)	72
158	NOT4	Butternut Creek	72
159	B1B	Little Ivy Creek (Ivy River watershed)	71
160	Toe4	North Toe River at Red Hill	71
161	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	70
162	M12	Grapevine Creek (Ivy River watershed)	70
163	M14	Middle Fork at Beech Glen (Ivy River watershed)	70
			Below Average
164	B14	Lower Flat Creek	69
165	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	69
166	M19	Laurel Valley Creek (Laurel River watershed)	69
167	M20	Puncheon Fork (Laurel River watershed)	69
168	M3	French Broad River at Hot Springs	69
169	HY7	Fines Creek downstream	68
170	B32	French Broad River at Walnut Island Park	67
171	B6A	French Broad River at the Ledges Park	67
172	HY19	Fines Creek upstream	67
173	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	67
174	Toe6	Bald Creek at Bald Crk Elem	67
175	TU6	Scott's Creek (Tuckasegee River watershed)	67
176	HY5	Pigeon River at Hepco Bridge	66
177	H4	Mud Creek at North Rugby Road	65
178	HY28	Hyatt Creek left branch	65
179	B4	Lower Newfound Creek	64
180	HY15	Fines Creek midstream	64

Appendix D: Stream Ranking Index - continued

181	B13	French Broad River at Corcoran Park (Hend/Bunc line)	62
182	H16	Cane Creek at Howard Gap Road	62
183	B37	Newfound Creek at Leicester Hwy	61
184	M17	Gabriel's Creek at Ivy River	61
185	B36	Newfound Creek at Dark Cove Road	60
186	B3B	Sandymush Creek at Willow Creek	60
187	HY14	Rush Fork upstream (Crabtree Crk watershed)	60
188	M2	French Broad River at Barnard Bridge	60
189	P10	Joels Creek downstream (N Pacolet River watershed)	60

			Poor
190	HY20	Cove Creek at NC 209 (Fines Creek watershed)	58
191	B48	South Creek Pond/Beaver Lake (Beaverdam Crk wtrshd)	56
192	HY22	Hyatt Creek downstream (Richland Creek watershed)	56
193	HY29	Hyatt Creek Owl Ridge branch	56
194	M1	Ivy River at NC 25/70	56
195	HY30	Hyatt Creek Green Valley branch	52
196	HY21	Hyatt Creek upstream (Richland Creek watershed)	51
197	B39	South Creek at Beaver Lake (Beaverdam Crk watershed)	49

	Percent - Excellent	Good	Average	Below Average	Poor
Buncombe	20	22	36	18	4
Henderson	29	46	18	7	0
Haywood	18	17	24	24	17
Hiwassee	100	0	0	0	0
Jackson/Lake Glenville	86	14	0	0	0
Lake James	29	57	14	0	0
Lake Lure	45	55	0	0	0
Madison	0	0	50	42	8
Nottely	67	22	11	0	0
Polk	14	43	36	7	0
Tuckasegee River	13	67	13	7	0
Toe	17	50	17	16	0
TOTAL	29	31	23	13	4

Appendix E: Data Summary

Site the number assigned to the VWIN site
 Sample # the number of samples collected for each parameter
 Low minimum value of any sample(s)
 Median median value for each site for last 3 years and then for all years monitored
 High maximum value of any sample(s)

		pH - Last 3 Years			All Results		Alkalinity - Last 3 Years/rept. limit 1 mg/L					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	6.4	6.7	7.4	186	6.8	1	36	6	12	20	188	15
2	36	6.2	6.7	7.2	195	6.8	2	36	6	17	27	196	16
3	36	6.5	6.7	7.1	197	6.7	3	36	10	19	25	200	17
4	36	6.6	6.9	7.3	190	6.9	4	36	14	27	38	191	24
5	36	6.6	6.9	7.2	188	6.9	5	36	8	25	33	189	21
7	36	6.2	6.8	7.1	197	6.8	7	36	5	9	18	198	9
8	36	6.2	6.6	7.1	195	6.6	8	36	3	10	58	196	10
9	36	6.2	6.6	7.0	199	6.7	9	36	5	10	16	200	10
10	36	6.2	6.6	7.0	202	6.7	10	36	3	11	19	202	10
11	36	6.2	6.6	6.8	174	6.6	11	36	1	15	21	175	14
12	36	6.3	6.7	7.1	190	6.7	12	36	7	13	17	190	12
13	36	6.4	6.9	7.4	191	7.1	13	36	13	22	28	191	19
14	36	6.5	6.9	7.4	187	7.0	14	36	14	21	29	187	18
15	36	6.4	6.7	7.0	183	6.7	15	36	10	22	27	184	20
16	36	6.7	7.0	7.4	181	7.1	16	36	19	28	41	180	26
18	35	6.5	6.9	7.2	176	6.9	18	35	14	22	29	179	20
19	36	6.5	6.8	7.1	138	6.8	19	36	7	14	20	139	12
20	36	6.4	6.8	7.1	157	6.9	20	36	11	19	25	158	16
21	35	6.6	6.8	7.2	125	6.8	21	35	12	20	25	125	18
22	35	6.6	6.8	7.1	132	7.0	22	35	16	29	40	132	24
23	35	6.3	6.8	7.2	125	6.8	23	35	13	17	26	125	16
24	11	6.5	6.7	6.8	82	6.7	24	11	10	12	18	82	14
25	35	6.5	6.8	7.1	129	6.8	25	35	22	35	49	129	31
26	35	6.6	6.9	7.3	125	7.0	26	35	23	28	40	125	27
27	34	6.7	7.0	7.3	130	7.1	27	34	29	39	53	130	35
28	34	6.6	7.0	7.3	127	7.0	28	34	18	26	35	128	24
29	35	6.0	6.9	7.8	128	6.8	29	35	7	15	78	129	14
30	35	6.5	6.8	7.7	130	6.8	30	35	22	32	42	131	30
LL1	36	6.8	7.2	7.8	159	7.3	LL1	36	15	23	32	159	22
LL2	35	6.5	7.1	8.9	158	7.2	LL2	35	10	17	24	158	16
LL3	35	6.7	7.2	7.9	158	7.2	LL3	35	10	17	26	158	16

Appendix E: Data Summary – continued

Turbidity (NTU) - Last 3 Years/rept. limit 1 NTU					All Results		TSS (mg/L) - Last 3 Years/rept. limit 4 mg/L					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	3.0	8.4	60	188	9.0	1	36	<4	8.2	61.2	187	9.6
2	36	3.7	8.0	190	196	9.0	2	36	<4	6.4	214.8	195	9.6
3	36	2.7	6.2	26	200	7.0	3	36	<4	4.0	50.4	199	6.4
4	36	2.9	8.2	90	191	11.0	4	36	<4	7.2	77.2	190	9.6
5	36	2.3	5.3	17	188	7.0	5	36	<4	3.4	21.6	187	5.4
7	36	1.3	3.0	10	198	2.8	7	36	<4	1.6	8.4	195	2.0
8	36	1.2	2.7	24	196	3.1	8	36	<4	1.2	19.2	193	2.0
9	36	1.1	3.4	23	201	3.1	9	36	<4	2.0	24.8	199	2.0
10	36	<1	3.4	27	203	3.5	10	36	<4	2.6	33.2	199	2.8
11	36	1.8	3.8	14	175	3.7	11	36	<4	1.6	8.8	174	1.6
12	36	1.5	3.4	45	191	3.0	12	36	<4	1.4	12.8	189	1.6
13	36	1.0	4.0	16	192	4.0	13	36	<4	2.0	49.6	190	3.6
14	36	3.2	7.3	70	188	7.3	14	36	<4	5.0	73.2	188	6.0
15	36	1.7	6.1	19	184	5.8	15	36	<4	2.0	12.4	182	2.8
16	36	2.7	7.3	650	181	7.2	16	36	<4	4.4	560.4	180	5.2
18	35	2.5	7.4	70	179	7.4	18	35	<4	6.4	78.8	178	6.8
19	36	2.2	4.5	45	139	4.1	19	36	<4	2.8	23.2	135	2.8
20	36	1.7	5.3	70	158	5.2	20	36	<4	3.2	57.6	156	4.4
21	35	2.2	5.4	17	125	6.0	21	35	<4	4.4	24.4	125	6.8
22	35	2.4	6.3	45	132	5.6	22	35	<4	4.8	47.2	132	4.9
23	35	2.3	5.4	24	125	5.1	23	35	<4	4.4	68.0	125	4.8
24	11	3.0	5.9	12	82	6.3	24	11	<4	4.4	11.6	82	5.9
25	35	6.9	9.6	29	129	9.7	25	35	<4	4.4	16.0	129	5.6
26	35	1.8	3.3	29	125	3.5	26	35	<4	1.6	22.8	125	2.0
27	34	2.3	5.4	70	130	5.0	27	34	<4	2.8	89.6	130	3.0
28	34	1.9	3.5	75	128	4.0	28	34	<4	2.4	69.6	128	2.8
29	35	2.3	4.8	50	130	5.0	29	35	<4	4.0	26.8	130	5.2
30	35	4.1	7.2	70	131	7.2	30	35	<4	3.2	38.4	131	4.4
LL1	36	1.2	4.7	85	159	4.3	LL1	36	<4	4.0	60.8	160	3.6
LL2	35	1.3	5.9	21	158	5.2	LL2	35	<4	4.8	21.6	159	6.8
LL3	35	1.0	5.4	27	158	5.1	LL3	35	<4	4.8	27.6	159	5.6

Appendix E: Data Summary – continued

Conductivity - Last 3 Years/rept. limit 10 umhos/cm					All Results		Copper (ppb) - Last 3 Years/rept. limit 2 ppb					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	21	27	42	188	33	1	36	<2	1.0	3.7	187	1.5
2	36	24	36	69	196	40	2	36	<2	2.2	11.9	196	1.7
3	36	31	41	48	200	40	3	36	<2	0.8	3.3	198	1.0
4	36	61	78	131	191	72	4	36	<2	1.7	4.5	191	1.6
5	36	52	61	69	189	56	5	36	<2	0.8	3.8	188	0.8
7	36	13	16	24	198	15	7	36	<2	0.4	2.6	197	0.5
8	36	12	15	130	196	15	8	36	<2	0.4	5.3	195	0.3
9	36	13	16	21	200	16	9	36	<2	0.3	2.0	200	0.3
10	36	15	18	41	202	18	10	36	<2	0.5	8.9	202	0.6
11	36	23	29	34	175	27	11	36	<2	0.5	6.9	174	0.4
12	36	19	23	30	190	22	12	36	<2	0.3	3.4	190	0.3
13	36	38	45	55	191	44	13	36	<2	0.5	2.4	191	0.5
14	36	35	46	90	187	41	14	36	<2	0.6	2.8	188	0.7
15	36	31	70	191	183	72	15	36	<2	0.8	2.4	183	1.0
16	36	57	69	132	180	62	16	36	<2	2.6	29.6	180	0.9
18	35	31	53	76	179	49	18	35	<2	1.9	5.3	177	1.5
19	36	21	27	33	139	25	19	36	<2	0.7	6.4	137	0.4
20	36	34	43	50	158	39	20	36	<2	0.7	12.1	157	0.6
21	35	32	44	88	125	43	21	35	<2	0.4	<2	124	0.5
22	35	48	61	84	132	58	22	35	<2	0.9	2.3	131	1.0
23	35	30	36	40	125	32	23	35	<2	0.8	3.5	124	0.5
24	11	24	28	30	82	26	24	11	<2	0.8	2.9	81	1.2
25	35	66	80	98	129	79	25	35	<2	1.0	3.0	128	1.3
26	35	70	76	240	125	74	26	35	<2	0.7	<2	124	0.9
27	34	60	217	275	130	183	27	34	<2	0.9	3.4	130	0.7
28	34	56	64	72	128	62	28	34	<2	0.3	2.2	127	0.4
29	35	39	57	157	130	61	29	35	<2	0.5	2.4	129	0.8
30	35	60	85	118	131	82	30	35	<2	1.6	4.9	129	1.7
LL1	36	42	51	65	159	50	LL1	36	<2	0.4	2.5	157	0.5
LL2	35	29	35	47	158	34	LL2	35	<2	0.6	<2	156	0.5
LL3	35	27	33	43	158	31	LL3	35	<2	0.5	<2	156	0.5

Appendix E: Data Summary – continued

Lead (ppb) - Last 3 Years/rept. limit 1 ppb					All Results		Zinc - Last 3 Years/rept. limit 20 ppb					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	<1	0.7	3.9	187	1.0	1	36	<20	4.0	25.0	186	7.4
2	36	<1	1.2	7.7	195	1.0	2	36	<20	10.0	63.3	196	7.9
3	36	<1	0.4	35.9	199	0.4	3	36	<20	2.3	121.2	199	3.0
4	36	<1	1.0	3.9	191	0.9	4	36	<20	7.0	33.8	191	8.2
5	36	<1	0.5	2.1	189	0.5	5	36	<20	4.6	<20	188	5.3
7	36	<1	0.3	8.1	198	0.2	7	36	<20	1.2	<20	198	1.5
8	36	<1	0.2	1.7	196	0.2	8	36	<20	0.7	123.0	196	1.2
9	36	<1	0.1	5.2	201	0.2	9	36	<20	0.0	<20	201	1.2
10	36	<1	0.3	7.7	203	0.3	10	36	<20	1.6	82.2	203	2.5
11	36	<1	0.2	1.6	175	0.2	11	36	<20	0.6	20.0	175	0.9
12	36	<1	0.3	1.9	191	0.2	12	36	<20	1.5	<20	191	2.1
13	36	<1	0.3	1.6	192	0.3	13	36	<20	1.5	35.2	192	1.8
14	36	<1	0.4	3.3	188	0.4	14	36	<20	2.3	32.3	188	3.5
15	36	<1	0.4	2.1	184	0.4	15	36	<20	4.5	21.1	184	7.5
16	36	<1	0.9	19.8	181	0.5	16	36	<20	8.9	102.2	181	4.2
18	35	<1	0.7	11.4	178	0.7	18	35	<20	5.9	34.0	178	6.5
19	36	<1	0.3	4.1	138	0.4	19	36	<20	3.2	38.8	138	3.2
20	36	<1	0.5	8.2	158	0.4	20	36	<20	2.5	82.9	158	2.4
21	35	<1	0.3	1.3	125	0.4	21	35	<20	2.4	<20	125	2.4
22	35	<1	0.7	56.3	132	0.6	22	35	<20	3.1	210.8	132	3.5
23	35	<1	0.6	4.8	125	0.3	23	35	<20	5.8	129.3	125	2.3
24	11	<1	0.6	1.5	82	0.9	24	11	<20	2.6	<20	82	5.9
25	35	<1	0.6	1.5	129	0.7	25	35	<20	8.9	22.1	129	13.2
26	35	<1	0.3	2.1	125	0.3	26	35	<20	4.1	<20	125	4.8
27	34	<1	0.3	2.9	130	0.3	27	34	<20	4.3	<20	130	5.5
28	34	<1	0.3	5.5	128	0.2	28	34	<20	1.7	35.3	128	2.2
29	35	<1	0.2	1.3	129	0.3	29	35	<20	3.5	92.2	129	5.3
30	35	<1	0.7	7.0	131	0.8	30	35	<20	5.7	<20	131	6.8
LL1	36	<1	0.3	1.6	159	0.2	LL1	36	<20	0.6	<20	158	0.6
LL2	35	<1	0.4	1.4	158	0.3	LL2	35	<20	1.5	34.2	157	0.9
LL3	35	<1	0.3	3.7	158	0.2	LL3	35	<20	1.1	36.1	157	0.3

Appendix E: Data Summary – continued

Orthophosphate (mg/L as PO4)-Last 3 Yrs/rept. lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	36	<0.02	0.05	0.22	186	0.04
2	36	<0.02	0.12	0.63	194	0.07
3	36	<0.02	0.02	0.13	198	0.05
4	36	0.02	0.41	2.03	190	0.33
5	36	<0.02	0.07	0.30	187	0.06
7	36	<0.02	0.01	0.10	196	0.02
8	36	<0.02	0.02	8.20	194	0.03
9	36	<0.02	0.01	0.10	200	0.03
10	36	<0.02	0.02	0.08	201	0.03
11	36	<0.02	0.02	0.31	173	0.02
12	36	<0.02	0.03	0.26	189	0.03
13	36	<0.02	0.03	0.28	190	0.04
14	36	<0.02	0.04	0.15	187	0.05
15	36	<0.02	0.04	0.18	182	0.06
16	36	<0.02	0.05	0.40	179	0.06
18	35	<0.02	0.03	0.15	177	0.05
19	36	<0.02	0.02	0.17	139	0.03
20	36	<0.02	0.07	0.40	158	0.06
21	35	<0.02	0.05	0.20	125	0.08
22	35	<0.02	0.08	0.21	132	0.09
23	35	<0.02	0.05	0.22	125	0.07
24	11	0.02	0.08	0.18	82	0.10
25	35	0.02	0.18	0.49	129	0.18
26	35	<0.02	0.04	0.14	125	0.05
27	34	0.04	0.12	0.44	130	0.12
28	34	<0.02	0.06	0.16	128	0.07
29	35	<0.02	0.05	0.74	130	0.10
30	35	<0.02	0.06	0.20	131	0.09
LL1	36	<0.02	0.06	0.17	159	0.07
LL2	35	<0.02	0.07	0.19	158	0.09
LL3	35	0.02	0.07	0.19	158	0.08

Appendix E: Data Summary – continued

<u>Ammonia-nitrogen (mg/L) - Last 3 Years/rept. lim. 0.02 mg/L</u>					<u>All Results</u>		<u>Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/rept. limit 0.1 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>	<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	36	0.06	0.14	0.24	185	0.13	1	36	<0.1	0.3	0.6	186	0.3
2	36	0.05	0.14	0.39	194	0.13	2	36	0.1	0.5	1.6	194	0.5
3	36	0.05	0.11	0.21	198	0.12	3	36	0.1	0.4	0.6	198	0.5
4	36	0.07	0.17	0.30	190	0.17	4	36	0.2	1.0	2.2	190	1.0
5	36	0.05	0.11	0.21	187	0.09	5	36	0.5	0.9	1.2	187	0.8
7	36	<0.02	0.05	0.13	196	0.03	7	36	<0.1	0.1	0.3	196	0.1
8	36	0.02	0.06	9.40	194	0.06	8	36	<0.1	0.2	0.8	194	0.1
9	36	0.02	0.06	0.24	200	0.04	9	36	<0.1	0.1	0.3	200	0.1
10	36	0.02	0.06	0.25	201	0.05	10	36	<0.1	0.2	0.6	201	0.2
11	36	0.04	0.10	0.19	173	0.06	11	36	<0.1	0.2	0.3	173	0.2
12	36	0.02	0.05	0.21	189	0.04	12	36	<0.1	0.2	0.9	188	0.2
13	36	0.02	0.06	0.16	190	0.05	13	36	0.1	0.5	0.9	189	0.5
14	36	0.05	0.09	0.31	187	0.09	14	36	0.1	0.6	0.9	187	0.5
15	36	0.04	0.12	0.44	182	0.10	15	36	0.5	1.2	2.0	182	1.3
16	36	0.03	0.13	1.30	179	0.10	16	36	0.2	0.5	2.4	179	0.5
18	35	0.08	0.13	0.27	177	0.13	18	35	0.2	0.5	0.7	177	0.5
19	36	0.02	0.07	0.22	139	0.06	19	36	<0.1	0.2	0.6	139	0.2
20	36	0.02	0.08	0.29	157	0.07	20	36	<0.1	0.7	1.0	158	0.6
21	35	0.04	0.08	0.24	125	0.10	21	35	0.2	0.5	0.9	125	0.5
22	35	0.05	0.13	0.23	132	0.11	22	35	0.2	0.5	0.7	132	0.5
23	35	0.04	0.09	0.18	125	0.08	23	35	0.2	0.3	0.7	125	0.3
24	11	0.03	0.07	0.14	82	0.11	24	11	0.1	0.1	0.4	82	0.2
25	35	0.07	0.20	1.29	129	0.23	25	35	0.1	0.6	1.6	129	0.8
26	35	0.03	0.07	0.21	125	0.08	26	35	0.5	0.8	1.1	125	0.8
27	34	0.05	0.11	0.28	130	0.10	27	34	0.1	0.8	1.1	130	0.8
28	34	0.02	0.07	0.23	128	0.08	28	34	<0.1	0.5	0.8	128	0.6
29	35	0.02	0.07	0.36	130	0.12	29	35	0.1	0.9	1.8	130	1.1
30	35	0.06	0.18	0.29	131	0.18	30	35	0.4	1.0	1.5	131	1.1
LL1	36	<0.02	0.05	0.17	159	0.05	LL1	36	0.2	0.4	1.6	159	0.4
LL2	35	<0.02	0.05	0.13	158	0.05	LL2	35	<0.1	0.2	0.5	158	0.2
LL3	35	<0.02	0.06	0.30	158	0.06	LL3	35	<0.1	0.1	0.4	158	0.1

Appendix F: Trends for Each Site Related to Flow

site #	site name	increases as flow increases										decreases as flow increases												
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
	Green/Broad River watershed																							
12	Green River upstream			X	X				X					X							X			
19	Green River above L Summit			X	X									X										
11	Green River below L Summit			X	X				X					X									X	
13	Big Hungry River	X		X	X									X									X	
LL1	Reedypatch Creek			X	X									X							X		X	
LL2	Hickory Creek			X	X				X					X							X		X	
LL3	Broad River			X	X				X					X							X		X	
	Mud Creek watershed																							
21	Mud Creek at Berea Ch Rd			X	X			X	X	X				X							X		X	
3	Mud Creek at Erkwood Road			X	X			X						X							X		X	
18	Mud Creek at 7th Ave/H'ville			X	X				X	X				X									X	
15	Bat Fork Creek				X									X										X
30	Devil's Fork			X	X			X		X				X									X	
26	Brittain Creek								X					X										
20	Clear Creek upstream				X				X					X							X			
5	Clear Creak downstream			X	X			X	X	X				X							X			
4	Mud Creek at N Rugby Rd			X	X				X					X							X		X	
	Mills River watershed																							
7	North Fork Mills River				X									X										
8	South Fork Mills River			X	X																			
9	Mills River at 191/280			X	X									X									X	
29	Brandy Branch					X			X					X									X	
10	Mills River at Hooper Ln			X	X																			

Appendix F: Trends for Each Site Related to Flow - continued

site #	site name	increases as flow increases										decreases as flow increases												
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
	Cane Creek watershed																							
22	Hooper's Creek			X	X			X	X				X											
16	Cane Creek/Howard Gap Rd			X	X			X				X	X											
	Etowah/Horseshoe																							
23	Big Willow Creek																				X			
24	Little Willow Creek				X									X								X		
25	Gash Creek			X										X							X			
28	Shaw Creek				X		X		X				X	X							X			
27	Mill Pond Creek			X	X				X			X		X							X			
14	Boylston Creek			X	X			X					X	X										
	French Broad River																							
1	French Broad River/Horseshoe			X	X		X	X				X		X							X			
2	French Broad River/Mt Home			X	X			X				X		X							X			

Appendix G: Trends for Each Site Related to Time

site	site name	increasing over time										decreasing over time												
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
	Green/Broad River watershed																							
12	Green River upstream																				X		X	
19	Green River above L Summit															X	X				X		X	
11	Green River below L Summit																						X	
13	Big Hungry River		X															X		X				
LL1	Reedypatch Creek																				X			
LL2	Hickory Creek																				X			
LL3	Broad River																				X			
	Mud Creek watershed																							
21	Mud Creek at Berea Ch Rd																				X	X	X	
3	Mud Creek at Erkwood Road															X					X		X	
18	Mud Creek at 7th Ave/H'ville							X	X	X											X		X	
15	Bat Fork Creek													X							X		X	
30	Devil's Fork																				X	X	X	
26	Brittain Creek															X			X	X	X			
20	Clear Creek upstream																				X			
5	Clear Creak downstream	X																						
4	Mud Creek at N Rugby Rd															X				X		X	X	
	Mills River watershed																							
7	North Fork Mills River	X														X					X			
8	South Fork Mills River																	X						
9	Mills River at 191/280															X	X	X	X	X	X			
29	Brandy Branch	X														X	X				X	X	X	
10	Mills River at Hooper Ln															X					X			

Appendix G: Trends for Each Site Related to Time - continued

site	site name	increasing over time										decreasing over time												
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
	Cane Creek watershed																							
22	Hooper's Creek							X													X			
16	Cane Creek/Howard Gap Rd						X	X	X												X		X	
	Etowah/Horseshoe																							
23	Big Willow Creek								X												X			
24	Little Willow Creek														X	X	X	X	X	X	X	X		
25	Gash Creek													X	X	X	X	X	X	X	X	X	X	
28	Shaw Creek	X													X	X				X	X	X	X	
27	Mill Pond Creek		X																X	X				
14	Boylston Creek																			X	X	X		
	French Broad River																							
1	French Broad River/Horseshoe													X	X			X	X	X	X	X	X	
2	French Broad River/Mt Home								X					X								X	X	

Appendix H: Number of Sites Exhibiting Seasonal Trends

Seasons include the following months:
 winter = December, January, February
 spring = March, April, May
 summer = June, July, August
 fall = September, October, November

Totals for Henderson County Sites

number of sites examined for trends = 28

parameter	high winter	high spring	high summer	high fall	low winter	low spring	low summer	low fall	trend sites	% sites showing trend
pH		1	16	2	19				19	67.9%
alkalinity			2	16	11	7			18	64.3%
turbidity			16		5			11	16	57.1%
total susp sol		1	18	1	14			6	20	71.4%
conductivity	4		2	19	2	22	1		25	89.3%
copper		1	5		5			1	6	21.4%
lead		2	4		3			3	6	21.4%
zinc	5					1	2	2	5	17.9%
orthophos.			4		3	1			4	14.3%
ammonia-N		1	17	5	21	2			23	82.1%
nitrate-N	15		4		1	4	6	8	19	67.9%

Totals for All VWIN Sites Examined for Trends

number of sites examined for trends = 177

parameter	high winter	high spring	high summer	high fall	low winter	low spring	low summer	low fall	trend sites	% sites showing trend
pH	0	2	88	35	104	19	0	2	125	70.6%
alkalinity	0	0	42	94	61	75	0	0	136	76.8%
turbidity	2	28	91	0	60	1	0	60	121	68.4%
total susp sol	0	39	95	1	82	0	0	53	135	76.3%
conductivity	12	4	47	78	22	111	4	4	141	79.7%
copper	1	13	42	0	41	1	1	13	56	34.4%
lead	15	86	405	208	370	207	5	132	40	24.5%
zinc	9	7	17	0	8	5	3	17	33	20.2%
orthophos.	0	9	64	5	55	19	0	4	78	44.1%
ammonia-N	1	6	92	11	91	10	1	8	110	62.1%
nitrate-N	77	9	39	0	11	12	24	78	125	70.6%