REQUEST FOR BOARD ACTION

HENDERSON COUNTY
BOARD OF COMMISSIONERS

MEETING DATE: Monday, June 5, 2006

SUBJECT: ECO/VWIN Report

ATTACHMENTS: Yes

SUMMARY OF REQUEST:

The Environmental & Conservation Organization (ECO) has provided their annual report on the Volunteer Water Information Network (VWIN) for the Board's review. See attached.

BOARD ACTION REQUESTED:

This report is being provided for the Board's information and review. No Board action is necessary.

ENVIRONMENTAL & CONSERVATION ORGANIZATION

ECO • 121 Third Avenue West, Suite 4 • Hendersonville, NC 28792
828-692-0385 • Fax 828-693-0942
e-mail: eco@main.nc.us web site: www.eco-wnc.org

May 10, 2006

Dear County Commissioners,

Attached is a copy of the newspaper article recently published in Hendersonville *Times-News* which presents a description of water quality in two watersheds in Henderson County. That report is based on the Henderson County Volunteer Water Information Network (VWIN) Year-Thirteen Report, which was recently published by the Environmental Quality Institute at UNCA.

The Environmental and Conservation Organization has coordinated the VWIN stream monitoring program in Henderson County for all thirteen years that data has been collected. Each year, Henderson County Commissioners have budgeted financial support to ECO for the VWIN program so that scientific data can be collected and analyzed to produce annual reports on the quality of our mountain streams. We have requested such an allocation in the 2006-07 budget and hope that you will again support the project.

At your upcoming commissioner's meeting, each of you will receive the full 60-page VWIN report. That report is made possible by the work of more than more than 30 volunteers who drive each month (the third Saturday at high noon) to their assigned sites at 33 locations on 28 different streams in Henderson County to take stream samples. They are trained in the method of taking the samples; the samples are then driven to large coolers at one of two locations – Van Wingerden Greenhouses in Mills River or Mr. Pete's Market on Kanuga Street; and then on Monday the samples are picked up by Marilyn Westphal who drives them to the labs at EQI for analysis. The above businesses donate significant space in their coolers for this project each month. Over a year's time, the volunteers donate a total of 420 hours and 1,980 miles as well. The funds donated by the county to the VWIN project are funneled through ECO to pay for analysis of the some of the samples at EQI and for the production of the annual report. Other donors support the project as well.

Marilyn is the coordinator of the VWIN program throughout the French Broad River Basin. She will be available at your commissioner's meeting to give a brief report and to answer questions. Jim and Sharon Spicer are volunteers who coordinate the VWIN program for ECO. You will see that data gathered from ECO's biological monitoring program is added to the VWIN report. Four years ago, ECO received a grant from the Helen Tarasov Reed Fund to support our bio-monitoring project, thus providing an excellent snapshot of the quality of our streams in Henderson County.

We very much appreciate your support of this award-winning program. If you have any questions once you have had time to peruse the report, please phone me at ECO or phone Marilyn Westphal at UNCA – 251-6823. The full report can also be downloaded from ECO's website.

Regards,

Mary Jo Padgett
Executive Director

The Environmental and Conservation Organization is a 501©(3) nonprofit that since 1987 has been dedicated to clean air, clean water, recreation, and the conservation and preservation of the natural heritage and resources of our mountain region.

Recycled Paper

TN 4-24-06

Water quality report shows some gains in area waterways

ECO NOTES

Mary Jo Padgett

The much anticipated annual report on the quality of streams in Henderson County was recently delivered to the office at the Environmental and Conservation Organization in downtown Hendersonville. The Volunteer Water Information Network report is based on monthly samples taken at 33 sites on 28 streams in the county that are analyzed in 11 parameters, and on bio-monitoring data collected at 25 sites during April and October. The stream samples were analyzed at the Environmental Quality Institute labs at UNCA and the report was created by EQI.

ECO volunteers are trained to do both methods of monitoring. Currently, 30 volunteers take the monthly samples for the VWIN program, and 43 volunteers do the bio-monitoring work twice a year. In fact, during this month, you may observe volunteers at many stream sites around the county. ECO volunteers have participated in the VWIN stream monitoring program since 1992. Our biological monitoring program was added in 2001.

Because there isn't space to give the entire report here, condensed reports from two important watersheds are given to reflect some good news with mixed results.

The good news is that the nine monitored sites in the Mud Creek Watershed are beginning to show marked improvement in certain parameters. On the other side of the coin, some sites in the Mills River Watershed, which is a drinking-water supply for thousands of residents in Henderson County, are beginning to deteriorate.

VWIN analysis covers 11 parameters: pH, alkalinity, turbidity, total suspended solids, conductivity, copper, lead, zinc, orthophosphate, ammonia-nitrogen and nitrate/nitrite-nitrogen.

• The Mud Creek Watershed — four sites on Mud Creek, one site on Bat Fork Creek, one site on Devil's Fork, one site on Brittain Creek and two sites on Clear Creek

Mud Creek at the Seventh Avenue and Bat Fork Creek sites, which have historically shown high pollution, now show declining pollutant concentrations. The declines have been most dramatic at the Bat Fork site, although median nitrate/nitrite concentrations are still much higher than average at that site. Median nitrogen concentrations are also somewhat higher than average at the Mud Creek at Seventh Avenue site, as are sediment and heavy metals. Biological monitoring at those sites shows both falling in the "fair" range over the four years of monitoring.

SPECIAL TO THE TIMES-NEWS

ECO volunteers do biological monitoring on the Big Hungry River on a recent Saturday.

Clear Creek at Nix Road rates average, but also reflects a steady increase over time in pollutant concentrations. Biomonitoring reflects a "fair" rating.

Brittain Creek, Devil's Fork and Mud Creek at Erkwood Road have an "average" rating. Relatively poor water clarity has long been an issue at the Devil's Fork site, and conductivity, heavy metals and nitrogen concentrations are higher than average. Water clarity and sediment are also problems in Mud Creek at Erkwood. Sedimentation is less of an issue on Brittain Creek, but conductivity and heavy metals are higher than average.

Although there are many water quality problems in the Mud Creek watershed, trend analysis shows several sites generally improving over time. Sediment levels are declining at the Bat Fork, Devil's Fork and Mud Creek at Seventh Avenue sites, and nutrient concentrations are declining at the Bat Fork site and in Mud Creek at Berea Church Road. Heavy

PLEASE SEE **WATER**, 2D

- Corn
- Oats
- Soybeans
- Late lilac
- Greenspire littleleaf linden

Water

Continued from Page 1D

metals, too, are declining at the Bat Fork, Mud Creek at Erkwood, and Mud Creek at Seventh Avenue.

• The Mills River Watershed — One site on the North Fork, one site on the South Fork, two sites on the Mills River and one site on Brandy Branch

All of the sites on the Mills River and on the North and South Forks rate excellent. In fact, all except the downstream site on Hooper Lane have perfect scores in every category. All sites have an overall biological rating of good, but have fallen from good/excellent to good/fair in the past year. The Mills River suffered significant bank erosion and severe flooding in the lower end of the watershed during the hurricanes in September 2004. This may have adversely affected the macroinvertebrate population.

Brandy Branch rated "average" due to higher-than-average nutrient concentrations and nitrate/nitrite-nitrogen readings, as well as significant sedimentation problems during storms.

Sixteen sites in the watershed are also monitored for stream sedimentation during storms. All the monitored sites show increased sedimentation during storms, but sites on Foster Creek, Brandy Branch and an unnamed tributary along Hall Road, downstream from a large development, showed the greatest sedimentation in 2005.

For complete details of the Year 13 Water Quality Report for Henderson County, visit www.eco-wnc.org or order a copy of the 60-page report by sending $2 for postage and handling to ECO, 121 Third Ave. W., Suite 4, Hendersonville, N.C. 28792.

Funding for the VWIN water quality program is provided by the Henderson County Commissioners, private donors, the Dornick Foundation and the town of Lake Lure. Funding for the biological monitoring program is provided by the Helen Tarasov Reed Fund.

ECO Notes is provided by the Environmental and Conservation Organization, a nonprofit group dedicated to conserving and preserving the natural heritage of the mountain region through education, recreation, civic action and service. For more information, call 692-0385.

D
S

Times-News
697-1346
1-800-849-8050

...fied as Executor of the Estate of Giselle A. Kayne, late of Hendersonville, Henderson County, North Carolina, the undersigned does hereby notify all persons, firms and corporations having claims against the estate of said decedent to exhibit them to the undersigned in care of Diana Armatage Johnston, Esquire, 1612 Asheville Highway, Suite 3, Hendersonville, NC 28791, on or before the 24th day of July, 2006, or this notice will be pleaded in bar of their recovery. All persons, firms and corporations indebted to the said estate will please make immediate payment to the undersigned.

This the 24th day of April, 2006.

David W. Kayne, Executor
of the Estate of Giselle A. Kayne

Diana Armatage Johnston, Esq.
Johnston & McCann PLLC
1612 Asheville Highway
Suite 3
Hendersonville, NC 28791

(08538747) 4/24, 5/1, 5/8, 5/15

CIRCLE THE ADS YOU NEED TO CALL!

...the line of the property now or formerly owned by Whitson as recorded in Deed Book 687, Page 341 Henderson County Registry South 88 deg. 45 min. 18 sec. East 83.30 feet to an existing iron pin; thence down and with the line of the property now or formerly owned by Landers as recorded in Deed Book 553, Page 297 Henderson County Registry South 20 deg. 15 min. 18 sec. East 144.48 feet to an iron pin (passign an iron pin at 115.12 feet); thence South 00 deg. 58 min. 13 sec. East 15.00 feet to an iron pin in the centerline of a 30 foot wide right of way; thence down and with the centerline of the Thirty (30) foot right of way North 89 deg. 26 min. 57 sec. West 193.94 feet to the point and place of BEGINNING containing 0.49 acres more or less as shown upon a survey map by Associated Land Surveyors entitled Survey for Kimberly Denise Long and Daniel Ray Long dated November 5, 1998 and bearing job number: S-88-98 and being a portion of Lot 7 of the Landers property shown on Plat Slide 1004 Henderson County Registry. Subject to and benefitted by a 30 foot wide right of way as shown upon the above referenced survey for road and utility purposes.

And Being more commonly known as: **500 Burns Creek Rd, Etowah, NC 28729**

Times-News*Online*
www.hendersonvillenews.com

Looking for a home?
Sunday Real Estate

Cemetery Lots

One Lot for 2 Cremated Burials. Includes double head stone, urns, & vaults. In Forest Lawn Military Section. $2,000. 606-9247 or 242-7388

ONE Lot for 2 cremated burials. Shepherd's Memorial Park on Hwy 25. $1,000. Call 693-0305

Mtn. Rd. are...
778-1802 or 7...

Jo... Opportu...

ACCEP...
APPLICATIO...
cellent op...
with expanding compa-ny. Industrial background. 12 hour shifts. Temp to hire. Excellent pay. High school diploma and drug screen required. **Call now.**
Asheville Staffing Resources
Hendersonville Office
696-3200

Are Your Hours This Good?
Clean with Merry Maids Mon.-Fri. No nights, weekends, holidays. Earn $8-$12 per hour. Weekly paycheck, bonuses, paid vacation. Car needed, paid mileage. Call Merry Maids: 684-4837

Asheville Staffing Resources
Hendersonville Office
(828) 696-3200

ASSISTED LIVING needs *Part Time 3rd Shift CNA.* 27-30 hours a week. Call 693-5417

ATTENTION:
Fleshers Fairview Healthcare Center now hiring
• 2nd & 3rd Shift Nurses &
• 7-3 CNA's
Call Dawn 628-2800

...small group...
to earn $10...
call 864-542...

Immediate Avail...
Warehouse Operators, ... borers, Pac... ers. Pleas... CYB Service...

Lake Point...
... as the fo... positions ...
Experi... Co...
for Coun... type envi... PT Break... Great wor... ment. Exc...
Wait...
part-time, ... evenings. encourage...
Appl... 333 Thon...

Local Pavin...
ny needs ***L... Dump Truc...***
Must have c... record. Call ...

Water Quality in the Mountains:

Henderson County Volunteer Water Information Network

Year-Thirteen Report

Steven C. Patch
Marilyn J. Westphal
Tamara Pandolfo
Jillian Fishburn
Elizabeth Wilcox

Technical Report #06-159
APRIL 2006

ENVIRONMENTAL QUALITY INSTITUTE

THE UNIVERSITY OF NORTH CAROLINA AT ASHEVILLE

TABLE OF CONTENTS

APPENDICES

Acknowledgments

We wish to thank the Henderson County Board of Commissioners, the Dornick Foundation, 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 Dave and Betty Bucher, Carl Kalitta, William Tharp, Richard Freudenberger, Sue and Walter Mahnken, Dick Black, Joe Boterf, Jim and Sharon Spicer, Bill Moore, Peter Colburn, Beth and Dave Harris, Denise Sherrill, Marilyn Westphal, Collette Summitt, Betty Shevick, Glenn Musser, Karen and Phil Cutright, Mary Landry, Lee Johnson, Richard and Brenda Cross, and Mandy Walline. In 2002 many more volunteers were added to the water testing program in Henderson County to add biological monitoring of many of the VWIN sites to the database. 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 past to Michelle Skeele who has graciously allowed the program to use her porch as a kit storage area, and to the county coordinator Jim and Sharon Spicer who have consistently ensured that all samples were collected each month. Thanks also to Mr. Gatti's Restaurant, Mr. Pete's Market VIII, and VanWingerden International for providing cold storage space for water monitoring kits. We also thank Angela Fernandini who was hired by ECO through AmeriCorps to be its Water Quality Administrator. Angela helped coordinate all ECO's water quality programs, including the bio-monitoring project.

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 Sierra Club of Transylvania County, the Lakefront Property Owners 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. Since that time most of the other counties in Western North Carolina have established sites to bring the total currrent total number of sites to over 200. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Catawba, Tuckasegee, New, Hiawassee, 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 15 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 nine years of water quality data. This annual report represents statistical analyses and interpretation of twelve years data gathered from August 1992 through July 2005 from the current sites in the county.

In 2002, the Environmental and Conservation Organization (ECO) initiated a biological stream monitoring program to augment VWIN testing in Henderson County. Biological monitoring involves collecting, identifying, and counting benthic macroinvertebrates living on the rocks and substrates on the bottoms of streams. Most of these organisms are the larval stages of insects, although they may also include crustaceans, mollusks, and other aquatic animals. Researchers have found that some species are very sensitive to pollutants while others are quite tolerant. Therefore, knowing what organisms are living in a stream is a good indicator of the health of the stream. While chemical analysis provides a snapshot of a stream at the specific time of sampling and can identify specific pollutants, biological monitoring gives a picture of the long-term effects of pollutants on stream life.

The ECO biological stream monitoring program, funded by the Helen Tarazov Reed Fund, utilizes the Save Our Streams (SOS) program of the Izaak Walton League of America (IWLA). This system provides water quality ratings based on the pollution tolerance levels of the organisms found and the diversity of the organisms in the sample. The original design (scope) of the program was to sample 15 to 20 sites two times per year and to sample at VWIN sites, if possible. In actual practice, seven teams of 3-5 volunteers each (or nearly 30 volunteers) sampled and analyzed 23 sites in April and October. Of these sites, 19 are VWIN sites and are noted with (*) in Table 1. Additional biological monitoring sites <u>not</u> located at VWIN sites are:

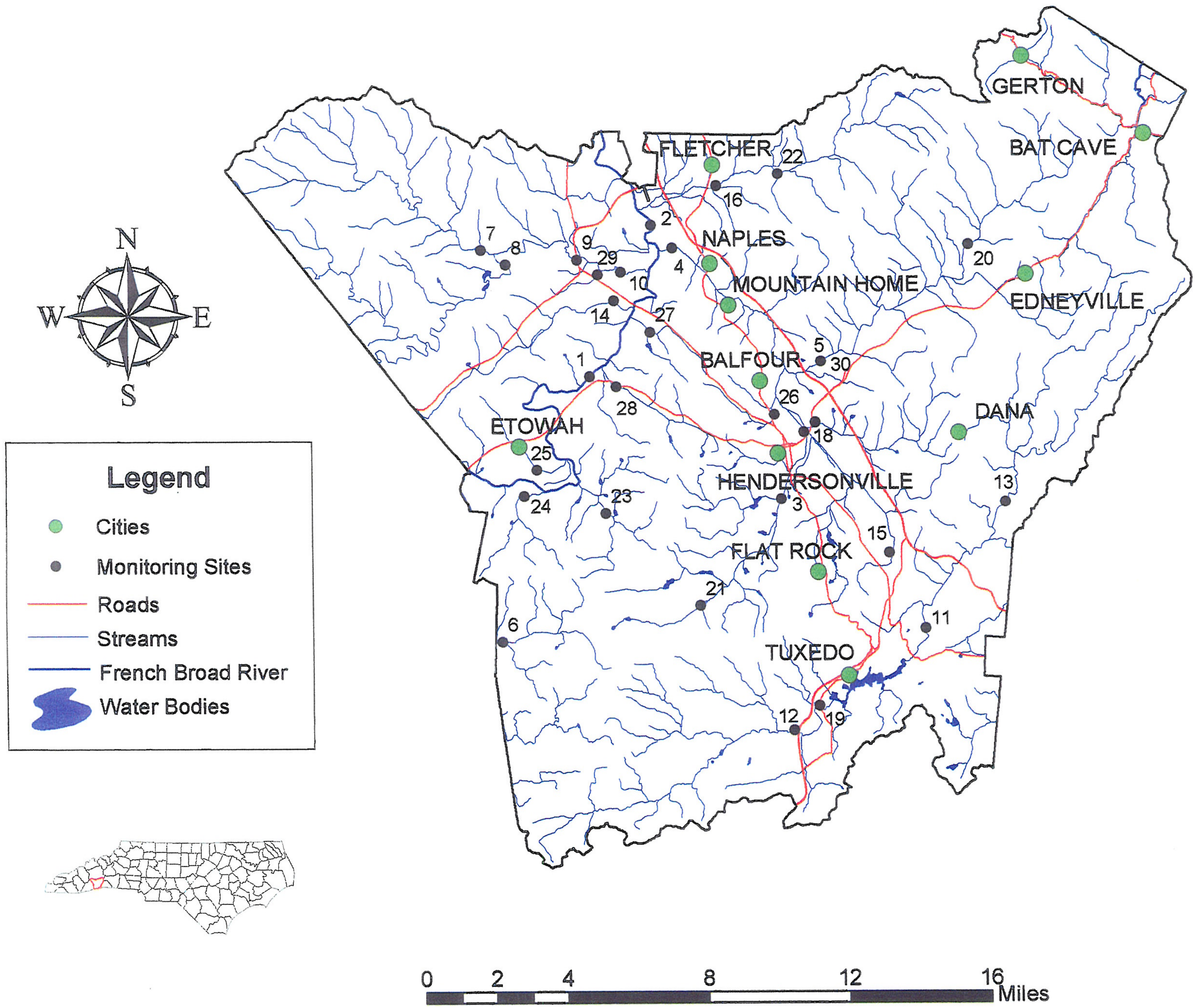
- Clear Creek at Bearwallow Rd. & Smith Rd.
- Clear Creek at Lancaster Rd. (near NHHS)
- Rock Creek (at private campground) on Rock Creek Rd.
- Green River at Bob's Creek Rd. (near Cedar Springs Baptist Church)
- Little Hungry River
- Big Hungry River upstream

The biological summary information given in this report is the result of four sampling campaigns and represents the beginning of baseline data. Several more sets of data will be required to provide a valid and reliable database from which deviations can be analyzed. However, this report will provide general observations based on experience to date.

Table 1: Location of Henderson Co. VWIN sites

Site#	Approximate Stream Location
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
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 VWIN 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.

Biological Monitoring

Prior to the initial sampling, volunteers attend a training workshop conducted by David Dudek, Haywood Community College instructor and certified biologist. Additional training is provided through hands-on instruction by the coordinator at the stream sites. New volunteers are trained in review sessions available to all volunteers before each sampling campaign and trained individually at the sites. The coordinator works with each team during the sampling period to insure consistency in procedures, identification, and analysis.

Each of the volunteer teams sample 2 to 4 sites during the April and October sampling campaigns. The specific sampling times during the designated months are left at the discretion of individual teams although the teams are asked to avoid severe weather events. At each site, three separate samples are taken. Each sample is taken at a riffle (a shallow fast-moving area with a depth of 3-12 inches and cobble-sized stone or larger) where the water is highly oxygenated. Only the sample with the highest score and, therefore, the best diversity (greatest number of different kinds of organisms) is recorded. This is to ensure that the sample is truly representative of the organisms present in the stream.

Volunteers use a 3-foot wide kick-seine (a 1/32- inch mesh net with a supporting pole on each side) to collect the benthic macroinvertebrate samples in selected riffle areas. The stream bed, including rocks, sand, and sediment, is disturbed (by rubbing rock surfaces and kicking the substrate) for a distance of 3 feet upstream of the kick-seine to dislodge any attached or burrowing organisms. All detached macroinvertebrates are carried into the net. The net is then carefully removed from the water, taken to shore, and placed in a well-lit area on a light background (i.e. white plastic trash bag). All living organisms are picked out of the net and roughly sorted based on distinguishing features (i.e.numbers of legs, gill location, tail structure, etc.). Plastic ice cube trays or other small containers are helpful in this segregation process. Once all the macroinvertebrates have been removed from the seine and separated into look-alike groups, the organisms are identified, counted, and recorded on a worksheet. The described procedure is then used to collect and analyze two additional samples at the site. These are taken from an upstream or an adjacent riffle to make sure organisms caught are new and not those disturbed from previous tests.

The sample with the highest score or "total index value" is recorded on the Save Our Streams Stream Quality Survey (Appendix C) and used to determine the Water Quality Rating of the site. The total index value for a sample is based on the number of different organisms in each of three pollution-sensitivity categories and a weighted factor for each category: (I) sensitive –3X (II) somewhat sensitive- 2X and (III) tolerant-1X. It should be noted that this result depends primarily on the number of different organisms found (i.e. diversity) and not on the number of individual organisms, as designated by letters, A, B, and C. However, the letters are valuable because they document changes in population over time. The Water Quality Rating for a particular site is related to total index value as follows: Excellent - >22, Good- 17 to 22, Fair - 11 to 16, and Poor - < 11.

III. Results and Discussion

This discussion is based on thirteen years of data gathered between August 1992 and July 2005. 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 12.4 mg/L over the past three years, which is equivalent to 12.4 ppm. Thus if you filter one liter of water from site 1 on average you will collect sediments that weigh 12.4 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 2002 through July 2005 (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 D describes the criteria used for the grading system for each parameter.

Appendix E is a list of all VWIN stream sites monitored in Western North Carolina

Table 2: Classification Grades Based on Parameters and Ranges

Site	Description	pH	Alk	Turb	TSS	Cond	Cu	Pb	Zn	Ortho P	NH3-N	NO3-N
1	French Broad River/Banner Farm Rd	A	D	C	D	A	A	A	B	B	A	B
2	French Broad River/Butler Br Rd	A	D	D	D	B	B	B	B	C	A	B
3	Mud Creek/Erkwood Rd	A	C	C	C	B	A	B	A	B	A	B
4	Mud Creek/N Rugby Rd	A	B	D	D	C	A	A	B	D	A	C
5	Clear Creek/Nix Rd	A	B	B	C	C	B	A	B	B	A	C
6	Crab Creek/Staton Rd	D	D	A	A	A	A	A	A	A	A	A
7	North Fork Mills River	A	D	A	A	A	A	A	A	A	A	A
8	South Fork Mills River	A	D	A	A	A	A	A	A	A	A	A
9	Mills River/Hwy 191	A	D	A	A	A	A	A	A	A	A	A
10	Mills River/Hooper Lane	A	D	B	A	A	B	A	A	A	A	A
11	Green River/down L Summit	A	D	B	A	A	B	A	A	A	A	A
12	Green River/Terry's Ck Rd	A	D	A	A	A	A	B	B	A	A	A
13	Big Hungry River below dam	A	C	B	B	B	A	A	A	B	A	B
14	Boylston Creek/Ladson Rd	A	C	C	C	B	A	A	A	B	A	B
15	Bat Fork Creek/Tabor Rd	A	C	B	A	C	A	A	B	B	A	C
16	Cane Creek/Howard Gap Rd	A	B	C	B	C	A	A	A	B	A	B
17	Cane Creek/Hwy 25	A	B	C	A	C	A	A	B	C	A	B
18	Mud Creek/7th Ave	A	C	B	B	B	B	A	B	A	A	B
19	Green River/Old 25	A	D	B	A	A	B	A	A	A	A	A
20	Clear Creek/Apple Valley Rd	A	C	A	B	B	B	B	A	B	A	B
21	Mud Creek/Berea Church Rd	A	C	C	D	B	B	A	A	B	A	B
22	Hoopers Creek/Jackson Rd	A	B	C	B	C	A	A	A	B	A	B
23	Big Willow Creek/Patterson Rd	A	C	B	B	B	A	A	A	B	A	A
24	Little Willow Creek/River Rd	A	D	B	C	A	B	B	B	B	A	A
25	Gash Creek/Etowah School Rd	A	B	D	B	C	A	A	D	C	C	C
26	Brittain Creek/Patton Park	A	B	C	A	C	A	A	B	B	A	C
27	Mill Pond Creek/S Rugby Rd	A	A	B	A	D	A	A	B	C	B	B
28	Shaw Creek/Hunters Glen	A	B	B	A	C	B	A	A	B	A	B
29	Brandy Branch/Mills R Village	B	C	C	B	C	A	A	B	B	B	C
30	Devil's Fork/Dana Rd	A	B	C	B	C	A	A	B	B	A	C
LL1	Reedypatch Creek at Bat Cave	A	B	B	B	B	A	A	A	B	A	B
LL2	Hickory Creek at Bat Cave	A	C	C	C	B	A	A	A	B	A	B
LL3	Broad River at Bat Cave	A	C	C	B	A	B	A	A	C	A	C

indexed and ranked using the grading system previously discussed and shown in Table 2. This 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 region-wide 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 F 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 217 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 observed in the data, and interpretations of what might be causing the trends are suggested. 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 G is a summary of trends related to flow, Appendix H shows trends related to time and Appendix I shows trends related to season. Appendix J is the biological score and rating for every biological monitoring event in the past three years.

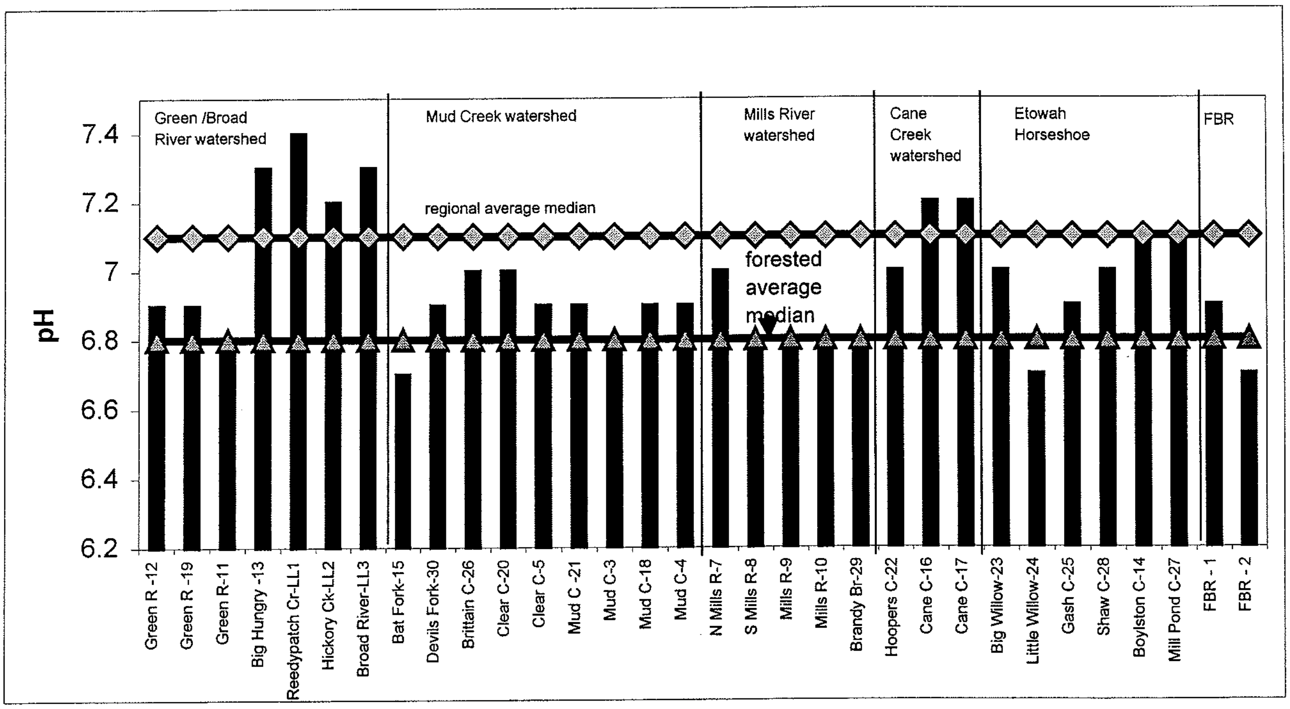
A. Acidity (pH) and Alkalinity: pH is used to measure acidity. The pH is a measure of the concentration of hydrogen ions in a solution. If the value of the measurement is less than 7.0, the solution is acidic. If the value is greater than 7.0, the solution is alkaline (more commonly referred to as basic). 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.

Almost all of the sites in Henderson County exhibit median pH levels lower than the Western North Carolina regional average (Figure 2). The exceptions are some of the sites in the far northern or eastern parts of the county that may receive less rainfall. None of the sites have exhibited pH levels outside of the acceptable range in the past three years. In fact, many sites show pH levels increasing over time. Most sites also show pH levels decreasing as stream flow increases. This is a typical trend throughout the region and occurs because rainwater has naturally low pH.

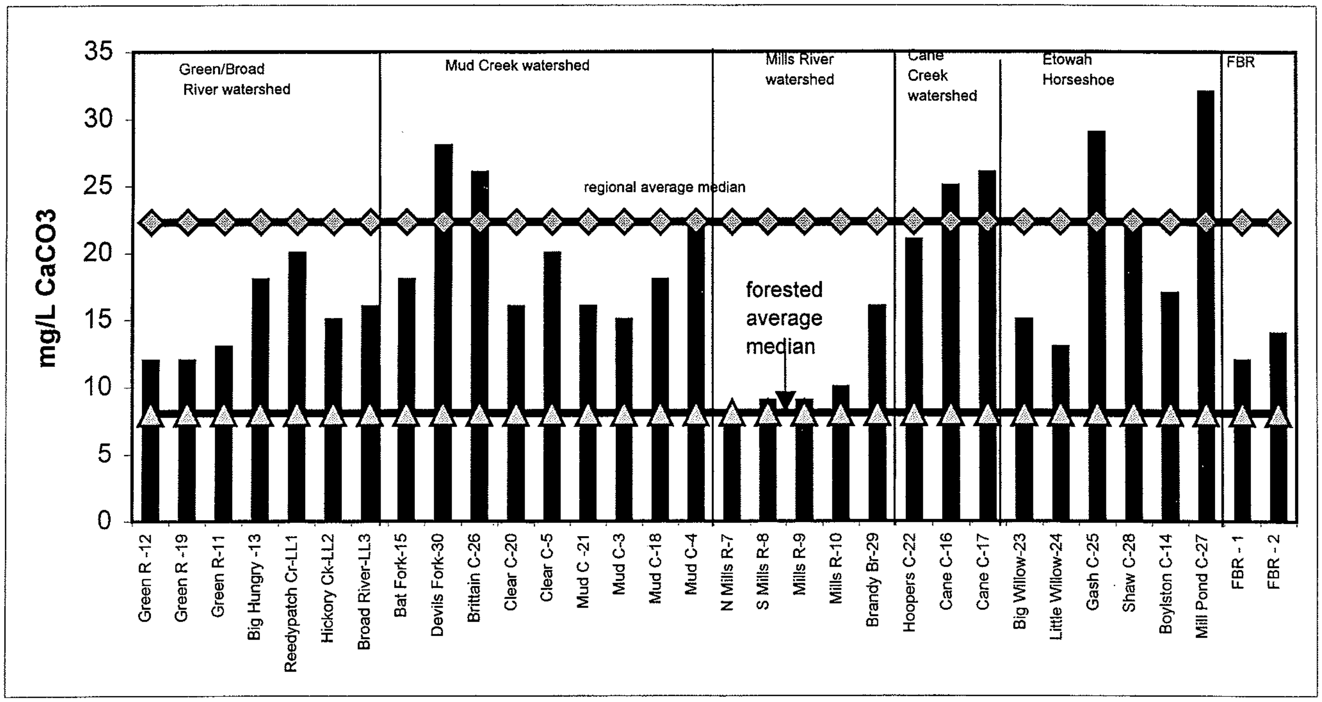
Figure 2: Median pH levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



Most sites also show lower median alkalinity levels than the median level for the WNC region (Figure 3). The exceptions in this case are streams with generally greater levels of pollutants, particularly certain pollutants that ionize in water. These sites includes Devil's Fork, Brittain Creek, Cane Creek, Gash Creek, and Mill Pond Creek. Like pH, most sites show alkalinity levels declining as stream flow increases because rainwater also has very low alkalinity. A few sites, particularly those in the Mills River watershed, show alkalinity levels decreasing over time. Median alkalinity levels are already very low in the Mills River watershed.

As is typical for the region, the sites that show seasonal trends indicate higher pH levels in summer and fall and lower levels in winter. Most sites exhibiting seasonal alkalinity trends show lower levels in fall and higher levels in spring.

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



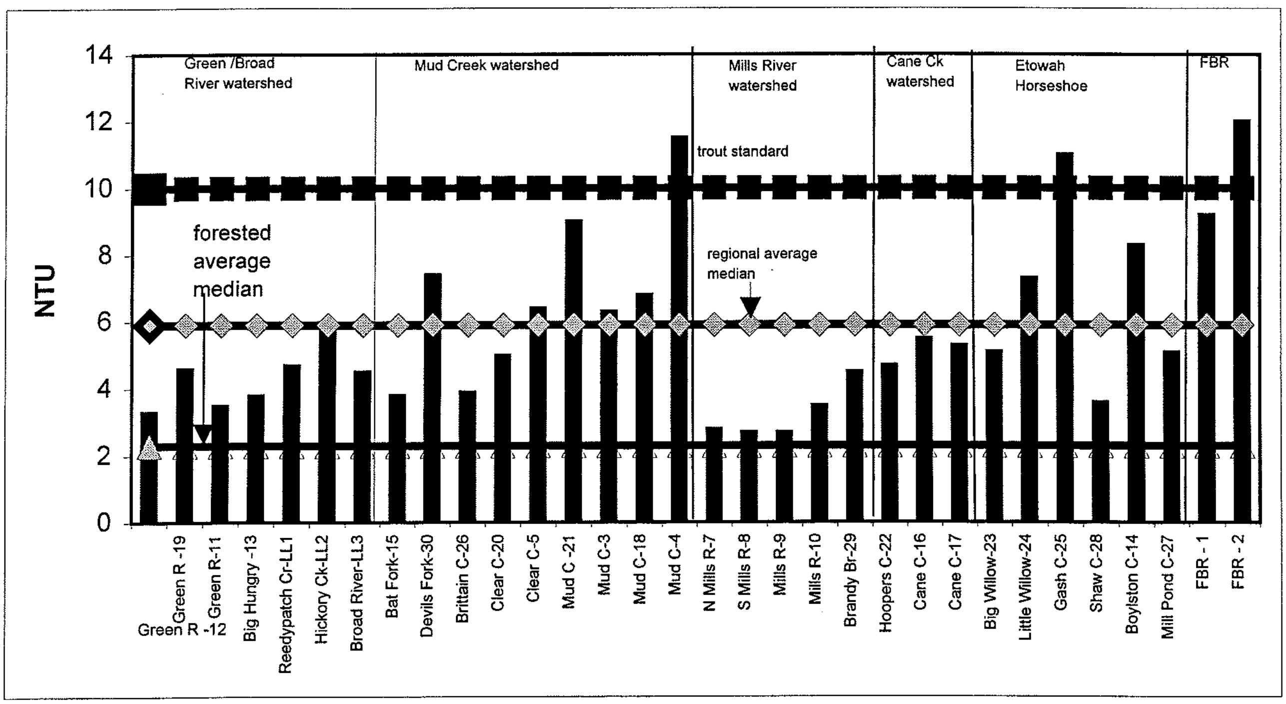
B. Turbidity and Total Suspended Solids (TSS): Turbidity is a measurement of the visual clarity of a water sample and indicates the presence of fine suspended particulate matter. The unit used to measure turbidity is NTU (nephelometric turbidity units), which measures the absorption and reflection of 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.

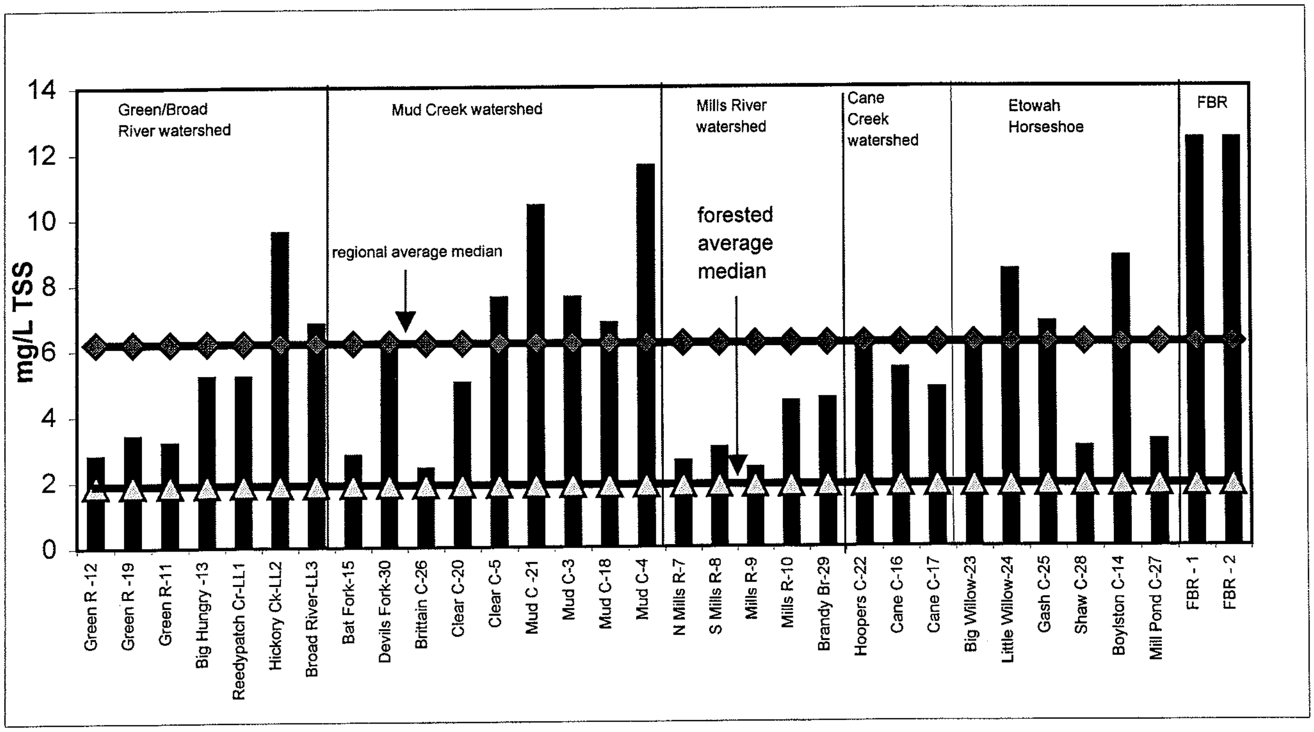
Median turbidity and total suspended solids levels are well below the regional average median at the sites in the Mills River and Green River watersheds, but most sites in the Mud Creek watershed, in the Etowah/Horseshoe area, and in the upper Broad River watershed show median turbidity and/or TSS levels equal to or higher than the regional median (Figures 4 and 5). Three sites show median turbidity levels exceeding the 10 NTU trout standard including Mud Creek at North Rugby Road, Gash Creek, and the downstream site on the French Broad River at Butler Bridge Road. Other sites with levels approaching the trout standard are Mud Creek at Berea Church Road, Boylston Creek, and the upstream site on the French Broad River at Banner Farm Road.

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



The turbidity and total suspended solids levels along the French Broad River have vacillated over the years somewhat, and have been most influenced by wet versus dry years, and possibly the amount of construction taking place in each area. However, levels have consistently increased greatly between the most upstream site in Rosman and the next downstream site in Transylvania County at Wilson Road. From there it usually levels off somewhat, then increases through Henderson County. It generally declines in southern Buncombe County, but increases

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



again in the northern part of the county. Levels have vacillated most over the years in Madison County, sometimes increasing over levels in Buncombe County and sometimes declining. Since the river descends at a much greater rate in Madison County, the flow energy is greater and the water can carry more sediment. The sediment fluctuations are also related to the sediment concentrations in the tributaries in each area, the amount of bank erosion along the river, and the amount of land disturbing activities taking place in each area.

Almost all sites show turbidity and total suspended solids levels increasing as flow increases, but only a few sites show trends related to time. The sites on the Broad River, Clear Creek at Bearwallow, and on the French Broad River show turbidity levels increasing over time. The sites on Mud Creek at 7th Avenue, Bat Fork Creek, and Devil's Fork show both turbidity and total suspended solids levels decreasing over time. Several other sites show turbidity levels decreasing over time. Seasonal trends clearly indicate turbidity and total suspended solids levels greater in summer and lower in the fall.

In addition to the monthly VWIN monitoring at the sites throughout the county, the Environmental Quality Institute has been monitoring stormwater sediment concentrations for the past few years in the upper Broad River watershed for the Upper Broad River Watershed Protection Project, and in the Mills River watershed for the Henderson County – Mills River Partnership Program. Samples are collected automatically at different stages as water level rises during storms, and sediment concentrations are analyzed at EQI. The purpose of the monitoring is to locate significant sources of stream sedimentation so that assistance can be provided to landowners to prevent further erosion.

Table 3 shows median total suspended solids concentrations in the upper Broad River watershed at each site for each year since monitoring began in August 1999. The median peak stream flow in cubic feet per second prior to sample collection is also provided (flow data from the USGS gauging station on nearby Cove Creek). The flow data provides comparisons of probable storm intensity. In the upper Broad River section only Hemlock Falls Creek is in Henderson County, but all of the sites in the Hickory Creek and Reedypatch Creek sections are in Henderson County. The first few years of monitoring from 1999 through 2002 were very dry

Table 3: Comparison of Median Total Suspended Solids Concentrations from Stage Samplers in the Broad River Watershed for the Period 8/99-12/02, 2003, 2004 and 2005

Broad River	**med peak flow prior 114 CFS 8/99-12/02**		**med peak flow prior 881 CFS 2003**		**med peak flow prior 773 CFS 2004**		**med peak flow prior 675 CFS 2005**	
site	**median**	**sample**	**median**	**sample**	**median**	**sample**	**median**	**sample**
upper Broad Rvr wtrshed	**mg/L**	**count**	**mg/L**	**count**	**mg/L**	**count**	**mg/L**	**count**
Upper Broad River	148.9	40	206.7	17	1647.4	14	135.0	19
Clear Branch	1808.0	4	878.8	13	1869.2	18	834.1	13
Upper Middle Broad River	219.4	24	476.2	13	521.1	11	455.1	25
Rock Creek	209.0	17	625.7	20	4579.8	11	273.3	18
Sand Branch	1470.1	6	901.8	13	1333.3	23	482.8	17
Rush Branch	487.7	15	554.6	15	497.6	11	821.6	11
Upper Flat Creek	221.0	19	650.0	15	4497.2	8		
Lower Flat Creek	349.1	44	705.4	28	3220.6	19	641.8	25
Lower Middle Broad River	158.3	24	439.5	14	1397.9	20	211.2	27
Hemlock Falls Creek	3750.0	7	3276.9	17	5595.0	17	752.1	21
Broad River at Chimney Rock	67.6	35	140.0	24	210.4	3		
Hickory Creek watershed								
Bearwallow Creek	966.6	16	935.7	5	3383.3	13	2957.7	3
Upper Hickory Creek	1062.1	12	1286.7	9	3121.7	17	640.9	20
Tom's Fork Creek	1043.8	10	1406.6	6	1922.7	7	1602.3	4
Middle Fork Creek	322.0	11	837.5	11	352.1	2		
Lower Hickory Creek	460.0	33	1274.3	16	2775.0	9	1855.2	12
Reedypatch Creek watershed								
Turnbreeches Creek	260.0	11	182.0	6	857.1	10	489.4	6
Upper Reedypatch Creek	2214.4	8	1287.7	12	1898.1	22	2076.9	6
Hominy Mill Branch	2345.8	3	855.4	6	2063.6	12	390.2	2
Little Creek	93.7	17	285.0	19	2246.7	11		
Lower Reedypatch Creek	215.5	27	337.5	13	708.7	12	687.3	20

years and fewer samples were collected, but it did provide some baseline data. In 2003 rainfall returned to normal or even above normal levels and median levels increased at most sites. Most of 2004 was relatively dry, but the hurricanes in September caused extreme stream sedimentation and overall results at sites where samplers were not damaged or destroyed by the storms were heavily influenced by these sampling events, thus most sites exhibit highest median total suspended solids levels in 2004.

In 2005 most sites returned to their typical sedimentation patterns, but a few sites that had exhibited frequent extreme sedimentation prior to the hurricanes actually improved following these storms. The most significant declines occurred at Hemlock Falls Creek and Hominy Mill Branch. These streams had excessive build-up of sediment in the streambeds prior to the storms, but the storms may have helped flush much of the sediment out. Other sites have exhibited consistently elevated sediment levels throughout the monitoring period, or have actually increased sediment levels over this period. Most notable of these are Bearwallow Creek, Tom's Fork, lower Hickory Creek, and upper Reedypatch Creek.

Table 4 shows median total suspended solids concentrations in the Mills River watershed at each site for each year since monitoring began in May 2003, along with median peak stream flow in the period prior to sample collection (flow data from the USGS gauging station on the Mills River). As with the Broad River results, many of the Mills River sites show highest

Table 4: Comparison of Median Total Suspended Solids Concentrations from Stage Samplers in the Mills River Watershed for (a) the period 4/03-12/03, 2004, and 2005

Mills River site	**med peak flow prior 499** **5/03-12/03 median mg/L**	**sample count**	**med peak flow prior 1150** **2004 median mg/L**	**sample count**	**med peak flow prior 685** **2005 median mg/L**	**sample count**
North Fork Mills River						
at campground	172.0	7	754.8	14	83.7	12
at River Loop	479.9	14	207.1	15	319.3	18
South Fork Mills River						
UT near Hall Road			327.5	20	1066.1	25
South Fork at bridge	138.1	20	253.4	22	152.7	12
Mills River						
Foster Creek in Pisgah Forest	563.5	6	606.8	8	587.4	6
Foster Creek/Humphrey prop	458.9	18	286.0	17	483.6	8
Foster Creek at N Mills R Rd	703.9	20	2805.1	18	1208.2	16
Foster Creek confl Mills R	489.3	18	1068.9	18	1392.0	15
Mills River at USGS gauge	258.0	15	2290.0	5	242.0	19
Mills River at Davenport Bridge	348.2	18	771.6	6	181.5	23
Brandy Branch at Pres Church	721.6	14	1020.7	14	288.2	24
Brandy Branch/VanWingerden	1322.2	18	858.7	17	1059.1	19
Mills River at Hooper Lane*	347.0	27	7087.5	21	3878.4	12

*Sampling device destroyed in June 2005 has not been replaced median levels in 2004 as a result of the great influence from the samples collected following the hurricanes in September of that year. However, some of the sites on Foster Creek and Brandy Branch have consistently exhibited elevated sediment concentrations throughout the monitoring period. The site on the unnamed tributary along Hall Road has been monitored to determine any differences in sediment levels over time as a result of construction of a large subdivision near the South Fork of the Mills River. Median sediment concentrations were more than three times greater in 2005 than in 2004.

Forest cover and percent slope are two very important factors that affect erosion and runoff in the mountains. There is much greater potential for erosion on land where the forest has been cleared and on steeper slopes. The combination of cleared land and steep slopes will usually result in very high erosion rates. Table 5 shows the average percent of land in three categories, forested, rural/semi-rural, and urban/suburban, in the monitored watersheds in each VWIN monitoring area. Note that this includes all land in the watersheds upstream from each site, not all land in the county or area. The table also shows the average percent slope for the watersheds in those areas (also from the land upstream from each site), and the average median total suspended solids concentrations at the sites analyzed in those areas. Delineation of subwatersheds, land cover, and slope were determined using ArcGIS 9.0. Subwatersheds were individually delineated from 1/3 arc second (10-meter resolution) elevation data obtained from the United States Geological Survey (USGS) National Elevation Dataset (NED). One arc second (30 meter resolution) land cover classification obtained from the USGS 2001 National Land Cover Database was used for the study.

Table 5: Average percent of land in three land use classifications, and average percent slope for watersheds analyzed in each VWIN monitoring area compared with average median Total Suspended Solids for sites in those areas

VWIN areas	forest/ shrub	rural/ sem-rural	urban/ suburban	percent slope	ave med TSS (mg/L)
Buncombe County	68.2%	26.7%	5.1%	29.6%	7.6
Henderson County	62.4%	33.7%	3.9%	20.7%	5.8
Transylvania County	90.4%	8.8%	0.8%	29.7%	4.0
Madison County	80.0%	19.3%	0.6%	34.9%	6.5
Haywood County	77.4%	21.5%	1.0%	36.5%	10.0
Polk County	71.9%	25.8%	2.3%	19.7%	6.7
Lake Lure (upper Broad River)	86.3%	13.5%	0.2%	30.5%	5.4
Glenville (Lake Glenville area)	80.0%	19.3%	0.7%	26.1%	4.1
New River watershed	81.6%	18.1%	0.3%	30.0%	6.6
Lake James (upper Catawba River)	87.1%	12.2%	0.6%	31.9%	4.5
Hiawasee (upper Hiawassee River)	89.3%	10.7%	0.0%	33.3%	3.8
Tuckasegee River watershed	90.6%	8.9%	0.4%	36.1%	7.4
Watauga River watershed	76.5%	21.9%	1.6%	26.6%	4.3
overall average	**80.1%**	**18.5%**	**1.3%**	**29.7%**	**5.9**

The watersheds analyzed in Henderson County have a greater average amount of deforested land than any other area analyzed. This would normally result in higher sediment concentrations, but the Henderson County watersheds also have the second lowest average percent slope (note that the Broad River sites are not included in the Henderson County grouping because they are already included with the Lake Lure grouping). Thus the Henderson County sites fall in the middle range of stream sedimentation. Table 6 shows land classifications, average slope, and median total suspended solids concentrations for each site in Henderson

Table 6: Average percent of land in three land use classifications, and average percent slope upstream from each site in Henderson County compared with median Total Suspended Solids for those sites

	forest/ shrub	rural/ sem-rural	urban/ suburban	percent slope	median TSS (mg/L)
Green River/Broad River Watershed					
212 Green River/Terry's Ck Rd	89.4%	10.6%	0.0%	26.7%	1.6
219 Green River/Old 25	87.0%	12.5%	0.5%	26.1%	3.4
211 Green River/down L Summit	84.5%	14.7%	0.8%	24.9%	3.2
213 Big Hungry River below dam	73.1%	26.5%	0.4%	24.4%	5.2
Mud Creek Watershed					
221 Mud Creek/Berea Church Rd	71.0%	28.6%	0.4%	23.0%	10.4
203 Mud Creek/Erkwood Rd	57.4%	40.8%	1.8%	17.7%	7.6
218 Mud Creek/7th Ave	49.6%	43.2%	7.2%	16.0%	6.8
215 Bat Fork Creek/Tabor Rd	30.4%	53.4%	16.2%	8.6%	2.8
230 Devil's Fork/Dana Rd	23.5%	69.9%	6.6%	5.2%	6.0
226 Brittain Creek/Patton Park	24.4%	52.4%	23.2%	14.1%	2.4
220 Clear Creek/Apple Valley Rd	69.7%	30.1%	0.2%	21.8%	5.0
205 Clear Creek/Nix Rd	54.8%	43.7%	1.5%	16.4%	7.6
204 Mud Creek/N Rugby Rd	44.5%	48.1%	7.4%	13.8%	11.6
Mills River Watershed					
207 North Fork Mills River	95.3%	4.7%	0.0%	35.8%	2.6
208 South Fork Mills River	96.0%	4.0%	0.0%	34.1%	3.0
209 Mills River/Hwy 191	93.3%	6.6%	0.1%	33.5%	2.4
229 Brandy Branch/Mills R Village	11.8%	74.3%	13.9%	3.8%	4.5
210 Mills River/Hooper Lane	92.4%	7.4%	0.2%	33.2%	4.4
Cane Creek watershed					
222 Hoopers Creek/Jackson Rd	76.1%	23.7%	0.2%	25.3%	6.0
216 Cane Creek/Howard Gap Rd	68.9%	29.5%	1.6%	22.2%	5.4
Etowah/Horseshoe					
223 Big Willow Creek/Patterson Rd	68.6%	30.8%	0.6%	21.1%	6.2
225 Gash Creek/Etowah School Rd	25.1%	67.9%	7.0%	8.3%	6.8
228 Shaw Creek/Hunters Glen	51.3%	45.8%	2.9%	19.1%	3.0
227 Mill Pond Creek/S Rugby Rd	30.4%	61.6%	8.0%	14.2%	3.2
214 Boylston Creek/Ladson Rd	61.7%	36.4%	1.9%	21.3%	8.8
French Broad River					
201 French Broad River/Banner Farm Rd	81.5%	17.4%	1.1%	25.0%	12.4
202 French Broad River/Butler Br Rd	72.8%	24.8%	2.4%	23.1%	12.4

County. In general, sites with the greatest amount of forested land cover have the lowest median TSS. Most sites with higher median TSS have either much less forest cover, or have a moderate amount of forest cover and a greater average slope.

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.

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.

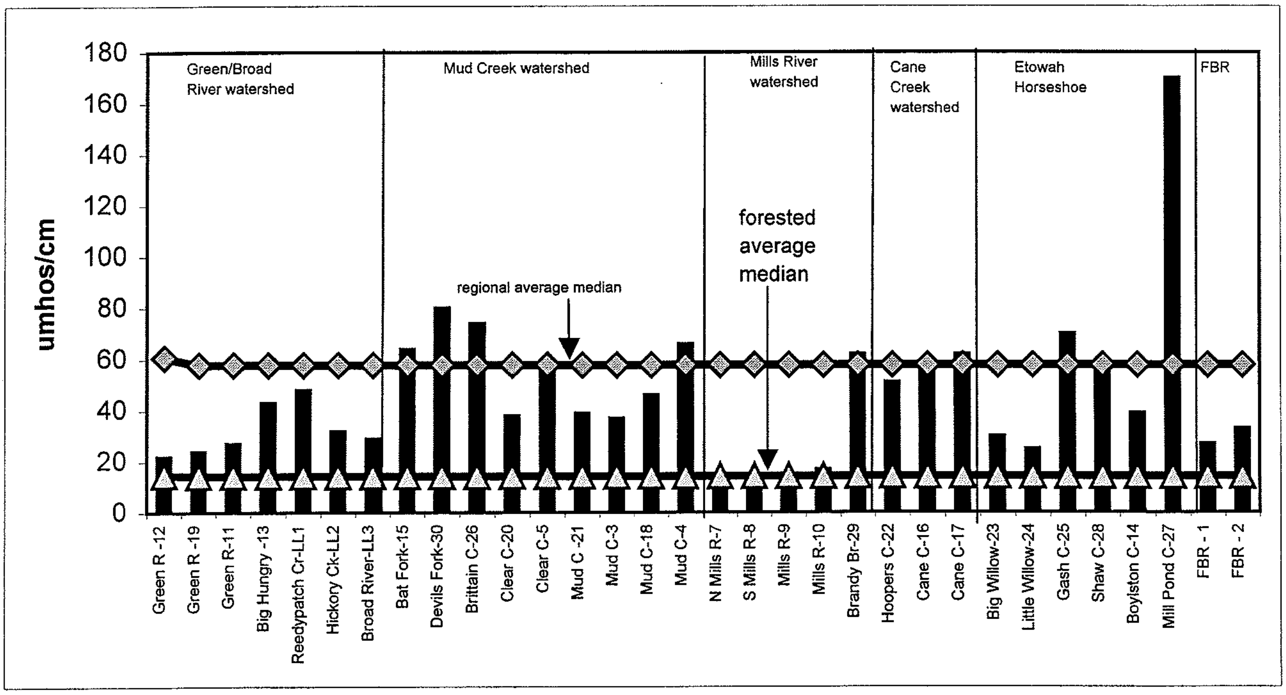
Lead: A standard of 25.0 ug/l has been established to protect aquatic life, while the normal ambient level is usually below 1.0 ug/l. Lead may be present in industrial wastewater and was once common in road runoff from the use of leaded gasoline. Roadside soils still generally contain high lead levels,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

Median conductivity levels at most sites in Henderson County are near or below the regional median for VWIN sites (Figure 6). The most notable exception is Mill Pond Creek, which has consistently exhibited conductivity levels well above average since this site was first monitored. Levels have varied somewhat as a result of rainfall differences from year to year, but have never approached normal. The headwaters for this stream bracket the county landfill. Sites with slightly higher than average conductivity include Bat Fork Creek, Devil's Fork, Brittain Creek, Mud Creek at Rugby Road, Brandy Branch, Cane Creek, and Gash Creek. All of these sites receive higher levels of certain pollutants such as nutrients and/or heavy metals and others that can affect conductivity levels.

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



Median conductivity levels are very low in the Green River and Mills River watersheds and even in the French Broad River. Levels have declined considerably all along the French Broad River since the closure of the Ecusta Paper plant in Transylvania County. Other sites showing declining conductivity levels over time include Mud Creek at Berea Church Road and at Seventh Avenue, Bat Fork Creek, Brandy Branch, the Mills River at Hooper Lane, and Gash Creek. Some of these sites show improving water quality in several categories. Sites showing increasing conductivity levels over time include all three sites on the Green River, the Big Hungry River, Reedypatch Creek, both sites on Clear Creek, both sites on Cane Creek, Mill Pond Creek, and Boylston Creek. Some of these sites show generally declining water quality over time. Seasonal trend analysis shows higher conductivity levels generally occurring in fall and lower levels in spring. Conductivity levels are closely related to stream flow with lower levels usually occurring during higher flow.

For the most part heavy metals concentrations have not been a significant issue at the Henderson County sites monitored, although some sites have exceeded water quality standards for at least one of the heavy metals analyzed at least once in the past three years. Median levels of heavy metals are highest at the sites on Mud Creek at Rugby Road, Devil's Fork, Clear Creek, Gash Creek, and the two sites on the French Broad River. Heavy metals concentrations are related most closely with flow at several sites in the Mud Creek watershed, but several of these sites, particularly those in the upper part of the watershed from Berea Church Road into Hendersonville, show heavy metals concentrations decreasing over time. Heavy metals concentrations are increasing over time at the sites on Clear Creek and the downstream site on the French Broad River.

D. Nutrients (Orthophosphate (PO_4^{3-}), Ammonia-Nitrogen (NH_4^+/NH_3), and Nitrate/Nitrite-Nitrogen (NO_3^-/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.**

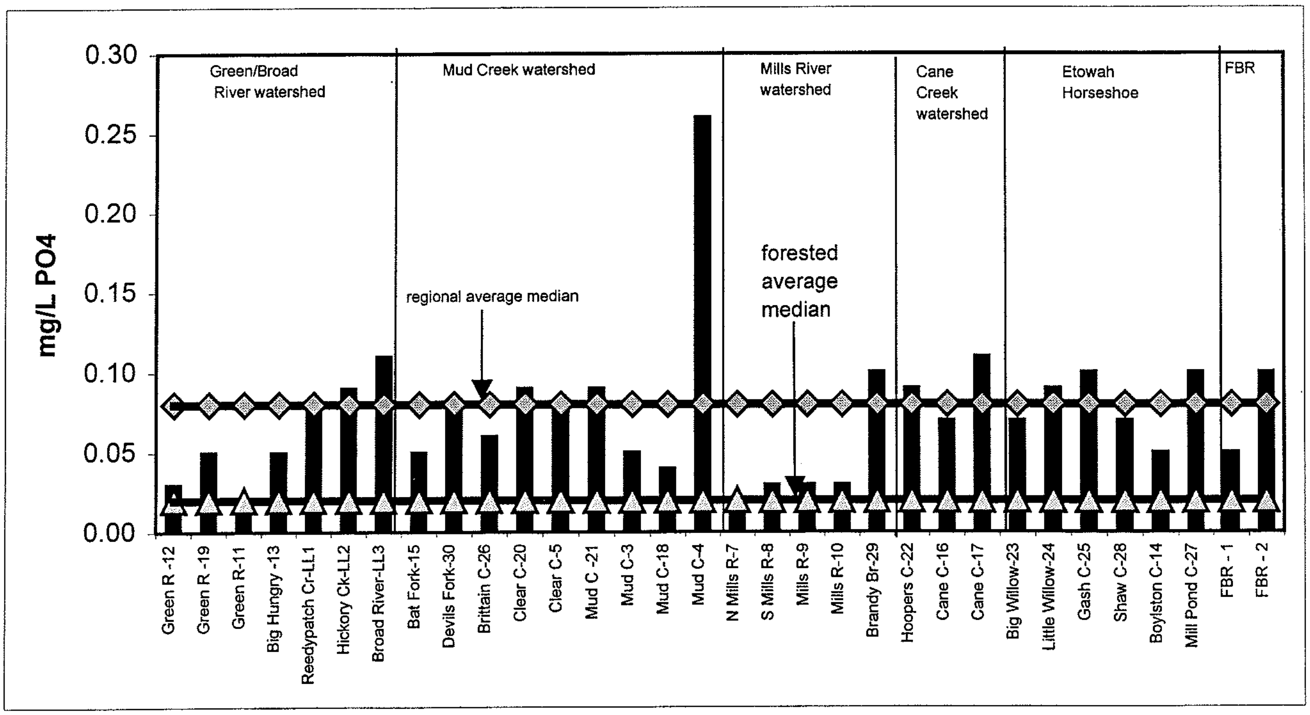
Orthophosphate: This is a measure of the dissolved phosphorus that is immediately available to plants or algae. Orthophosphate is also referred to as phosphorus in solution. There is no legal water quality standard, but generally levels must be below 0.05 mg/l to prevent downstream eutrophication.

Ammonia-Nitrogen (NH_4^+/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 (NO_3^-/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.

Median orthophosphate concentrations are much lower than the regional median at most sites in the Mills River and Green River watersheds, but are near normal at almost all other sites (Figure 7). The one exception is Mud Creek at Rugby Road where median levels are more than three times greater than the regional average median. It is typical for streams receiving wastewater effluent to show relatively elevated orthophosphate concentrations. The most dramatic change in orthophosphate concentrations has occurred at the Gash Creek site. Orthophosphate concentrations are now less than a quarter of what they were before the effluent from the Etowah wastewater treatment plant was diverted to the French Broad River, and are now near average for the region.

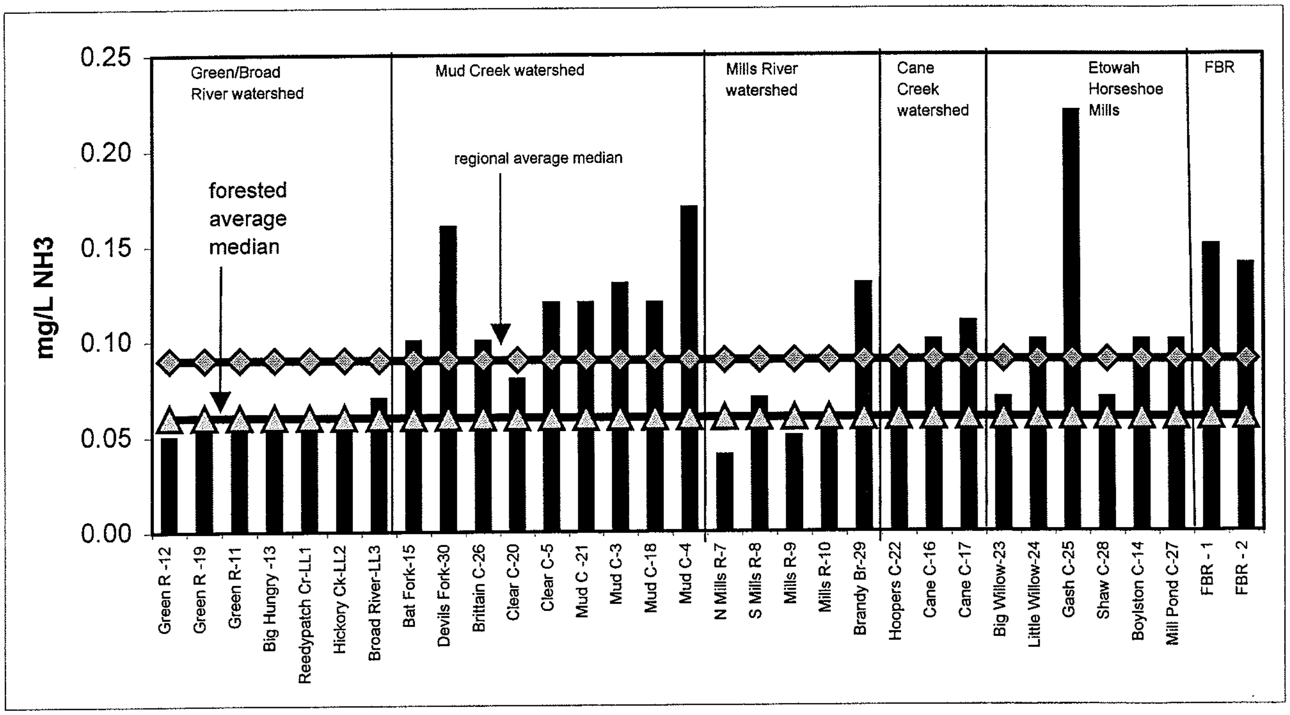
Figure 7: median orthophosphate concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas



Most sites show orthophosphate levels decreasing as flow increases. For the few sites that show seasonal trends, most show higher levels in summer.

Once again, most sites in the Mills River and Green River watersheds show lower than average median ammonia-nitrogen and nitrate/nitrite-nitrogen concentrations, but most other sites show median levels greater than the regional average median (Figures 8 and 9). Median ammonia-nitrogen concentrations are highest at the Gash Creek, Devil's Fork, and Mud Creek at Rugby road sites. All three of these sites are located in areas where the streams are somewhat deeper and slower moving allowing more breakdown of organic matter. Only the Gash Creek site has exceeded water quality standards for ammonia-nitrogen in the past three years, and this occurred in 2002 before the Etowah wastewater effluent was diverted. Since that time ammonia-N concentrations have declined considerably.

Figure 8: 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

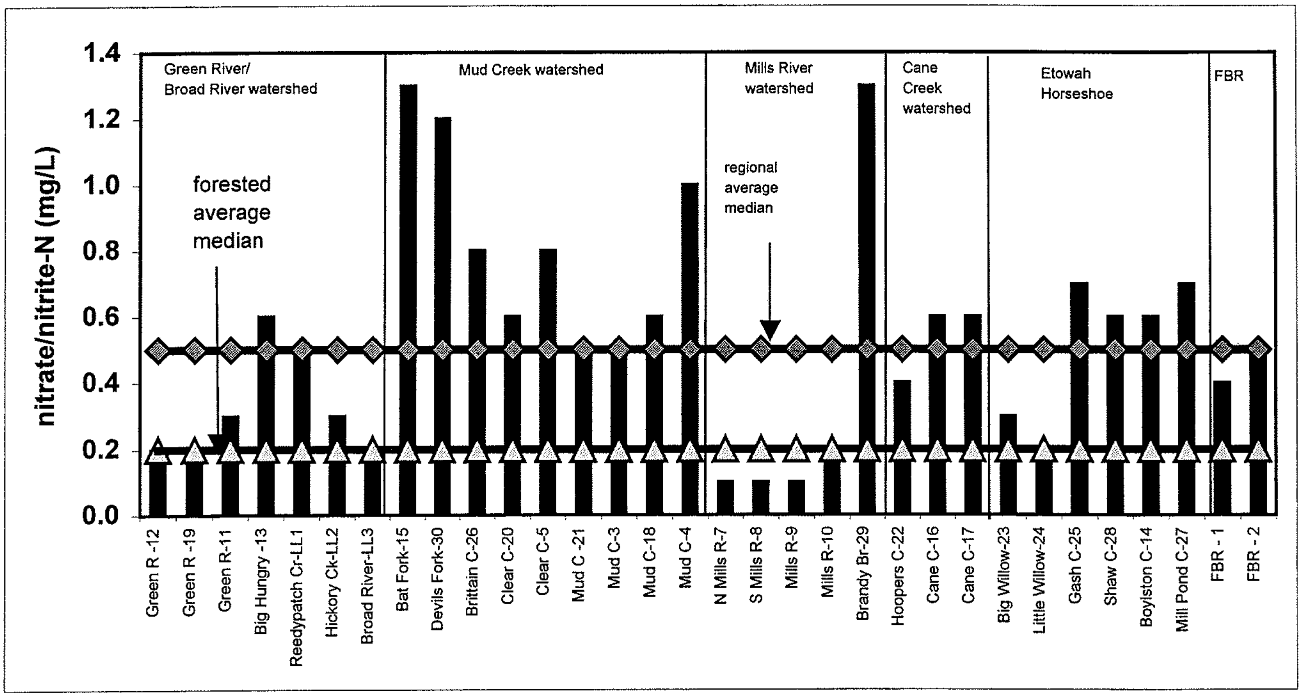


Highest median nitrate/nitrite-N concentrations occur at the Bat Fork, Devil's Fork, Brandy Branch, and Mud Creek at Rugby Road sites. These sites are probably also affected by livestock waste. Unlike most other parameters that show higher levels in summer, seasonal trends for nitrate-N show higher levels largely in winter. This trend is common because plants do not utilize nitrates in the soil in winter, so it is often carried away to streams in ground water.

Sites in the Green River and Broad River watersheds, Clear Creek, Cane Creek, Boylston Creek, and the French Broad River show nutrient concentrations increasing over time. The sites on Mud Creek at Berea Church Road, Bat Fork Creek, and Gash Creek show nutrient concentrations decreasing over time.

E. Biological Monitoring: This was the fourth year of biological sampling in Henderson County. A spreadsheet providing detailed data and observations collected at each of the

Figure 9: 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



biological monitoring sites is available in the EQI database. Total index values for each site sampled in April and October 2002, 2003, 2004, and 2005 are shown in Appendix J. Total Index Values have been converted to Water Quality Ratings with >22= Excellent, 17 to 22 = Good, 11 to 16 = Fair, and <11 = Poor. Appendix J shows the ranges of these ratings and is helpful in observing changes over time. As described earlier, the total index value is a measure of the diversity and pollution sensitivity of organisms found at a site and provides a quality "score" for the specific location. These results are grouped according to the sites sampled by each of the monitoring teams, but also correspond to the grouping designated in chemical analysis sections of this report.

Most sites show relatively consistent results throughout the monitoring period, but a few have exhibited some decline in recent years. Most sites in the Green River watershed show consistently **good** water quality through the four years of monitoring. The exception is the site on the Big Hungry River downstream from the dam. This site has only been analyzed for two years, but water quality was **good** in 2004 and **poor** in 2005. Dams can cause significant changes in macroinvertebrate populations because the water flow is controlled and can vary greatly. During dry periods more water is held back and the flow downstream can be exceptionally low, and during floods enormous amounts of water may be released, which can scour the streambed. This can destroy macroinvertebrate populations that need a more consistent flow regime. This may have been the cause of the extreme change in macroinvertebrate populations at this site on the Big Hungry River.

Most sites in the Mud Creek watershed have rated **fair** during most monitoring events. The ratings for Brittain Creek have vacillated much more, ranging from **excellent** to **poor**. With 23.2 % of the watershed classified as urban/suburban (Table 6 Section III-B) this watershed is more urbanized than any of the other sites in Henderson County. Almost the entire watershed flows through subdivisions, commercial property, or parks. Urbanized watersheds are more subject to sudden toxic events and streambed scour from stormwater runoff from impervious surfaces. Construction in the watershed has also caused some significant sedimentation at times.

The site on Clear Creek at Bearwallow has also exhibited some significant differences over time. The site rated **excellent** in 2002, declined to **good** in 2003, then to **fair** in 2004 and 2005. Mud Creek at 7th Avenue has also exhibited some decline in water quality. In 2002 it rated **good**, in 2003 **fair**, and in 2004 and 2005 **fair/poor**. The watershed upstream from this site in the center of Hendersonville also has a relatively high percentage of land classified as urban/suburban (7.2%) and it may also experience sudden toxic events and/or streambed scour from urban runoff.

While all of the sites analyzed in the Mills River watershed have an overall rating of **good**, the North and South Fork sites have declined from fairly consistent ratings of **good/excellent** 2002 through April 2004 to **good/fair** from October 2004 through 2005. Stream bank erosion and streambed scouring during the hurricanes in September 2004 may have had an adverse effect on macroinvertebrate populations. These populations are expected to recover.

The sites in the Cane Creek watershed have consistently rated **fair/poor** throughout the four-year monitoring period. This area has been undergoing rapid development in recent years, the stream banks in some areas are eroding, and there is often insufficient vegetative buffer along the streams.

Most sites in the Etowah/Horseshoe area have consistently rated **fair/poor** throughout the four-year monitoring period. The reasons vary, but most of these streams have significant sediment build-up in the streambed, some like Mill Pond Creek, Gash Creek, and Shaw Creek are somewhat urbanized and receive more road runoff, Gash Creek may be receiving pesticides from golf course runoff, and Mill Pond Creek receives runoff and groundwater flow from the county landfill. Some of these creeks have also been straightened and often do not have sufficient streamside vegetation. Stream habitat degradation is a general problem in this area.

IV. Summary and Conclusions

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 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. The VWIN program is currently monitoring over 200 sites in fifteen Western North Carolina counties. A comparison of Henderson County stream sites with all other sites in the program is presented in Appendix E. These comparisons are based on the most recent three years of analysis. This ensures that only current water quality is being rated. Summarized observations and trends for Henderson County stream sites are presented below. Summaries of trends are presented in Appendices G, H, and I. Data from all 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 7 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. The addition of biological monitoring carried out twice annually for the past three years allows for comparison of chemical water quality data and biological water quality data.

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.

The Green River/Broad River Watershed

Four sites including three sites on the Green River and one site on the Big Hungry River (Three additional sites monitored by the Lake Lure VWIN program include one on The Broad River, one on Hickory Creek, and one on Reedypatch Creek)

All of the sites on the Green River continue to rate **excellent**, and the site on the Big Hungry River rates **good**. No significant water quality problems have been found, but median levels of most parameters are slightly higher at the Big Hungry River site, and median nitrate concentrations exceed the regional average median at that site. All of the sites in the Green River watershed show conductivity levels and nutrient concentrations increasing over time.

The biological monitoring rating fell from **good** in 2004 to **poor** in 2005 at the Big Hungry River site. This site is downstream from the dam and the inconsistent flow on the river can destroy macroinvertebrate populations. With the exception of the Green River at Terry's Creek Road, the other sites have fairly consistently rated **good** or **excellent** for biomonitoring.

The three sites in the upper Broad River watershed rate lower than the Green River watershed sites. Reedypatch Creek rates **good** and Hickory Creek and the Broad River at Bat Cave rate **average**. Stream sedimentation continues to be a major concern, particularly in the Hickory Creek watershed and in the upstream area of Reedypatch Creek. Median total suspended solids levels are well above average at the Hickory Creek site. The average slope in the Hickory Creek watershed is one of the greatest of the sites monitored in Henderson County, and the high energy, fast-flowing stream can carry more sediment than most streams. In the past two years Bearwallow Creek, a tributary of Hickory Creek, has had either the highest or among the highest median total suspended solids concentrations of the sites monitored for stormwater sediment concentrations in the upper Broad River watershed. Tom's Fork and lower Hickory Creek have also consistently had very high median stormwater total suspended solids concentrations.

Upper Reedypatch Creek has also consistently had very high median total suspended

Table 7: Index Ratings for Henderson County Monitoring Sites

site #	site name	sediment	metals	nutrients	overall	chemical rating	biological score	biological rating
	VWIN - WNC Regional Average	**69**	**86**	**82**	**79**			
	Green River/Broad River Watershed							
	Rock Creek						20	**good**
	Green River at Bob's Creek Road						20	**good**
12	Green River at Terry's Creek Road	100	88	100	96	**excellent**	15	**fair**
19	Green River upstream from Lake Summit	88	94	100	94	**excellent**		
11	Green River downstream from Lake Summit	88	94	100	94	**excellent**	20	**good**
	Little Hungry River						22	**good**
	Big Hungry River upstream						20	**good**
13	Big Hungry River downstream	75	94	83	84	**good**	13	**fair**
LL1	Reedypatch Creek	75	94	83	84	**good**		
LL2	Hickory Creek	50	94	92	78	**average**		
LL3	Broad River at Bat Cave	63	94	75	77	**average**		
	Average for this grouping	**77**	**93**	**90**	**87**		**19**	
	percent sites below regional average	**29%**	**0%**	**14%**	**29%**			

site #	site name	sediment	metals	nutrients	overall	chemical rating	biological score	biological rating
	Mud Creek Watershed							
21	Mud Creek at Berea Church Road	38	88	83	69	**below average**	15	**fair**
3	Mud Creek at Erkwood Road	50	88	83	74	**average**	13	**fair**
18	Mud Creek at 7th Avenue	75	81	92	83	**good**	13	**fair**
15	Bat Fork Creek	88	81	75	81	**good**		
30	Devil's Fork	63	81	75	73	**average**		
26	Brittain Creek	75	81	75	77	**average**	15	**fair**
	Clear Creek at Lancaster						16	**fair**
20	Clear Creek at Bearwallow	88	81	83	84	**good**	18	**good**
5	Clear Creek at Nix Road	63	75	75	71	**average**	16	**fair**
4	Mud Creek at N Rugby Rd	25	81	58	55	**poor**		
	Average for this grouping	**63**	**82**	**78**	**74**		**15**	
	percent sites below regional average	**56%**	**78%**	**56%**	**67%**			

site #	site name	sediment	metals	nutrients	overall	chemical rating	biological score	biological rating
	VWIN - WNC Regional Average	**69**	**86**	**82**	**79**			
	Mills River Watershed							
7	North Fork Mills River	100	100	100	100	**excellent**	19	**good**

Table 7: Index Ratings for Henderson County Monitoring Sites-continued

8	South Fork Mills River	100	100	100	100	excellent	19	good
9	Mills River at Davenport Bridge	100	100	100	100	excellent	18	good
29	Brandy Branch	63	81	67	70	average		
10	Mills River at Hooper Lane	88	94	100	94	excellent	17	good
	Average for this grouping	**90**	**95**	**93**	**93**		**18**	
	percent sites below regional average	**20%**	**20%**	**20%**	**20%**			

	Cane Creek watershed							
22	Hoopers Creek	63	88	83	78	average	11	fair
16	Cane Creek at Howard Gap Rd	63	88	83	78	average	13	fair
17	Cane Creek at US 25	75	81	75	77	average		
	Average for this grouping	**67**	**86**	**80**	**78**		**12**	
	percent sites below regional average	**67%**	**33%**	**33%**	**100%**			

	Etowah/Horseshoe							
23	Big Willow Creek	75	94	92	87	good	13	fair
24	Little Willow Creek	63	81	92	78	average	12	fair
25	Gash Creek	50	69	50	56	poor	8	poor
28	Shaw Creek	88	81	83	84	good	14	fair
27	Mill Pond Creek	88	75	67	76	average	10	poor
14	Boylston Creek	50	94	83	76	average	11	fair
	Average for this grouping	**69**	**82**	**78**	**76**		**11**	
	percent sites below regional average	**50%**	**67%**	**33%**	**67%**			

	French Broad River							
1	French Broad River/Horseshoe	38	94	83	72	average		
2	French Broad River/Mt Home	25	75	75	58	poor		
	Average for this grouping	**32**	**85**	**79**	**65**			
	percent sites below regional average	**100%**	**50%**	**50%**	**100%**			

	Overall County Rating							
	Average for All Sites	**71**	**86**	**83**	**80**		**15**	
	percent sites below regional average	**47%**	**44%**	**34%**	**56%**			

solids concentrations over the entire four-year monitoring period. This part of the watershed drains part of the Edneyville area and there has been some serious erosion and runoff near the stream in that area. Two other streams, Hominy Mill Branch in the Reedypatch Creek watershed and Hemlock Falls Creek in the upper Broad River near Bat Cave, have exhibited declining stormwater sedimentation in the past year. These two streams may have experienced extensive scouring during the September 2004 hurricanes, which may have removed much of the sediment built up in the streambeds.

The Mud Creek Watershed

Nine sites including four sites on Mud Creek, one site on Bat Fork Creek, one site on Devils Fork, one site on Brittain Creek, and two sites on Clear Creek

Ratings for sites in this watershed range from **good** to **poor**. Sites rating **good** include Mud Creek at 7th Avenue, Bat Fork Creek, and Clear Creek at Bearwallow. The Mud Creek at 7th Avenue and Bat Fork Creek sites show declining pollutant concentrations over time. The declines have been most dramatic at the Bat Fork site although median nitrate/nitrite-N concentrations are still much higher than average at that site. Median nitrogen concentrations are also somewhat higher than average at the Mud Creek at 7th Avenue site, as are sediment and heavy metals, although the heavy metals concentrations have never exceeded water quality standards in the past three years. Although the upstream site on Clear Creek is rated **good**, trends over time show water pollutant concentrations increasing when adjusted for flow changes. The downstream site on Clear Creek at Nix Road rates **average**. Almost all parameters show higher median levels at this site than at the upstream site, and median levels of most parameters exceed the regional average median. This site also shows levels of most parameters increasing over time when adjusted for flow differences. This is in contrast with almost all other sites in the Mud Creek watershed, which show pollutant concentrations generally declining over time.

Also rating **average** in the Mud Creek watershed are Britain Creek, Devil's Fork, and Mud Creek at Erkwood Road. Relatively poor water clarity has long been an issue at the Devil's Fork site, and conductivity, heavy metals, and nitrogen concentrations are higher than levels typical of most other streams analyzed in the mountains. Water clarity and sediment concentrations are also the main problem at the site on Mud Creek at Erkwood Road. Sedimentation is less of an issue at the Britain Creek site, but conductivity and heavy metals concentrations are higher than average, probably as a result of urban runoff.

The upstream site on Mud Creek at Berea Church Road rates **below average**. Poor water clarity and stream sedimentation are, once again, the main problem at this site. In fact, median turbidity and total suspended solids levels are even higher at this site than at the downstream site. The most downstream site on Mud Creek continues to rate **poor**. Even median turbidity levels exceed the trout standard at that site, and median sediment concentrations are well above average. Median heavy metals and nutrient concentrations are also well above average. Many factors contribute to the poor water quality in this part of Mud Creek, including sediment and nutrient runoff from agricultural areas, heavy metals runoff from Hendersonville, and wastewater effluent from the Hendersonville wastewater treatment plant. The tributaries contribute many of the pollutants, but there are also some serious stream bank erosion and habitat degradation problems along Mud Creek itself.

Although there are many water quality problems in the Mud Creek watershed, trend analysis shows several sites generally improving over time. Sediment levels are declining at the Bat Fork, Devil's Fork, and Mud Creek at 7th Avenue sites, and nutrient concentrations are declining at the site on Mud Creek at Berea Church Road and at Bat Fork. Heavy metals concentrations are also declining at the site on Bat Fork and at the sites on Mud Creek at Erkwood Road and at 7th Avenue. No improvements have occurred at the site on Mud Creek at Rugby Road.

Biological monitoring in the Mud Creek watershed shows all sites usually falling in the **fair** range over the past four years of monitoring, with occasional tests resulting in **good** or **poor**. Results were generally best in 2002 when many sites rated good or even excellent, but have been much more consistently rated fair since then. This may be because 2002 was a dry year, and water quality in general often improves in dry years because of the reduced pollutant runoff.

The Mills River Watershed

Five sites including one site on the North Fork of the Mills River, one site on the South Fork of the Mills River, one site on Brandy Branch, and two sites on the Mills River

All of the sites on the Mills River and on the North and South Forks rate **excellent**. In fact, all except the downstream site on Hooper Lane have perfect scores in every category. Median levels of all parameters are typical of those found in largely forested areas. Median levels of turbidity, TSS, and heavy metals are greater at the Hooper Lane site. The downstream area of the Mills River passes through a commercial area where road and parking lot runoff probably add to the heavy metals concentrations. All sites have an overall biological rating of **good**, but have fallen from **good/excellent** to **good/fair** in the past year. The Mills River experienced significant bank erosion and severe flooding at the lower end of the watershed as a result of the hurricanes that passed through the area in September 2004. This may have affected the macroinvertebrate population.

The Brandy Branch subwatershed is heavily agricultural and suburban and rates **average**. Median nutrient concentrations are higher than average, and in the case of nitrate/nitrite-nitrogen much higher than average. This is often an indication of livestock runoff. Brandy Branch also experiences significant sedimentation during storms.

Sixteen sites in the Mills River watershed are also monitored for stream sedimentation during storms for the Mills River Partnership program. Because of road closings as a result of hurricane damage, two of these sites have been largely inaccessible for the past year and a half. All other sites show increased sedimentation during storms, but the two downstream sites on Foster Creek, the downstream site on Brandy Branch, and the site on the unnamed tributary along Hall Road exhibited the greatest sedimentation in 2005. The Foster Creek and Brandy Branch sites have consistently exhibited elevated sediment concentrations throughout the 3-year monitoring period. The Hall Road site was established in April 2004 to analyze for changes in water quality before, during, and after construction of a large development. Median levels in

2005 were more than three times greater than they were in 2004, even though many of the samples in 2004 were collected during the September 2004 hurricane events when most sites exhibited much higher than normal sediment levels. Construction continues in the new development and stream sedimentation will probably continue to be a problem.

The Mills River Partnership program has completed a great deal of stream bank restoration in the watershed, but there is still much to do. Since the Mills River is the major water supply for Henderson County and also supplies water to Buncombe County, protecting this watershed is of vital importance.

The Cane Creek Watershed

Three sites including two sites on Cane Creek and one site on Hooper's Creek

All sites in the Cane Creek watershed rate **average**. The site on Cane Creek at US-25 was discontinued in the past year, so the data is less up-to-date. The sites on Hooper's Creek and on Cane Creek at Howard Gap Road have the same rating in every category. Both sites are vulnerable to stream sedimentation during storms, and both sites carry about the average pollutant levels compared to the sites in the WNC region. Both sites also rate an overall **fair** for biological monitoring. Both sites have continued to rate either fair or poor for every biological monitoring event in the past four years. This watershed has less forest cover than either the Green River or Mills River watersheds, and reduced forest cover often results in increased pollutant levels. Areas of this watershed are developing rapidly and controlling runoff will continue to be a problem.

The Streams of the Etowah and Horseshoe

Seven sites including one site each on Big Willow Creek, Little Willow Creek, Gash Creek, Shaw Creek, Boylston Creek, and Mill Pond Creek

In this grouping Big Willow Creek and Shaw Creek rate **good**, Little Willow Creek, Mill Pond Creek, and Boylston Creek rate **average**, and Gash Creek rates **poor**. Like the Mud Creek watershed, the watersheds monitored in the Etowah/Horseshoe area have a relatively low percentage of land with forest cover, and a relatively low average slope. Loss of forest cover often means increased pollutant levels, but lower gradient reduces the effect of the loss of forest cover. In Henderson County all of the sites that rate excellent are in watersheds with greater than 80% forest cover. All of the watersheds analyzed in the Etowah/Horseshoe area have less than 70% forest cover.

Stream sedimentation is the most significant water quality problem for most of the sites in the Etowah/Horseshoe area. Greatest median turbidity levels and suspended solids concentrations are found at the Boylston Creek, Little Willow Creek, and Gash Creek sites. Even median turbidity levels at the Gash Creek site exceed the standard for trout waters. It is unusual for streams in the mountains to exhibit such consistently elevated turbidity, even in non-designated trout waters. Median levels of most parameters exceed the regional average median at the Gash Creek site, but levels of many pollutants have been declining over time. The most dramatic declines have occurred with conductivity and orthophosphate. Median conductivity has decreased by 20% since 2001, and median orthophosphate has declined by 80% since 2001. Median orthophosphate was once one of the highest in the region, but now is near average. These improvements have taken place largely because the Etowah wastewater treatment plant has diverted its effluent flow to the French Broad River. The larger river is much more able to sufficiently dilute the wastewater effluent. Sediment, zinc, and ammonia-nitrogen levels continue to be elevated, however, and it will be necessary to find the sources of these pollutants to continue water quality improvement in Gash Creek.

As mentioned, Boylston Creek also exhibits significant sedimentation and poor water clarity. This stream flows through an extensive agricultural area and lack of sufficient vegetative buffers can contribute to sedimentation. Trend analysis shows conductivity levels and nitrogen concentrations increasing over time at this site, but zinc concentrations decreasing.

The overall rating at the Mill Pond Creek site is average largely as a result of the consistently elevated conductivity levels and higher than average nutrient concentrations. The headwaters of this stream bracket the Henderson County landfill and water quality is influenced by groundwater flow from the landfill. Trend analysis shows conductivity levels increasing over time at this site, but turbidity, lead, and ammonia-N levels declining.

All sites in the Etowah/Horseshoe area receive either a **fair** or **poor** biological rating. Mill Pond Creek and Gash Creek have consistently rated poor throughout the four years of biological monitoring, and the other sites have ranged from good to poor with poor ratings occurring more frequently in the past two years. Habitat degradation and water quality are certainly affecting the ratings at these sites.

The French Broad River

Includes two sites on the French Broad River

There are twelve sites monitored on the French Broad River from Rosman in Transylvania County to Hot Springs in Madison County. It is instructive to look at the big picture when analyzing the French Broad River. The river has already been influenced by inputs from Transylvania County before it arrives in Henderson County, and inputs from Henderson County have an effect on water quality downstream in Buncombe and Madison Counties. Water quality varies as the river flows from the headwaters to the Tennessee border. It is influenced largely be the tributaries that flow into the river in each area. Table 8 shows the ranking for each site in each category from Rosman in Transylvania County to Hot Springs in Madison County. This table follows the order the sites are located from upstream to downstream.

Water quality at the most upstream site in Transylvania County is rated **excellent**. Most of the upper part of the watershed is in National Forest land. Outside of the National Forest in southern Transylvania County the river forms a large flood plain, which is used extensively for agricultural purposes. In this area there is often insufficient streamside vegetation and considerable bank erosion. This causes stream sedimentation to increase considerably. The river is narrow and has a relatively deep channel, and the flow velocity is relatively low through Transylvania County and there is a great deal of sediment build-up in the riverbed. Because of the excessive sedimentation in this section of the river the rating declines to **average** at the Wilson Road site. There is a slight improvement from Wilson Road to the Everett Road site and the rating rebounds to good.

Through Henderson County the rating declines rapidly from **good** at Everett Road, to **average** at Banner Farm Road, to **poor** at Butler Bridge Road. The main reason for the rise and decline of ratings can be seen in Table 9, which shows median values of most parameters at each site on the river. As can be seen, median levels of most parameters either increase in Henderson County, or remain about the same. In southern Buncombe County they decline, then increase again in Asheville and just downstream from Asheville. The sites at the Buncombe/Madison County line and those in Madison County show pollutant levels declining again. Not too many years ago it was largely the agricultural areas that had the greatest influence on water quality, but the proportion of land used for agriculture is declining, and now the urban and suburban areas seem to have a greater influence on water quality.

Table 8: Site ranking for each site on the French Broad River

site #	site name	sediment	metals	nutrients	overall	rating
	VWIN - WNC Regional Average	**69**	**86**	**82**	**79**	
T-1	at Mt Lyon Rd	88	100	92	93	**excellent**
T-15	at Wilson Rd	38	100	92	76	**average**
T-7	at Everett Rd	50	100	92	81	**good**
H-1	at Banner Farm Road	38	94	83	72	**below average**
H-2	at Butler Bridge Road	25	75	75	58	**below average**
B-13	at Corcoran Park	38	88	83	69	**below average**
B-12B	at Bent Creek	50	94	75	73	**average**
B-23	at Jean Webb Park	38	75	83	65	**below average**
B-6A	at Ledges Park	25	81	58	55	**poor**
B-32	at Walnut Island Park	25	75	58	53	**poor**
M-2	at Barnard Bridge	25	75	58	53	**poor**
M-3	at Hot Springs	38	75	50	54	**poor**

Trend analysis shows both sites on the French Broad River in Henderson County with increasing turbidity and nutrient levels over time, and decreasing conductivity level over time. The downstream site also shows increasing heavy metals concentrations over time. Mud Creek may be having a greater influence on water quality in the French Broad River now that additional water is being withdrawn from the Mills River from the various water treatment facilities. However, the declining conductivity levels are certainly the result of the closure of the Ecusta plant in Transylvania County. Conductivity levels have declined at all sites on the river downstream from the plant since the closure of that facility.

Land use has an enormous effect on water quality everywhere, but in the mountains land gradient is also a very important factor. Western North Carolina historically has been heavily forested. The forest stabilizes land even on very steep slopes, recycles nutrients, and has kept the streams in steady ecological balance for millions of years. A recent study on the effects of the

Table 9: Median levels of most parameters analyzed at each site on the French Broad River from Rosman in Transylvania County to Hot Springs in Madison County

		Turbidity NTU	TSS mg/L	Cond umhos/cm	Zinc ug/L	Ortho-P mg/L	Ammonia-N mg/L	Nitrate-N mg/L
T-1	at Mt Lyon Rd	3.8	3.6	17.0	1.4	0.07	0.07	0.2
T-15	at Wilson Rd	8.6	11.0	22.0	4.1	0.05	0.10	0.3
T-7	at Everett Rd	8.1	9.4	24.0	2.9	0.07	0.13	0.3
H-1	at Horseshoe	9.2	12.4	27.0	8.3	0.05	0.15	0.4
H-2	at Mountain Home	12.0	12.4	33.0	7.6	0.10	0.14	0.5
B-13	at Corcoran Park	8.2	10.0	35.0	4.2	0.09	0.13	0.5
B-12B	at Bent Creek	8.8	9.4	35.0	2.6	0.12	0.12	0.5
B-23	at Jean Webb Park	8.9	8.4	47.0	5.7	0.08	0.13	0.5
B-6A	at Ledges Park	16.0	18.2	59.0	7.5	0.30	0.29	0.7
B-32	at Walnut Island Park	15.1	16.6	59.0	6.4	0.26	0.22	0.7
M-2	at Barnard Bridge	14.0	11.2	60.0	5.4	0.21	0.16	0.7
M-3	at Hot Springs	11.5	9.6	58.0	3.8	0.19	0.14	0.7

hurricanes in September 2004 on long-term water quality carried out by the Environmental Quality Institute (Patch, Westphal, Evans, Fariss, and Fariss, January 2006) shows that most monitored streams, and particularly those in largely forested areas, either were relatively unscathed by the storms, or recovered from those storms very quickly. However, the effects of changes made to the landscape by humans have been far more detrimental to water quality, and have had a much longer-term effect.

As was shown in Table 5 in Section III-B, in most areas with both extensive cleared land (20% or greater) and high percent average slope (29% or greater) such as in Haywood, Madison, and Buncombe Counties, watersheds exhibit higher than average stream sedimentation. Areas with greater forest cover and/or lower average slope show lower overall average stream sedimentation. Henderson County monitored watersheds have the least amount of overall forest cover, but also the second lowest average slope, and overall stream sedimentation is about average for the region.

In Henderson County only 30% of the sites are in watersheds with more than 80% forest cover, and all of these sites except the French Broad River show very low stream sedimentation. All of these sites except the French Broad River have an overall **excellent** rating even though all of them also have higher average percent slope than the other sites, and these are the only sites in the county with **excellent** ratings. For all of the other sites the reduction in forest cover certainly is one of the factors contributing to stream sedimentation and overall pollutant concentrations. Retaining as many trees on the landscape as is possible with future development will play an important role in protecting water resources. Retaining an ever increasing amount of forest cover with increased slope will be equally, if not even more important.

Patch, S.C., Westphal, M.J., Evans, B.S., Fariss, B., Fariss, B., 2006, Assessment of Water Quality Impacts of Hurricanes in Western North Carolina Through Strategic Monitoring and Statistical Analysis.

Appendix A: Sample Data Sheet

Volunteer Water Information Network

Henderson County

1) Sample Site Number ____________________

2) Sample Site Name ____________________

3) Collection Date ____________________

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) Stream Flow Measurement no longer needed - using USGS gauging stations in the watershed

11) 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	
Cu	ug/L	
Zn	ug/L	
Pb	ug/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. 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 and kept refrigerated.

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.

PARAMETER	REPORTING LIMIT	UNITS
Ammonia Nitrogen	0.02	mg/L
Nitrate 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: Save Our Streams – Stream Quality Survey

SAVE OUR STREAMS
Stream Quality Survey

The purpose of this form is to aid you in gathering and recording important data about the health of your stream. By keeping accurate and consistent records of your observations and data from your macroinvertebrate count, you can notice and document changes in water quality. Refer to the SOS insect card and instructions to learn how to trap and identify the organisms.

Stream ______________________ Station ______________________

County ______________ State ______ Location ______________________

Group or individual ______________________ Number of participants ______________

Weather conditions ____

Stream width (max.) ______ ft. Stream depth (max.) ______ ft.

Flow rate: high ______ low ______ normal ______

You should select a riffle where the water is not running too fast (ideal depth is 3 - 12 inches), and the bed consists of cobble-sized stones or larger.

Monitored riffle area (should be 3 foot square) __________ Water depth (inches) __________

Sample number ______________ Date ______________ Time ______________

Type of test: ______ macroinvertebrate count ______ chemical test ______ other

MACROINVERTEBRATE COUNT

Use the stream monitoring instructions to conduct a macroinvertebrate count. Use letter codes (A = 1 - 9, B = 10 - 99, C = 100 or more) to record the numbers of organisms found in a 3 foot by 3 foot area. Then add up the number of letters in each column and multiply by the indicated index value. The following columns are divided based on the organism's sensitivity to pollution.

SENSITIVE	SOMEWHAT-SENSITIVE	TOLERANT
☐ caddisfly larvae	☐ beetle larvae	☐ aquatic worms
☐ hellgrammite	☐ clams	☐ blackfly larvae
☐ mayfly nymphs	☐ crane fly larvae	☐ leeches
☐ gilled snails	☐ crayfish	☐ midge larvae
☐ riffle beetle adult	☐ damselfly nymphs	☐ pouch (and other) snails
☐ stonefly nymphs	☐ dragonfly nymphs	
☐ water penny larvae	☐ scuds	
	☐ sowbugs	
	☐ fishfly larvae	
	☐ alderfly larvae	
☐ # of letters times 3 = ______ index value +	☐ # of letters times 2 = ______ index value +	☐ # of letters times 1 = ______ index value

Now add together the three index values = ______ total index value.

Compare this total index value to the following numbers to determine the water quality of your stream. Good water quality is indicated by a variety of different kinds of organisms, with no one kind making up the majority of the sample.

WATER QUALITY RATING

☐ Excellent (> 22) ☐ Good (17 - 22)

☐ Fair (11 - 16) ☐ Poor (< 11)

Note: You should test at least 3 different riffles within a 24-foot area to ensure that you have a truly representative sample which includes all key organisms. Record results from the sample which gives the best diversity.

Izaak Walton League of America, SOS Program 1401 Wilson Blvd., Level B, Arlington, Va. 22209 (703)528-1818
Defenders of Air, Woods, Waters and Wildlife

Appendix D: 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 ppm (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 ppb
Grade B= exceeded 7 ppb in less than 10% of samples
Grade C= exceeded 7 ppb in 10 to 20% of samples
Grade D= exceeded 7 ppb in more than 20% of samples

Appendix D (continued)

Total Lead -

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

Total Zinc -

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

Total Phosphorous -

Grade A= median not above 0.10 mg/L
Grade B= median greater than 0.10 mg/L but less than 0.20 mg/L.
Grade C= median greater than 0.20 mg/L but less than 0.30 mg/L
Grade D= median greater then 0.30 mg/L

Orthophosphate -

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 E: 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 occassional 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=Hiawassee River Watershed
HY = Haywood County
LG = Lake Glenville
LJ = Lake James
LL = Lake Lure
M = Madison County
N = New River
NOT=Nottely River Watershed
P = Polk County
T = Transylvania County
TU = Tuckasegee River watershed

	site #	site description	Excellent
1	B28	Bent Creek below Lake Powhatan	100
2	**H7**	**North Fork Mills River**	**100**
3	**H8**	**South Fork Mills River**	**100**
4	**H9**	**Mills River at SR 191 (Davenport Bridge)**	**100**
5	HW2	Martin's Creek	100
6	HW6	Eagle Fork Creek	100
7	HW7	Upper Shooting Creek	100
8	HW8	Lower Shooting Creek	100
9	HW10	Upper Fodder Creek	100
10	HW11	Hog Creek	100
11	HY2	East Fork Pigeon River/Bethel	100
12	HY3	East Fork Pigeon River/Cruso	100
13	LG1	Hurricane Creek/Norton Br Rd (Tuckasegee R wtrshd)	100
14	LG5	Cedar Creek at Beetree Rd (Tuckasegee R wtrshd)	100
15	NOT5	Coosa Creek	100
16	NOT9	Conley Creek	100
17	T5	West Fork French Broad River at 64/215	100
18	T6	Little River at Dupont Road	100
19	T11	King Creek headwaters	100
20	T12	Davidson River at confluence with FBR	100
21	T19	West Fork French Broad River upstream	100
22	T20	Catheys Creek upstream of water supply	100
23	TU1	East Fork Tuckasegee River	100
24	TU3	Caney Fork (Tuckasegee River watershed)	100
25	TU14	Deep Creek (Tuckasegee River watershed)	100
26	TU15	Oconoluftee River (Tuckasegee River watershed)	100

Appendix E: Stream Ranking Index-continued

27	HY1	West Fork Pigeon River/Bethel	98
28	T10	King Creek at Brevard College	98
29	T18	North Fork French Broad River headwaters	98
30	B22	Ivy Creek at Dillingham Road	97
31	LG7	Norton Creek/up Grassy Cmp (Tuckasegee R wtrshd)	97
32	LL6	Pool Creek (Broad River watershed)	97
33	T8	Williamson Creek	97
34	**H12**	**Green River at Terry's Creek Rd**	**96**
35	M8	Little Laurel Creek (Laurel River watershed)	96
36	NOT8	Ivy Log Creek	96
37	TU2	West Fork Tuckasegee River	96
38	TU5	Tuckasegee River upstream from Scott's Creek	96
39	TU16	Soco Creek (Tuckasegee River watershed)	96
40	M9	Shelton Laurel Creek (Laurel River watershed)	95
41	T9	Davidson River at entrance to Pisgah National Forest	95
42	T16	Little River at Sherwood Forest	95
43	**H10**	**Mills River at Hooper Lane**	**94**
44	**H11**	**Green River below Lake Summit**	**94**
45	**H19**	**Green River at Old Hwy 25 S**	**94**
46	P13	Green River at Hwy 9	94
47	NOT3	Nottely River	93
48	NOT7	Young Cane Creek	93
49	T1	French Broad River at Mt Lyon Rd (Rosman)	93
50	HW5	Geisky Creek	92
51	HW9	Upper Bell Creek	92
52	T14	Lamb Creek at confluence with FBR	92
53	HY12	Jonathan Creek near confluence with Pigeon River	91
54	HW1	Upper Hiawassee River	90
55	HW3	Hightower Creek	90
56	TU4	Cullowhee Creek (Tuckasegee River watershed)	90

			Good
57	B12A	Bent Creek at SR 191	89
58	B20	Ivy Creek at Buckner Branch Road	89
59	HW12	Woods Creek	89
60	LG2	Norton Creek at Norton Rd br (Tuckasegee R wtrshd)	89
61	T4	North Fork French Broad River at 64/215	89
62	B24	Swannanoa River at confluence with North Fork	88
63	N3	Buffalo Creek (New River watershed)	88
64	NOT6	Anderson Creek	88
65	TU9	Tuckasegee River at Barker's Creek	88
66	**H23**	**Big Willow Creek at Patterson Rd**	**87**
67	HY11	Richland Creek at Lake Junaluska	87
68	HY13	Allens Creek (Richland Creek watershed)	87
69	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	87
70	LL10	Fairfield Mts Creek (Broad River watershed)	87
71	T13	Lamb Creek headwaters	86
72	B38	Swannanoa River at Bull Creek	85
73	B43	Ross Creek at Swannanoa River (Swannonoa R wtrshd)	85
74	HY10	Richland Creek at West Waynesville	85
75	HW4	Scataway Creek	85
76	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	85
77	T2	East Fork French Broad River at Rosman	85
78	T3	Middle Fork French Broad River at Rosman	85
79	TU11	Conley Creek (Tuckasegee River watershed)	85

Appendix E: Stream Ranking Index-continued

80	**H13**	**Big Hungry River below dam (Green River watershed)**	**84**
81	**H20**	**Clear Creek at Apple Valley Rd (Mud Crk watershed)**	**84**
82	**H28**	**Shaw Creek at Hunters Glen**	**84**
83	**LL1**	**Reedypatch Creek at Bat Cave (Broad River watershed)**	**84**
84	NOT2	Arkaqua Creek	84
85	B9A	Beetree Creek (Swannanoa River watershed)	83
86	B9B	Swannanoa River at Beetree Creek	83
87	**H18**	**Mud Creek at 7th Avenue**	**83**
88	LL4	Broad River at Chimney Rock	83
89	LL5	Broad River at Lake Lure	83
90	TU12	Tuckasegee River downstream from Bryson City	83
91	LG4	Pine Creek/Pine Creek Rd br (Tuckasegee R wtrshd)	82
92	LL9	Buffalo Creek (Broad River watershed)	82
93	NOT4	Butternut Creek	82
94	B17A	Swannanoa River at NC 81	81
95	B31	Swannanoa River at Grassy Branch confluence	81
96	B33	North Fork Swannanoa River at Grovestone Quarry	81
97	**H15**	**Bat Fork Creek at Tabor Road (Mud Creek watershed)**	**81**
98	HY9	Plott Creek in Hazelwood (Richland Crk watershed)	81
99	LJ5	Linville River at Hwy 126	81
100	T7	French Broad River at Everett Road	81
101	B10	Bull Creek at Swannanoa River (Swannanoa R wtrshd)	80
102	M10	Laurel River	80
103	P17	White Oak Creek at Weidman's	80

			Average
104	B8	Beaverdam Creek at Beaver Lake	79
105	LG3	Mill Creek/dnstrm Norton br (Tuckasegee R wtrshd)	79
106	N5	North Fork (New River watershed)	79
107	TU7	Savannah Creek (Tuckasegee River watershed)	79
108	TU8	Green's Creek (Tuckasegee River watershed)	79
109	B5B	Reems Creek at Ox Creek	78
110	B21	Paint Fork at Barnardsville (Ivy River watershed)	78
111	**H16**	**Cane Creek at Howard Gap Road**	**78**
112	**H22**	**Hoopers Creek at Jackson Rd (Cane Creek watershed)**	**78**
113	**H24**	**Little Willow Creek at River Road**	**78**
114	HY27	Jonathan Creek at Maggie Valley	78
115	**LL2**	**Hickory Creek at Bat Cave (Broad River watershed)**	**78**
116	TU6	Scott's Creek (Tuckasegee River watershed)	78
117	B27	Flat Creek at NC 19/23	77
118	**H17**	**Lower Cane Creek at NC 25**	**77**
119	**H26**	**Brittain Creek at Patton Park (Mud Creek watershed)**	**77**
120	HY5	Pigeon River at Hepco Bridge	77
121	**LL3**	**Broad River at Bat Cave**	**77**
122	M6	Big Pine Creek	77
123	**H14**	**Boylston Creek at Ladson Road**	**76**
124	**H27**	**Mill Pond Creek at South Rugby Road**	**76**
125	P2	White Oak Creek at SR 1531 (Fox Mt Rd)	76
126	P15	North Pacolet River at Melrose	76
127	T15	French Broad River at Wilson Road	76
128	TU10	Barker's Creek (Tuckasegee River watershed)	76
129	HY26	Crabtree Creek at Crabtree Rd	75
130	N1	Helton Creek (New River watershed)	75
131	N2	Big Horse Creek (New River watershed)	75
132	P5	Horse Creek at SR 1516 (River Road) N Pacolet R wtrshd	75

Appendix E: Stream Ranking Index-continued

133	TU13	Kirkland Creek (Tuckasegee River watershed)	75
134	**H3**	**Mud Creek at Erkwood Road**	**74**
135	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	74
136	LJ1	Catawba River at SR 1501	74
137	M12	Grapevine Creek (Ivy River watershed)	74
138	T17	North Fork French Broad River at Macedonia Bridge	74
139	B12B	French Broad River at Bent Creek	73
140	**H30**	**Devils Fork at Dana Road (Mud Creek watershed)**	**73**
141	P8	Demannu Creek at SR 1140 and Hwy 9 (Green River wtrshd)	73
142	B1A	Big Ivy Creek at Forks of Ivy	72
143	B6B	Reems Creek at French Broad River	72
144	B7A	Reed Creek at UNCA Botanical Gardens	72
145	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	72
146	**H1**	**French Broad River at Banner Farm Road in Horseshoe**	**72**
147	HY4	Pigeon River downstream from Canton	72
148	M14	Middle Fork at Beech Glen (Ivy River watershed)	72
149	**H5**	**Clear Creek at Nix Road (Mud Creek watershed)**	**71**
150	HY25	Raccoon Creek downstream (Richland Creek watershed)	71
151	LJ2	Catawba River at US 221A	71
152	LJ3	North Fork of the Catawba River at SR 1552	71
153	LJ4	Catawba River at Resistoflex	71
154	P16	North Pacolet River at Rte 108	71
155	**H29**	**Brandy Branch at Mills River Village (Mills River watershed)**	**70**

			Below Average
156	B5A	Ox Creek at Reems Creek (Reems Creek watershed)	69
157	B13	French Broad River at Corcoran Park (Hend/Bunc line)	69
158	**H21**	**Mud Creek at Berea Church Road**	**69**
159	HY6	Rush Fork at Crabtree (Crabtree Creek watershed)	69
160	P1	White Oak Creek at SR 1137/Houston Road	69
161	P4	White Oak Creek at SR 1322 (Moore Road)	69
162	P14	White Oak Creek at Briar Hill Farm	69
163	B15A	Cane Creek at Hwy 74 (FBR watershed)	68
164	B40	Ross Creek at Lower Chunns Cove Rd(Swannanoa R wtrshd)	68
165	M13	California Creek at Beech Glen (Ivy River watershed)	68
166	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	67
167	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	66
168	HY7	Fines Creek downstream	66
169	P6	Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)	66
170	B23	French Broad River at Jean Webb Park - Asheville	65
171	B35	Smith Mill Creek at Louisiana Blvd.	65
172	HY19	Fines Creek upstream	65
173	LJ12	North Fork of the Catawba River below Limekiln Creek	65
174	M17	Gabriel's Creek at Ivy River	65
175	LG6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	65
176	P10	Joels Creek downstream (N Pacolet River watershed)	65
177	B14	Lower Flat Creek	64
178	M7	Spring Creek	64
179	M15	Paint Fork at Beech Glen (Ivy River watershed)	64
180	B16A	Cane Creek at Mills Gap Road	63
181	B30	Grassy Branch (Swannanoa River watershed)	63
182	B41	Ross Creek at Tunnel Road (Swannanoa River watershed)	63
183	N4	Big Laurel Creek (New River watershed)	63

Appendix E: Stream Ranking Index-continued

184	HY14	Rush Fork upstream (Crabtree Crk watershed)	60
185	HY24	Raccoon Creek upstream (Richland Creek watershed)	60
186	M1	Ivy River at NC 25/70	60

			Poor
187	B2	Lower Sandymush Creek	59
188	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	59
189	P7	North Pacolet River at SR 1516 (S River Rd)	59
190	**H2**	**French Broad River at Butler Bridge Road**	**58**
191	HY20	Cove Creek at NC 209 (Fines Creek watershed)	58
192	P9	Joels Creek upstream (N. Pacolet Rvr watershed)	58
193	P18	Camp Creek (Green River watershed)	58
194	B47	Reed Creek at entrance to UNCA	57
195	**H25**	**Gash Creek at Etowah School Road**	**56**
196	LJ13	North Fork of the Catawba River at Old Linville Rd	56
197	M4	East Fork Bull Creek (Ivy River watershed)	56
198	B6A	French Broad River at the Ledges Park	55
199	**H4**	**Mud Creek at North Rugby Road**	**55**
200	HY15	Fines Creek midstream	55
201	B1B	Little Ivy Creek (Ivy River watershed)	54
202	M3	French Broad River at Hot Springs	54
203	B3B	Sandymush Creek at Willow Creek	53
204	B32	French Broad River at Walnut Island Park	53
205	B25	South Turkey Creek (Sandymush Creek watershed)	53
206	B34	Lower Hominy Creek at NC 191	53
207	M2	French Broad River at Barnard Bridge	53
208	B37	Newfound Creek at Leicester Hwy	52
209	HY22	Hyatt Creek downstream (Richland Creek watershed)	52
210	B26	North Turkey Creek (Sandymush Creek watershed)	51
211	HY21	Hyatt Creek upstream (Richland Creek watershed)	51
212	M11	Bull Creek (Ivy River watershed)	50
213	B4	Lower Newfound Creek	49
214	B15B	Ashworth Creek at Hwy 74 & Cane Crk Rd (Cane Ck wtrshd)	49
215	B48	South Creek Pond/Beaver Lake (Beaverdam Crk wtrshd)	49
216	B36	Newfound Creek at Dark Cove Road	47
217	B39	South Creek at Beaver Lake (Beaverdam Crk watershed)	44

Percent -	Excellent	Good	Average	Below Average	Poor
Buncombe	4	22	18	22	33
Henderson	**24**	**21**	**41**	**4**	**10**
Haywood	17	17	25	24	17
Hiawassee	83	17	0	0	0
Lake Glenville	43	29	14	14	0
Lake James	0	14	58	14	14
Lake Lure	10	70	20	0	0
Madison	13	7	20	33	27
New River	0	20	60	20	0
Nottely	63	37	0	0	0
Polk	7	7	33	33	20
Transylvania	65	25	10	0	0
Tuckasegee River	50	19	31	0	0
TOTAL	26	22	24	14	14

Appendix F: 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	29	6.3	6.9	7.2	137	6.8	1	29	2	12	18	139	17
2	35	6.3	6.7	7.2	146	6.8	2	35	4	14	18	147	17
3	35	6.1	6.8	7.1	149	6.7	3	36	6	15	23	152	17
4	36	6.5	6.9	7.3	142	6.8	4	36	11	22	34	143	23
5	34	6.5	6.9	7.2	140	6.9	5	34	8	20	70	141	20
7	36	6.3	7.0	7.5	149	6.8	7	36	6	8	18	150	9
8	36	6.2	6.8	7.2	147	6.6	8	36	4	9	18	148	10
9	34	6.3	6.8	7.2	151	6.7	9	35	5	9	13	152	9
10	36	6.3	6.8	7.7	154	6.7	10	36	4	10	19	154	10
11	32	6.4	6.8	7.3	126	6.7	11	32	8	13	20	127	13
12	35	6.3	6.9	7.2	142	6.8	12	35	6	12	16	142	12
13	35	6.8	7.3	7.8	143	7.1	13	35	12	18	24	143	18
14	36	6.6	7.1	7.4	139	7.0	14	36	12	17	26	139	17
15	35	6.3	6.7	7.1	135	6.7	15	35	11	18	22	136	20
16	34	6.8	7.2	7.6	133	7.1	16	34	16	25	35	132	25
17	25	6.7	7.2	7.4	135	7.1	17	25	20	26	33	135	25
18	33	6.6	6.9	7.3	130	6.9	18	33	13	18	34	133	19
19	34	6.3	6.9	7.2	90	6.8	19	34	8	12	17	91	12
20	34	6.2	7.0	7.5	110	6.9	20	34	12	16	28	111	16
21	34	6.4	6.9	7.2	78	6.9	21	34	12	16	26	78	18
22	36	6.6	7.0	7.2	85	7.0	22	36	13	21	37	85	22
23	30	6.4	7.0	7.4	77	6.8	23	30	12	15	22	77	16
24	23	6.4	6.7	7.1	71	6.7	24	23	8	13	18	71	14
25	33	6.5	6.9	7.2	81	6.8	25	33	20	29	40	81	31
26	33	6.7	7.0	7.2	78	7.0	26	33	8	26	34	78	27
27	36	6.7	7.1	7.4	84	7.1	27	36	10	32	43	84	32
28	36	6.6	7.0	7.2	81	7.0	28	36	17	22	32	82	23
29	36	5.7	6.8	7.2	81	6.8	29	36	9	16	44	82	14
30	36	6.5	6.9	7.1	83	6.8	30	36	13	28	40	84	28
LL1	36	6.9	7.4	8.2	108	7.3	LL1	36	7	20	35	108	21
LL2	35	6.5	7.2	7.9	107	7.2	LL2	35	9	15	26	107	16
LL3	35	6.2	7.3	7.7	107	7.3	LL3	35	9	16	26	107	16

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	29	3.1	9.2	50	139	9.0	1	29	<4	12.4	57.6	138	10.4
2	35	3.1	12.0	55	147	9.0	2	35	<4	12.4	59.2	146	10.8
3	36	2.5	6.3	120	152	7.5	3	36	<4	7.6	104.5	151	6.4
4	36	2.6	11.5	130	143	12.0	4	36	<4	11.6	128.4	142	11.2
5	34	2.9	6.4	50	140	7.9	5	34	<4	7.6	49.6	139	6.0
7	36	1.1	2.8	17	150	2.8	7	36	<4	2.6	17.6	147	2.0
8	36	<1	2.7	23	148	3.4	8	36	<4	3.0	26.4	145	2.4
9	35	<1	2.7	34	153	3.0	9	35	<4	2.4	44.4	151	2.0
10	36	<1	3.5	31	155	3.5	10	36	<4	4.4	46.4	151	3.2
11	32	1.5	3.5	31	127	3.7	11	32	<4	3.2	34.4	126	1.6
12	35	<1	3.3	21	143	3.0	12	35	<4	2.8	17.2	141	1.6
13	35	1.2	3.8	24	144	4.0	13	35	<4	5.2	37.6	142	4.0
14	36	2.4	8.3	70	140	7.9	14	36	<4	8.8	85.6	140	6.8
15	35	1.6	3.8	34	136	6.0	15	35	<4	2.8	31.6	134	3.4
16	34	1.7	5.5	85	133	6.6	16	34	<4	5.4	91.2	132	6.4
17	25	<1	5.3	110	136	7.1	17	25	<4	4.8	96.4	133	7.2
18	33	3.1	6.8	50	133	7.7	18	33	<4	6.8	78.0	132	6.8
19	34	1.3	4.6	50	91	3.9	19	34	<4	3.4	40.8	87	3.6
20	34	2.0	5.0	28	111	5.0	20	34	<4	5.0	35.2	109	4.4
21	34	3.5	9.0	180	78	6.3	21	34	<4	10.4	134.4	78	7.8
22	36	1.4	4.7	70	85	5.4	22	36	<4	6.0	135.4	85	5.6
23	30	1.1	5.1	22	77	4.6	23	30	<4	6.2	32.4	77	4.8
24	23	3.4	7.3	18	71	6.3	24	23	<4	8.4	20.8	71	6.0
25	33	5.9	11.0	80	81	10.0	25	33	<4	6.8	72.1	81	6.4
26	33	1.3	3.9	60	78	3.4	26	33	<4	2.4	74.0	78	2.4
27	36	1.9	5.1	45	84	4.7	27	36	<4	3.2	46.4	84	2.8
28	36	1.2	3.6	19	82	5.1	28	36	<4	3.0	53.6	82	3.2
29	36	2.1	4.5	230	83	5.3	29	36	<4	4.5	137.0	83	5.6
30	36	2.9	7.4	160	84	7.2	30	36	<4	6.0	50.0	84	4.8
LL1	36	<1	4.7	18	108	4.3	LL1	36	<4	5.2	20.0	109	4.0
LL2	35	1.5	5.9	80	107	5.2	LL2	35	<4	9.6	95.0	108	7.8
LL3	35	<1	4.5	300	107	4.9	LL3	35	<4	6.8	310.0	108	5.6

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	29	20	27	38	139	39	1	29	<2	1.4	4.8	138	1.7
2	35	23	33	51	147	41	2	35	<2	1.7	8.2	147	1.7
3	36	32	37	55	152	41	3	36	<2	1.3	5.2	150	1.3
4	36	30	66	86	143	69	4	36	<2	1.6	6.7	143	1.6
5	34	14	56	74	141	55	5	34	<2	1.3	7.2	140	0.9
7	36	13	15	21	150	15	7	36	<2	0.9	2.7	149	0.8
8	36	12	15	19	148	15	8	36	<2	0.4	2.4	147	0.2
9	35	13	15	24	152	16	9	35	<2	0.2	2.1	152	0.3
10	36	15	17	30	154	18	10	36	<2	1.1	54.2	154	0.8
11	32	22	27	35	127	26	11	32	<2	0.4	11.5	126	0.4
12	35	20	22	54	142	22	12	35	<2	0.3	2.2	142	0.3
13	35	35	43	54	143	43	13	35	<2	0.6	2.5	143	0.5
14	36	26	39	65	139	40	14	36	<2	0.8	3.4	140	0.8
15	35	51	64	90	135	75	15	35	<2	0.7	5.1	135	1.3
16	34	49	59	100	132	60	16	34	<2	0.9	5.6	132	0.7
17	25	49	62	92	134	62	17	25	<2	1.9	6.1	136	0.9
18	33	40	46	60	133	48	18	33	<2	1.3	8.9	131	1.4
19	34	19	24	31	91	24	19	34	<2	0.5	12.2	89	0.4
20	34	31	38	54	111	38	20	34	<2	0.8	16.0	110	0.6
21	34	33	39	64	78	42	21	34	<2	0.8	14.3	77	0.7
22	36	44	51	73	85	57	22	36	<2	1.1	4.5	84	1.1
23	30	28	30	40	77	32	23	30	<2	0.2	1.2	76	0.5
24	23	21	25	34	71	26	24	23	<2	1.2	8.1	70	1.5
25	33	63	70	130	81	79	25	33	<2	1.3	5.0	80	1.7
26	33	43	74	152	78	74	26	33	<2	0.8	4.6	77	1.0
27	36	99	170	262	84	172	27	36	<2	0.5	1.6	84	0.7
28	36	52	59	73	82	61	28	36	<2	0.3	8.2	81	0.6
29	36	41	62	100	83	64	29	36	<2	0.6	5.2	82	1.0
30	36	66	80	94	84	80	30	36	<2	1.6	6.2	82	1.7
LL1	36	42	48	67	108	50	LL1	33	<2	0.5	6.0	103	0.5
LL2	35	27	32	46	107	33	LL2	32	<2	0.5	2.7	102	0.5
LL3	35	27	29	42	107	30	LL3	32	<2	0.3	10.6	102	0.5

Appendix F: 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	29	<2	1.4	6.5	138	1.2	1	29	<20	8.3	23.9	137	8.8
2	34	<2	1.5	12.2	146	1.0	2	35	<20	7.6	25.0	147	8.0
3	36	<2	0.4	12.5	151	0.4	3	36	<20	3.0	<20	151	3.5
4	36	<2	1.1	5.1	143	0.9	4	36	<20	8.4	31.3	143	8.6
5	34	<2	0.8	2.2	141	0.5	5	34	<20	7.9	24.4	140	5.7
7	36	<2	0.2	2.3	150	0.2	7	36	<20	1.9	<20	150	1.8
8	36	<2	0.1	2.0	148	0.2	8	36	<20	1.5	<20	148	1.4
9	35	<2	0.2	<2	153	0.2	9	35	<20	1.1	<20	153	1.6
10	36	<2	0.3	<2	155	0.3	10	36	<20	3.7	<20	155	2.9
11	32	<2	0.2	<2	127	0.2	11	32	<20	0.6	<20	127	1.0
12	35	<2	0.2	21.2	143	0.2	12	35	<20	2.7	60.5	143	2.1
13	35	<2	0.4	2.5	144	0.3	13	35	<20	1.4	<20	144	1.9
14	36	<2	0.5	3.1	140	0.4	14	36	<20	2.8	<20	140	4.5
15	35	<2	0.3	2.1	136	0.4	15	35	<20	5.1	124.9	136	9.6
16	34	<2	0.3	7.9	133	0.4	16	34	<20	3.1	36.3	133	3.7
17	25	<2	0.4	3.6	136	0.5	17	25	<20	6.1	69.1	136	4.5
18	33	<2	0.7	5.9	132	0.6	18	33	<20	6.1	29.7	132	7.3
19	34	<2	0.5	4.7	90	0.5	19	34	<20	2.1	<20	90	3.2
20	34	<2	0.5	18.2	111	0.4	20	34	<20	5.0	28.3	111	2.2
21	34	<2	0.5	6.7	78	0.4	21	34	<20	3.6	35.4	78	2.1
22	36	<2	0.6	4.7	85	0.5	22	36	<20	4.5	<20	85	3.5
23	30	<2	0.2	<2	77	0.2	23	30	<20	2.2	<20	77	1.9
24	23	<2	0.5	10.5	71	0.9	24	23	<20	7.2	49.9	71	8.7
25	33	<2	0.6	3.5	81	0.9	25	33	<20	11.8	38.3	81	16.9
26	33	<2	0.4	3.5	78	0.3	26	33	<20	6.5	36.8	78	5.5
27	36	<2	0.2	2.0	84	0.3	27	36	<20	6.4	<20	84	6.6
28	36	<2	0.2	2.0	82	0.1	28	36	<20	3.4	32.6	82	2.2
29	36	<2	0.2	8.1	82	0.3	29	36	<20	6.3	53.1	82	7.1
30	36	<2	0.8	4.7	84	0.8	30	36	<20	7.6	<20	84	7.0
LL1	33	<2	0.2	<2	105	0.2	LL1	33	<20	0.0	<20	104	0.6
LL2	32	<2	0.3	2.2	104	0.3	LL2	32	<20	0.6	<20	103	0.8
LL3	32	<2	0.2	6.0	104	0.2	LL3	32	<20	0.4	43.3	103	0.0

Orthophosphate (mg/L as PO4)-Last 3 Yrs/rept. lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	29	<0.02	0.05	0.18	137	0.04
2	35	<0.02	0.10	0.36	145	0.07
3	36	<0.02	0.05	0.20	150	0.06
4	36	0.04	0.26	1.07	142	0.29
5	34	<0.02	0.08	0.21	139	0.06
7	36	<0.02	0.02	0.12	148	0.02
8	36	<0.02	0.03	0.23	146	0.04
9	35	<0.02	0.03	0.16	152	0.03
10	36	<0.02	0.03	0.24	153	0.03
11	32	<0.02	0.02	0.15	125	0.02
12	35	<0.02	0.03	0.15	141	0.03
13	35	<0.02	0.05	0.15	142	0.04
14	36	<0.02	0.05	0.30	139	0.05
15	35	<0.02	0.05	0.38	134	0.06
16	34	<0.02	0.07	0.22	131	0.06
17	25	0.02	0.11	2.95	134	0.07
18	33	<0.02	0.04	0.15	131	0.07
19	34	<0.02	0.05	0.18	91	0.04
20	34	<0.02	0.09	0.33	111	0.06
21	34	<0.02	0.09	0.52	78	0.11
22	36	<0.02	0.09	0.25	85	0.10
23	30	<0.02	0.07	0.18	77	0.07
24	23	<0.02	0.09	0.18	71	0.10
25	33	<0.02	0.10	0.72	81	0.22
26	33	<0.02	0.06	0.22	78	0.06
27	36	<0.02	0.10	0.25	84	0.13
28	36	<0.02	0.07	0.27	82	0.08
29	36	<0.02	0.10	0.59	83	0.13
30	36	<0.02	0.08	0.25	84	0.09
LL1	36	<0.02	0.08	0.25	108	0.08
LL2	35	0.05	0.09	0.25	107	0.09
LL3	35	<0.02	0.11	0.42	107	0.09

Ammonia-nitrogen (mg/L) - Last 3 Years/rept. lim. 0.02 mg/L					All Results		Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/rept. limit 0.1 mg/L					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	29	0.09	0.15	0.26	136	0.12	1	29	0.1	0.4	0.6	137	0.3
2	35	0.07	0.14	0.28	145	0.12	2	35	0.3	0.5	1.0	145	0.4
3	36	0.05	0.13	0.33	150	0.12	3	36	0.2	0.5	1.1	150	0.5
4	36	0.10	0.17	0.32	142	0.17	4	36	0.5	1.0	1.6	142	1.0
5	34	0.05	0.12	0.25	139	0.07	5	34	0.1	0.8	1.4	139	0.8
7	36	<0.02	0.04	0.19	148	0.03	7	36	<0.1	0.1	0.3	148	0.1
8	36	0.02	0.07	0.19	146	0.06	8	36	<0.1	0.1	0.3	146	0.1
9	35	<0.02	0.05	0.23	152	0.04	9	35	<0.1	0.1	0.5	152	0.1
10	36	0.02	0.06	0.21	153	0.05	10	36	0.1	0.2	0.6	153	0.2
11	32	0.03	0.06	0.22	125	0.06	11	32	0.1	0.3	0.4	125	0.2
12	35	<0.02	0.05	0.14	141	0.03	12	35	<0.1	0.2	0.7	140	0.2
13	35	<0.02	0.06	0.18	142	0.05	13	35	0.4	0.6	0.9	141	0.5
14	36	0.04	0.10	0.25	139	0.09	14	36	0.3	0.6	1.1	139	0.5
15	35	0.04	0.10	0.26	134	0.10	15	35	0.7	1.3	2.2	134	1.4
16	34	0.03	0.10	0.22	131	0.08	16	34	0.3	0.6	1.4	131	0.5
17	25	0.05	0.11	0.39	134	0.08	17	25	0.3	0.6	1.5	134	0.5
18	33	0.06	0.12	0.27	131	0.13	18	33	0.3	0.6	0.8	131	0.6
19	34	0.03	0.06	0.19	91	0.05	19	34	0.1	0.2	0.8	91	0.2
20	34	0.03	0.08	0.18	110	0.07	20	34	0.4	0.6	0.9	111	0.6
21	34	0.04	0.12	0.22	78	0.11	21	34	0.3	0.5	1.7	78	0.6
22	36	0.04	0.09	0.22	85	0.11	22	36	0.2	0.4	1.3	85	0.5
23	30	0.02	0.07	0.25	77	0.08	23	30	0.1	0.3	0.7	77	0.3
24	23	0.06	0.10	0.20	71	0.12	24	23	0.1	0.2	0.5	71	0.2
25	33	0.11	0.22	1.17	81	0.24	25	33	0.5	0.7	2.6	81	0.9
26	33	<0.02	0.10	0.21	78	0.09	26	33	0.5	0.8	1.4	78	0.7
27	36	0.04	0.10	0.65	84	0.10	27	36	0.4	0.7	1.1	84	0.7
28	36	0.04	0.07	0.30	82	0.09	28	36	0.3	0.6	0.9	82	0.6
29	36	0.02	0.13	0.74	83	0.15	29	36	0.3	1.3	2.1	83	1.2
30	36	0.08	0.16	0.31	84	0.17	30	36	0.7	1.2	2.3	84	1.1
LL1	36	<0.02	0.06	0.16	108	0.04	LL1	36	0.2	0.5	0.8	108	0.5
LL2	35	0.02	0.06	0.17	107	0.05	LL2	35	0.1	0.3	0.7	107	0.2
LL3	35	<0.02	0.07	0.39	107	0.05	LL3	35	<0.1	0.2	1.1	107	0.1

Appendix G: 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				X		
19	Green River above L Summit			X	X									X			X			X		X	
11	Green River below L Summit			X	X		X		X			X		X			X						
13	Big Hungry River			X	X									X			X					X	
LL1	Reedypatch Creek			X	X							X		X			X				X		
LL2	Hickory Creek			X	X			X				X	X	X			X				X		
LL3	Broad River			X	X				X			X	X	X			X						
	Mud Creek watershed																						
21	Mud Creek at Berea Ch Rd			X	X		X	X	X		X	X	X	X									
3	Mud Creek at Erkwood Road			X	X			X	X			X	X	X			X						
18	Mud Creek at 7th Ave/H'ville			X	X			X	X				X	X			X				X		
15	Bat Fork Creek			X	X			X						X			X						X
30	Devil's Fork			X	X		X		X		X	X	X	X			X						
26	Brittain Creek			X							X		X	X							X		
20	Clear Creek upstream				X								X	X			X				X	X	X
5	Clear Creak downstream			X	X			X	X				X	X			X				X		
4	Mud Creek at N Rugby Rd			X	X			X					X	X			X				X	X	X
	Mills River watershed																						
7	North Fork Mills River				X									X			X	X			X	X	
8	South Fork Mills River			X	X																	X	
9	Mills River at 191/280				X												X					X	
29	Brandy Branch					X			X			X											
10	Mills River at Hooper Ln			X	X								X				X				X		

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

		increases as flow increases											decreases as flow increases										
site #	site name	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			X						
17	Cane Creek at US 25			X	X							X	X	X			X						
	Etowah/Horseshoe																						
23	Big Willow Creek																				X		
24	Little Willow Creek											X	X										
25	Gash Creek			X									X	X			X				X		
28	Shaw Creek				X		X		X				X	X							X		
27	Mill Pond Creek			X	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			X				X		

Appendix H: Trends for Each Site Related to Time

site		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				X	X	X											
19	Green River above L Summit	X				X				X	X	X											
11	Green River below L Summit					X					X	X			X					X			
13	Big Hungry River	X				X				X	X	X								X			
LL1	Reedypatch Creek	X				X					X												
LL2	Hickory Creek	X									X	X											
LL3	Broad River	X		X						X	X	X											
	Mud Creek watershed																						
21	Mud Creek at Berea Ch Rd	X															X				X	X	X
3	Mud Creek at Erkwood Road													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	X	X	X	X	X	X		X
30	Devil's Fork														X	X		X				X	
26	Brittain Creek	X																X					
20	Clear Creek upstream	X	X	X		X	X	X	X	X	X	X											
5	Clear Creak downstream					X	X	X		X	X												
4	Mud Creek at N Rugby Rd	X								X	X	X											
	Mills River watershed																						
7	North Fork Mills River	X					X			X	X									X			
8	South Fork Mills River	X									X			X	X								
9	Mills River at 191/280										X			X									
29	Brandy Branch														X		X						X
10	Mills River at Hooper Ln	X					X				X			X			X						

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

		increasing over time											decreasing over time										
site #	site name	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								
16	Cane Creek/Howard Gap Rd	X				X				X	X	X											
17	Cane Creek at US 25		X			X	X			X	X	X											
	Etowah/Horseshoe																						
23	Big Willow Creek	X																X				X	
24	Little Willow Creek																						
25	Gash Creek	X															X	X		X	X	X	X
28	Shaw Creek	X													X							X	
27	Mill Pond Creek	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						
2	French Broad River/Mt Home			X			X	X		X	X	X		X			X						

Appendix I: 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 = 29

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	trend sites	% sites showing trend
pH		1	10	5	16				16	55.2%
alkalinity			4	13	2	15			17	58.6%
turbidity	1	1	14		2	1		13	16	55.2%
total susp sol		1	17		5	1		12	18	62.1%
conductivity	6		2	11		17	2		19	65.5%
copper			4	2	2	4			6	20.7%
lead			4	1	2			3	5	17.2%
zinc	2		2			3		1	4	13.8%
orthophos.	1		6	1	2	6			8	27.6%
ammonia-N			3	1	2	1		1	4	13.8%
nitrate-N	13		4			3	2	12	17	58.6%

Totals for All VWIN Sites Examined for Trends
number of sites examined for trends = 162

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	trend sites	% sites showing trend
pH		4	46	41	76	13		2	91	56.2%
alkalinity			40	60	15	85			100	61.7%
turbidity	4	25	82		53	2	1	55	111	68.5%
total susp sol	1	34	98		68	1		64	133	82.1%
conductivity	10	3	35	76	19	100	3	2	124	76.5%
copper		3	18	2	15	6		5	23	14.2%
lead		12	33	1	27	1		18	46	28.4%
zinc	3	8	23		6	10	1	17	34	21.0%
orthophos.	1	1	43	5	24	23		3	50	30.9%
ammonia-N	3	2	37	3	23	8	3	11	45	27.8%
nitrate-N	77	13	28	1	9	12	14	84	119	73.5%

Appendix J: Biological Monitoring Index and Rating for Every Monitoring Event from 2002 through 2005

VWIN Site # (where applicable)	Site Description	Total Index Value Apr-02	Water Quality Rating Apr-02	Total Index Value Oct-02	Water Quality Rating Oct-02	Total Index Value Apr-03	Water Quality Rating Apr-03	Total Index Value Oct-03	Water Quality Rating Oct-03	Total Index Value Apr-04	Water Quality Rating Apr-04	Total Index Value Oct-04	Water Quality Rating Oct-04	Total Index Value Apr-05	Water Quality Rating Apr-05	Total Index Value Oct-05	Water Quality Rating Oct-05
	Green River Watershed																
19*	Green River at Bob's Crk. Rd.	15	Fair	20	Good	27	Excellent	20	Good	18	Good						
	Rock Creek	24	Excellent	23	Excellent	16	Fair	24	Excellent	22	Good	15	Fair	15	Fair		
12	Green River at Terry's Crk. Rd.	9	Poor	17	Good	15	Fair	19	Good	16	Fair						
11	Green River below Lake Summit	22	Good	21	Good	16	Fair	17	Good	21	Good			17	Good	26	Excellent
	Little Hungry									25	Excellent	25	Excellent	23	Excellent	16	Fair
	Big Hungry									21	Good	21	Good	19	Good	18	Good
13	Big Hungry below dam									21	Good	21	Good	9	Poor	0	Poor
	Mud Creek Watershed																
21	Mud Creek at Berea Church Rd.	21	Good	7	Poor	12	Fair	15	Fair	14	Fair	17	Good	15	Fair	17	Good
3	Mud Creek at Erkwood Rd.	17	Good	16	Fair	11	Fair	11	Fair	7	Poor	13	Fair				
18	Mud Creek at 7th Ave.	18	Good	18	Good	12	Fair	15	Fair	14	Fair	6	Poor	11	Fair	10	Poor
26	Brittain Creek at Patton Pk.	13	Fair	23	Excellent	17	Good	14	Fair	15	Fair	14	Fair	7	Poor	13	Fair
20*	Clear Creek at Bearwallow Rd.	24	Excellent	23	Excellent	22	Good	18	Good	16	Fair	14	Fair	11	Fair	14	Fair
	Clear Creek at Lancaster Rd.	17	Good	24	Excellent	16	Fair	17	Good	14	Fair	12	Fair	15	Fair	15	Fair
5	Clear Creek at Nix Rd.	17	Good	15	Fair	18	Good	15	Fair	15	Fair	18	Good	14	Fair	14	Fair
	Mills River Watershed																
7	North Mills River	23	Excellent	22	Good	19	Good	19	Good	24	Excellent	14	Fair	14	Fair	16	Fair
8	South Mills River	22	Good	22	Good	13	Fair	23	Excellent	21	Good	15	Fair	19	Good	15	Fair
9	Mills River at Hwy 191	22	Good	17	Good	21	Good	19	Good	18	Good	20	Good	15	Fair	15	Fair
10	Mills River at Hooper Lane	16	Fair	16	Fair	17	Good	19	Good	17	Good	15	Fair	19	Good	19	Good
	Cane Creek Watershed																
22	Hooper's Creek at Jackson Rd.	10	Poor	13	Fair	9	Poor	12	Fair	10	Poor	11	Fair	11	Fair	12	Fair
16	Cane Creek at Howard Gap Rd.	9	Poor	14	Fair	15	Fair	14	Fair	19	Good	9	Poor	9	Poor	12	Fair
	Etowah/Horseshoe																
23	Big Willow Crk at Patterson Rd.	14	Fair	13	Fair	15	Fair	15	Fair	12	Fair	11	Fair	12	Fair		
24	Little Willow Creek at River Rd.	19	Good	9	Poor	6	Poor	16	Fair	17	Good	8	Poor	9	Poor		
25	Gash Crk at Etowah School Rd.	7	Poor	10	Poor	7	Poor	11	Fair	11	Fair	5	Poor	5	Poor		
28	Shaw Creek at Hunters Glen	20	Good	18	Good	16	Fair	16	Fair	11	Fair	9	Poor	12	Fair	6	Poor
27	Mill Pond Ck at Haywood Knolls	10	Poor	12	Fair	10	Poor	14	Fair	9	Poor	9	Poor	6	Poor	10	Poor
14	Boylston Creek at Ladson Rd.	17	Good	15	Fair	3	Poor	11	Fair	6	Poor			12	Fair	10	Poor

*Location within 1 mile of actual VWIN site