Polk County Stream Water Quality: Year Sixteen

Volunteer Water Information Network

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Technical Report #10-200

December 2009

ENVIRONMENTAL QUALITY INSTITUTE

THE UNIVERSITY OF NORTH CAROLINA AT ASHEVILLE

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Acknowledgments

We wish to thank the Pacolet Area Conservancy for their continued support of the monitoring program. Their support has enabled Polk 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 Polk County program also provides essential information to complete the assessment of water quality in the Broad River watershed. Every county should be clearly aware of the part they play in the overall water quality of the region.

Special credit should be given to Bill Meanix, the coordinator of the Polk County program and to David Rice and Rebecca Kemp who deliver the samples to the Environmental Quality Institute laboratory every month. Of course, the volunteers who collect the samples every month are the most important part of the program. Many thanks to the Polk County volunteers including Larry Boyd, McCrae Dalton, Ray Dittmar, James Donlan, Deborah Hahn, Bill Janes, Jeff Jenkins, Jerry Johnson, Steve King, Bill Meanix, Alfred Page, Chris Price, David Prudhomme, Al Rolla, and Alex Salley. Without volunteers any monitoring program would be prohibitively expensive. These conscientious citizens are making an important contribution to the preservation of clean water resources in Polk County and their efforts are greatly appreciated. Concern about water quality continues to grow and the information gathered by these dedicated volunteers will play an important role in developing a comprehensive management plan for the Broad River watershed and will provide valuable data for local resource planning.

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 Pacolet Area Conservancy (PAC), the Environmental Conservation Organization (ECO), Haywood Waterways Association, the Asheville Metropolitan Sewerage District, the Friends of Lake Glenville, the Town of Lake Lure, the Lake James Environmental Association, the Hiawassee River Watershed Coalition, the Madison County Soil and Water Conservation District, the Watershed Association of the Tuckasegee River, the National Committee for the New River, Equinox Environmental, and others provide administrative support. The UNC-Asheville Environmental Quality Institute (EQI) has provided technical assistance through laboratory analysis of water samples, statistical analysis of water quality results, and written interpretation of the data. Volunteers venture out once per month to collect water samples from designated sites along streams and rivers in the region.

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 can use this data to identify streams of high water quality that need to be preserved, as well as streams that cannot support further development without significant water quality degradation. In addition, the information allows planners to assess the impacts of increased development and the success of pollution control measures. Thus, this program provides the 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 27 stream sites in Buncombe County. The program expanded to 45 sites by November of 1990. Since that time, thirteen other area counties have begun monitoring of local streams, rivers, and lakes to bring the total monitoring sites to over 200. In July 2009, most VWIN sampling was halted when UNC-Asheville closed EQI due to budget cuts. Laboratory services are expected to resume in the summer of 2010 when EQI reopens as a nonprofit organization. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Hiawassee, Catawba, Tuckasegee, New, and Watauga River watersheds in Western North Carolina. Sample sites were chosen to adequately cover as many watershed drainage areas as possible within each county. Some sites were chosen to cover potential future water supplies. Several sites were also selected as control sites to provide comparison between undeveloped and developed watersheds.

The Polk County VWIN Program

In April of 1993, the Pacolet Area Conservancy began a VWIN program that monitored 10 selected streams in order to begin providing an assessment of water quality conditions in Polk County. PAC named the program "streamwatch" and it became an instant success. The program has expanded and now includes 14 sites. The approximate location of all the monitoring sites in the county can be found on the map in Figure 1. Table 1 is list of the monitoring sites and their locations.

Under the administration of the Pacolet Area Conservancy, this program has gathered sixteen years of water quality data. This report represents statistical analyses and interpretation of data gathered by VWIN volunteers from April 1993 through June 2009.

Table 1: Approximate Locations of Current Polk County VWIN Monitoring Sites

1. White Oak Creek at S.R. 1137 (Houston Rd.)

2. White Oak Creek at S.R. 1531 (Fox Mtn. Rd.)

4. White Oak Creek at S.R. 1322 (Moore Rd.)

5. Horse Creek at S.R. 1153 (Skyuka Rd.) (North Pacolet River watershed)

6. Horse Creek at S.R. 1516 (River Rd.) (North Pacolet River watershed)

7. North Pacolet River at S.R. 1516 (S. River Rd.)

8. Demannu Creek at S.R. 1140 & R. 9N (Green River watershed)

9. Joel's Creek upstream/Saluda Treatment Plant (North Pacolet River watershed)

10. Joel's Creek downstream/Saluda Treatment Plant (North Pacolet River watershed)

13. Green River at Hwy 9

14. White Oak Creek at Briar Hill Farm

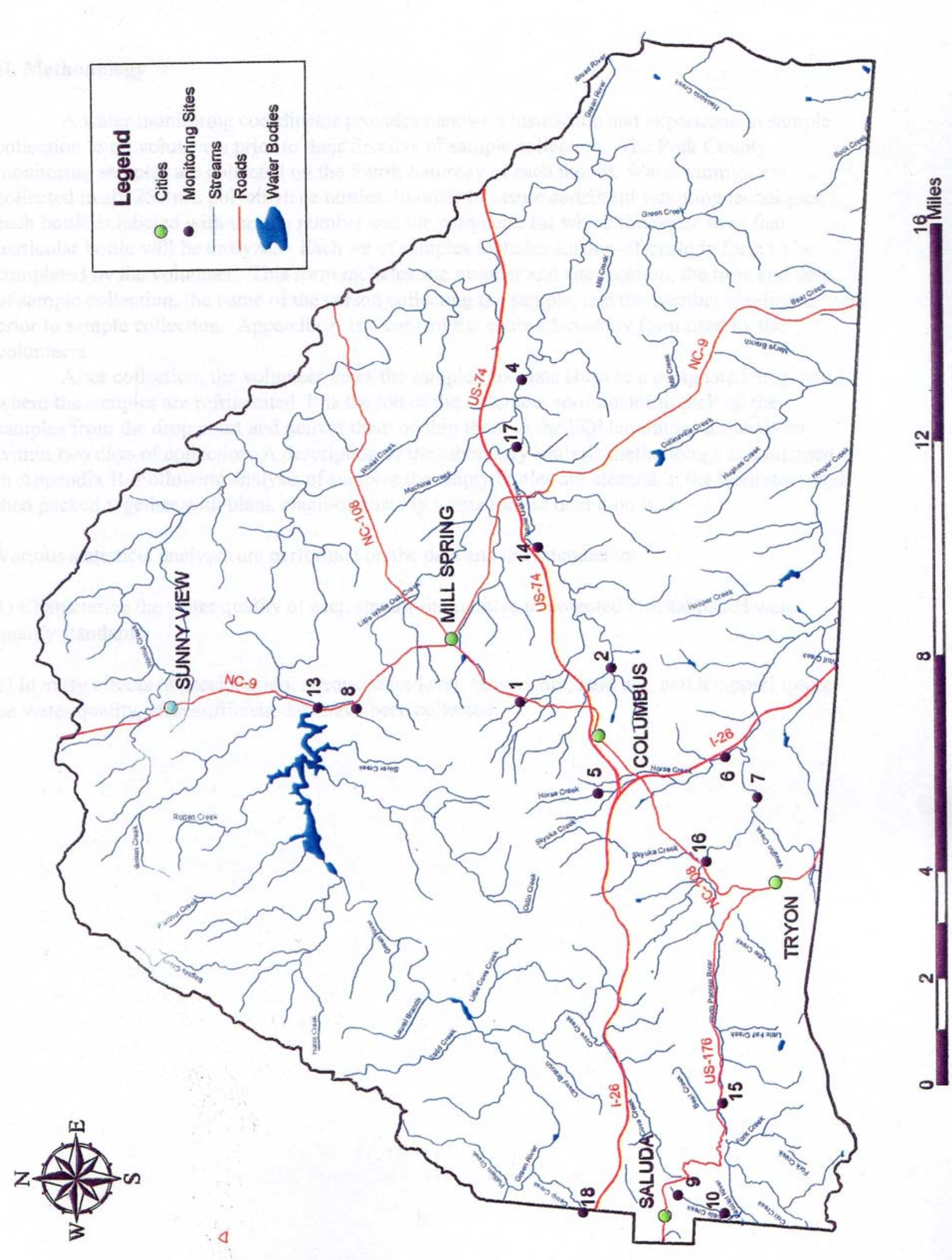
15. North Pacolet River at Melrose

16. North Pacolet River at Rte 108

17. White Oak Creek at Weidman's (discontinued)

18. Camp Creek (Green River watershed)

Figure 1: Polk County VWIN Monitoring Sites



II. Methodology

A water monitoring coordinator provides hands-on instruction and experience in sample collection to all volunteers prior to their first day of sample collection. The Pamlico-Tar monitoring samples are collected on the second Saturday of each month. 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. Each set of samples includes a chain-of-custody form to be completed by the volunteer. This form includes site number and site location, the time and date of sample collection, the name of the person collecting the sample, and the weather conditions prior to sample collection. Appendix A is a copy of the chain-of-custody form used by the volunteers.

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 or ship them to the EQI laboratory for analysis within two days of collection. A description of the laboratory analysis methodology is contained in Appendix B. Following analysis of samples the empty bottles are cleaned in the laboratory and then packed together with blank chain-of-custody forms 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) Identify effects of precipitation, stream water level, seasonality, land use, and temporal trends on water quality, after sufficient data have been collected.

III. Results and Discussion

This discussion is based on sixteen years of data gathered from April 1993 through June 2009. Trends in water quality become more evident with each additional year of continuous stream monitoring, 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 Polk County (Appendix E), site 1 had a median TSS concentration of 3.8 mg/L over the past three years, which is equivalent to 3.8 ppm. Thus if you filter one liter of water from site 1 on average you will collect sediments that weigh 3.8 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 July 2006 through June 2009 (Table 2). Using only the past three years of data allows streams to show the most current water quality status. Thus, streams that may show improved water quality as a result of newly implemented management practices will reflect improvement in their grade. Likewise streams where water quality has been deteriorating will show lower grades than past years. The grades are designed to characterize the water quality at each site with regard to individual parameters. Water quality standards were used where applicable to assess the possible impacts these levels could have on human health and organisms in the aquatic environment. For example, the 7 ppb water quality standard for copper was used to determine grades for the sites. A grade of "A" would be assigned to a site if, over the last three years, no samples had a concentration that exceeded this standard. In contrast, due to the detrimental effects decreases in pH can have on the organisms that live in streams, a site could receive an "A" if minimum pH value was never lower than 6.0. Appendix C describes the criteria used for the grading system for each parameter.

Appendix D is a list of all VWIN stream sites monitored in Western North Carolina indexed and ranked using the grading system previously discussed and shown in Table 2. This indexing system was developed to facilitate comparisons of specific problem areas such as

Table 2: Classification Grades Based on Parameters and Ranges

Site	Name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Orthophosphate	Ammonia-nitrogen	Nitrate/nitrite-nitrogen
1	White Oak Creek at S.R. 1137 (Houston Rd)	A	B	C	A	C	A	A	A	A	A	A
2	White Oak Creek at S.R. 1531 (Fox Mtn Rd)	A	A	D	B	C	B	A	A	A	A	A
4	White Oak Creek at S.R. 1322 (Moore Rd)	A	B	D	A	C	A	A	A	B	A	B
5	Horse Creek at S.R. 1153 (Skyuka Rd)	A	B	C	B	B	A	A	A	A	A	A
6	Horse Creek at S.R. 1516 (River Rd)	A	B	B	A	C	A	A	A	A	A	A
7	North Pacolet River at S.R. 1516 (S River Rd)	A	B	C	B	C	A	A	A	B	A	A
8	Demannu Creek at S.R. 1140 & R. 9N	A	B	C	B	C	B	A	A	B	A	A
9	Joel's Creek upstream/Saluda Wastewater TP	A	B	B	B	C	A	A	A	B	A	B
10	Joel's Creek downstream/Saluda Wastewater TP	A	B	C	B	C	B	A	B	D	C	C
13	Green River at Hwy 9	A	C	B	A	B	B	A	A	A	A	A
14	White Oak Creek at Briar Hill Farm	A	B	C	B	C	B	A	A	C	A	B
15	North Pacolet River at Melrose	A	C	C	B	B	A	A	A	B	A	A
16	North Pacolet River at Rte 108	A	B	C	B	B	A	A	A	A	A	B
18	Camp Creek (Green River watershed)	A	C	D	D	B	A	A	A	A	A	A

A = Excellent, B = Good, C = Average, D = Poor

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

The data from all VWIN monitoring sites in Western North Carolina are used in this report to compare water quality from the stream sites in Polk County with water quality from the mountain region in general. It should be noted that, although there are always some sites in each area 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 were determined by 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, it has shown largely to be effective. With this method the control for flow is more accurate and allows for more precise examination of the effects of other factors. The USGS gauging station on the North Pacolet River at Fingerville, S.C. (#02154500) was utilized to estimate relative flow for the sites in Polk County. Each site was matched to that gauge station. 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 Polk County monitoring program in 1992 to present. Appendix F is a summary of trends related to flow, Appendix G shows trends related to time and Appendix H shows trends related to season.

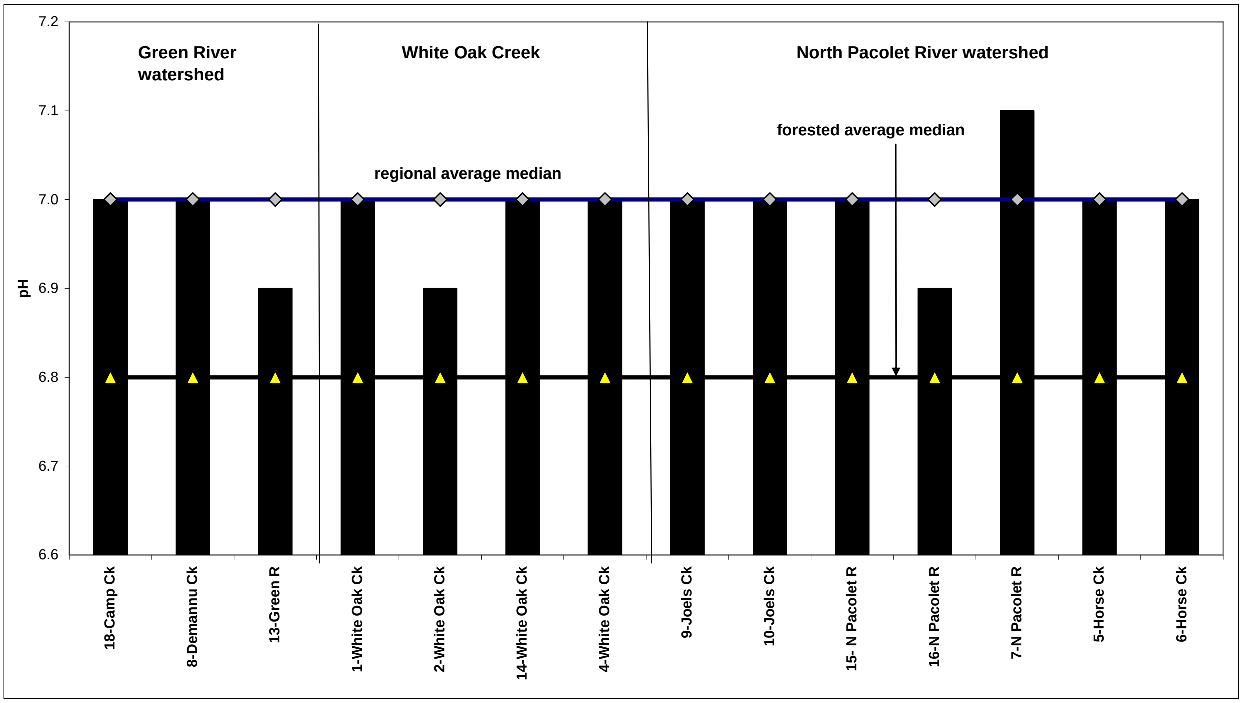
A. Acidity (pH) and Alkalinity: pH is used to measure acidity. The pH is a measure of the concentration of hydrogen ions in a solution. If the value of the measurement is less than 7.0, the solution is acidic. If the value is greater than 7.0, the solution is alkaline (more commonly referred to as basic).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

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

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

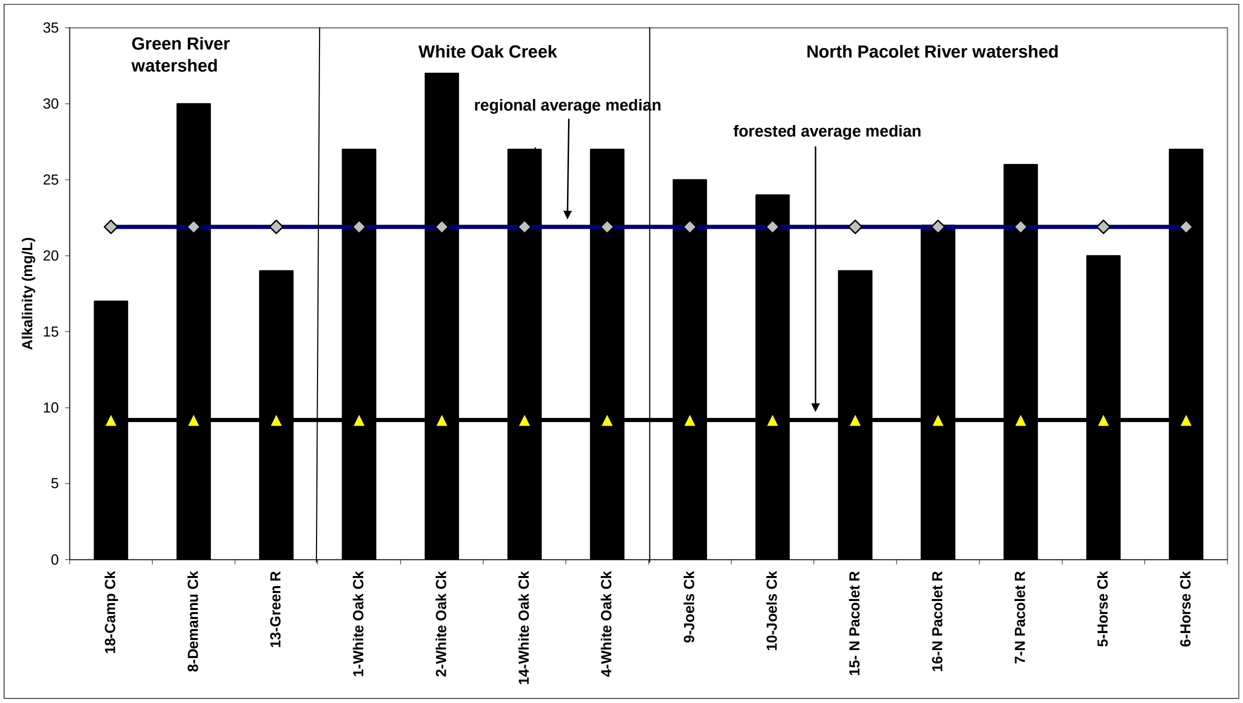
Figures 2 and 3 show median pH and alkalinity levels at the Polk County monitoring sites compared to the regional median from all VWIN sites in Western North Carolina and to the median at sites in largely undisturbed forested areas.

Figure 2: Median pH levels at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites



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.

Figure 3: Median alkalinity levels at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites



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.

Figures 4 and 5 show median turbidity and total suspended solids levels at the Polk County monitoring sites compared to the regional median from all VWIN sites in Western North Carolina and to the median at sites in largely undisturbed forested areas.

Figure 4: Median turbidity levels at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites

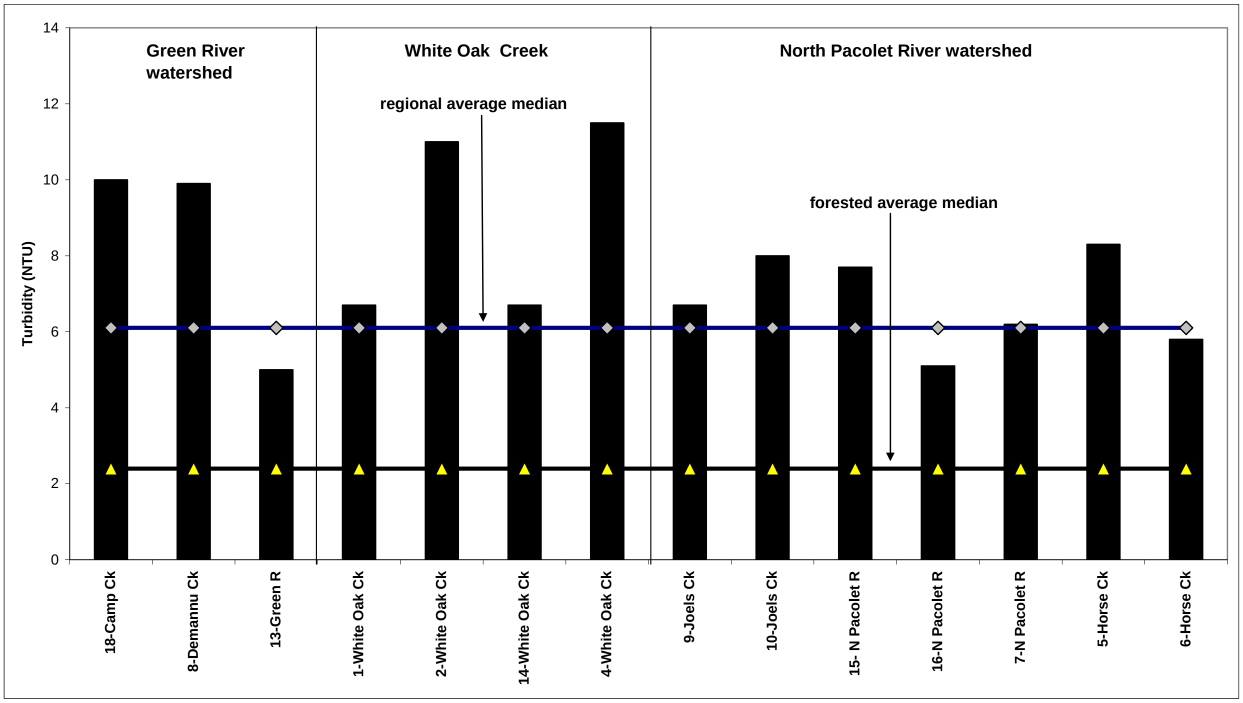
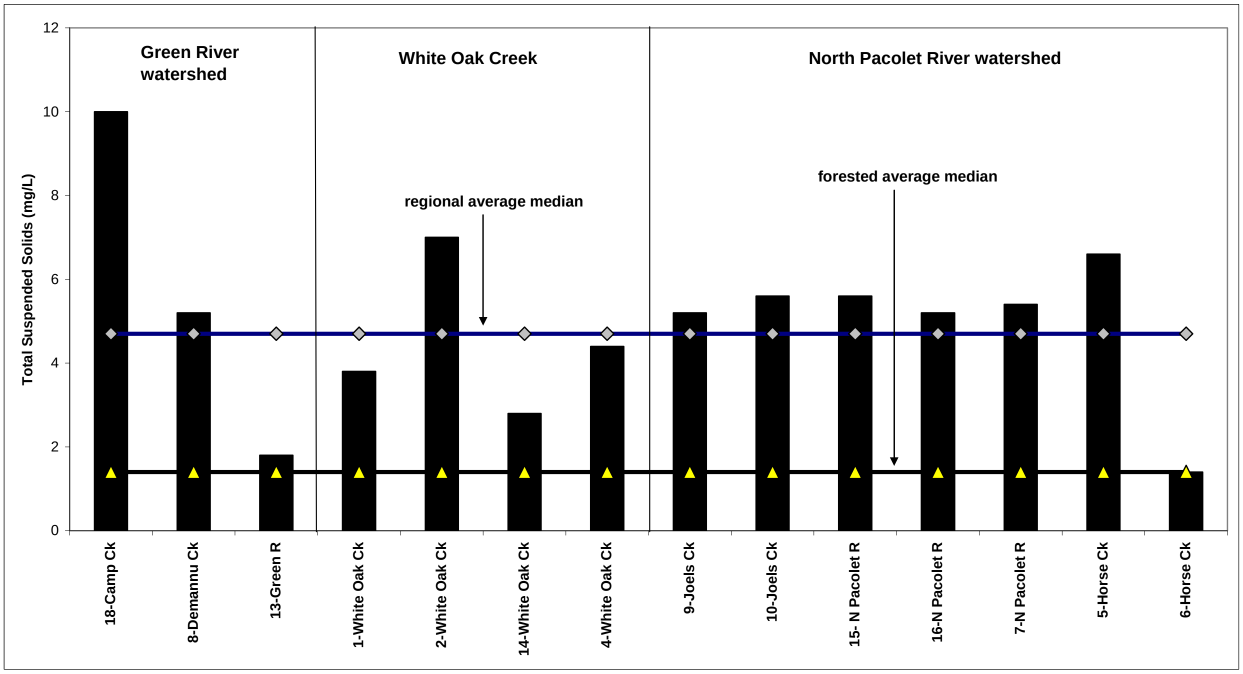


Figure 5: Median total suspended solids concentrations at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites



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.

Figures 6 and 7 show median conductivity levels and zinc concentrations at the Polk County monitoring sites compared to the regional median from all VWIN sites in Western North Carolina and to the median at sites in largely undisturbed forested areas.

Figure 6: Median conductivity levels at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites

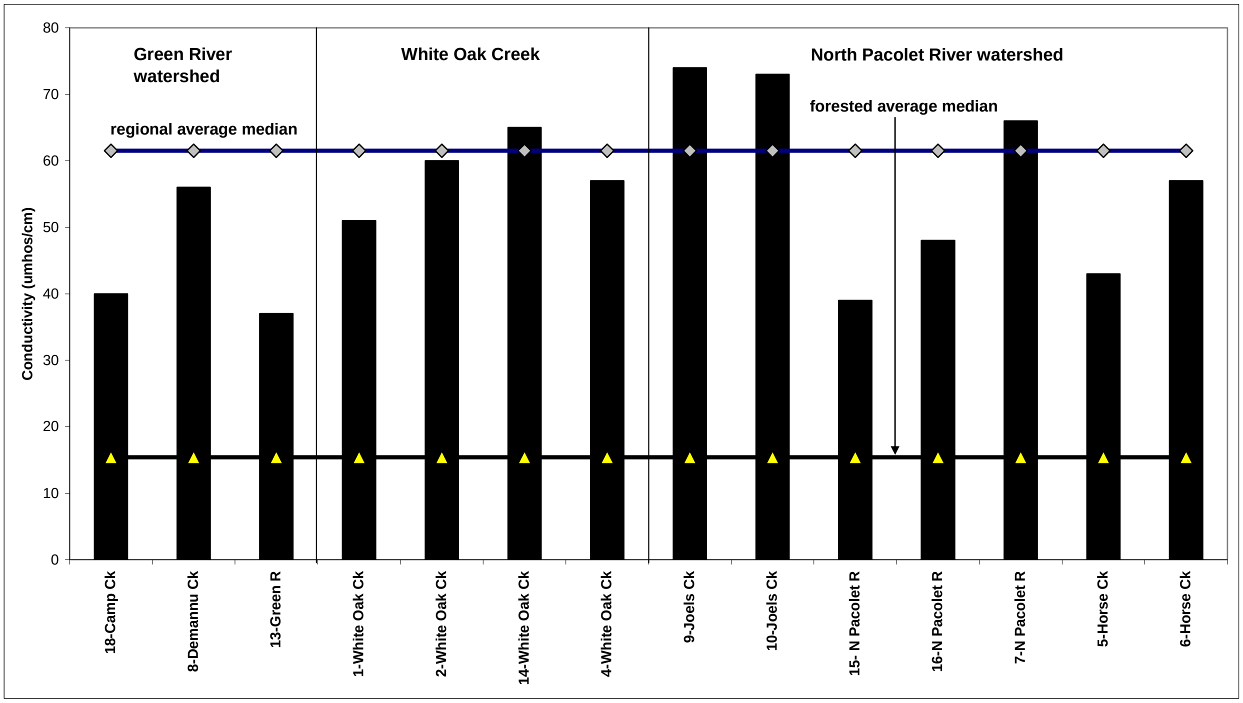
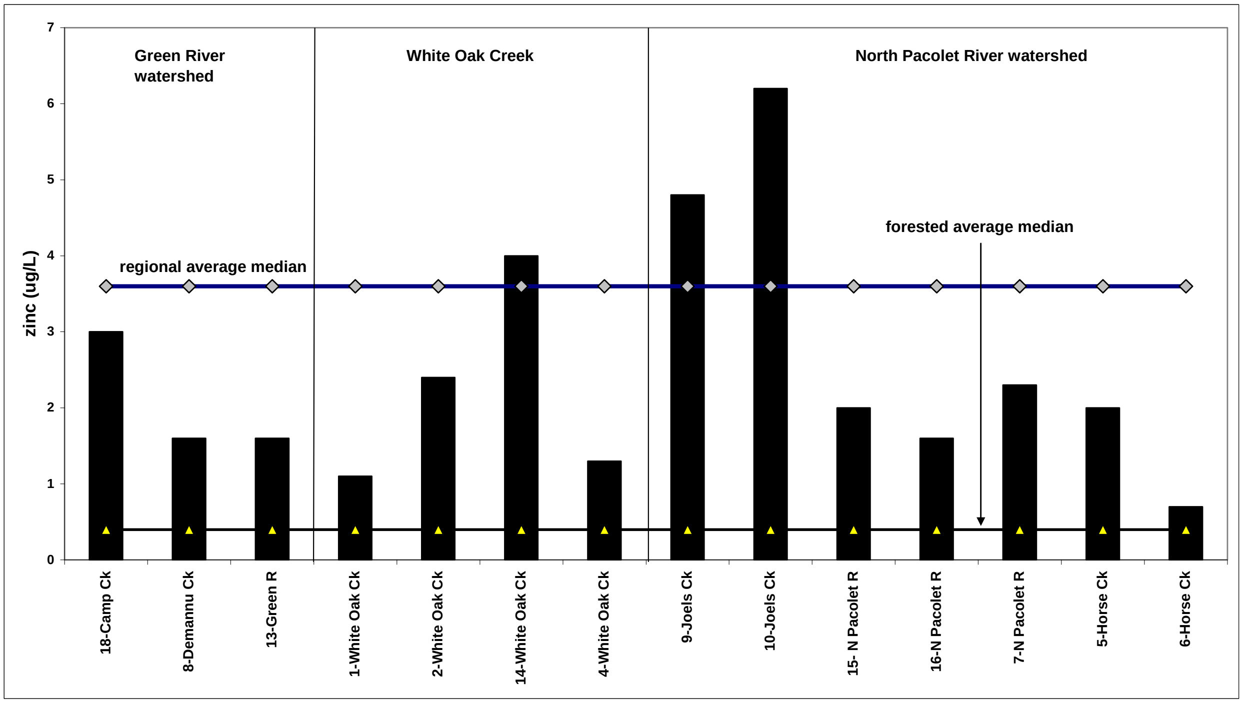


Figure 7: Median zinc concentrations at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites



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 possible sources of pollution from sewage or animal waste during dry weather.

Figures 8, 9, and 10 show median orthophosphate, ammonia-nitrogen, and nitrate/nitrite-nitrogen concentrations at the Polk County monitoring sites compared to the regional median from all VWIN sites in Western North Carolina and to the median at sites in largely undisturbed forested areas.

Figure 8: Median orthophosphate concentrations at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites

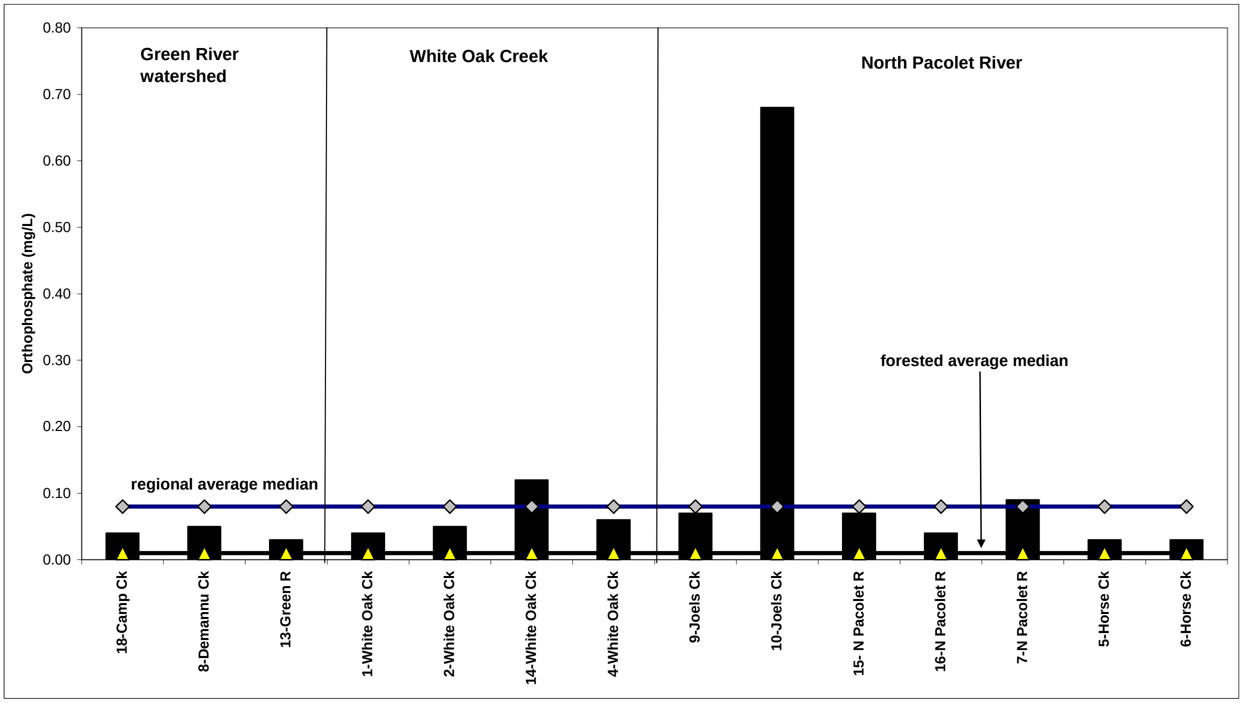


Figure 9: Median ammonia-nitrogen concentrations at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites

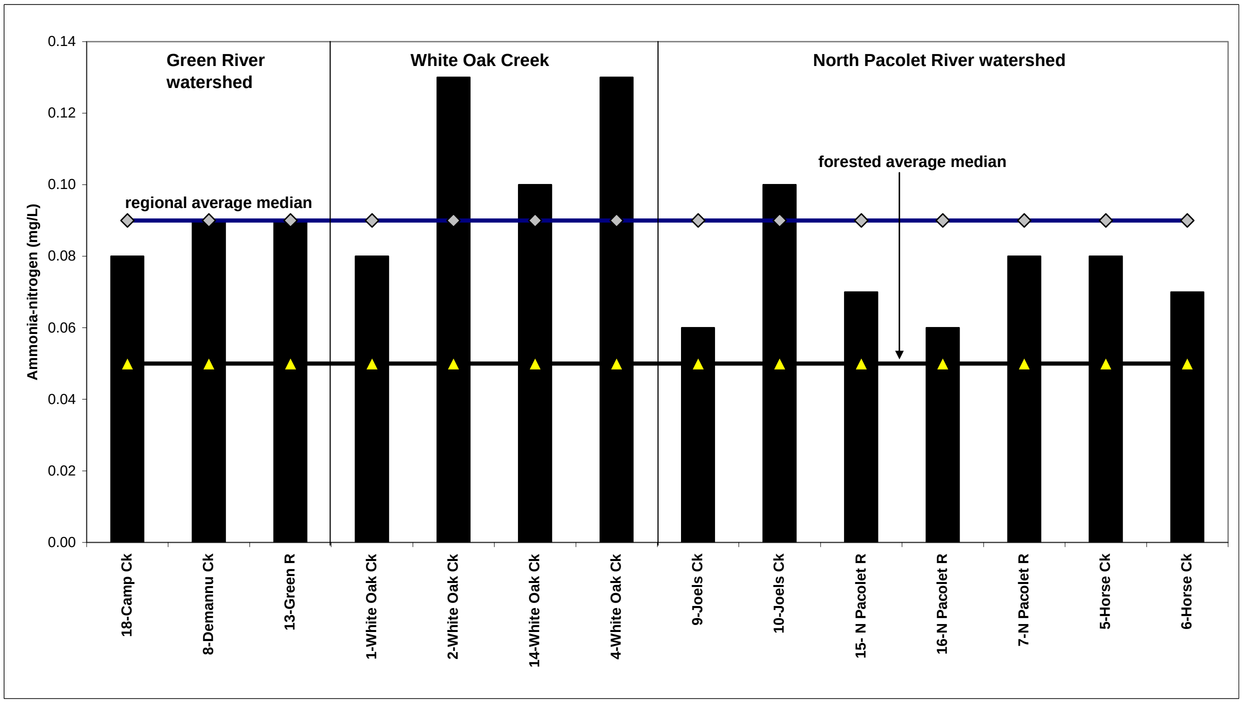
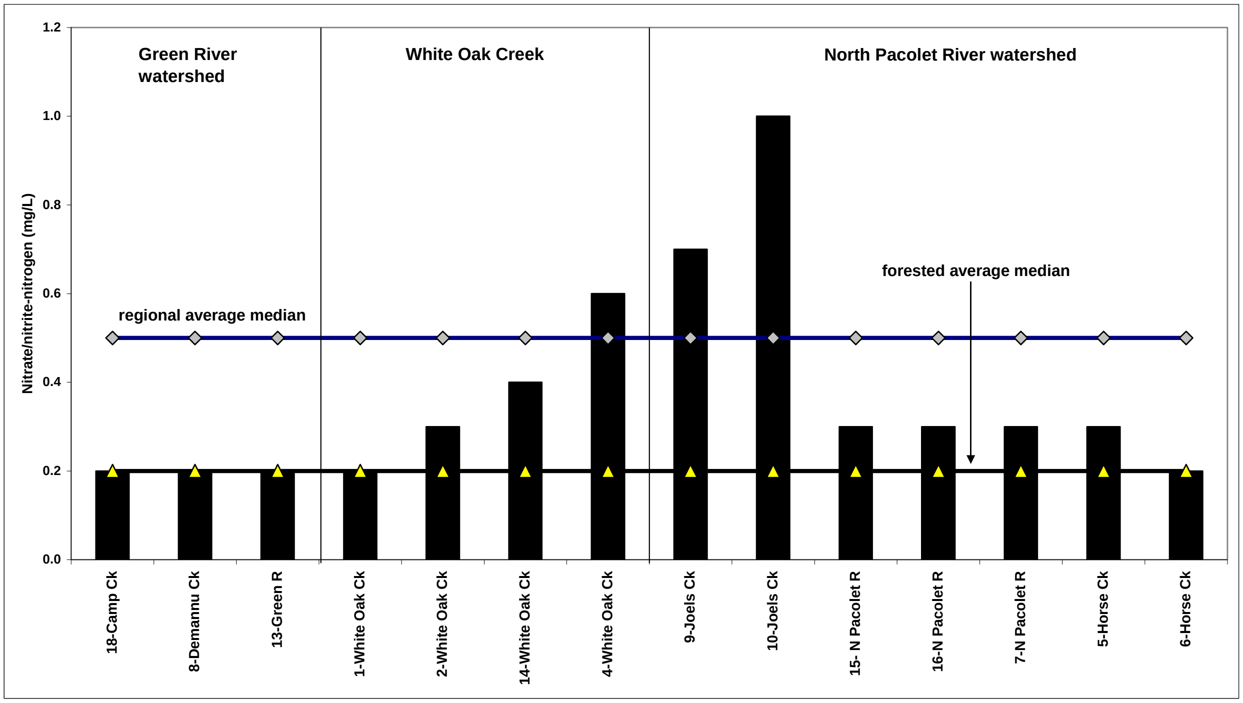


Figure 10: Median nitrate/nitrite-nitrogen concentrations at each monitoring site compared with the VWIN Western NC regional average median and the average median at largely undisturbed forested sites



IV. Summary and Conclusions

Chemical analysis of samples collected at Polk 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 this information to help identify problems and evaluate solutions. Characterizing the water quality of the county is a complex task, and interpretation of the data can be difficult due to many factors. With continued long term monitoring, however, various trends become more evident. Until July 2009, the VWIN program was monitoring over 200 sites throughout Western North Carolina. A comparison of Polk County stream sites with all other sites in the program is presented in Appendix D. Table 3 is a summary of ranking of Polk County sites by water quality issues and by watershed. 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. Note that White Oak Creek is actually in the Green River watershed, but will be treated separately in this report since it is a major drainage area of the county. Summarized observations and trends for Polk County stream sites are presented below, and summaries of trends are presented in Appendices F, G, and H.

Table 3: Index Ratings for Polk County Monitoring Sites

site #	site name	sediment	metals	nutrients	overall	rating
	VWIN - WNC Regional Average	**74**	**86**	**85**	**82**	
	White Oak Creek Watershed					
1	White Oak Creek at Houston Road	75	88	100	88	good
2	White Oak Creek at Fox Mountain Road	50	81	100	77	average
14	White Oak Creek at Briar Hill Farm	63	81	75	73	average
4	White Oak Creek at Moore Road	63	88	83	78	average
	Average for this grouping	**63**	**85**	**90**	**79**	
	percent sites below regional average	**75%**	**50%**	**50%**	**75%**	
	Green River Watershed					
18	Camp Creek	25	94	100	73	average
8	Demannu Creek	63	81	92	78	average
13	Green River at Highway 9	88	88	100	92	excellent
	Average for this grouping	**59**	**88**	**97**	**81**	
	percent sites below regional average	**66%**	**33%**	**0%**	**66%**	
	North Pacolet River Watershed					
9	Joel' s Creek upstream	75	88	83	82	good
10	Joel's Creek downstream	63	75	42	60	below average
5	Horse Creek at Skyuka Road	63	94	100	85	good
6	Horse Creek at River Road	88	88	100	92	excellent
15	North Pacolet River at Melrose	63	94	92	83	good
16	North Pacolet River at Rte 108	63	94	92	83	good
7	North Pacolet River at S. River Road	63	88	92	81	good
	Average for this grouping	**68**	**89**	**86**	**81**	
	percent sites below regional average	**71%**	**14%**	**28%**	**28%**	
	Overall County Rating					
	Average for All Sites	**65**	**87**	**89**	**80**	
	percent sites below regional average	**71%**	**28%**	**28%**	**50%**	

Sites in **the Green River watershed** include Demannu Creek, Camp Creek, and the Green River. Although the Green River site still rates **excellent**, levels of several parameters including turbidity, total suspended solids, conductivity, alkalinity, and zinc continue to increase over time. The rating for the Demannu Creek site has declined from good to **average,** with the sediment rating below the regional average. Either there is extensive stream bank erosion occurring, or there is a consistent source of sediment runoff, or there is an excessive amount of sediment built up in the stream bed. The Camp Creek site rates **average**, primarily since it has the poorest sediment index rating for sediment in Polk County. Sediment from Camp Creek flows into the Green River and is carried into Lake Adger.

The White Oak Creek watershed includes four sites along the creek. The most upstream site on White Oak Creek at Houston Road has declined from excellent to **good**. However, trend analysis continues to show turbidity, TSS, copper, zinc, orthophosphate, ammonia-nitrogen, and nitrate/nitrite-nitrogen levels decreasing over time. The three other sites on White Oak Creek rate **average**. High sediment levels are likely due to extensive sediment built up in the stream bed, and possibly higher amounts of organic matter in the stream.

The North Pacolet River watershed includes two sites on Horse Creek, two sites on Joel's Creek, and three sites on the North Pacolet River. The Joel's Creek downstream site rates lower than the other sites in this watershed and county with **below average**. This is largely a reflection of high nutrient and metal concentrations. Stormwater runoff from the Saluda area probably influences the upstream site, and wastewater effluent from the Saluda wastewater treatment plant certainly influences the downstream site. Joel's Creek upstream and Horse Creek at Skyuka Road sites rate **good**. The three sites on the North Pacolet River also rate **good**. Ratings have improved at all three sites in recent years, but most dramatically at the downstream site at South River Road. Orthophosphate concentrations have declined dramatically since 2002 and conductivity levels have also decreased. At the two upstream sites only stream sedimentation is lowering the rating. The upper part of the North Pacolet River watershed is clearly vulnerable to erosion and runoff. Clearing land near headwaters streams can result in excessive stream sedimentation because erosion rates are higher where slope gradient is greater, and the water can carry more sediment because streams have greater energy in high gradient areas.

Overall, four sites had decreased ratings and one site had an increased rating compared to previous reporting periods, but it could be more a reflection of changes in rainfall than to actual trends. Sites falling below the average rating score for the region, increased from 22% to 50% in the past year. Additionally, sites falling below the regional average score in the sedimentation category increased from 57% to 71%, indicating that stream sedimentation is still an important issue. Most other areas monitored in Western North Carolina have higher gradient slopes, so Polk County streams should rate better in this category since erosion rates are greater in high gradient areas. Continued monitoring will allow identification of actual trends as rainfall patterns fluctuate.

Appendix A: Chain of Custody form

Volunteer Water Information Network

Polk County

1) Sample Site Number ____ .

2) Sample Site Name ____.

3) Collection Date ________________________ Day ____________________.

4) Time Collected ____.

5) Temperature at drop-off site (in cooler)____________________________.

6) Volunteer's Name ____.

7)Volunteer's Phone# &/or Email: __________________________________.

________________ (please provide current mailing address if there has been a change)

8) Water Flow Rate (please circle one) Very High High Normal Low

9) Type of Rain in past 3 days (please circle one) Heavy Medium Light Dry

10) General Observations (turbidity, waste matter, dead animals upstream, anything out of the ordinary) ____ .

____ .

____ .

Parameter Results (For Lab Use Only)

Parameter and Result Date of Analysis

NH3 ________________ mg/L ______________________________.

NO3 ________________ mg/L ______________________________.

Po ________________ mg/L ______________________________.

Turb ________________ NTU ______________________________.

TSS ________________ mg/L ______________________________.

Cond ________________ umhos/cm ______________________________.

Alk ________________ mg/L ______________________________.

pH ____.

Appendix B: Laboratory Analysis

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

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

Approximate Analytical Reporting Limits
for VWIN Water Quality Parameters.

PARAMETER	REPORTING LIMIT	UNITS
Ammonia Nitrogen	0.02	mg/L
Nitrate/nitrite Nitrogen	0.1	mg/L
Total Phosphorus (as PO_4^{3-})	0.02	mg/L
Orthophosphate (as PO_4^{3-})	0.02	mg/L
Alkalinity	1.0	mg/L
Total Suspended Solids	4.0	mg/L
Conductivity	10.0	umhos/cm
Turbidity	1.0	NTU
Copper	2.0	ug/L
Zinc	20.0	ug/L
Lead	2.0	ug/L
pH	n/a	n/a

Appendix C: Parameters and Ranges for Stream Quality Classifications

pH -

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

Alkalinity -

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

Turbidity -

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

Total Suspended Solids -

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

Conductivity -

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

Total Copper -

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

Appendix C (continued)

Total Lead -

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

Total Zinc -

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

Total Phosphorous (as P)-

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

Orthophosphate (as PO_4^{3-}) -

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

Ammonia Nitrogen -

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

Nitrate Nitrogen -

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

Appendix D: Stream Ranking Index

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

B = Buncombe County
H = Henderson County
HW = Hiawassee River Watershed
HY = Haywood County
J = Jackson/Lake Glenville
LJ = Lake James
LL = Lake Lure
M = Madison County
NOT=Nottely River Watershed
P = Polk County
TOE = Toe River Watershed
TU = Tuckasegee River watershed

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

Appendix D: Stream Ranking Index -continued

28	H10	Mills River at Hooper Lane	96
29	H19	Green River at Old Hwy 25 S	96
30	HW4	Scataway Creek	96
31	HW9	Upper Bell Creek	96
32	HY3	East Fork Pigeon River/Cruso	96
33	NOT3	Nottely River	96
34	NOT8	Ivy Log Creek	96
35	B12A	Bent Creek at SR 191	95
36	HW12	Woods Creek	95
37	J6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	95
38	B24	Swannanoa River at confluence with North Fork	94
39	LJ5	Linville River at Hwy 126	94
40	NOT1	Nottely River upstream	94
41	H24	Little Willow Creek at River Road	93
42	HW5	Geisky Creek	93
43	LL10	Fairfield Mts Creek (Broad River watershed)	93
44	LL9	Buffalo Creek (Broad River watershed)	93
45	NOT7	Young Cane Creek	93
46	B17A	Swannanoa River at NC 81	92
47	B33	North Fork Swannanoa River at Grovestone Quarry	92
48	LJ1	Catawba River at SR 1501	92
49	**P13**	**Green River at Hwy 9**	**92**
50	**P6**	**Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)**	**92**
51	TU3	Caney Fork (Tuckasegee River watershed)	92
52	B20	Ivy Creek at Buckner Branch Road	91
53	B5B	Reems Creek at Ox Creek	91
54	H13	Big Hungry River below dam (Green River watershed)	91
55	HY10	Richland Creek at West Waynesville	91
56	LL2	Hickory Creek at Bat Cave (Broad River watershed)	91
57	LL3	Broad River at Bat Cave	91

			Good
58	H23	Big Willow Creek at Patterson Rd	89
59	H26	Brittain Creek at Patton Park (Mud Creek watershed)	89
60	B38	Swannanoa River at Bull Creek	88
61	H21	Mud Creek at Berea Church Road	88
62	LJ2	Catawba River at US 221A	88
63	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	88
64	NOT2	Arkaqua Creek	88
65	**P1**	**White Oak Creek at SR 1137/Houston Road**	**88**
66	Toe1	Cane Creek at Bakersville	88
67	Toe5	Cane River at MH High Sch	88
68	TU10	Barker's Creek (Tuckasegee River watershed)	88
69	TU14	Deep Creek (Tuckasegee River watershed)	88
70	TU5	Tuckasegee River upstream from Scott's Creek	88
71	B1A	Big Ivy Creek at Forks of Ivy	87
72	B43	Ross Creek at Swannanoa River (Swannonoa R wtrshd)	87
73	H3	Mud Creek at Erkwood Road	87
74	LL5	Broad River at Lake Lure	87
75	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	87
76	B16A	Cane Creek at Mills Gap Road	86
77	H15	Bat Fork Creek at Tabor Road (Mud Creek watershed)	86
78	TU4	Cullowhee Creek (Tuckasegee River watershed)	86

Appendix D: Stream Ranking Index -continued

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

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

Appendix D: Stream Ranking Index -continued

130	H27	Mill Pond Creek at South Rugby Road	77
131	H30	Devils Fork at Dana Road (Mud Creek watershed)	77
132	HY25	Raccoon Creek downstream (Richland Creek watershed)	77
133	M11	Bull Creek (Ivy River watershed)	77
134	**P2**	**White Oak Creek at SR 1531 (Fox Mt Rd)**	**77**
135	B12B	French Broad River at Bent Creek	76
136	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	76
137	B2	Lower Sandymush Creek	76
138	B34	Lower Hominy Creek at NC 191	76
139	B9B	Swannanoa River at Beetree Creek	76
140	H18	Mud Creek at 7th Avenue	76
141	HY24	Raccoon Creek upstream (Richland Creek watershed)	75
142	HY26	Crabtree Creek at Crabtree Rd	75
143	B47	Reed Creek at entrance to UNCA	74
144	B7A	Reed Creek at UNCA Botanical Gardens	74
145	B8	Beaverdam Creek at Beaver Lake	74
146	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	74
147	LJ13	North Fork of the Catawba River at Old Linville Rd	74
148	B25	South Turkey Creek (Sandymush Creek watershed)	73
149	H2	French Broad River at Butler Bridge Road	73
150	M15	Paint Fork at Beech Glen (Ivy River watershed)	73
151	**P14**	**White Oak Creek at Briar Hill Farm**	**73**
152	**P18**	**Camp Creek (Green River watershed)**	**73**
153	B26	North Turkey Creek (Sandymush Creek watershed)	72
154	H25	Gash Creek at Etowah School Road	72
155	HY32	Beaverdam Creek upstream	72
156	HY4	Pigeon River downstream from Canton	72
157	M13	California Creek at Beech Glen (Ivy River watershed)	72
158	NOT4	Butternut Creek	72
159	B1B	Little Ivy Creek (Ivy River watershed)	71
160	Toe4	North Toe River at Red Hill	71
161	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	70
162	M12	Grapevine Creek (Ivy River watershed)	70
163	M14	Middle Fork at Beech Glen (Ivy River watershed)	70

			Below Average
164	B14	Lower Flat Creek	69
165	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	69
166	M19	Laurel Valley Creek (Laurel River watershed)	69
167	M20	Puncheon Fork (Laurel River watershed)	69
168	M3	French Broad River at Hot Springs	69
169	HY7	Fines Creek downstream	68
170	B32	French Broad River at Walnut Island Park	67
171	B6A	French Broad River at the Ledges Park	67
172	HY19	Fines Creek upstream	67
173	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	67
174	Toe6	Bald Creek at Bald Crk Elem	67
175	TU6	Scott's Creek (Tuckasegee River watershed)	67
176	HY5	Pigeon River at Hepco Bridge	66
177	H4	Mud Creek at North Rugby Road	65
178	HY28	Hyatt Creek left branch	65
179	B4	Lower Newfound Creek	64
180	HY15	Fines Creek midstream	64

181	B13	French Broad River at Corcoran Park (Hend/Bunc line)	62

Appendix D: Stream Ranking Index -continued

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

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

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

Appendix E: Data Summary

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

pH - Last 3 Years					All Results	
site	sample #	low	median	high	sample #	median
1	34	6.6	7.0	7.5	191	7.0
2	32	6.6	6.9	7.1	189	7.0
4	36	6.3	7.0	7.2	190	7.1
5	36	6.7	7.0	7.3	194	7.1
6	36	6.7	7.0	7.3	191	7.1
7	36	6.8	7.1	7.3	193	7.1
8	32	6.8	7.0	7.3	189	7.1
9	35	6.8	7.0	7.3	168	7.2
10	35	6.8	7.0	7.2	191	7.1
13	32	6.5	6.9	7.3	139	6.9
14	35	6.3	7.0	7.3	127	7.1
15	36	6.4	7.0	7.3	133	7.2
16	36	6.6	6.9	7.2	133	7.0
18	37	6.6	7.0	7.3	119	7.1

Alkalinity - Last 3 Years/reprt. limit 1 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	34	14	27	36	192	24
2	32	18	32	43	189	29
4	36	14	27	38	190	22
5	36	14	20	29	193	19
6	36	16	27	39	191	25
7	36	16	26	34	193	24
8	32	20	30	42	189	25
9	35	17	25	36	168	24
10	35	18	24	35	192	21
13	32	12	19	32	139	16
14	35	16	27	40	128	25
15	36	10	19	28	133	18
16	36	14	22	32	133	21
18	37	12	17	24	120	17

Turbidity (NTU) - Last 3 Years/reprt. limit 1 NTU					All Results	
site	sample #	low	median	high	sample #	median
1	34	2.0	6.7	60	192	7.2
2	32	3.2	11.0	80	189	6.0
4	36	1.3	11.5	70	190	11.0
5	36	2.3	8.3	70	194	10.5
6	36	2.0	5.8	26	191	5.5
7	36	1.5	6.2	70	193	6.4
8	32	2.7	9.9	75	189	9.3
9	35	2.0	6.7	24	168	7.0
10	35	1.5	8.0	31	192	7.2
13	32	2.2	5.0	15	139	4.0
14	35	3.1	6.7	170	128	5.7
15	36	2.2	7.7	45	133	6.8
16	36	1.5	5.1	55	133	4.9
18	37	3.0	10.0	35	120	10.5

TSS (mg/L) - Last 3 Years/reprt. limit 4 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	34	<4	3.8	23.2	189	6.0
2	32	<4	7.0	102.8	184	2.8
4	36	<4	4.4	36.0	187	5.6
5	36	<4	6.6	239.6	192	12.4
6	36	<4	1.4	40.8	186	2.2
7	36	<4	5.4	40.4	190	6.4
8	32	<4	5.2	249.6	187	6.0
9	35	<4	5.2	36.8	167	7.6
10	35	<4	5.6	41.2	190	9.0
13	32	<4	1.8	8.0	139	1.6
14	35	<4	2.8	153.6	128	2.4
15	36	<4	5.6	43.2	133	6.0
16	36	<4	5.2	33.2	133	4.4
18	37	<4	10.0	32.0	119	10.4

Appendix E: Data Summary – continued

Conductivity - Last 3 Years/reprt. limit 10 umhos/cm					All Results	
site	sample #	low	median	high	sample #	median
1	34	38	51	81	191	49
2	32	49	60	69	188	58
4	36	43	57	139	189	53
5	36	34	43	52	193	40
6	36	41	57	63	190	53
7	36	46	66	95	192	77
8	32	<10	56	61	188	49
9	35	49	74	84	168	70
10	35	61	73	103	191	68
13	32	31	37	62	139	34
14	35	47	65	106	128	59
15	36	31	39	50	133	37
16	36	41	48	56	133	47
18	37	33	40	47	120	36

Copper (ppb) - Last 3 Years/reprt. limit 2 ug/L					All Results	
site	sample #	low	median	high	sample #	median
1	33	<2	0.8	5.6	189	0.9
2	31	<2	0.9	7.3	187	0.6
4	35	<2	0.8	2.8	188	0.8
5	35	<2	0.9	2.5	192	1.1
6	35	<2	0.4	2.3	189	0.5
7	35	<2	0.8	2.7	191	1.5
8	31	<2	0.5	12.3	187	0.4
9	34	<2	0.8	5.9	166	0.9
10	34	<2	1.6	7.6	189	1.1
13	31	<2	0.5	9.3	137	0.5
14	34	<2	0.8	18.2	126	0.8
15	35	<2	0.7	2.1	131	0.5
16	35	<2	0.6	3.4	131	0.5
18	36	<2	0.6	4.9	118	0.5

Lead (ppb) - Last 3 Years/reprt. limit 2 ug/L					All Results	
site	sample #	low	median	high	sample #	median
1	32	<2	0.4	<2	189	0.4
2	31	<2	0.5	4.0	188	0.2
4	35	<2	0.4	<2	189	0.3
5	35	<2	0.5	<2	193	0.5
6	35	<2	0.3	2.4	189	0.2
7	35	<2	0.4	<2	192	0.4
8	31	<2	0.4	3.0	188	0.3
9	34	<2	0.7	4.0	166	0.8
10	34	<2	0.8	6.0	190	0.6
13	31	<2	0.3	<2	138	0.2
14	34	<2	0.3	7.5	127	0.2
15	35	<2	0.3	2.1	132	0.4
16	35	<2	0.3	3.1	131	0.3
18	36	<2	0.6	3.8	119	0.6

Zinc - Last 3 Years/reprt. limit 20 ug/L					All Results	
site	sample #	low	median	high	sample #	median
1	33	<20	1.1	<20	189	2.1
2	31	<20	2.4	22.5	187	1.8
4	35	<20	1.3	37.8	188	2.3
5	35	<20	2.0	38.2	192	2.6
6	35	<20	0.7	31.3	189	1.5
7	35	<20	2.3	<20	191	3.3
8	31	<20	1.6	22.9	187	1.3
9	34	<20	4.8	25.1	166	5.1
10	34	<20	6.2	50.3	189	6.2
13	31	<20	1.6	<20	137	0.3
14	34	<20	4.0	32.9	127	2.6
15	35	<20	2.0	<20	132	1.3
16	35	<20	1.6	<20	132	1.2
18	36	<20	3.0	<20	119	2.4

Appendix E: Data Summary – continued

Orthophosphate (mg/L as PO4)-Last 3 Yrs/reprt. lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	34	<0.02	0.04	0.20	192	0.06
2	32	<0.02	0.05	0.15	189	0.06
4	36	<0.02	0.06	0.16	190	0.08
5	36	<0.02	0.03	0.11	194	0.04
6	36	<0.02	0.03	0.21	191	0.05
7	36	0.02	0.09	0.31	193	0.20
8	32	<0.02	0.05	0.24	189	0.06
9	35	0.02	0.07	0.35	168	0.09
10	35	0.02	0.68	1.08	192	0.45
13	32	<0.02	0.03	0.11	139	0.03
14	35	0.02	0.12	0.99	128	0.13
15	36	0.02	0.07	0.20	133	0.08
16	36	<0.02	0.04	0.16	133	0.07
18	37	<0.02	0.04	0.20	120	0.08

Ammonia-nitrogen (mg/L) - Last 3 Years/reprt. lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	34	0.02	0.08	0.19	191	0.07
2	32	0.07	0.13	0.27	188	0.07
4	36	0.04	0.13	0.21	189	0.10
5	36	0.02	0.08	0.16	193	0.05
6	36	0.04	0.07	0.19	190	0.06
7	36	0.05	0.08	0.21	192	0.07
8	32	0.03	0.09	0.17	188	0.06
9	35	<0.02	0.06	0.16	168	0.04
10	35	<0.02	0.10	1.04	191	0.10
13	32	0.04	0.09	0.17	139	0.08
14	35	0.05	0.10	0.29	128	0.09
15	36	<0.02	0.07	0.46	133	0.06
16	36	<0.02	0.06	0.21	133	0.05
18	37	<0.02	0.08	0.17	120	0.08

Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/reprt. limit 0.1 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	34	<0.1	0.2	0.4	192	0.2
2	32	<0.1	0.3	0.9	189	0.2
4	36	0.1	0.6	1.0	190	0.5
5	36	0.1	0.3	0.4	194	0.3
6	36	0.1	0.2	0.4	191	0.3
7	36	0.1	0.3	0.5	193	0.3
8	32	<0.1	0.2	0.6	189	0.2
9	35	0.4	0.7	1.1	168	0.8
10	35	0.5	1.0	1.7	192	1.0
13	32	0.1	0.2	0.4	139	0.2
14	35	0.1	0.4	1.2	128	0.4
15	36	0.1	0.3	0.7	133	0.3
16	36	0.1	0.3	1.2	133	0.3
18	37	<0.1	0.2	0.4	120	0.2

Appendix F: Trends for Each Site Related to Flow

		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
	White Oak Creek Watershed																						
1	White Oak Creek at Houston Road			X	X		X				X	X		X			X				X		
2	White Oak Creek at Fox Mountain Road											X		X			X				X		
14	White Oak Creek at Briar Hill Farm			X	X			X			X			X			X				X		
4	White Oak Creek at Moore Road			X	X		X	X			X	X	X	X			X						
	Green River Watershed																						
18	Camp Creek			X	X			X	X		X	X						X					
8	Demannu Creek			X	X						X	X	X	X			X				X		
13	Green River at Highway 9			X	X						X	X		X			X				X		
	North Pacolet River Watershed																						
9	Joel' s Creek upstream	X			X						X										X		
10	Joel's Creek downstream				X						X			X			X				X		X
5	Horse Creek at Skyuka Road										X	X											
6	Horse Creek at River Road			X	X		X	X	X		X	X		X			X						
15	North Pacolet River at Melrose			X	X		X	X	X		X			X			X				X		
16	North Pacolet River at Rte 108			X	X		X	X	X		X	X		X			X						
7	North Pacolet River at S. River Road			X	X			X	X		X	X		X			X				X		

Appendix G: Trends for Each Site Related to Time

		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
	White Oak Creek Watershed																						
1	White Oak Creek at Houston Road		X												X	X		X		X	X	X	X
2	White Oak Creek at Fox Mountain Road		X	X	X						X										X		
14	White Oak Creek at Briar Hill Farm																				X		
4	White Oak Creek at Moore Road		X															X			X		
	Green River Watershed																						
18	Camp Creek					X							X								X		
8	Demannu Creek		X																		X		
13	Green River at Highway 9		X	X	X	X			X												X		
	North Pacolet River Watershed																						
9	Joel's Creek upstream												X								X		X
10	Joel's Creek downstream										X		X										X
5	Horse Creek at Skyuka Road				X	X									X			X			X		
6	Horse Creek at River Road																				X		X
15	North Pacolet River at Melrose																				X		X
16	North Pacolet River at Rte 108																				X		
7	North Pacolet River at S. River Road																X	X			X		

Appendix H. Number of Sites Exhibiting Seasonal Trends

POLK COUNTY SITES

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	tot trend sites	% of total sites
pH			6		6				6	42.9%
alkalinity			5	4	8	1			9	64.3%
turbidity			9		8			1	9	64.3%
total susp sol			8		7			1	8	57.1%
conductivity			6		2	4			6	42.9%
copper			3		3				3	21.4%
lead			3		3				3	21.4%
zinc									0	0.0%
orthophos.			1		1				1	7.1%
ammonia-N			8	1	6	2		1	9	64.3%
nitrate-N	4	1	6				2	9	11	78.6%

total sites analyzed for trends = 14

ALL VWIN SITES IN WESTERN NORTH CAROLINA

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

total sites analyzed for trends = 177