A Survey of Water Quality in the Broad River Watershed (2006-2007)

Broad River Watershed Association
in cooperation with
GA EPD Adopt A Stream Program

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Summary

In December 2006, the Broad River Watershed Association (BRWA) began a watershed-wide survey of water quality in the streams and tributaries of the Broad River. BRWA volunteers used conductivity meters to measure ion concentrations and thus the potential presence of pollutants. When the survey was complete in December 2007, volunteers had taken roadside water samples at 583 sites or one sample per every 2.6 square miles.

The average conductivity for all 583 sites was 84 microSiemes/centimeter (uS/cm). However, this value was inflated by inclusion of 57 sites clustered in a 150-175 square mile area of Elbert and Oglethorpe counties where soil characteristics contributed to naturally high stream conductivity levels. Sites in this cluster averaged 235.5 uS/cm (range 110 – 800) or three to four times the average conductivity of streams elsewhere in the watershed.

The remaining 90% of the watershed had only 22 sites with conductivity over 100 uS/cm. The nutrient contaminants nitrate-nitrogen and orthophosphate were detected more frequently and at higher levels in sites with the highest conductivity levels. At four sites, phosphate levels were at or above levels that would contribute to stream eutrophication (0.1 mg/L). Two of these high phosphate sites were downstream from municipal wastewater treatment plants. Nitrate levels at three sites were at or above nitrate concentrations for an unpolluted stream (1.0 mg/L). Two of these sites were downstream of municipal wastewater treatment plants. At one municipal wastewater treatment plant site, both nitrate and phosphate were elevated. The reason for the high conductivity levels at the remaining sites could not be determined as stream flow came from private property.

To the extent that low conductivity levels are an indicator of the absence of contaminants, we conclude that water quality is generally good in the Broad River Watershed. One reason is likely the high number of waterways that are protected by relatively undisturbed riparian land cover. Of the 559 sites where our survey recorded the type of streamside land cover, 358 sites (64%) were covered with trees, shrubs and other naturally occurring undisturbed vegetation. The lowest conductivity readings of the survey were obtained from the headwaters of the Middle Fork of the Broad River, which lies entirely within the Lake Russell Wildlife Management Area of the Chattahoochee National Forest. Conductivity at sampling sites began a gradual increase once the river left the national forest to flow southeastward through populated and agricultural areas, and at the junction of the Middle and North Forks, conductivity had more than doubled.

Periodic water quality surveys will be needed to determine the extent that projected human population growth in the watershed will adversely affect water quality. Furthermore, the 2006-2007 survey did not address two other major problems: high levels of sediment-loaded water runoff throughout the watershed (the major problem identified by the state Environmental Protection Division) and the high fecal coliform bacteria levels in some river and stream stretches of the watershed.

Introduction

The Broad River begins in northeast Georgia in the Chattahoochee National Forest and flows approximately 90 miles southeast into Clark Hill Lake near Bobby Brown State Park (figure 1). As part of the Savannah River Basin, the river drains a portion of the upper Piedmont Region of Georgia with seven major sub-watersheds: the North, Middle and South Forks, Hudson River, Long Creek, Mill Shoal Creek and Falling Creek. Although its 1504 square miles (962,233 acres) encompass parts of 12 northeastern counties[1], 92% of the watershed is located in six counties: Banks, Elbert, Franklin, Madison, Oglethorpe and Wilkes. Major counties and their larger communities are shown in Table 1 and Figure 1.

The Georgia Northeastern Regional Development Center (RDC) projects the human population in our area to nearly double in the next 25 years. This growth and development will place additional demands on water usage. More people also means the likely release of more water-borne pollutants into our waterways, including increased sediment loads in runoff and more fecal coliform bacterial contamination.

The Georgia Environmental Protection Division (EPD) is the state agency responsible for monitoring Georgia's water quality. EPD and its federal, state and municipal cooperators can monitor only a small percentage of the more than 70,000 miles of Georgia's rivers and streams - and these at infrequent intervals[2]. Volunteer watershed organizations, especially those participating in the EPD sponsored Adopt A Stream Program (AAS), can play an important role in watershed protection by monitoring streams and providing data on water quality in their area. In response to this need for local involvement, BRWA began a watershed-wide survey in December 2006.

[1] Percent of county in Broad River Watershed: Banks (15.5), Clarke (0.3), Elbert (13.2), Franklin (15.6), Habersham (1.2), Hart (0.5), Jackson (1.0), Lincoln (0.3), Madison (17.7), Oglethorpe, (21.3), Stevens (4.9) and Wilkes (8.3) Counties.
[2] GA EPD Water quality in Georgia 2000-2001 (http://www.gaepd.org/documents/305b.html).

Table 1. Counties and Larger Communities of the Broad River Sub-Watersheds[1]

Sub-Watershed	Counties	Larger Communities
South Fork	Madison, Oglethorpe, Clarke	Hull, Colbert, Comer, Carlton, Winterville, Arnoldsville, Danielsville, Ila
Long Creek	Oglethorpe, Wilkes	Crawford, Lexington, Rayle, Tignall
Hudson River	Banks, Franklin, Jackson	Baldwin, Alton, Homer, Mayville, Commerce, Banks Crossing
North/Middle	Banks, Franklin, Hart, Stevens	Bowersville, Canon, Franklin Springs, Royston, Lavonia, Toccoa, Cornelia, Baldwin, Carnesville
Falling/Mill Shoal	Elbert, Hart, Madison, Oglethorpe, Wilkes	Royston, Bowman, Elberton, Tignall

[1] Portions of some counties and communities lie in more than one sub-watershed.

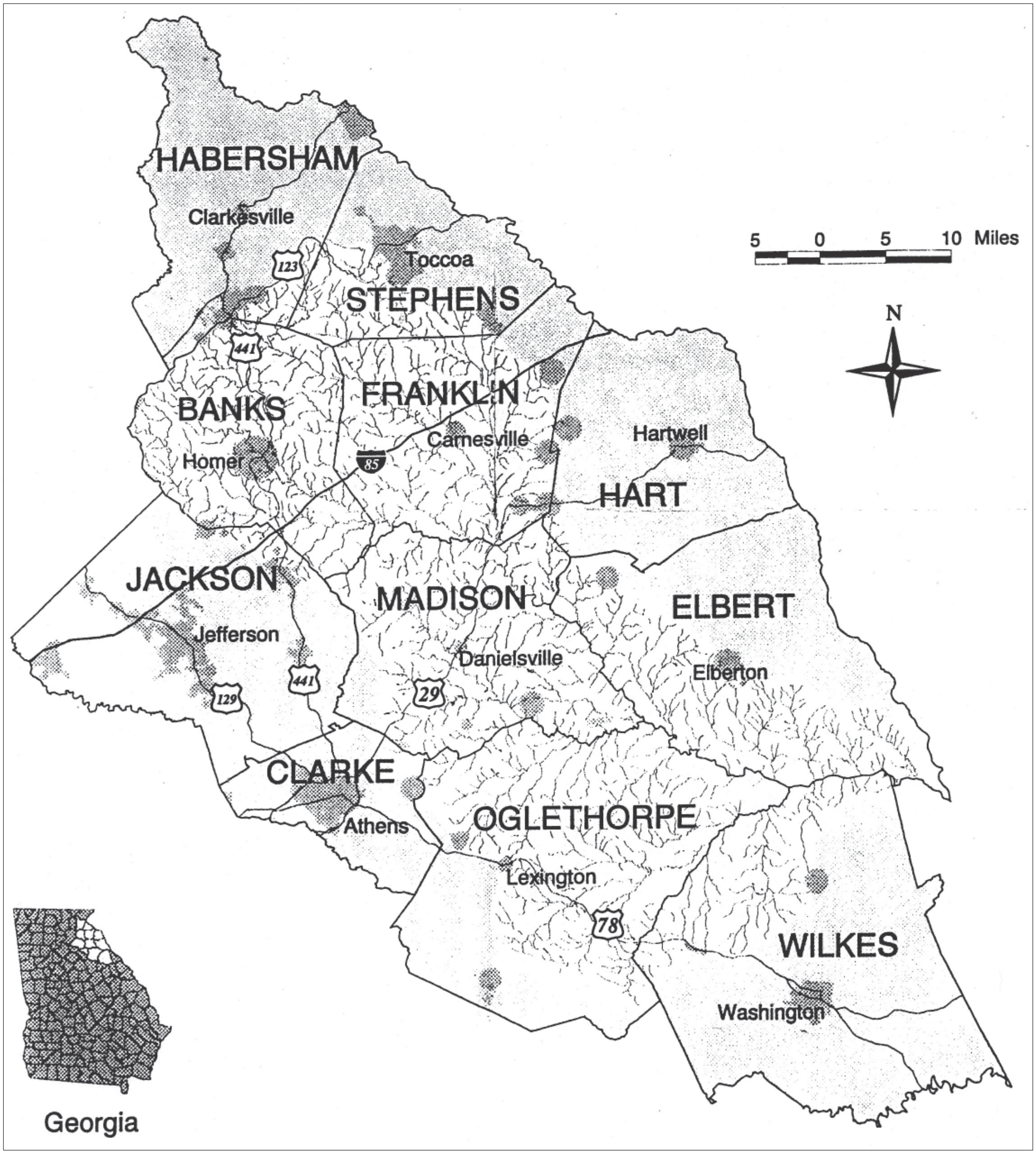

Figure 1. Map of Broad River Watershed.

Methods

The BRWA Watershed Committee sought advice from the Upper Oconee Watershed Network (UOWN) and EPD's Adopt-A-Stream (AAS) Outreach Program coordinators on how to implement a water quality survey using volunteers to sample and record field data. Based on the groups' recommendations, we chose to survey for the potential presence of water-borne contaminants by measuring the concentration of charged particles (ions) with a low range conductivity meter (ECTestr, $65, HACH, Ft. Collins, CO).

No data were available for normal ion concentrations (and conductivity levels) for the small streams and tributaries that we sampled in the Broad River Watershed. Some ions occur naturally in water as minerals picked up from bedrock or soil; however, the granite underlying most of our area led us to expect a healthy stream to record a conductivity of <100 micro Siemens/cm (μS/cm). Streams with good water quality in the adjacent Upper Oconee Watershed monitored by UOWN have conductivity levels in the 50 uS/cm range, further suggesting that conductivity levels should be low in healthy streams within our watershed. Because UOWN views conductivity readings >100 uS/cm as reason for concern as to water quality (AAS newsletter 10(5):1, Oct 2003), we chose a similar cut-off value for evaluating water quality in the streams of our watershed.

Survey volunteers were solicited by postal card, email and at AAS certification classes sponsored by AAS and BRWA. Depending on the number of volunteers, each survey was conducted by seven or eight teams of two to three persons. At least one member of each team had completed the AAS chemical certification class. Survey routes followed county and state-maintained roads and water samples were taken at bridges or culverts; access to private lands was seldom required. Volunteers and survey organizers first met at a central location to discuss survey methods and distribute equipment. Each team was provided with a county map, a large-scale area map marked with numbered potential sample sites and a field data form. Volunteers were also given printed cards with BRWA contact information to hand out to persons inquiring about the survey. Route maps were derived from Bureau of Transportation, National Hydrography, GA Department of Transportation, and NE GA RDC databases. In the week preceding each survey, the sheriff and board of commissioners in each county were notified by letter of the presence of the upcoming survey in their area.

Surveys were conducted quarterly on Saturdays from December 2, 2006 to December 1, 2007. Surveys of smaller sub watersheds were combined so that only five survey days were needed to complete the survey.

Sample sites for the first two surveys were visited and flagged in the weeks prior to the survey. This time consuming step was eliminated for subsequent surveys and survey teams selected suitable sites based on their maps and criteria provided to the team on the day of the survey.

For all surveys, teams hung numbered flagging at test sites. Standardized report forms were used to record physical data about the site such as the names of intersecting road and streams, if known, and the type of riparian land cover[3]. Numbered digital photos of the each collection site, and upstream and downstream of the site, were taken and filed for future analysis of physical changes to sites over time. Water samples were taken using a 250ml plastic bottle affixed to a 4 to 9.5 foot extension pole. A small bucket with nylon cord was used to sample from high bridges. Stream conductivity was recorded on the report form at the time of measurement.

All conductivity meters were recalibrated before each survey. Instructions for using the meters were repeated before each survey and each survey kit included a spray bottle of distilled water for cleaning the meter electrodes between sites and a small cup for testing a meter's reading of distilled water. Volunteers were instructed to zero their meter and immediately resample and retest any stream with conductivity over 100 uS/cm.

Teams collected 110 to 131 conductivity measurements for each sub-watershed with each team locating and sampling 10-20 sites during a 4 to 5 hour survey period. Volunteers also collected 82 water samples for further chemical tests. Chemical tests included pH (a measure of how acidic or basic the water is based on the concentration of hydrogen ions), alkalinity (the ability of water to neutralize acids) and tests for the nutrient contaminants, nitrate-nitrogen and orthophosphate. All tests were conducted using the LaMotte Chemical Test Kit and protocols of the GA EPD Adopt A Stream Program. At the end of the entire watershed survey, the 22 sites where conductivity levels had exceeded 100 uS/cm were resampled for conductivity and water samples taken for correlation of conductivity with levels of nitrate and phosphate.

All data are maintained by BRWA and will be provided to AAS for their statewide database.

[3] *Categories of riparian land cover were: agricultural/ pasture; forested; urban; mining for gravel, sand etc; near waste treatment facility; industrial site; known impaired water site; near land fill site; construction site; other.*

Results

Table 2 summarizes the survey results. A total of 583 sites were sampled in five surveys, an average of 117 sites per survey (range 110 to 131). Volunteers surveyed the South Fork sub-watershed on December 2, 2006, Long Creek on March 10, 2007, the Hudson River on June 9, 2007, the North and Middle Forks on September 29, 2007 and Mill Shoal and Falling Creek on December 1, 2007. Data from each survey are summarized below.

South Fork

The South Fork sub-watershed (245 sq mi in Madison and Oglethorpe Counties) encompasses 16.3% of the total watershed. Volunteers sampled 131 sites for a sample coverage of one test site per 1.9 sq mi. Of the 120 sites where land use was recorded, 85 sites (70.8%) had a forested riparian land cover. No water samples were taken during the survey for chemical tests.

Average conductivity was 55.6 uS/cm, with a range of 30 to 290 uS/cm. Three sites (2.6%) had conductivity readings >100 uS/cm and were resampled in January 2008. Water from all three sites showed detectable nutrient levels (table 3). Phosphate levels in a sample taken below a municipal water treatment plant were sufficient to produce excessive eutrophication in the affected stream. Interestingly, this facility is scheduled for renovation and improvement.

Long Creek

The Long Creek sub-watershed (266 sq mi in Elbert, Oglethorpe and Wilkes Counties) encompasses 17.7% of the total watershed. Volunteers sampled 117 sites - producing a sample coverage of one test per 2.3 sq mi. Average conductivity for all sites was 87.7 uS/cm, with a range of 30 to 250 uS/cm (Table 2). No water samples were taken during the survey for additional chemical tests. Of the 107

Table 2.
Conductivity Survey Results for the Seven Sub-Watersheds of the Broad River

Sub-Watershed	Square Miles	Survey Date	Sites Tested	Avg. conductivity in uS/cm[1] (range)	Sites with >100 uS/cm (%)	Forested Sites[2] (%)
South Fork	245	12/2/06	131	55.6 (30 - 290)	4 (3.1%)	85/120 (70.8)
Long Creek	266	03/10/07	117	87.7 (30 - 250)	27 (23.1%)*	84/107 (87.5)
Hudson River	308	06/09/07	110	74.7 (40 - 160)	8 (7.3%)	64/107 (59.8)
North/Middle	302	09/29/07	113	70.1 (30 – 150)	5 (4.4%)	51/113 (45.1)
Falling/Mill Shoal	383	12/01/07	112	132.2 (30 – 800)	30 (26.8%)*	75/112 (70.1)
Totals	**1504**		**583**	**84.0 (30 - 800)**	**74 (12.7%)**	**359/559 (64.2)**

[1] micro Siemans/centimeter (uS/cm)
[2]. Land cover was not specified for all survey sites.

*A cluster of high conductivity values recorded in an approximately 150 to 175 sq mi portion of Oglethorpe and Elbert Counties south and east of Elberton were approximately three to four times higher than elsewhere in the watershed. For example, in the survey in the Falling/Mill Shoal sub-watersheds of Elbert County, 30/35 sites (85.7%) had conductivity readings >100 uS with an average conductivity of 276.3 (range 80 – 800). Surveys outside of this area found only 6/ 77 sites (7.8%) with conductivity readings >100 uS (range 30 – 340). According to the Natural Resource Conservation Service, the Iredell soils in these high conductivity areas are a type of clay (smectite) that holds calcium, sodium and magnesium ions on its crystal lattice in a way that allows the ions to be flushed out by rain water. Since ground water movement and natural erosion of this underlying substrate can release these ions into the streams, raising pH and alkalinity levels, we believe that this area's geology and soil characteristics rather than human activity was the source of the high conductivity readings in this area. These findings bring into question the use of conductivity to detect pollutants in this specific area of the Broad River Watershed.

Table 3.
Conductivity and Nutrient Levels for Sites with Elevated Conductivity Resampled at Survey Completion (N = 22)

Conductivity[1]	Nitrate-N[1]	Phosphate[1]	Location
240 (310)	>/= 1.0 (0.8)	0.4 (0)	Mill Shoals/Falling[2]
230 (210)	0.1	0.6	South Fork[2]
140 (140)	>/= 1.0	0	South Fork
130 (170)	>/= 1.0 (0.4)	Trace (0)	Mill Shoals/Falling[2]
110 (120)	0.8	0	Hudson River
100 (110)	0.85	0.6	North/Middle
100 (110)	0.5	0	Hudson River
100 (120)	0.1	0	Hudson River
90 (110)	0.9	0	Hudson River
90 (110)	0.4	0	North/Middle
90 (120)	0.75	trace	Mill Shoals/Falling[2]
90 (110)	trace	0	Mill Shoals/Falling
80 (110)	0.5	0	North/Middle
80 (160)	0.1	0	Hudson River
70 (140)	0.25 (trace)	0 (0)	North/Middle[2]
70 (110)	0	0	Hudson River
60 (140)	0	0.1	South Fork
60 (130)	0.1	0	North/Middle
60 (120)	trace (trace)	0	Mill Shoals/Falling
60 (120)	0	0	Hudson River
50 (140)	0	0	Hudson River
50 (110)	0	0	Mill Shoals/Falling

[1] Value in parentheses is for sample collected in initial survey.
[2] Site is downstream of municipal water treatment facility

sites in Long Creek where land cover type was recorded, 84 sites (87.5%) had a forested riparian land cover.

Although average conductivity for all sites in Long Creek was 87.7 uS/cm, this measurement was inflated by inclusion of 27 sites (23.1% of total sites tested) that formed an oval shaped "cluster" of approximately 5 X 13 miles along the main channels of Long Creek and Dry Fork Creek in Oglethorpe and Wilkes counties. Conductivity readings in this cluster were >100 uS/cm and averaged 157.5 uS/cm. Because our initial survey had followed a relatively rainy period (the downtown Lexington weather station, KGALEXIN1A, recorded 2.63 inches of rain on March 1), we revisited 15 of the high conductivity sites on June 6, 2007 to determine if conductivity had changed from the initial tests. The 30 days prior to this subsequent visit had been a period of low rainfall (4 inches in the 30 days prior) and 5 of the 15 sites had dried up. The average conductivity for the remaining 10 sites was 215.4 uS/cm, whereas average conductivity for the 10 sites had been 164 uS/cm in March.

In addition to retesting conductivity at 10 sites, water was collected into glass screwcap jars, then refrigerated for testing the next day by AAS methods for alkalinity and pH. Alkalinity values for the 10 samples ranged from 50 to 170 mg/L with an average of 103.0 mg/L. Eight of the 10 samples had pH values of 7.0 or above (range 6.5 to 8.0).

Subsequent to the above observations, we found that this area of high conductivity in the Long Creek sub-watershed (as well as adjacent parts of the Falling Creek and Mill Shoals Creek sub-watersheds in Elbert County) includes areas mapped as Iredell soil by the Natural Resource Conservation Service (see Figure 2 and Table 2 footnote). Iredell soils are composed of a type of clay (smectite) that holds calcium, sodium and magnesium ions on its crystal lattice in a way that allows the ions to be flushed out by rainwater. These ions raise the conductivity, pH and alkalinity levels of affected streams above that found in areas with a granite subsoil and in many cases the natural conductivity of area streams was much higher than our survey cutoff level of >100 uS/cm. Since geology and soil characteristics likely accounted for the high conductivity readings in this area, no further resampling was performed in this part of the watershed.

Hudson River

This sub-watershed (308 sq mi) in Banks and Franklin Counties encompasses 20.5% of the Broad River drainage. Volunteers selected and tested 110 sites within their survey area. These sites produced a sample coverage of one test site per 2.8 sq mi. Of the 107 sites in the Hudson River where land use was recorded, 64 sites (59.8%) had a forested riparian land cover.

Average conductivity for all sites was 74.7 uS/cm, with a range of 40 to 160 (Table 2). The eight sites (7.3%) with readings above 100 uS /cm were widely distributed throughout the drainage with no apparent relationship to geographic features.

Volunteers collected a total of 15 water samples (1 to 2 per team) for later chemical analyses. Average conductivity for their 15 samples was 81.3 (range 50 to 110). This average was slightly higher than the overall average for the entire Hudson River sub-watershed, but volunteers were not given guidelines for sample collection and participants tended to select higher conductivity sample sites for further testing. Tests of the 15 sites for alkalinity and pH showed an alkalinity average of 31.3 (range 20 to 40 mg/L) and a range of pH from 6.5 to 7.0. Low levels of nitrate nitrogen were found in one of two samples tested for nutrient contaminants (table 4).

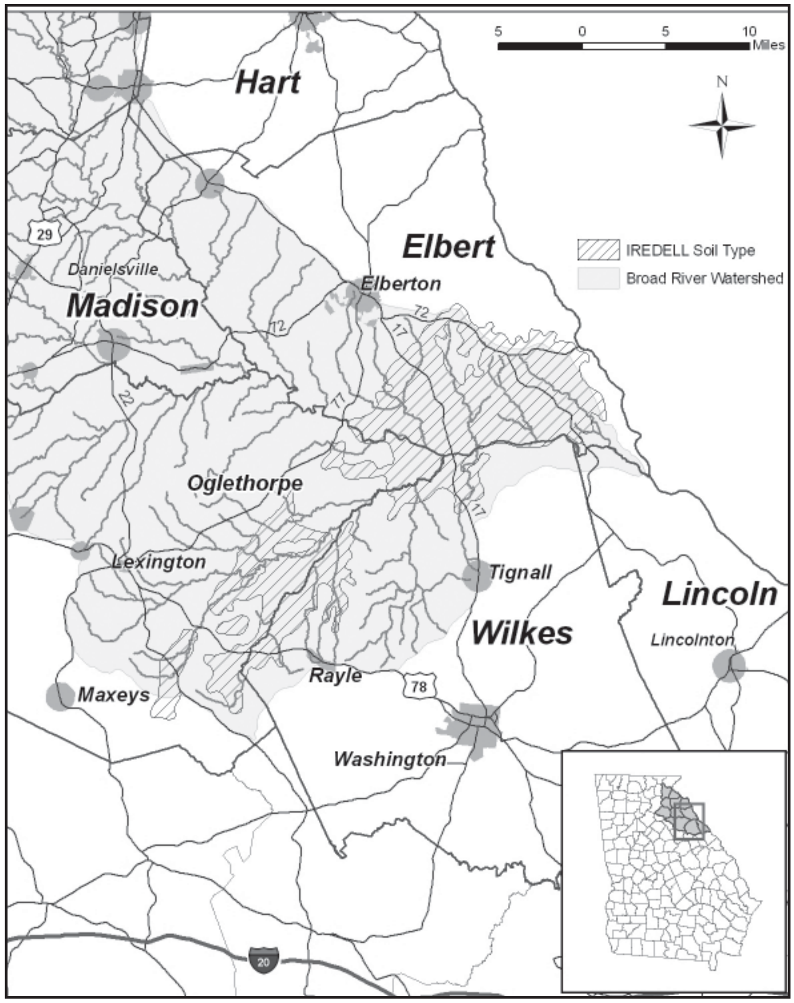

Figure 2. Cluster of 57 sample sites in SE portion of Broad River Watershed with conductivity greater than 100 uSiemens/cm associated with Iredell soil type.

Eight sites with conductivity readings >100 uS/cm were resampled in January and February 2008 (table 3). Conductivity was lower at all sites than had been recorded in the original survey, possibly because of increased rainfall, greater stream flow and dilution of any contaminants prior to resampling. Nutrient levels for all samples were at acceptable levels.

North and Middle Forks

The North Fork and Middle Fork sub-watersheds (302 sq mi) constitute 20.1% of the watershed. These adjacent tributaries are located primarily in Franklin and Stevens Counties with minor portions in Banks and Hart Counties. Both were surveyed on September 29, 2007 and the results combined. Volunteers sampled 113 sites for a coverage of one test site per 2.7 sq mi. Of the 113 sites where land cover was recorded, only 51 sites (45.1%) were classified as forested and overall, this area was the least forested within the entire watershed.

Average conductivity for all sites in this survey area was 70.1 uS/cm, with a range of 30 to 150 (Table 2). Conductivity levels recorded in the Middle Fork headwaters were among the lowest in the entire watershed (30 – 40 uS/cm). The Middle Fork, approximately 33 miles long, is the only sub-watershed to have its headwaters in an entirely forested and unpopulated area - the Lake Russell Wildlife Management Area located within the Chattahoochee National Forest. Once the river left the national forest, the conductivity gradually increased at sample sites as the tributary flowed southeastward through populated and agricultural areas. When it reached its junction with the North Fork, the conductivity level had more than doubled to 90 uS/cm.

Volunteers collected a total of 15 water samples (1 to 2 per team) for later chemical analyses. Average conductivity for the 15 samples was 75.3 (range 40 to 140). Tests for alkalinity and pH showed an alkalinity average of 30.0 (range <20 to 40 mg/L) and a range of pH from 6.0 to 7.0. All 15 samples were tested for nitrate and phosphate levels (Table 4). Phosphate levels in a sample taken on the North Fork River near Toccoa were sufficient to produce problems with eutrophication. All other samples were within accepted ranges for nutrient contamination.

Five sites (4.4% of total) had readings above 100 uS /cm and were later resampled in January 2008. Three of these high conductivity sites were located in or near Carnesville and a fourth site was near the Lavonia wastewater treatment plant. Conductivity was lower at all sites than had been recorded in the original survey; likely because of increased rainfall and higher stream flow. Only one site had excessive nutrient levels: the phosphate level of 0.6 mg/L detected in the sample taken from Unawatti Creek near Lavonia could produce stream eutrophication.

Falling Creek and Mill Shoals Creek

The two contiguous sub-watersheds of Falling Creek and Mill Shoals Creek flow into the main stem of the Broad River and lie in portions of Elbert, Hart, Madison, Oglethorpe and Wilkes Counties. Falling and Mill Shoals Creeks collectively comprise 25.5% of the total watershed. Because of their smaller size, both were surveyed on December 1, 2007. Forested sites in Falling and Mill Shoals

Table 4.
Conductivity and Nutrient Levels for Routine Survey Samples (N=27)

Conductivity	Nitrate-N	Phosphate	Location (date sampled)
340*	0	0	Long Creek (6/06/07)
310	0.8	0	Mill Shoals/Falling (12/01/07)
170	0.4	0	Mill Shoals/Falling (12/01/07)
140	trace	0	North/Middle (09/29/07)
140	0.3	0	Mill Shoals/Falling (12/01/07)
120	trace	0	Mill Shoals/Falling (12/01/07)
110	0.7	0	Hudson (6/9/07)
110	0.3	0	North/Middle (09/29/07)
100	0.2	0	North/Middle (09/29/07)
100	0	0	Hudson (6/9/07)
90	0	0.1	North/Middle (09/29/07)
90	0.7	0	Mill Shoals/Falling (12/01/07)
90	0	0	North/Middle (09/29/07)
90	0	0	North/Middle (09/29/07)
80	0.2	0	North/Middle (09/29/07)
80	0	0	North/Middle (09/29/07)
80	0	0	North/Middle (09/29/07)
70	0	0	North/Middle (09/29/07)
70	trace	0	Long Creek (6/06/07
50	0	0	Mill Shoals/Falling (12/01/07)
50	trace	0	North/Middle (09/29/07)
40	trace	0	Mill Shoals/Falling (12/01/07)
40	0	0	North/Middle (09/29/07)
40	0	0	North/Middle (09/29/07)
40	0	0	North/Middle (09/29/07)
30	0	0	North/Middle (09/29/07)
30	0	0	Mill Shoals/Falling (12/01/07)

* Taken from area with Iredell soil (see footnote to Table 2).

Results

sub watersheds comprised 70.1% of all sites sampled.

Seven volunteer teams assessed conductivity at 112 sites or one site per 3.4 sq mi of these sub-watersheds. The average conductivity was high (132.5 uS/cm, range 30 – 800) because two survey lines were in areas of Iredell soil where high conductivity could be attributed to the geology and soil type rather than to human activity (see Figure 2 and Table 2 footnote).

Volunteers collected a total of 15 water samples (1 to 2 per team) for later chemical analyses. Average conductivity for the 15 samples was 144 (range 40 to 480), but these samples included sites in Iredell soil types. The alkalinity average for the 15 samples was 40.7 (range 40 to 160 mg/L) and a range of pH from 6.0 to 8.0, with the higher values obtained from sites with Iredell soil type. Eight of the 15 samples were tested for nitrate and phosphate levels; all were within accepted ranges for nutrient contamination.

Six sites outside of the Iredell soil area (5.3 % of total for this sub-watershed) had readings above 100 uS/cm and were resampled in February 2008. Conductivity was lower at all sites than had been recorded in the original survey, possibly because of increased rainfall and greater stream flow prior to resampling.

Three of the high conductivity sites were on Hannah Creek downstream of a wastewater treatment plant (table 3). Nutrient contaminants were detected for several miles downstream of the plant and the sample closest to the plant contained an elevated phosphate level.

Discussion

Volunteer interest remained high during the yearlong survey period with the majority of participants attending all five surveys. Experienced volunteers had no difficulty selecting and locating representative sample sites from the large number of potential sites shown on their survey maps; thus pre-survey flagging of sites was felt to be unnecessary after volunteer experience was attained. We found that long term marking of sites located on dirt or gravel roads was impractical. Periodic grading of roads and removal of flagging by passers–by or by wind and weather resulted in the loss of many such markers. We also found some variation among teams as to how they determined what land cover type to assign to their sample sites. Future surveys should include more volunteer instruction on types of land cover and the physical characteristics that define land use. Review of site photographs taken during the recently completed survey should help resolve this problem. For future surveys we will also consider adopting national standard terminology for land cover types. Future survey data forms should also include a category to indicate sites disturbed by logging, grading or undergoing development as residential or commercial sites. This land use will be an important component of future population increase and potential degradation of water quality.

We found that the LaMotte chemical test kit was not entirely suitable for rapidly processing the numerous samples generated in a survey over a short period of time. We purchased additional water test tubes so that multiple samples could be processed simultaneously and processing time reduced. As suggested by UOWN, we also considered a more rapid and practical field method for determining dissolved oxygen than the Winkler method provided in the LaMotte kit. Results from this colorimetric technique using reagent filled ampoules that take up a known sample of water were satisfactory, but are not approved for use as a test method by the AAS program.

In the areas of our watershed underlain with granite bedrock, the average natural conductivity levels in streams were well below 100 uS/cm. In these areas we found a correlation between elevated conductivity and concentrations of the nutrient contaminants, nitrate and phosphate. Elevated nutrient levels were detected in five of the eight sites (62.5%) where conductivity was above 100 uS/cm in samples taken both in the initial survey and when resampled at the end of the survey (table 3). In contrast, nutrient levels were elevated in only one of 14 sites (7.1%) where conductivity levels had dropped below 100 uS/cm when the site was resampled.

A relationship between levels of nutrient contamination detected and elevated conductivity was also found in the 27 samples collected at random by volunteers during the survey (table 4). Eight of ten samples (80%) with conductivity above 100 uS/cm contained detectable nutrient contaminants; six of 17 (35.2%) sample with conductivity below 100 uS/cm contained detectable nutrient contaminants.

Although the survey did not specifically target effluent from water treatment plants as sample sites, our survey included several samples taken downstream of facilities in Comer and Danielsville in Madison County and Royston and Lavonia in Franklin County. Effluent from the Comer and Royston facilities had the highest conductivity levels of any water in the survey. Water from the Royston facility entering Hannah Creek maintained a conductivity level >100 uS/cm for several miles downstream. Water from these two facilities also had some of the highest phosphate levels detected in the survey. In contrast, although effluent from the Lavonia treatment facility had conductivity levels greater than 100 uS/cm during the September 2007 survey, only low levels of nitrate were detected at this site, no phosphate was detected, and pH and alkalinity were 7.0 and 40 respectively. Resampling of the site in January 2008 gave similar results. Conductivity at the Danielsville water treatment plant was not above 100 uS/cm during the September survey, no tests for nutrients were conducted, and the site was not resampled.

The cut-off level of 100 uS/cm as an indicator of polluted water was not applicable to sites in a 150-175 square mile area of Elbert and Oglethorpe Counties. Soil in this area is composed of minerals that ionize when washed into water and conductivity at 57 sites in this area averaged 235.5 uS/cm (ranges 110 – 800) or three to four times the average conductivity of streams elsewhere in the watershed. Because of the extreme variability of natural conductivity in this area of the watershed, no effort was made there to correlate conductivity with excess nutrient levels.

Conductivity can detect only ionic contaminants; oils, some organic chemicals and other uncharged pollutants will not be detected. Additionally short term or one-time inflows of pollutants would not be detected unless they coincide with a survey. Sampling during high flow periods will also dilute contaminants, perhaps below levels detectable by AAS methods. It is therefore possible that much was missed in our survey. Nonetheless our data suggest that the waterways thus far sampled are generally in good health. The majority of sites (69.8%) were classified as having the forested land cover recommended by water managers as a means of preventing potential contaminants from reaching streams and waterways. Our watershed is primarily rural and the local economy is strongly based upon agriculture, which may also help preserve water quality. And relatively few polluted sites were found despite drought conditions during most of our survey and lower than normal water levels that might have concentrated contaminants.

We also believe that future surveys should sample fewer sites but sample them more frequently. This would enable us to gather data showing the extent to which factors such as rainfall, runoff and seasonal application of agricultural fertilizers and manures may affect conductivity levels. We should concentrate our efforts on sites that are likely to be impaired, such as those downstream of wastewater treatment plants as well as sites known to have higher than expected conductivity.

Our initial watershed wide survey resulted in a high level of interest and motivation by BRWA members, taught us much about our watershed, informed local governments and the public about our activities and allowed us to modify our survey procedures to better evaluate water quality. Despite these encouraging observations, excessive sedimentation in our waterways due to grading and runoff and fecal coliform levels in streams and rivers that exceed EPD's standards are causes for concern. For these reasons, it will be important for BRWA to monitor trends in water quality as our population grows and demands on water resources increase.

Acknowledgements

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