A STRATEGY FOR ATTAINING BACTERIAL WATER QUALITY STANDARDS

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Abstract. Fecal coliform bacteria are attributed to be the leading cause of water quality impairment in Georgia. According to Georgia's most recent 305(b)/303(d) list, 4,320 stream miles (or 55% of those identified as impaired) are not supporting designated uses by violating water quality standards for fecal coliform bacteria. Two stream segments in the Soque River watershed in Habersham County are included in this listing; the upstream segment is addressed in this paper.

Since 2004, the Soque River Watershed Partnership (SRWP) has coordinated planning and implementation of a strategy to reduce sources of fecal coliform bacteria and attain water quality standards. In order to meet applicable standards and support designated uses, bacterial loads must first be reduced and subsequently documented in accordance with Georgia Environmental Protection Division (GAEPD) guidance. The Partnership's strategy includes monitoring and identification of bacterial "hot spots", prioritization of corrective action locations, and implementation of management measures to eliminate or reduce sources of bacteria.

Using this strategy, assessment and prioritization of corrective actions have been in place since 2005. Design and installation of appropriate best management practices in priority locations began in 2008 and continues today. Monitoring data collected in 2009-2010 indicate attainment of bacterial water quality standards. Data and associated documentation have been submitted to GAEPD for consideration in the 2012 305(b)/303(d) listing process.

Funding for this project is made possible by CWA §319(h) grants administered by GAEPD and local partner organization and property owner contributions. The strategy detailed is very simple, but not necessarily easy to implement. A willing municipal partner, voluntary involvement from property owners, a local stakeholder group able to take ownership of this process, and sufficient project funding are critical for success.

INTRODUCTION

Pathogens have been identified as the leading cause of impaired waters in the United States. According to the U.S. Environmental Protection Agency's (USEPA) most recent water quality report to Congress, 72,305 stream miles (or 29% of those categorized as impaired) do not

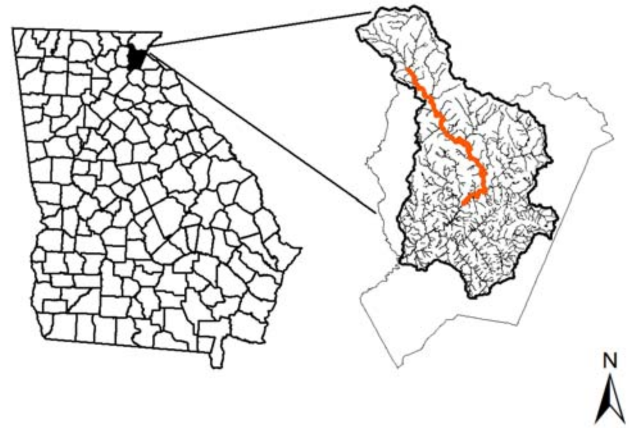

Figure 1. Location of Habersham County and the Soque River Watershed; 303(d) listed segment in bold

meet state water quality standards for pathogens (USEPA 2009). In Georgia, pathogens are also attributed to be the single greatest source of water quality impairment, and at a higher percentage than nationally. The most recent 305(b)/303(d) report indicates 4,320 stream miles, or 55% or those classified as impaired, do not meet water quality standards for pathogens (GAEPD 2010).

Fecal coliform bacteria, or specific members of this group (e.g. *Escherichia coli*), are commonly used as indicators of pathogen levels in surface waters. They are also used for regulatory purposes (e.g. by states to set ambient water quality standards, and to monitor compliance with National Pollutant Discharge Elimination System [NPDES] permits and the Safe Drinking Water Act). These bacteria are easily quantifiable (to compare with numeric water quality standards), inexpensive and easy to test for, and may be associated with an increased incidence of other pathogens and waterborne illness in humans. Most fecal coliforms originate in the gut of warm blooded animals, and thus come from wild animals, livestock, pets, and people. Pathogens may enter surface waters from both point and non-point source pollution.

Georgia's water quality standards for bacteria fluctuate seasonally to be more protective when most primary contact recreation occurs. To meet Georgia's water quality standards for the months of May through October, fecal coliform levels shall not exceed a geometric mean of 200 colony forming units (cfu's) per 100 ml of sample. For the months of November through April, fecal coliform levels shall not exceed a geometric mean of 1,000 cfu's per 100 ml of sample and shall not exceed a maximum of 4,000 cfu's per 100 ml for any single sample. All geometric mean calculations are based on at least four samples collected from a given sampling site over a 30-day period at intervals no less than 24 hours apart (GAEPD 2002a).

Based on routine sampling by GAEPD during 2001-2002, a 29 mile segment of the mainstem Soque River was determined as "not supporting designated uses" and was classified as impaired due to excessive bacterial levels (GAEPD 2002b). This segment of the river (reach code 031300011115, located in 8-digit HUC – Upper Chattahoochee River Basin), has remained on Georgia's 303(d) list of impaired waters on subsequent reports since that time (GAEPD 2010). In order to meet GAEPD guidelines for water quality standard attainment following 303(d) listing for fecal coliform bacteria (as outlined in the previous paragraph), 16 grab samples, specifically four samples collected within a 30 day period over four calendar quarters to calculate four geometric means, are required to document attainment of water quality standards for fecal coliform bacteria (GAEPD 2002a).

In recognition of this water quality impairment, and in response to the anticipated impacts of rapid growth in the watershed in the early part of the decade, the SRWP was formed to address water quality issues. Guided by a local partner stakeholder steering committee and a technical advisory committee of scientific and resource professionals, the SRWP formulated a strategy to identify hot spots of bacterial pollution, relate those locations to bacterial sources in the watershed, prioritize and implement corrective actions, and evaluate the effectiveness of those actions. The goal of these efforts was documenting water quality improvements due to corrective actions resulting in attainment of bacterial water quality standards and subsequent removal of the target stream segment from Georgia's 303(d) list of impaired waters. Funding for these efforts is possible via a Clean Water Act (CWA) §319(h) grant from the USEPA, administered by GAEPD, and by contributions from local partners.

METHODS

The study area for the project included contributing sub-watersheds to the 29 mile (upstream) 303(d) listed segment of the mainstem Soque River, the northeastern most tributary of the Upper Chattahoochee River. Initial bacterial sampling focused on identifying "hot-spots" of pathogen pollution. Hot spots were considered to be sample locations that consistently violated water quality standards across seasons and in multiple years.

Figure 2. *E. coli* sample locations and contributing sub-watersheds along the Soque River, a major tributary of the Upper Chattahoochee River. Gray circles indicate 42 sample locations.

Quarterly bacteria sampling, using *E. coli* as the indicator microorganism, began in 2005 and continues to the present. Sample locations were selected to maximize characterization of the watershed area and for ease of access. In all, 42 sample locations are included in the four contributing sub-watersheds to the listed segment (Figure 2).

Samples were collected by sub-watershed, working downstream to upstream, and as quickly as possible, to minimize spatial and temporal variation among samples. Grabs were collected regardless of weather conditions, and results were compared to indicate relative pathogen contributions in each sub-watershed and site. All samples for hot-spot prioritization were collected, held, and analyzed in accordance with a Quality Assurance Project Plan (QAPP) approved by GAEPD and USEPA (SRWP 2004). Most probably number (MPN) determinations (or cfu counts) per 100 ml of sample were made using the IDEXX Colilert-18 and the Quanti-Tray method as described by the manufacturer (IDEXX 2001). Data from these samples were used to identify locations with consistently high *E. coli* levels and to prioritize sites for corrective actions, in the form of best management practices (BMPs). Sites were prioritized using MPN values obtained from the USEPA and a literature survey of thresholds in states where *E. coli* is used to set water quality standards (Table 1) (USEPA 1986). Priority levels were then established based on these references and actual data values.

Table 1. Parameters used for site prioritization based on literature and data values

E. coli count	Priority
<127	Meets standards
128-254	Low priority
255-508	Medium priority
> 508	High priority

Beginning in 2008, quarterly monitoring data were used, in conjunction with field surveys and local knowledge of landuse practices, to identify the most likely significant sources of bacteria in the project area. There are no NPDES permitted discharges in the target watershed. Based on this evaluation, many of the BMPs targeted involved excluding livestock from streams with fencing and providing for alternative water sources (in the form of wells, troughs with gravity feed from streams, improved stream crossings etc). All farm projects relied on approved conservation plans from the local Natural Resources Conservation Service (NRCS) field office, and BMPs were designed and installed in accordance with applicable NRCS standards. Projects were paid for on a cost-share basis according to the NRCS Environmental Quality Incentives Program (EQIP) payment schedule. Projects in the target area resulted in approximately four miles of stream fencing and >175 livestock excluded from surface waters.

Following "hot-spot" sampling, prioritization and implementation of corrective actions, and continued sampling to evaluate BMPs, the SRWP undertook sampling for regulatory compliance with applicable fecal coliform water quality standards in the 303(d) listed segment of the mainstem Soque River. Samples were collected based on a predetermined schedule; during the first month of each quarter beginning in October, 2009, and continuing through July, 2010, and in accordance with standard protocols and a GAEPD approved Sampling Quality Assurance Plan (SQAP) (SRWP 2010). To eliminate potential sample bias, all grabs were collected on the same day of the week (Tuesday) at approximately the same time (mid-morning) regardless of precipitation, temperature, or streamflow conditions. The selection of time and day were selected to best accommodate staff performing the laboratory analysis. All samples were collected at the following location; the same location which warranted 303(d) listing:

King's Bridge (at Ben Jones Rd.)
on Hwy. 197 N. @ the Soque River
Latitude = 34.67922
Longitude = -83.53265

Samples were collected and transported at 4ºC to the City of Clarkesville Wastewater Treatment Plant for analysis. Laboratory analysis was accomplished by qualified City of Clarkesville personnel under the supervision of the Utilities Director. These personnel are certified in compliance with the Georgia State Board of Examiners for Certification of Water and Wastewater Treatment Plant Operators and Laboratory Analysts Act. Samples were analyzed for fecal coliform (MPN/100mL) using USEPA A-1 Medium Most Probable Number Method 8368.

Quality Assurance Plan. All sample collection, field parameters, and lab analysis for fecal coliform and *E. coli* were conducted in accordance with GAEPD's Quality Assurance Manual, 40 CFR Part 136, and USEPA guidelines. Additionally, all sampling and analysis complies with GAEPD's "Guidance on Submitting Water Quality Data for Use by the Georgia Environmental Protection Division in 305(b)/303(d) Listing Assessments" (GAEPD 2002a).

Data quality is in part addressed by consistent performance of valid procedures documented in the SQAP and adherence to approved sample collection and laboratory analytical methods (SRWP 2010).

<u>Field Replicates</u> were collected at random for 10% of all field measurements and samples

<u>Field Blanks</u> were collected at random for 10% of all samples.

<u>Lab Duplicates</u> were analyzed for 10% of all samples.

<u>Lab Blanks</u> were run for 10% of all samples to ensure that laboratory apparatus and procedures are functioning properly.

All records, including chain of custody documentation and laboratory bench sheets, will be kept on file and will be available for review for a period of at least three years following data collection and analysis. Records are housed in the office of the SRWP Watershed Coordinator at North Georgia Technical College.

RESULTS

More than 800 samples were collected from 42 sites in the watershed area of the target stream segment during the "hot-spot" prioritization phase. Data from those samples are not presented here, but are available by request from the author. Results of continued quarterly monitoring indicate an overall decrease in *E. coli* levels in subwatersheds contributing to the 303(d) listed stream segment. There are individual sites where bacteria levels have fluctuated by season and year (and in some cases increased), possibly due to climatic factors, normal seasonal changes, weather patterns, and landuse.

Based on these data, monitoring towards meeting regulatory requirements for attainment of water quality standard began in October, 2009. To meet GAEPD requirements for data acceptability for regulatory purposes, fecal coliform samples were collected based on the schedule in Table 2. Fecal coliform data, along with precipitation data from the United States Geological Survey stream gaging station on the Soque River (USGS Station # 023312495; located within the target stream segment) are also presented. The geometric means to meet water quality standards are 200 (May-October) and 1000 cfu's (November-April) respectively.

Table 2. Fecal coliform sample schedule and results

Week	Dates of Sampling	Precipitation (inches) (previous 48 hrs)	MPN*	Geometric Mean*
Fall Quarter				
1	10/6/2009	0.60	300	
2	10/13/2009	1.85	220	
3	10/20/2009	0.00	170	195.4
4	10/27/2009	1.79	130	
Winter Quarter				
1	1/5/2010	0.00	50	
2	1/12/2010	0.00	240	
3	1/19/2010	1.11	900	171.4
4	1/26/2010	0.10	80	
Spring Quarter				
1	4/6/2010	0.00	240	
2	4/13/2010	0.00	130	
3	4/20/2010	0.24	500	261.6
4	4/27/2010	0.00	300	
Summer Quarter				
1	7/6/2010	0.00	170	
2	7/13/2010	0.82	170	
3	7/27/2010	0.20	280	192.6
4	7/28/2010	0.00	170	

***MPN and geometric mean are reported as cfu's/100mL of sample**

CONCLUSIONS

Data from Table 2 (and supporting documentation) were submitted to GAEPD in August, 2010. These results indicate attainment of bacterial water quality standards. It is anticipated that these data will lead to the removal of the target stream segment from the "not supporting designated uses" list in Georgia's 2012 305(b)/303(d) list document (publication in 2012).

There are many ways that pathogens may enter surface waters, some of which are impossible to control. A coordinated effort on the local level can eliminate or reduce some sources, however. Pathogen sources identified and prioritized by routine sampling over a sufficient period of time can be addressed with targeted and site specific BMPs. The cooperation and involvement of both public entities and private property owners is necessary, as is the funding to monitor water quality over time and design and install appropriate BMPs.

Just as there are multiple sources of pathogens, there are multiple ways to achieve bacterial water quality improvements. One size does not fit all; the cooperation of local partners, number and location of major pollutant sources, size of the watershed, and many other factors affect the likelihood of success. This strategy for delisting works in the Soque River Watershed because many critical pieces (as outlined above) have been in place for several years. The strategy is very simple, but not necessarily easy to implement. The elimination of pathogen sources causes pathogen levels to decrease. Such a strategy might be applicable in a watershed where similar pollutant sources exist, and the resources needed to address them are available. It is necessary to identify major pollutant sources in critical locations, which can be addressed by appropriate BMPs (including point sources as needed).

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