DESIGN OF AN ENVIRONMENTAL MONITORING PROGRAM FOR THE LAKE ALLATOONA/UPPER ETOWAH RIVER WATERSHED

James B. Stribling[1], Steven R. Davie[2]

AUTHORS: [1]Tetra Tech, Inc., 400 Red Brook Boulevard, Suite 200, Owings Mills, Maryland 21117-5159; [2] Tetra Tech, Inc., 2110 Powers Ferry Road, Suite 202, Atlanta, GA 30339.
REFERENCE: *Proceedings of the 2005 Georgia Water Resources Conference*, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute Ecology, The University of Georgia, Athens, Georgia

Abstract. The proximity of the Upper Etowah River watershed to such a vast urban and urbanizing area (Atlanta, Georgia) makes proactive watershed management essential because there is critical need to balance water and wastewater demands with efforts to maintain and enhance overall ecological conditions. The monitoring program is intended to be comprehensive, help address multi-jurisdictional watershed management objectives, and focus on ecological condition at multiple spatial scales. Therefore, the purpose of this project is the development of a valid and technically defensible, long-term monitoring design for the Upper Etowah River watershed. The Lake Allatoona/Upper Etowah River Watershed Partnership specified a list of management objectives and questions that the data gathered under the monitoring program should address. The set of objectives required an approach that incorporates sites selected based on expected problems or issues (targeted), as well as sites from which data could be aggregated for assessments at broader spatial scales (probability-based). The resulting network design is a set of sites that will, in part, be sampled annually; intermittently; and as part of a regular, rotating-basin schedule. Constituents to be sampled include selected laboratory and field chemistry, various aspects of flow and physical habitat quality, benthic macroinvertebrates, and fish. Over a 6-year period, these data will be gathered from approximately 400 locations throughout the upper basin. Implementation of the program will require training, tracking of data quality characteristics, and performing analyses focused on answering, with known confidence, the stated objectives of the program.

INTRODUCTION

The Lake Allatoona/Upper Etowah River Watershed is located in northern Georgia, northeast of Atlanta (Figure 1). The drainage area covers 1,120 mi^2 that is bounded on its downstream end by Lake Allatoona and upstream end by the Tennessee Valley Divide on the Blue Ridge Mountains near Dahlonega, Georgia. Although most of the watershed is within a 50-mile radius of downtown Atlanta, land cover in the drainage area is predominantly forested. However, there are dense residential and commercial areas in the watershed near Woodstock, Roswell, Marietta, and Canton. The area is located within the region of north Georgia that is experiencing rapid development and population growth from the expanding Atlanta Metropolitan Area. It is this growth that is posing a significant threat to the environmental quality and ultimate economic sustainability of the water resources of the area. There will be an ever-increasing need to balance water resources protection while allowing for smart economic development in the local communities.

The Lake Allatoona/Upper Etowah River Watershed Partnership has been formed with the United States Army Corps of Engineers (USACE), Mobile District to assist in

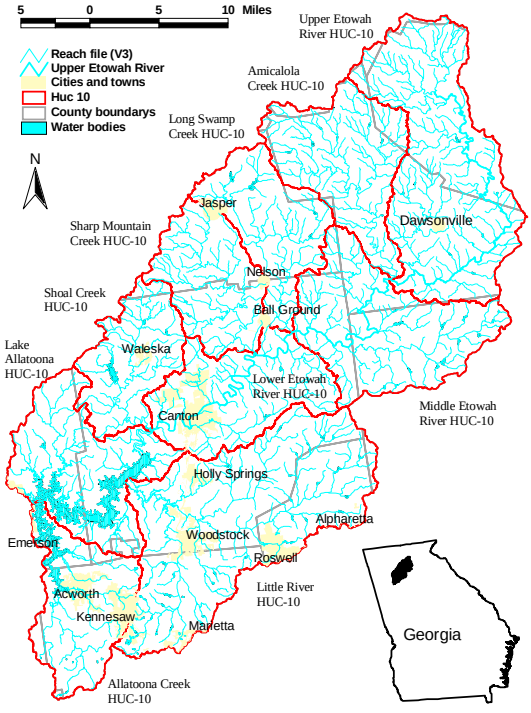

Figure 1 Location of the Upper Etowah River watershed, Georgia.

the development of a comprehensive watershed protection plan for the area. The partnership includes the following Local Sponsors: Bartow County, Bartow County Water Systems, Cherokee County, Cherokee County Water and Sewerage Authority, Cobb County-Marietta Water Authority, Cobb County, Cobb County Water System, Dawson County, Etowah Water and Sewer Authority, Forsyth County, Forsyth County Water and Sewer Authority, Lumpkin County, Lumpkin County Water and Sewerage Authority, Pickens County, and Pickens County Water Authority.

The ultimate goal is to produce a WPP for the entire Lake Allatoona/Upper Etowah River Watershed regardless of geo-political boundaries. The WPP will be used to guide management decisions in the watershed to protect water resources. The WPP is comprised of two key components: the Watershed Assessment (WA) and the Monitoring Plan (MP). The MP will lead the collection of data for the WA, which provides the technical basis for the WPP. Each forms the core for the subsequent step, ultimately leading to appropriate adaptive management strategies. The overall design specifically addresses the MP objectives, strategy, and requirements to develop a sound WA.

MONITORING GOALS, OBJECTIVES, AND NETWORK DESIGN

The overall purpose of this monitoring program is to provide credible data, and valid, defensible results, to address objectives specified by the local sponsors, which include questions related to status and trends of stream and watershed ecological condition; problem identification; documentation of the relationship among stressor sources, stressors, and response indicators; and evaluation of environmental management activities. Sampling and assessment will address questions of water quantity, water quality, and ecological condition at multiple spatial scales. The water quantity monitoring will provide data on flow and volume into Lake Allatoona; monitoring of water quality constituents, in combination with flow data, is intended to address question of pollutant loadings (in particular, phosphorus) and specific regulatory requirements; the ecological monitoring will provide an unbiased estimate of water resource quality (that is, not based on the spatial arrangement of known problems or stressor sources). In line with recommendations by the National Research Council (NRC 1990, 2001) and the directive of the Clean Water Act of 1972 (U. S. GPO 2001), the design is also intended to meet the State of Georgia's goal of comprehensive watershed monitoring and management and planning (DeMeo and Kundell 2001). The set of objectives required that an approach be used that combined results from sites selected based on expected or known problems or issues (targeted), as well as those from which data could be aggregated for assessments at broader spatial scales (probability-based). Targeted assessments are intended to provide information on known "hotspots" or stressor sources and effects (Freeman et al. 2002 [draft]), such as point source discharges, new or ongoing land cover conversions, or (potentially) locations of threatened and endangered species. Assessments using stratified, probability-based sampling site networks can be used to address questions at multiple spatial and temporal scales, including watershed-wide (Larsen 1997, Urquhart et al. 1998).

To perform the selection of station locations and determine various monitoring activities, the watershed was divided into Hydrologic Unit Codes (HUCs), a standard defined by the US Geological Survey, which provides a spatial framework useful in organizing geographic and other environmental information. The 10-digit HUCs and, the smaller in size 12-digit HUCs, were used in the MP to locate sampling sites according to the three major components: water quantity, water quality, and water resource quality (biological and physical habitat).

The goal of the ***water quantity*** monitoring is to measure the volume and timing of water flow to the Etowah River and Lake Allatoona from surrounding drainage basins. The 10-digit HUCs were used as the spatial scale to examine the percentage of the watershed that is currently being measured. Based on the existing four USGS gages and the five installed by the counties from July-August 2004, approximately 80% of the watershed is being monitored. It is proposed that three new sites be added to quantify 90% of the watershed. The additional sites will cover three large 10-digit HUCs, which currently are not monitored. All gages would provide a continuous record of water surface elevation and flow.

For the ***water quality*** monitoring, the goal is to determine pollutant loadings into the Etowah River and Lake Allatoona. Calculation of pollutant loading requires measurement of both continuous water quality and, at least monthly water chemistry (grab sampling). Water quality monitoring involves measuring *in situ* parameters such as water temperature, pH, dissolved oxygen, conductivity, and turbidity. Water chemistry will involve laboratory analysis of grab samples for constituents such as nutrients, BOD, metals, and sediment. Three wet weather sampling sites were positioned based on land cover, one in each of the following: forest, agriculture, and urban. There are eighteen §303(d)-listed streams in the Upper Etowah River Watershed that will be monitored for fecal coliform and *Escherichia coli* (E. coli) on a quarterly basis.

The *ecological condition* of a waterbody is determined by sampling and analysis of one or more components of the aquatic community, and comparison to that of similar waterbodies minimally exposed to physical, chemical, or hydrologic stressors; it also includes some understanding of the five categories of environmental factors that can affect the survival and reproduction of aquatic organisms: biotic interactions, energy sources, chemical variables, habitat structure, and flow regime (Stanford and Ward 1992, Karr et al. 1986). Assessment of ecological condition for this program will include sampling and analysis of biological response indicators (benthic macroinvertebrates) and potential stressors (physical habitat quality, rapid geomorphic assessment, and selected field chemistry). Field sampling and data analysis methods will follow those of Georgia EPD, and Gore et al. (2004 [draft]). Although fish will not be sampled as part of this program, assessment results based on sampling of the fish assemblage by GAEPD (Shaner and Biagi 1999 [draft]) will be used as supplemental indicators. Because there is substantial natural variability in stream and watershed ecosystems, understanding of these factors at numerous locations across the entire watershed is important to confidently predict change. Using biological data previously evaluated for these ecoregions (Gore et al. 2004 [draft]), statistical power analysis revealed that five samples/sites per 12-digit HUC are necessary to meet the programmatic data quality objectives (ability to detect a 30% change in mean biological index score [sensitivity], 80% of the time [power], with 95% confidence [uncertainty]). To allow the entire watershed to be assessed, a random network design was chosen, and stratified by 12-digit HUC and stream order. Thus, five wadeable stream sites were randomly chosen within each 12-digit HUC, and further stratified among stream orders. Assessments from all sites within each 12-digit HUC will be aggregated to a mean biological index score (with known confidence). Following Year 1, a 5-year rotating basin design will result in ten or eleven 12-digit HUCs being sampled per year (approximately 53 sites). To develop the basis for a watershed-wide assessment during the first year of the program, one site per 12-digit HUC was randomly selected from each of the 53 units. Because there are usually multiple stressors that affect biology, and each site is unique, water quality and chemistry data will be collected at each site where water resource quality data are collected during Year 1. Table 1 summarizes the number of sites that will be sampled on an annual basis for water quantity, quality, and resource quality.

The long term monitoring portion of this program, will, in part, allow confirmation (or adjustment) of assessment results from the Year 1 sampling and analyses. It also provides an increased likelihood that individual sampling sites will be located on specific streams or subwatersheds for which data needs are currently unknown. The component of this program focused on ecological, thus, will be comprised of sampling approximately 53 sites per year over a 6-year period (318 total) throughout the watershed. Ecological condition will also be evaluated for 11 sites targeting the effects of new and ongoing municipal development activities and to fill potential gaps in a gradient of land cover conditions. Implementation of the monitoring program will require training, tracking of data quality characteristics, performing analyses focused on answering programmatic objectives, customization of a data management system to the data and their required uses, and coordination with ongoing activities of organizations such as the USEPA Region 4, GAEPD, the USGS, the University of Georgia, U. S. Fish and Wildlife Service/Habitat Conservation Plan, and The Nature Conservancy, and long-term monitoring by the local counties.

Table 1 Summary of the number of sites to be sampled in the watershed over a 6-year period.

	Number of Locations					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Water Quantity [a]	12	12	12	12	12	12
Water Quality [b]	68	75	65	65	70	65
Water Chemistry [c]	72	19	19	19	19	19
Ecological Condition [d]						
Stratified random	53	60	50	50	55	50
Targeted	11	-	11	-	11	-
Total No. Sites	72	79	69	69	74	69

a - flow and volume; b - DO, pH, temperature, conductivity, turbidity; c - nutrients, BOD, metals, sediment; d - biology, physical habitat, geomorphology

ACKNOWLEDGEMENTS

This project and report was completed through the U.S. Army Corps of Engineers (USACE)-Mobile District contract no. W91278-04-D-002 with Tetra Tech, Inc. James Stribling and Steven Davie were assisted by Jon Harcum, Colin Hill, Nick Jokay, and Mary Matella, all of Tetra Tech. The Lake Allatoona/Upper Etowah River Watershed Partnership consists of the following sponsors: Gene Camp (Bartow County and Bartow County Water Systems), David Kubala, Michael Morrissey (Cherokee County and Cherokee County Water and Sewerage Authority), Jim Parsons, Scott Pherson (Cobb County-Marietta Water Authority), Bill Higgins, Steve Shelton, Bob Bourne (Cobb County and Cobb County Water System), Jim King (Dawson County), Sandy Adams, Doris Cook (Etowah Water and Sewer Authority), Tim Perkins (Forsyth County and Forsyth County Water and Sewer Authority, Kevin Flanagan, Steve Gooch (Lumpkin County and Lumpkin County Water and Sewerage Authority), and Norman Pope (Pickens County and Pickens County Water Authority). James A. Gore (University of South Florida [formerly of Columbus State University, Columbus, Georgia]), Duncan Hughes (North Georgia Technical College [formerly of Columbus State University]), and Michelle Brossett (Columbus State University) provided biological and reference site data and information on the state's ecoregional reference condition project.

LITERATURE CITED

DeMeo, T. A. and J. E. Kundell. 2001. *Linking State Water Programs to Watershed Management*. Carl Vinson Institute of Government, University of Georgia. Sponsored by the Georgia Environmental Protection Division. *(http://www.cviog.usg.edu/catalog/watershedmgmt.pdf)*

Freeman, B., S. Wenger, S. McClurg, and C. Straight. 2002 (draft). Etowah River Basin Stressor Analysis. Report prepared for the U. S. Fish and Wildlife Service. July 5, 2002.

Gore, J. A., J. R. Olson, D. L. Hughes, and P. M. Brossett. 2004 (draft). Reference conditions for wadeable streams in Georgia with a multimetric index for the bioassessment and discrimination of reference and impaired streams. Ecoregion Reference Site Project. Phase 1. Final Report. Columbus State University. Columbus, GA. *(for further information, contact James Gore at 727-553-4825 or jagore@stpt.usf.edu)*

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Waters: A Method and Its Rationale. Illinois Natural History Survey Special Publication No. 5. Champaign, IL.

Larsen, D. P. 1997. Sample survey design issues for bioassessment of inland aquatic ecosystems. Human and Ecological Risk Assessments 3(6): 979-991.

NRC (National Research Council). 1990. *Managing Troubled Waters. The Role of Marine Monitoring*. National Academy Press, Washington, DC.

NRC. 2001. Assessing the TMDL Approach to Water Quality Management. National Academy Press, Washington, DC.

Shaner, B. and J. Biagi. 1999 (draft). Draft Fish Biomonitoring Standard Operating Procedures. Georgia Department of Natural Resources, Wildlife Resources Division. Atlanta, GA.

Stanford, J. A. and J. V. Ward. 1992. Management of Aquatic Resources in Large Catchments: Recognizing Interactions Between Ecosystem Connectivity and Environmental Disturbance. Chapter 5, IN, Robert J. Naiman (editor), *Watershed Management. Balancing Sustainability and Environmental Change*. Springer-Verlag. New York, NY.

U. S. GPO (Government Printing Office). 1989. Federal Water Pollution Control Act (33 U. S. C. 1251 et seq.) as amended by a P. L. 92-500. In: Compilation of selected water resources and water pollution control laws. Printed for use of the Committee on Public Works and Transportation. Washington, DC.

Urquhart, N. S., S. G. Paulsen, and D. P. Larsen. 1998. Monitoring for policy-relevant regional trends over time. Ecological Applications 8(2): 246-257.