Sediment Source Assessments and establishing Priorities for Abatement

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Abstract
Strategic efforts to abate sediment in impaired watersheds face numerous challenges in achieving tangible water quality improvements that are measurable, attributable to project actions, and focused on principle causative sources. As part of a small watershed sediment control strategy, the Soque River Watershed Partnership will examine the feasibility of conducting sediment source assessments for five small catchments (first and second order streams approximately one square mile or less) in order to prioritize remedial actions based on relative contribution of sediment, opportunities for greatest sediment reduction, cooperation of land owners, and anticipated sediment reduction achieved per dollar spent. The assessments will integrate GIS modeling, field scale channel and hillslope stability evaluations, and in-stream suspended loadings. These data will then be overlain onto a cultural and resource management framework to identify practical and cost efficient remedial actions. This project attempts to develop a strategic and data driven approach to prioritizing sediment abatement activities at the small catchment scale in impaired watersheds.

INTRODUCTION

Two segments and nine miles of the Hazel Creek subbasin (31.9 square miles, 20,416 acres) of the Soque River Watershed are currently listed as impaired according to Georgia's 2008 list of impaired waters for failure to support aquatic life due to excessive sedimentation. The Soque River Watershed (160 square miles 102,400 acres) has been a priority watershed for non-point source pollution abatement since first being listed as impaired in 2002 due to its contribution to the Upper Chattahoochee River drinking water supply watershed. The Soque River accounts for approximately 1/6 of the inflow to Lake Sidney Lanier, the principal drinking water source to 5.5 million residents of the Metropolitan Atlanta region.

Since 2004 the Soque River Watershed Partnership consisting of greater than 20 organizations, municipalities and agencies in Habersham County have organized to assess impairments in the Soque Basin and to implement water quality improvement projects to de-list segments of the stream. Many of these projects, funded by CWA §319 funding, have focused on reductions of fecal coliform bacteria through cattle exclusion projects, with ancillary benefits to sediment reduction through recovery of riparian buffers.

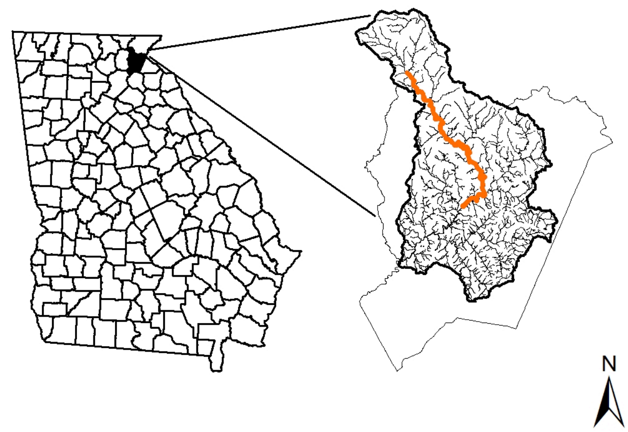

Figure 1. Location of Habersham County and the Soque River Watershed; 303(d) listed segment in bold

Beginning in 2010 the Soque Partnership initiated a new sediment abatement strategy to be built on sediment source assessments at the small catchment scale. Due to the challenging nature of sediment loadings measurement, many abatement strategies lack an assessment and prioritization phase to identify Critical Source Areas (CSA) or areas that contribute a disproportionate fraction of the total sediment pollutant load (White 2009). One of the principal challenges in mounting a successful sediment abatement program is targeting sediment sources and areas contributing the highest sediment loads, followed by implementation of activities that achieve the greatest load reductions for the least cost. Achieving water quality improvements that are measurable and attributable to project actions is another challenge to sediment abatement due to the slow removal of channel bedload following project implementation.

The case for small catchment emphasis

A new emphasis on critical source areas (CSAs) or hot-spots (source areas of sediments) within small catchment areas (one square mile or less) is likely to yield better results in developing detailed sediment abatement strategies.

Small catchments offer the benefits of 1) a more rapid in-stream sediment response to abatement activities; 2) abatement activities more likely to significantly improve total catchment sediment yields; 3) and less likelihood of extensive land-use / hydrologic changes during study period (catchments chosen for this study will emphasize land use stability).

The small catchment scale also allows sediment models (such as the USLE and RUSLE) to overcome many of the recognized inadequacies of modeling (Boardman, 2006) such as:

- Increases ability to compare results against landscape scale field data
- Greater refinement and validation of the input data (such as soil types, land coverage, rainfall)
- Hot spots identified can be directly tied to specific cultural and resource management strategies and identify practical and cost efficient remedial actions.

The emphasis on small catchment size allows this project to ground verify land use classification data, implement field reconnaissance for upland and channel erosion data, and collect in-stream suspended loadings data.

The Soque Partnership has achieved and measured significant improvements in fecal coliform bacteria counts by focusing attention on identified hotspots for remedial action, even identifying individual fields that are likely contributors to in-stream water quality conditions. This hotspot identification approach is desired for sediment abatement activities as well. Research on the contribution of critical source areas suggests great potential in improving water quality projects. In a combined study of six priority watersheds in Oklahoma, White (2009) found that just 5% of the mixed cover watershed area contributed 50% of the sediment load, and 5% of the agricultural watershed area generated 13% of sediment load. This disproportionate contribution of sediment from CSAs "illustrates the potential advantages of the targeted placement of conservation measures." (White, 2009)

Goals

The goal of this project is to explore the feasibility of developing a model sediment assessment and abatement strategy for five-seven small catchments (1st-3rd order streams approximately one square mile or less) in order to prioritize remedial actions based on:

- relative contribution of sediment,
- opportunities for greatest sediment reduction,
- cooperation of land owners, and
- anticipated sediment reduction achieved per dollar spent.

The assessments will integrate GIS modeling, field scale channel and hillslope stability evaluations, and in-stream suspended loadings. These data will then be overlain onto a cultural and resource management framework to identify practical and cost efficient remedial actions.

METHODS

Prior to development of sediment abatement strategy, the Soque Partnership will collect and analyze approximately one to two years of sediment source assessment data using a combination of GIS modeling, and empirical field assessments of upland (hillslope) and stream channel erosion rates.

GIS Modeling Methods

The Universal Soil Loss Equation (USLE) is perhaps the most widely used empirically based erosion and sediment transport model in the world and is represented by the equation: $E=RKSLCP$; where E is the average annual soil loss in tons per acre, R is a rainfall erosivity index, K is a soil erodibility index, S is slope, L is length of slope, C is a cropping management factor, and P is a conservation practice factor. It is still a useful tool for estimating sediment yield for a catchment, and its non-differential input data is easy to acquire. For this reason, this will be the first model used to assess priority catchments based on sediment yield. However the weaknesses of the USLE lies in its inability to estimate sediment deposition, delivery of sediment from fields to streams, runoff, channel erosion, or impoundment effects (Flanagan et. al 2007).

The Watershed Erosion Prediction Project (WEPP) model designed by the USDA-ARS has specific advantages for use in evaluating small watersheds in articulating sediment transport processes at the hillslope and steam channel scales, and incorporating greater hydrologic and erosional science fundamentals such as infiltration, surface runoff, and deposition (Aksoy and Kavvas, 2005; Baigorria, 2007). Both the USLE (for upland sources) and the WEPP models (both upland and channel sources) will be utilized to identify erosional hotspots. These areas will then be considered for more in-depth analysis using empirical field data collection methods.

Upland and Channel field reconnaissance Methods

Lateral erosion of streambanks has been found to be a principle source of suspended sediments in an adjacent Piedmont watershed, the Broad River (60% of suspended load, Mukundan, et. al 2010). Channel erosion is expected to likewise be a considerable factor in sediment loadings within many of the study catchments.

In order to identify specific channel reaches for potential restoration this study will conduct an inventory of streambanks for erosion potential based on the bank erosion hazard index (BEHI) and evaluation of near-bank shear stress (NBSS) as described in Van Eps et. al. 2004. The BEHI method collects bank angle, height, ratio, root density, rooting depth, percent bank protected by structures such as rock and roots, and bank materials. NBSS is then estimated based on cross section dimensions and stream slope. BEHI and NBSS data will be collected for all walkable / wadeable segments of the five catchments and is expected to be approximately 5-7 miles. Inventoried streambank reaches will be categorized according to low, moderate, high, very high and extreme erosion risk categories. At least one permanent survey site will be established within each catchment in order to establish lateral erosion rates using toe pin survey techniques at a one-year interval.

An upland / hillslope field assessment protocol has yet to be developed for this project.

<u>In-stream suspended load Data Methods</u>
Suspended load and streamflow will be estimated using five ISCO automatic water samplers established at the base of each catchment and calibrated to capture 3-5 storm events. Depth integrated samples using the US DH-81 hand-held will also be taken at each site for more accurate readings of cross-sectional suspended sediment. Datasets will be compared to estimate potential under/over representation by ISCO samplers and we will calibrate, as needed, the ISCO fixed-point pumped samples to cross section average concentrations.

A Price AA flowmeter will be used to measure flow at each catchment outlet and a permanent staff gage installed so that a stage-discharge curve using cross-sectional area and velocity can be used to estimate streamflow. 8-10 measurements during low and high flows will be used to establish the stage-discharge curve. An annual sediment budget and sediment yield will be generated from the above datasets.

<u>Cultural / Resource Management Framework</u>
A frequently lacking component in many watershed protection plans are adaptive strategies for implementing pollution abatement projects within a given cultural terrain, taking into account particular opportunities for partnerships or building of goodwill. A key component in the development of the Soque Partnership's sediment abatement strategy is assessment of projects that 1) garner significant support from watershed landowners, 2) represent practical projects that are cost effective and timely, 3) prioritize projects based on maximum abatement achieved per dollar spent.

During the process of data acquisition for the sediment source assessment, Soque Partnership representative will also inventory catchment land ownership and potential collaborators by disseminating information re: streambank restoration, upland erosion BMPs, and other educational brochures oriented towards abatement projects.

Sediment abatement project locations, and specific BMP selections, will be determined based upon the above criteria. The goal of this methodology is prioritization of sites to effectively eliminate or reduce sources of excessive sediment contributing to in-stream habitat degradation. The anticipated long-term result is habitat improvement and recovery of the biotic community, resulting in attainment of aquatic life use criteria and subsequent removal from the 303(d) list.

RESULTS AND CONCLUSIONS

The project is in the early stages of development and full results will be forthcoming over the next three years.

Catchment delineation of the Hazel Creek Basin has yielded seven headwater catchments of one square mile area. Land use in these catchments ranges from 55% urban cover in catchment #6, to only 7-10% urban cover in catchments #1,2, and 7.

Hazel Creek one square mile catchments

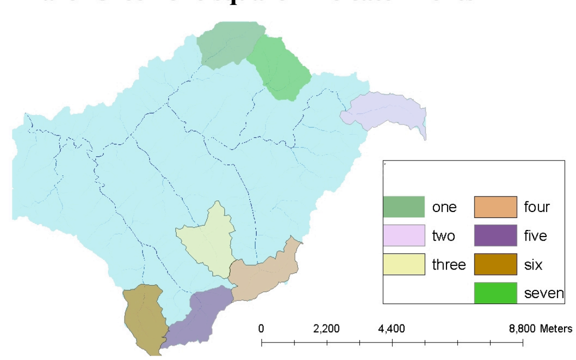

Figure 2. Location of one square mile catchments within the Hazel Creek sub-basin.

Preliminary USLE modeling data estimates erosion between 450 to 716 tons/yr within each of the seven catchments, with the model predicting lowest surface erosion within the most urbanized catchment (catchment #1).

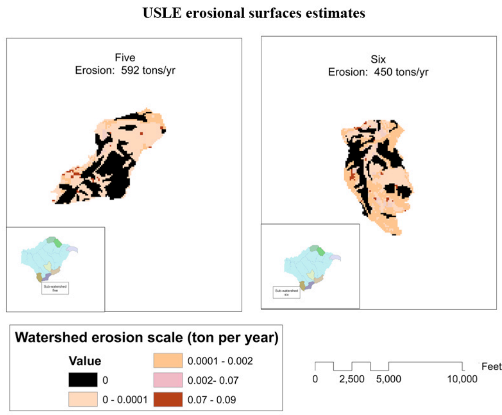

Figure 3. USLE erosional estimates for two sample one square mile catchments in Hazel Creek sub-basin.

USLE data already suggest potential hotspot locations for abatement activities for field scale assessment and verification.

Anticipated sediment sources include: eroding dirt roads, inadequate stream buffers, streambank erosion, cattle access to streams, poor pasture management, development, fill dirt mining, instream scour (due to altered hydrology), and gullies and washes. Anticipated sediment abatement projects will consist of channel stabilization, stormwater controls, improved road management, riparian zone re-establishment, improved pasture management, improved soil and vegetative management, and slope stabilization. Remedial projects will focus on opportunities for comprehensive sediment abatement at the small catchment scale. This approach is intended to serve as a model approach for sediment reduction that can be replicated in other areas of the basin, as well as in other watersheds.

The small catchment, critical source area assessments combined with fixed point water quality sampling at catchment outlets both before and after abatement projects will allow us to track water quality improvements tied to remedial actions. These monitoring efforts will continue well after the three year project time frame.

Input from both the academic and the water quality management community will increase the potential of this effort to develop a model approach for developing sediment abatement strategies within small watersheds.

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