STREAM CHANNEL POST-RESTORATION MONITORING OF THE SOQUE RIVER, GEORGIA

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Abstract. Reconstruction and stabilization were conducted on a 1250-foot reach of the Left Fork Soque River near Batesville, GA in October 1998. Two years after restoration, stream channel recovery measurements were collected on this stream restoration project that incorporated the principles of natural channel design. The channel has remained stable, with desirable sedimentation occurring on the inside of meanders, resulting in decreases to the width-depth ratios. Riparian vegetation and stream banks are recovering.

INTRODUCTION

The Upper Chattahoochee Riverkeeper (Riverkeeper) and the U.S. Environmental Protection Agency (EPA) implemented a stream channel and riparian restoration project on the Left Fork of the Soque River in Habersham County, Georgia in October, 1998. This restoration project was designed and constructed using the natural channel design principles of fluvial geomorphology (Rosgen, 1996). This work was done as a component of the Chattahoochee River Headwaters Riparian Restoration and Education Project ("Headwaters Project") initiated in 1996 by Riverkeeper to help address nonpoint source pollution prevention in the Chattahoochee Headwaters (see Baer and Derby, 1997). A description of the design, field methods, and implementation of the Soque restoration project was presented in the Proceedings of the 1999 Georgia Water Resources Conference (Baer et al., 1999).

Stream channel stability and recovery has been documented two years post-restoration. The project was designed to demonstrate the benefits of reclaiming previously cattle-grazed, eroding stream banks to properly functioning riparian zones. The primary objectives of the restoration project were to prevent the further contribution of sediment into the Soque River, and the resulting loss of property, from a severely eroding stream bank, and as well, to improve fish habitat and the aquatic community. Excessive siltation, such as was occurring at the Soque site, has been identified by EPA as the most common pollutant affecting assessed rivers and streams and contributes to 38% of the reported water quality problems in the impaired rivers and streams nationwide (U.S. EPA, 2000). Stream bank erosion is a significant source of this siltation, and results in habitat impairments, increased water treatment costs and channel instability. For example, prior to the Soque site restoration, it was calculated that more than 32 tons of soil eroded from banks into the water during a four month period, in one especially unstable meander, where six-foot vertical banks were regularly sloughing into the water (Baer et al., 1999).

Site Description

At the project site, the Left Fork of the Soque River drains a 7.55 mi^2 watershed, with headwaters within the U.S. Forest Service Tray Mountain Wilderness. The Soque River, a major tributary to the Chattahoochee above Lake Lanier, provides the drinking water supply for the City of Clarkesville, and is a state-designated trout stream. The health of the Soque is threatened by sediment, as evidenced by an EPA study of sediment delivery to the Chattahoochee River, in which the Soque River had the highest sediment loading of any tributary between the headwaters and Highway 384 (above Lake Lanier) (U.S. EPA, 1997).

RESTORATION PROJECT

Design principles of fluvial geomorphology were used to construct a channel segment capable of transporting both flood flows and sediment load. As described by Rosgen (1996), a river that is geomorphically stable is in dynamic equilibrium with the volume of water and sediment it must transport. Natural stream channel stability is achieved by allowing the river to develop a stable dimension (cross section), pattern (meanders) and profile (slope) such that over time, channel features are maintained and the stream system neither aggrades nor degrades. For a stream to be stable it must be able to consistently transport its sediment load, both in size and type, associated with local deposition and scouring. Applying these principles at the Soque restoration site, a stable stream channel was designed and constructed. Channel reconstruction and vegetative stabilization was completed in October, 1998.

MONITORING METHODS AND RESULTS

Labeling of cross sections reference their location from a bridge crossing just upstream of the project. For example, location 2+71 represents a station 271 feet downstream of the bridge.

Channel Cross-Sections

Four channel cross-sections (XS) were surveyed pre- (April to June 1998) and post-restoration (December 2000) to aid in the restoration design and to monitor the success of the project, respectively (Figure 1, A-D). Station LFS10 (location 1+94) was located at the reconstructed meander as graphically depicted in Figure 1A. LFS50 (7+09) was located along an unrestored, but stable, section of the existing channel. LFS60 (9+60) was located across a multi-channel reach that exhibited extreme bank failure on the right bank as depicted in Figure 1C. LFS70 (12+39) was located immediately downstream of the restoration project, and consequently was in a segment considered unaffected by the restoration. Thus, station LFS 70 was representative of pre-restoration conditions of the stream. Bankfull (return interval 1-2 years) measurements included average depth (D_{bkf}), width (W_{bkf}), and cross-sectional area (A_{bkf}). In addition, bankfull width to depth ratios (W/D) were calculated.

D_{bkf} increased at stations LFS10, LFS50 and LFS 60. However, the most dramatic increase in D_{bkf} was observed within one of the reconstructed channels at LFS60, where it more than doubled (0.8 to 1.8 ft). W_{bkf} decreased at all XS with the exception of LFS70 where it increased from 47 to 54 feet. The loss of approximately four feet of bank material from the right bank contributed to the increase in W_{bkf} at LFS70 (Figure 1D). A_{bkf} increased at all XS with the exception of LFS50. W/D ratios decreased at stations LFS10, LFS50 and LFS60 and increased at LFS70. However, the largest changes were observed within the reconstructed channels at LFS10 (where W/D decreased from 29 to 21) and LFS60 (50 to 17). W/D increased slightly at LFS 70, immediately downstream of the restored reach, from 65 to 69.

Sampling Coarse River-Bed Material

Prior to restoration it was hypothesized that the over-widened (high width-depth ratio) channel had reduced sediment transport capacity and increased the percentage of finer particles (i.e., % sands and fines) within the streambed surface. The bed surface particle distribution was therefore sampled by conducting pebble counts, and the results are expressed as the "D_{50}". The D_{50} represents the median particle size (in millimeters), i.e., the size that is larger than half of the other particles measured in the bankfull channel. Wentworth "pebble counts," were conducted according to methods prescribed by Harrelson (1994), Rosgen (1996), Leopold (1994) and others. Pebble counts were collected using Wentworth size classes according to Wolman, 1954.

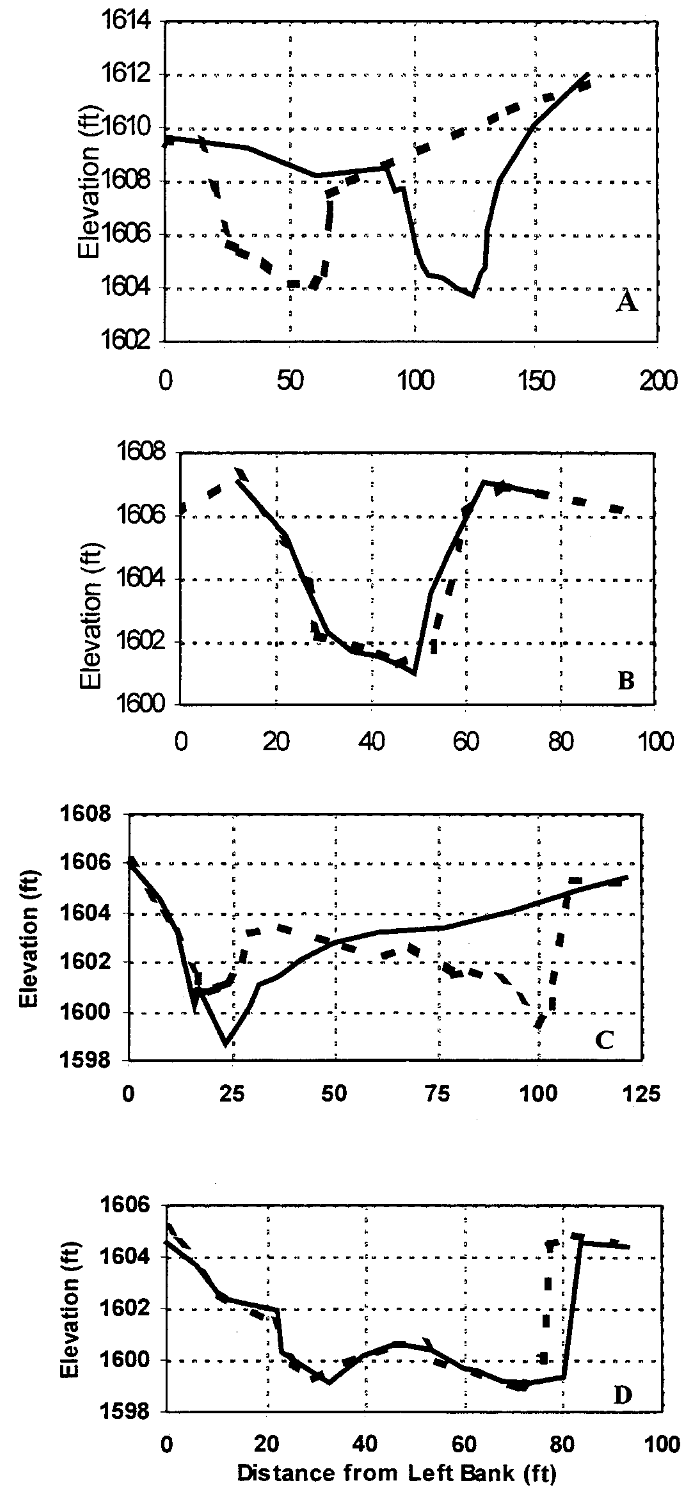

Figure 1. Left Fork Soque River Cross-Sections (Broken Line = Pre-Construction, April-June 1998, Solid Line = Post-Construction, Dec. 2000; A = LFS10, B = LFS50, C = LFS60, D = LFS70; Vertical Axis Exaggerated)

Particles smaller than 2 mm were either placed in a <2 mm or "silt/clay" size class, or were differentiated into specific sand-sized fractions (e.g., 0.125, 0.250, 0.500, 1.00 mm) with the aid of a waterproof "sand-gauge" (© 1984 by W.F. McCollough). Wherever possible, representative habitats (riffles, pools, runs) were sampled from bank to bank at bankfull stage along the study reach. An effort was made to sample at least 100 particles at each established stream cross-section.

Bevenger and King (1995) developed a zig-zag pebble count procedure that crosses all habitat features within a stream channel. Various federal and state partners are still evaluating the utility of this alternative method. The zig-zag method was not used in this study due to its potential lack of reproducibility, since it incorporates stones from many populations and because an inadequate number of representative streambed particles may be sampled from any given population.

The Wentworth size categories collected for this study adapted from Wolman (1954) were: silt/clay, < 0.0625 mm; sand, 0.0625 – 2.0 mm; gravel, 2.0 – 64 mm; cobble, 64 – 256 mm; boulder, 256 – 4096 mm; bedrock >4096 mm.

Cumulative "% finer than" plots of the river bed material collected in October 1998 and December 2000 at four permanent cross-sections yielded the following median particle size diameters or, D_{50} (mm):

	1998	2000
LFS 10, 1+94	30	15
LFS 50, 7+09	33	32
LFS 60, 9+60	23	20
LFS 70, 12+39	24	6

Following restoration, the D_{50} shifted at station LFS 10 from coarse gravel to medium gravel. At stations LFS 50 and LFS 60, the D_{50} remained as coarse gravel. At station LFS 70, the D_{50} shifted from coarse gravel to fine gravel.

Channel Bank Erosion Rates

Bank erosion rates were measured using bank pins, which were four-foot lengths of half-inch diameter rebar driven horizontally into the stream banks. As bank erosion occurred, the rebar was exposed. The amount of pin exposure, measured in feet, represented the amount of bank erosion. Seven stations within the restored reach were located between 1+52 and 11+00. Stations downstream of the restored reach that received no restoration work were at locations 12+69 and 14+42.

Prior to the restoration, in the meander experiencing the most bank erosion (location LFS 60, 9+60), thirty-two tons (2 dump truck loads) were lost between December 5, 1997 and April 20, 1998. Although historic erosion was evidenced by bare soil banks at location LFS 70 (12+39) before restoration within the impaired reach, bank pins placed at this location indicated minimal measurable erosion during this same four month period.

Bank pins installed in January and February 1999, were used to measure bank erosion approximately two years post-restoration, on December 13, 2000. The results indicated that no bank erosion occurred in the restored channel. However, at one station downstream of the project, where no restoration was implemented, bank erosion has continued. At station 12+69, 1.5 feet of erosion occurred equaling 7.6 tons. Downstream station 14+42 showed no signs of erosion.

Riparian Vegetation

Immediately following channel reconstruction, standard erosion control vegetative techniques were employed. Winter rye and fescue grasses, along with willow stakes (cuttings) and biomat were installed to provide short-term bank stabilization. Over the course of the next two dormant seasons (Winters 1999 and 2000) community volunteers helped plant approximately 700 native shrubs and trees including river birch, sycamore, red maple and others. Trees have been planted to create up to a 50-foot buffer along the banks. Despite two years of drought, the native trees have close to a 100% survival rate. Recruitment of one native tree species, tag alder, has been observed throughout the banks of the new channel. Native shrubs (such as silky dogwood, ninebark and sweet shrub) were less successful. This result could be due to the drought or to competition with the quick-growing black willow and fescue. Willow heights along the banks have already reached up to 12 feet, providing valuable shade for the river. Although there are beaver in the area, no herbivory on newly planted trees has been observed (some trees were initially protected with drainpipe collars).

DISCUSSION AND CONCLUSIONS

W/D ratios play an important part in a stream's bedload transport energy. Streams with insufficient transport energy aggrade their channel because bedload cannot be transported downstream. Conversely, streams with excess transport energy degrade as they remove their channel bed (and banks) through erosion. Over-widened streams, or streams with highW/D ratios, have less overall bedload transport capacity and are susceptible to channel aggradation (channel filling). On the other hand, channels that are narrow and deep (low W/D ratios) have high bedload transport capacity.

It was anticipated that the restored section of the constructed channel would maintain low width-depth ratios and bed material sizes would increase. Conversely, in the unrestored sections downstream, the opposite result was expected. Two years after restoration, low W/D ratios (17 to 21) were maintained as designed and constructed.

From empirical data these ratios are considered appropriate for a stable channel of this type. From Rosgen (1996), ratios should range from 12 to 20 in this type of flat stream valley. A reference stream reach used in designing the Soque restoration had an average W/D ratio of 21.8. Empirical data from Williams (1986) indicate an average W/D ratio for this type of stream to be 17.5. Visual observation on the restored section of the Soque indicates that point bars are building on the inside of meanders. With vegetation colonizing and stabilizing the point bars, the W/D ratios appear to be declining. Magilligan and McDowel (1997) found in the literature and in their own data that as riparian vegetation is allowed to return to over-widened (grazed) channels, W/D ratios decline.

River-bed particle sizes have not yet increased to exceed the sizes measured prior to restoration. The shift from coarse gravel to medium gravel at LFS 10 could be due, in part, to the unconsolidated silt, clay and fine sands that remained from a shallow pond that existed at this location before construction of this meander. At LFS 70, where accelerated bank erosion has recently been documented, there has been a shift from coarse gravel to fine gravel. Possible reasons for the lack of the recruitment of larger river-bed material into the restored stream segment are: 1) Some fine-grained material was introduced to the channel during channel reconstruction. With two years of lower than normal rainfall, sufficient transport energy may not have been produced to move the smaller particles that remain from construction downstream. 2) There are little data on monitored restoration projects to determine at what rate the bed material shifts to larger size-classes. It may take years for the size-classes of bed material to increase. 3) Land use activities such as development and in-stream cattle watering upstream of the project may be introducing fine particles that are being deposited in the channel of the restored reach.

Downstream of the restored reach the channel continues to be unstable with increasing width-depth ratios and decreasing river-bed particle size distributions. Due to eroding banks, the unrestored reach continues to be a source of siltation to downstream sections of the river. Since access to cattle has been stopped and riparian vegetation is being allowed to return in that section, it is expected that the unrestored reach will also eventually begin to recover. Magilligan and McDowel (1997) found, consistent with other studies, that channel narrowing (and W/D ratio reduction) is one of the most consistent and widespread adjustments to removing channel disturbance from grazing pressures. This narrowing was partly due to near-bank sediment deposition created by roughness and soil stability from the recovery of riparian vegetation. Recovery of this downstream unrestored segment will, however, be at a much slower rate than the restored segment.

Future monitoring will be necessary to assess the long-term success of this project. Although the stability of the restored channel has been "tested" by several bankfull storm events, rainfall levels have thus far been below normal. There have yet to be major floods well above bankfull to test the ability of the channel to remain stable.

Results of a benthic invertebrate inventory were not available at the time of this printing, but qualitative observations during that study revealed abundant macroinvertebrates within the restored reach. Since restoration, the channel has been a successful trout fishery. One week after restoration, trout were caught from pools formed by rock vanes. Sightings of trout in excess of fifteen inches are common.

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