EVALUATING STREAM RESTORATION TECHNIQUES IN THE MITCHELL WATERSHED

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Abstract. A stream restoration initiative was implemented in the Mitchell River Watershed in the mid 1990's. The Mitchell River is located in the Piedmont of North Carolina with its headwaters originating along the Blue Ridge escarpment. The watershed scale effort is led by the Natural Resources Conservation Service and a watershed coalition comprised of state an local agencies, private consultants, private industry, non profits, and land owners.

The number one water quality impairment to the Mitchell River is sediment pollution, primarily from streambank erosion along the South Fork Mitchell and Snow Creek, two major tributaries to the Mitchell. Stream restoration using natural channel design techniques has been the primary method used to decrease sediment inputs into the Mitchell River. The first project was implemented in 1996 and work continues today. Currently, over 30,000 feet of stream channels has been restored through the implementation of 14 projects.

In 2002, the NC Clean Water Management Trust Fund provided a grant to the Surry Soil and Water Conservation District to study the effectiveness of using natural channel design techniques to improve water quality in the Mitchell River. Five projects were selected for the study ranging from small step pool channels with gravel/cobble beds to low gradient meandering channels with sand/small gravel beds. During the four year study period the project sites have experienced multiple bankfull events, including two hurricanes.

Results show that the study sites remain dynamically stable with the majority of cross sections trending towards narrower bankfull widths and increased mean depths. Maximum riffle depths are generally unchanged, while maximum pool depths have increased. The longitudinal profile for the high gradient step pool channel showed an increase in the number of pools present, as well as a decrease in pool to pool spacing. Stream substrate data have shown a trend toward coarsening through reductions in fine sediments. Floodplain deposition was observed on all sites, particularly after the hurricanes on the sites with high sediment supply from upstream sources.

INTRODUCTION

In 2002, the Surry Soil and Water Conservation District (SWCD) was awarded a grant from the North Carolina Clean Water Management Trust Fund (CWMTF) to evaluate the success of the District's Stream Restoration Program towards meeting restoration objectives. These restoration goals included: reductions in stream bank erosion, improvement in sediment transport, improvement in aquatic habitat, and improvement in riparian function. Geomorphic surveys, riparian vegetation, benthic macroinvertebrate monitoring, and fish surveys have been conducted for SWCD since 2003 to evaluate restoration objectives. The study is also being complimented by the continuation of a ten year study of Total Suspended Solids (TSS) throughout the Mitchell River Watershed. This paper will focus only on the geomorphic evaluation component of the monitoring program.

Five stream restoration sites were selected for geomorphic monitoring in the Mitchell River Watershed. The five restoration sites represent a range of stream types (B4 and C4), slopes (0.034 to 0.0045), and drainage areas (0.45 square miles to 17.5 square miles). The restoration sites were constructed between July 2001 and October 2002. Geomorphic monitoring began February of 2003 and has continued annually for four years, with one year remaining.

METHODOLOGY

Year 1 monitoring of the five sites began in February of 2003. Year 1 monitoring was used to establish the baseline for subsequent years of geomorphic assessments. Three of the five sites were completed in the fall of 2002; two sites were over a year old and had already experienced bankfull flow events.

The geomorphic survey consisted of a longitudinal profile that measured thalweg and water surface elevations along each channel feature or bedform. All bedforms and structures were surveyed along the longitudinal profile. Permanent cross section pins were installed at each site using rebar and concrete. Cross sections were established at riffles and pools, and at some sites, runs and glides were also collected if they were present.

Bed material (pavement and subpavement) samples were taken at two riffle cross section locations per reach (Rosgen, 2002). Pavement analysis was performed using a 100 count zig-zag pattern within the wetted perimeter of the riffle length. Subpavement was collected using a 5-gallon plastic bottomless bucket placed over a representative area of the pavement substrate near the head of the riffle, and between thalweg and edge of channel. Pavement particles were removed from the bucket and discarded. Subpavement particles were collected to a depth equal to twice the intermediate length of the largest pavement particle taken from the sampling bucket. A reach wide zig-zag pebble count method (Bevenger et al., 1995; Bunte and Abt, 2001) was used for monitoring annual changes in the grain size distribution of the bed material. Photo points were established using land marks as points of reference.

Geomorphic data were collected in March of years 2004, 2005, and 2006. All surveys were completed using a total station, except for the 2003 monitoring, which used a survey level, rod and tape. The switch was made to a total station to improve survey accuracy. Data were collected in the same format as Year 1 (2003) with the exception that longitudinal profiles were surveyed every other year.

Documentation of bankfull events was accomplished by correlating water surface stage with the height of total suspended solid (TSS) sampling bottles at locations near each project site. TSS samples are collected every two weeks and immediately after large flood events. Wrack lines were also observed and noted on project sites.

RESULTS

Each site has experienced at least four documented bankfull events since construction. Two events were the result of back to back hurricanes (Frances and Ivan) in the fall of 2004. Design maximum riffle depths were used at each riffle cross section to re-establish the bankfull stage throughout the reach. This was done where the bankfull benches and floodplains received considerable deposition after large floods, creating small natural levees. Floodplain deposition was observed on all sites, particularly on the sites with high sediment supplies from the upstream watershed. One project site experienced over two feet of point bar deposition. Overall, however, the riffle features maintained their cross sectional geometry and longitudinal slope and the pools remained flat and deep. In other words, even though there was significant deposition on the floodplain, sediment transport competency and capacity were maintained in the channel. Furthermore, sand deposition on the point bars has caused pool widths to decrease. This narrowing of the pools is a positive change in terms of channel evolution because the pools were designed wider than reference reach pool widths. The pool widths are now approaching the reference reach width.

Many pools experienced additional bed scour, increasing their depth from the post construction condition. The longitudinal profile for the high gradient B4 stream type showed an increase in the number of pools present in 2004 as compared to what was measured a month after the restoration was completed. This increase in the number of pools led to a decrease in pool to pool spacing, especially the maximum values, as shown in Table 1. These new pools formed from large cobble clusters and small woody debris jam that formed between the constructed step-pools.

Table 1. Mickey Pool to Pool Spacing/Bankfull Width (2003-2006)

Year	**Minimum**	**Maximum**	**Mean**
2002(pre-restoration)	1.1	41.4	20.5
2003	0.5	6.1	2.5
2005	0.5	5.0	1.9
2006	0.4	3.9	1.8

Note: The pre-restoration condition included only seven pools out of 3,300 feet of channel.

Bed material data have demonstrated reductions in fine grained sediments and increases in gravel and cobble. This is likely due to the reduction in sediment supply from streambank erosion. Data collected in 2003 contained high amounts of sands for all of the reaches compared to subsequent years, with the exception of 2005. The bed material data collected in Winter 2005 showed a “fining” of the bed, presumably as a result of the two fall 2004 hurricanes. In 2006, after a year of “normal” rain events and one bankfull event, the bed material coarsened at all sites. An example of the coarsening trend, with the 2005 “fining”, is shown in Table 2 below for the Kraft stream reach

Table 2. Kraft bed material grain size distribution results (2003-2006)

	2002 (pre-restoration)	**2003**	**2004**	**2005**	**2006**
d16 (mm)	0.9	2.5	2.0	0.6	7.2
d50 (mm)	10.0	22.4	28.0	18.0	25.5
d84 (mm)	41.7	62.8	59.9	71.7	61.0

CONCLUSIONS

The stream reaches appear to be meeting the project goals. Results from the geomorphic analysis show that the streams are in a dynamic equilibrium. Cross sections are trending towards narrower streams widths and increased mean depths as the constructed channels evolve into more mature channels with vegetated banks and floodplains. Bedform diversity has increased in each of the five sites through the presence of riffle-pool sequences, which were not evident prior to restoration. The increase in the number of pools and decrease in pool to pool spacing seen in the B4 stream is an example of increased bedform diversity. The coarsening substrates should allow for improved aquatic habitat. Data show that the channels are capable of responding to post-flood events by transporting the fine sediments through the project reach.

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