Case Study 9

Little Blue River, Washington County, Kansas

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Cover photo: Treated section of the Little Blue River, Washington County, Kansas

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

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Introduction

Sediment is the most common pollutant in streams throughout the United States (U.S. Environmental Protection Agency (EPA) 1998). Streambank erosion is a major source of stream sediment (Simon 2003). As the EPA continues to focus on Total Maximum Daily Loads (TMDL), stream sediment reduction via streambank stabilization and erosion control methods will become a major financial commitment for states trying to comply with sediment standards. A cost-effective solution to streambank erosion must be developed to resolve this water quality problem and restore America's degraded stream corridors to a healthy condition.

The Little Blue River Stream Stabilization and Riparian Corridor Restoration Project is the first such attempt in Kansas to remedy large-scale streambank erosion with limited funds. Other project goals were to:

- reduce excess stream sediment
- improve stream channel dimension, pattern, and profile
- improve aquatic habitat
- establish a riparian ecosystem
- improve terrestrial habitat
- improve water quality
- reduce nutrients and chemical pollutants

The Little Blue River flows through the eastern portion of Washington County, Kansas, and has a drainage basin of approximately 9,065 square kilometers (3,500 mi^2). In late 1999, three landowners along the river contacted the Washington County Conservation District and the District Conservationist with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) regarding severe streambank erosion on their properties. The district conservationist requested assistance from the Kansas State Conservation Commission (SCC).

During their preliminary site visits, the SCC staff determined that several stream reaches were severely overwidened by excessive bank erosion, and the river had become bed-load driven. Measurements of aerial photographs show a total cropland loss of 149.3 hectares (369 acres) along 12.9 kilometers (8.0 mi) of river between 1977 and 2001. This resulted in a dry weight sediment input of about 11,397,100 metric tons (12,565,300 tons), or approximately 502,600 semi truck loads. Soil analysis showed that nutrient content of the eroded streambank soils equaled 41,845 kilograms (92,270 lb) of nitrate (NO_3), 380,620 kilograms (839,270 lb) of phosphorous (P), and 3,156,400 kilograms (6,959,900 lb) of potassium (K).

Bendway weirs were chosen as the primary structure for stabilization because of their ability to help reduce width/depth ratios, reduce water velocities in the near bank region, induce sediment deposition, and maintain cost effectiveness. Additional project goals included reestablishing a riparian corridor and improving aquatic habitat. In early 2000, the SCC, Kansas Department of Health and Environment (KDHE), and NRCS staff began conducting total station surveys of problem sites.

Initial project surveys, maps, and designs were developed by the SCC staff and reviewed by David Derrick, U.S. Army Corps of Engineers (USACE), Waterways Experiment Station in Vicksburg, Mississippi. The project currently involves 29 project sites on 12.9 kilometers (8.0 mi) of the river. Project construction began in November 2001, and was completed in April 2004. This project stabilized 12.9 kilometers (8.0 mi) of eroding streambanks, established 44.5 hectares (110 acres) of riparian habitat, planted more than 70,000 trees and shrubs, and will reduce 495,520 metric tons (546,320 tons) of sediment to the river annually.

The Little Blue River

The Little Blue River flows through the eastern portion of rural Washington County, Kansas, and has a drainage basin of approximately 9,065 square kilometers (3,500 mi^2). More than half of the river basin is in south-central Nebraska. The bed material is predominantly sand and gravel (.062–64 mm in diameter) (fig. CS9–1).

Figure CS9–1 Little Blue River streambed

The bank material composition varies from silts and clays (<0.062 mm in diameter) to sand (0.062–2 mm in diameter). The Little Blue River has not been impounded by large reservoirs and does not contain areas of major levee construction. The river is slightly entrenched. Natural riparian vegetation includes three species of willow (*Salix* spp.), eastern cottonwood (*Populus deltoides* Marsh.), silver maple (*Acer saccharinum* L.), box elder (*Acer negundo* L.), elm (*Ulmus* spp.), burr oak (*Quercus macrocarpa* Michx.), American linden (*Tilia americana* L.), black walnut (*Juglans nigra* L.), hackberry (*Cetlis occidentalis* L.), red mulberry (*Morus rubra* L.), and green ash (*Fraxinus pennsylvanica* Marsh.).

Riparian understory vegetation is dominated by wild ryes (*Elymus* spp.), poison ivy (*Rhus radicans* L.), reed canarygrass (*Phalaris arundinacea* L.), buckbrush (*Symphoricarpos orbiculatus* Moench), and wild gooseberry (*Ribes missouriense* Nutt.).

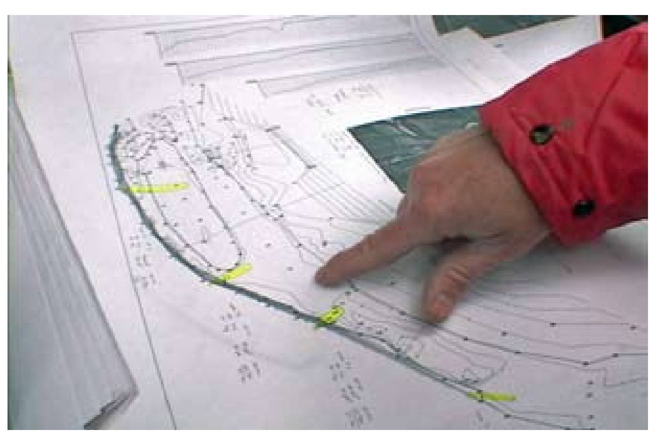
Most fields along the stream were under cultivation within a few meters of the streambank edge each year (fig. CS9–2). Among the stabilized areas, only site 3 had any permanent riparian vegetation.

Figure CS9–2 Site 22, prior to construction

Survey and design

Each site was surveyed by the SCC and NRCS staff with a total station survey instrument. Data points were downloaded into computers, and topographic maps were produced for each site. The maps were then used for measurements and project stabilization design (fig. CS9–3).

Figure CS9–3 Typical project map and design



Initial site assessments recognized that the Little Blue River had severe bed load problems. Numerous sites contained mid bars, and the stream was extremely shallow. The areas surveyed with water depths greater than 0.5 to 0.75 meter (18–25 in) were upstream of a few isolated, large, woody material piles. The SCC and KDHE staffs designed all projects, choosing bendway weirs for the primary stabilization structure because of the stream's high width/depth ratio (fig. CS9–4).

Bendway weirs redirect water flowing over them, which slows water velocities along the near bank region (Derrick 2001). A weir also moves the thalweg away from the bank to the end of the weir. The design height of all bendway weirs was a third to a half meter (1–1.5 ft) above the water surface at low flow. David Derrick, USACE, reviewed the initial 20 project designs.

The design of redirective techniques, such as bendway weirs, is provided in NEH654 TS14H. Soil bioengineering practices are addressed in NEH654 TS14I.

On sites 8 and 21, the radius of curvature was very low. To keep from pushing the thalweg a great distance from the bank and keep from radically redirecting streamflow, rock vanes were chosen as the stabilization method for these sites (fig. CS9–5).

Project funding

The SCC's Riparian and Wetland Protection Program (RWPP) was originally targeted as the main source of project funding. Increasing numbers of landowners enrolling in the project rapidly grew beyond the RWPP's financial capabilities. Fortunately, KDHE was able to provide $265,000 of EPA Clean Water Act, Section 319 funds to the project. Additional financing came from the SCC's Nonpoint Source Pollution Control Program, the Kansas Governor's Water Quality Initiative, the Kansas Alliance for Wetlands and Streams (KAWS), and the Kansas Chapter of the National Wild Turkey Federation. Combining Federal and state funds provided 100 percent funding for the stabilization portion of the projects. This project required participating landowners to enroll a 30.5-meter-wide (100 ft) strip into the USDA's Continuous Conservation Reserve Program (CCRP). Costs associated with planting and maintenance of the CCRP strip were not included in the construction cost. Tree planting costs for the riparian area between the CCRP strip and the edge of water were included in the construction cost or shared with the Kansas Forest Service's (KFS) Forest Land Enhancement Program (FLEP) and RWPP. Total construction costs for the Little Blue River Stabilization Project and repairs are estimated at $550,000. This equals $42.63 per meter of streambank ($13.02/lf). This figure does not include any cost associated with the CCRP plantings.

Structure installation and revegetation

On early projects, weirs were constructed by excavating ramps into the streambanks, dumping rock on the ramp, and then pushing the rock into the stream with bulldozers (fig. CS9–6).

After the first few projects, rock was dumped directly over the streambank and then moved into place with an excavator (fig. CS9–7).

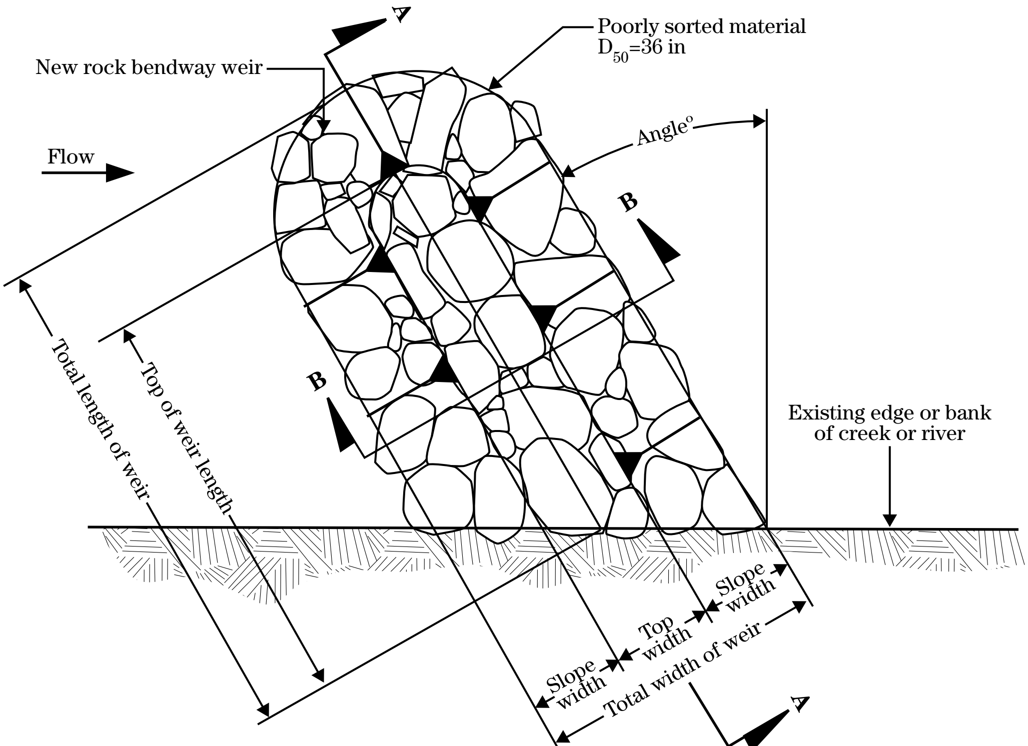
Following construction of the bendway weirs, the vertical banks were reshaped to a 3H:1V slope (fig. CS9–8). On all sites using bendway weirs for stabilization, the near vertical banks were shaped by pushing them into the river channel (cut and fill method). This accomplished three things: it eliminated the need to key the weirs into the bank, reduced construction costs by reducing required equipment time, and reduced the amount of valuable cropland required for the slope.

After reshaping the vertical banks, winter wheat or oats were sown on the slopes and mulched with native prairie hay. Projects constructed in phases 2 and 3 were sown to wheat or oats but not mulched (fig. CS9–9).

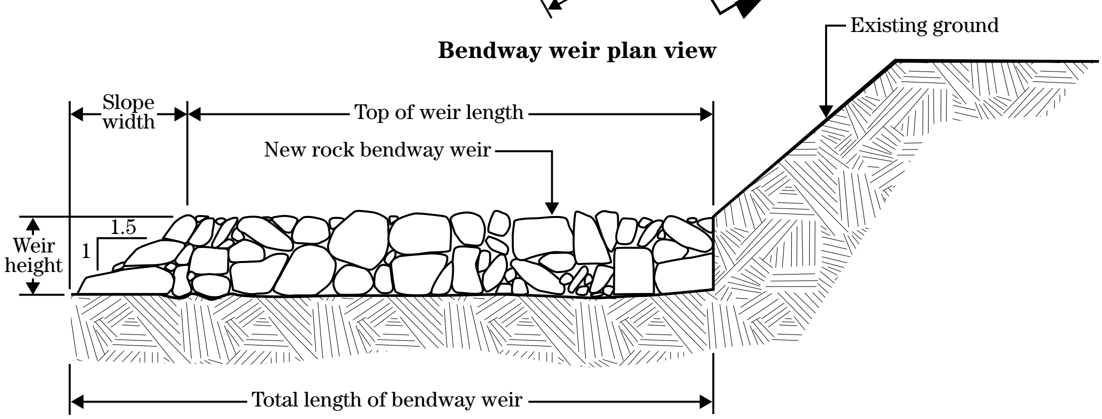
The riparian area between the CCRP strip and edge of water was planted with live willow stakes and bareroot cottonwood seedlings. Live willow stakes were planted on 1.2- by 1.2-meter (4 by 4 ft) spacing. Cottonwood seedlings were planted on 1.8- by 1.8-meter (6 by 6 ft) spacing. In the CCRP strip, trees were planted on 2.4- by 2.4-meter (8 by 8 ft) spacing or 3.0- by 3.7-meter (10 by 12 ft) spacing. All shrubs were planted on 1.8- by 1.8-meter (6 by 6 ft) spacing. Planting a 7.62-meter-wide (25 ft) strip of native grasses and forbs between the shrubs and the cultivated crop field completed the CCRP (fig. CS9–10).

All trees on the slope were planted by hand. Trees on the flat portion of the buffer were planted with farm tractors and tree planters (fig. CS9–11).

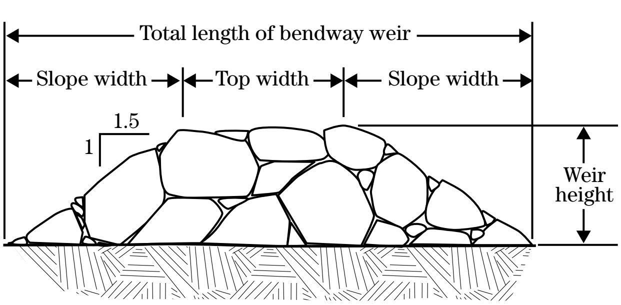
Figure CS9–4 Bendway weir detail



Bendway weir plan view



Bendway weir cross section A–A



Bendway weir cross section B–B

Figure CS9–5 Rock vane design detail

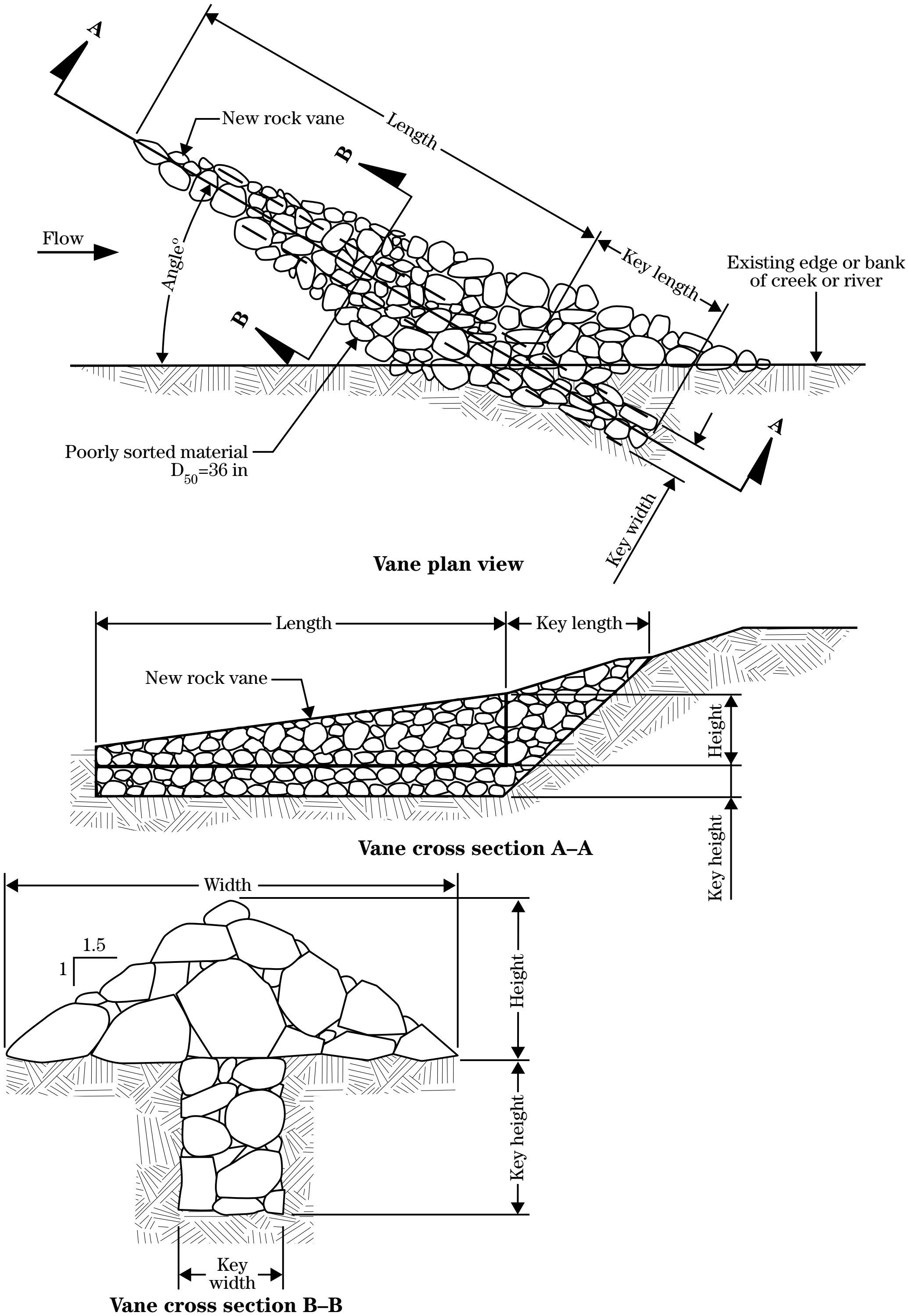


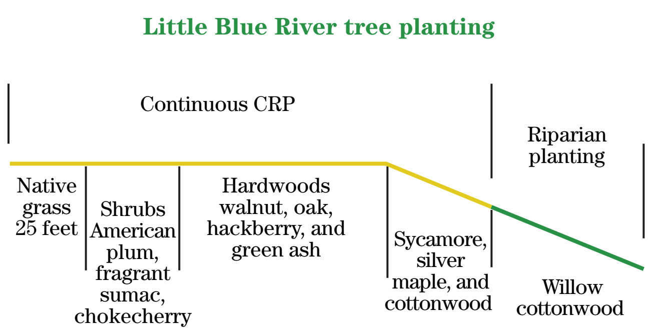
Figure CS9–6 Building weir on site 28

Figure CS9–7 Weir construction on site 22

Figure CS9–8 Bank shaping with bulldozer

Figure CS9–9 Site 1, 04/02/03: Oats beginning to grow

Figure CS9–10 Planting diagram



Agency personnel with NRCS, SCC, and the KFS measured and flagged the tree rows (fig. CS9–12).

Prior to planting, willows were soaked for a minimum of 10 days (fig. CS9–13).

Research has shown that the survival rate for live willow stakes doubles when the stakes are soaked for this amount of time prior to planting (Schaff, Pezeshki, and Shields 2002). Student members of area Future Farmers of America chapters harvested all willow stakes used in the 2002 planting season. Live willow stakes for the 2003 planting season were purchased from the KFS.

In the spring of 2002, landowners, agency personnel, and conservation district personnel planted the trees on 12 sites with volunteer help from several Boy Scouts of America troops. In the 2003 planting season, landowners and agency personnel planted all trees on 12 additional sites. Landowners planted native grasses with a no-till drill provided by the Washington County Conservation District. More than 70,000 trees and shrubs were planted during the springs of 2002, 2003, and 2004.

From drought to flood

The project area experienced a severe drought during the late spring and summer of 2002. Rainfall throughout the project area totaled less than 7 inches during the summer. Because of the drought, trees were replanted on a few sites dominated by sandy soils and south-facing slopes in April 2003.

Projects completed in early 2002 were inundated with two flows that approached the bankfull magnitude in June and September 2002. Another bankfull flow event occurred in early May 2003. Minimal erosion occurred at the stabilized sites during these flows. Slight erosion from the moderate flows required the addition of one structure on two sites. In late June 2003, severe weather and torrential rainfall in south-central Nebraska resulted in substantial flooding along the Little Blue River (fig. CS9–14).

The U.S. Geological Survey (USGS) gage logged the flood flows, which peaked at 1,132.8 cubic meters per

Figure CS9–11 Tree planting on site 11

Figure CS9–12 Measuring and flagging tree rows

Figure CS9–13 Willow cuttings soaking in ponds

second (40,000 ft^3/s) at the Hollenberg, Kansas, stream gage. Downstream, at the USGS gage near Barnes, Kansas, flows peaked at 906.3 cubic meters per second (32,000 ft^3/s). No damage occurred at 20 of the 24 completed sites (fig. CS9–15). Four sites did incur slight damage that was limited to a small portion of each. The problems all appeared on the lower third of the project sites and were corrected in the fall and winter of 2003 by installing Longitudinal Peaked Stone-Toe Protection or additional rock on the weirs.

Sediment deposition occurred on several sites. This was evident between the weirs and on the banks (fig. CS9–16).

Figure CS9–14 Site 1, June 24, 2003, prior to peak flood

Figure CS9–15 Site 1, July 2, 2003, following 1,133 cubic meter (40,000 ft^3/s) flow

Figure CS9–16 Sediment deposition

Research

Various types of research projects were conducted at project sites. One of the first was installation of bank erosion pins. In April 2001, 1.2-meter-long (4 ft) and 1.8-meter-long (6 ft) bank (erosion monitoring) pins were installed at six sites (fig. CS9–17). At another site, severe erosion warranted placing two benchmarks 8.5 meters (28 ft) away from the bank edge.

Five weeks later, an inspection trip discovered all pins lost at the six sites due to streambank erosion. At the other site, only 2.4 meters (8 ft) of the original 8.5 meters (28.3 ft) remained between the bank and one remaining benchmark.

Soil samples were also taken at each site. On most sites, one sample was taken for every meter of bank height (fig. CS9–18).

The Kansas State University (KSU) soils laboratory analyzed all soil samples. The total nutrient input associated with the bank erosion was calculated using the resulting data and soil loss calculations.

Dr. Charles Barden, KSU Research and Extension forester, assisted with tree planting design and also conducted research on various types of tree shelters (fig. CS9–19).

Figure CS9–18 Taking soil samples, site 6

Figure CS9–17 Installing bank erosion pins

Figure CS9–19 Tree shelter test on site 11

Fisheries biologists with Kansas Department of Wildlife and Parks (KDWP) conducted fish sampling sessions at several sites prior to project construction. These sites will be resampled in subsequent sessions to determine any changes in fisheries species composition and biomass (fig. CS9–20).

Similar studies in Mississippi have shown a greater increase in total biomass and species diversity at sites with rock weir type structures than at sites with other stabilization methods (Shields, Knight, and Cooper 2000).

In October 2001, researchers with the USDA Agricultural Research Station (ARS), National Sediment Laboratory in Oxford, Mississippi, conducted research on the root strength and density of various species of willow and eastern cottonwood (fig. CS9–21).

The ARS National Sedimentation Laboratory also conducted soil tension strength analysis on limited sites and is now investigating possible causes for the severe bank instability throughout the river basin.

Three sites were chosen for comparison studies of riparian planting methods. Two sites will look at riparian area natural regeneration. The other will compare direct seeding and nut plantings to sites planted with bare-root tree seedlings.

The KSU Department of Agricultural Economics was enlisted to conduct a socioeconomic study of the project. The results of this study showed the average landowner gained an additional $810 annually from participating in the project. Gains were realized by the value of cropland acres not lost to streambank erosion, income from the acres not lost, and income from the continuous CRP payments. Furthermore, the assessment showed a positive net present value to the landowner for establishing a riparian buffer in CRP and a negative net present value if removing an existing riparian buffer.

Figure CS9–20 Fish sampling on site 2

Figure CS9–21 Root strength testing

Conclusion

The Little Blue River stabilization and riparian corridor establishment project has proven that large-scale streambank stabilization can be constructed in a cost-effective, river-friendly manner. Bendway weirs on sand-bed streams can diversify fisheries habitat and assist in restoring a stable fluvial geomorphology to streams. A cost comparison between bendway weirs and riprap was conducted for site 28. The cost estimate for riprap at this site was $165,000. The actual construction cost to install six bendway weirs, reshape the 1,200 linear feet of streambank, and plant trees was $17,789. This project not only reduced the amount of sediment entering the stream due to bank erosion but also removed excess sediment from the stream during high-flow events as evidenced by sediment deposition in several locations.

The Little Blue River Stabilization and Riparian Corridor Establishment Project has reduced loss of valuable cropland to bank erosion, extended downstream reservoir life, increased wildlife habitat, increased fisheries habitat diversity, and improved water quality. Figure CS9–22 shows the sequence changes of site 1.

Figure CS9–22 Photo sequence of site 1

December 2001

January 2002

April 2002

July 2002

Figure CS9–22 Photo sequence of site 1—Continued

October 2002

June 26, 2003

July 2, 2003

December 5, 2003

March 17, 2004