WALNUT BASIN STREAMBANK EROSION ASSESSMENT

ArcGIS® Comparison Study: 1991 vs. 2010 Aerial Photography

DRAFT: June 2012

Photo taken by: Katie Hermes, KWO; Walnut River, Cowley County

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Executive Summary

Federal reservoirs are a vital source of water supply in Kansas and provide water for approximately two-thirds of Kansas' citizens. The ability of a reservoir to store water over time starts to diminish as the capacity is reduced through sediment accumulation. In some cases, reservoirs are filling with sediment faster than anticipated. Whether sediment is filling the reservoir on or ahead of schedule, it is beneficial to take efforts to reduce sedimentation to extend the life of the reservoir. The State of Kansas currently owns storage in thirteen federal reservoirs that are operated by the U.S. Army Corps of Engineers (USACE).

The Kansas Water Authority has established a *Reservoir Sustainability Initiative* that seeks to integrate all aspects of reservoir input, operations, and outputs into an effective plan for each reservoir to ensure water supply storage availability long into the future. Reduction of sediment input is an important part of this initiative.

The Walnut Basin Assessment, an ArcGIS® Comparison Study, was initiated to partially implement the *Reservoir Sustainability Initiative*. This assessment identifies areas of streambank erosion to provide a better understanding of the Walnut basin for streambank restoration purposes and to increase understanding of streambank erosion to reduce excessive sedimentation in reservoirs across Kansas. The comparison study was designed to guide prioritization of streambank restoration by identifying reaches of streams where erosion is most severe in the Walnut basin, excluding the El Dorado Lake Watershed, which was completed by the Kansas Water Office (KWO) in a previous study (KWO, 2011).

The KWO 2012 assessment quantifies annual tons of sediment eroding from streambanks within the Walnut basin, over a 19 year period between 1991 and 2010 in southeastern Kansas. A total of 109 streambank erosion sites were identified, covering 97,535 feet of unstable streambank and transporting 324,759 tons of sediment downstream per year. It should be noted that the identified streambank erosion locations are only a portion of all streambank erosion occurrences in the basin. Streambank erosion sites were analyzed by stream reach. Based on an average stabilization cost of $71.50 per linear foot, as reported in the TWI *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*, conducting streambank stabilization practices on all 109 streambank erosion sites would cost approximately $23.2 million.

Information contained in this assessment can be used by KWO and interested parties to target streambank stabilization and riparian restoration efforts toward high priority stream reaches in the Walnut basin. Similar assessments are ongoing in selected watersheds above and below reservoirs throughout Kansas and are available on the KWO website at www.kwo.org, or may be made available upon request to agencies and interested parties for the benefit of streambank and riparian restoration projects.

Introduction

Streambank erosion is a natural process that contributes a large portion of annual sediment yield, but acceleration of this natural process can lead to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Many land use activities can affect and lead to accelerated bank erosion (EPA, 2008). In most Kansas watersheds, this natural process has been accelerated due to changes in land cover and the modification of stream channels to accommodate agricultural, urban and other land uses.

A naturally stable stream has the ability, over time, to transport the water and sediment of its watershed in such a manner that the stream maintains its dimension, pattern and profile without significant aggregation or degradation (Rosgen, 1997). Streams significantly impacted by land use changes in their watersheds or by modifications to streambeds and banks go through an evolutionary process to regain a more stable condition. This process generally involves a sequence of incision (downward erosion), widening and re-stabilizing of the stream. A large number of streams in Kansas are, in fact, incised (SCC, 1999).

Streambank erosion is often a symptom of a larger, more complex problem requiring solutions that may involve more than just stabilizing the actual streambank (EPA, 2008). It is important to analyze watershed conditions and understand the evolutionary tendencies of a stream when considering stream stabilization measures. Efforts to restore and re-stabilize streams should allow the stream to speed up the process of regaining natural stability along the evolutionary sequence (Rosgen, 1997). A watershed-based approach to developing stream stabilization plans can accommodate the comprehensive review and implementation.

Wetlands and riparian areas are vital components of proper watershed function that, when managed wisely in context of watershed systems, can moderate and reduce sediment input. Additional research in Kansas has found the effectiveness of forested riparian areas on bank stabilization and sediment trapping (Geyer, 2003; Brinson, 1981; Freeman, 1996; Huggins, 1994). Vegetative cover based on rooting characteristics can mitigate erosion by protecting banks from fluvial entrainment and collapse by providing internal bank strength. Riparian vegetative type is an important tool that provides indicators of erosion occurrence from land use practices. Forested riparian areas are superior to grassland in holding banks during high flows, when most sediment is transported. When riparian vegetation is changed from woody species to annual grasses, sub-surface internal strength is weakened, causing acceleration of mass wasting processes (extensive sedimentation due to sub-surface instability) (EPA, 2008). The primary threats to wetlands and forested riparian areas are agricultural production and suburban/urban development.

Reservoirs are a vital source of water supply, provide recreational opportunities, support diverse aquatic habitat, and provide flood protection throughout Kansas. Excessive sediment can alter the aesthetic qualities of reservoirs and affect their water quality and useful life as well (Christensen, 2000). Sediment deposition in reservoirs can be attributed to many factors, including precipitation, topography, contributing-drainage area of the watershed, and differing soil types. Decreases in reservoir storage capacity from sediment deposition can affect reservoir allocations used for flood control, drinking-water supplies, recreation and wildlife habitat. Land use has considerable effect on sediment loading in a reservoir. Intense agricultural use in the watershed, with limited or ineffective erosion prevention methods, can contribute large loads of sediment along with contaminants (such as phosphorus) to downstream reservoirs (Mau, 2001). Farming techniques that may help reduce soil erosion include "no-till" farming in which crops are cut and residue is not tilled into the land; planting cover crops such as clover and rye between crop rows; plowing in circular bands along the contours of the land to slow the flow of water and any topsoil it might carry down a slope and constructing step-like ridges, called terraces, by leveling sections of a hillside which reduces runoff by creating flatter terrain and shorter sections of slope.

In Kansas, monitoring the extent of sediment loss due to erosion is difficult, and current up-to-date inventories are needed. This assessment identifies areas with erosion concerns and estimates erosion losses to provide a better understanding of this watershed for mitigation purposes and for application of understanding to other watersheds across Kansas.

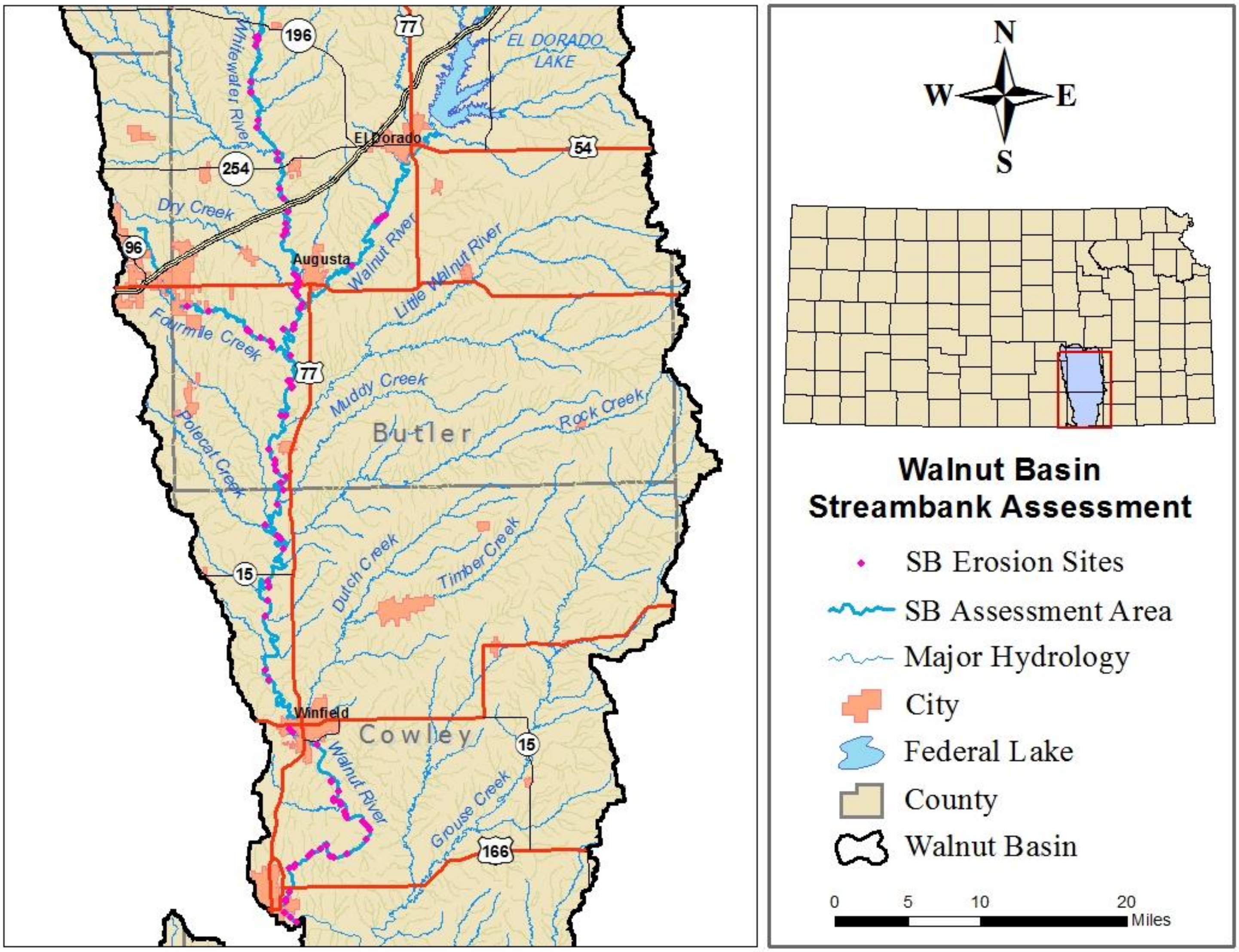
Study Area

The Walnut River basin covers approximately 2,380 square miles and encompasses most of Butler and Cowley counties and small portions of five other counties in south central Kansas (Figure 1). The Walnut River rises in the northeastern part of Butler County, joining the Arkansas River at Arkansas City in Cowley County, about 120 miles to the south, and just north of the Kansas-Oklahoma state line.

Other major streams in the basin are the Whitewater River, Timber Creek, Little Walnut River, West Branch Walnut River (all tributaries to the Walnut River), Fourmile Creek and Grouse Creek. Both the Walnut River and Grouse Creek join the Arkansas River just before it leaves the State of Kansas.

Photo taken by: Katie Hermes, KWO; Whitewater River, Butler County

Figure 1: Walnut Basin Assessment Area



Based on the 2006 Soil and Water Assessment Tool (SWAT) model performed by the USACE, land use in the Walnut basin consists of grasslands devoted to rangeland and cattle grazing that account for 72%, croplands account for 12%, managed pasture/hay land account for 11%, with the remainder distributed between other minor land uses. SWAT (Arnold et al., 1993) is a basin-scale model "…developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time" (Neitsch et al., 2001).

The Verdigris-Brewer-Norge Association is the predominant soil series along the main tributaries in the Walnut basin. These soils occupy 18% of Butler County and are classified as nearly level sloping, deep soils that have a silt loam or silty clay loam surface layer and a silt clay subsoil, on flood plains and terraces. Verdigris, Brewer, and Norge soils account for roughly 50%, 10%, and 10% of the soil association, respectively. Except for areas of Verdigris soils that are frequently flooded, most of the acreage of this association is cultivated (NRCS, 2010).

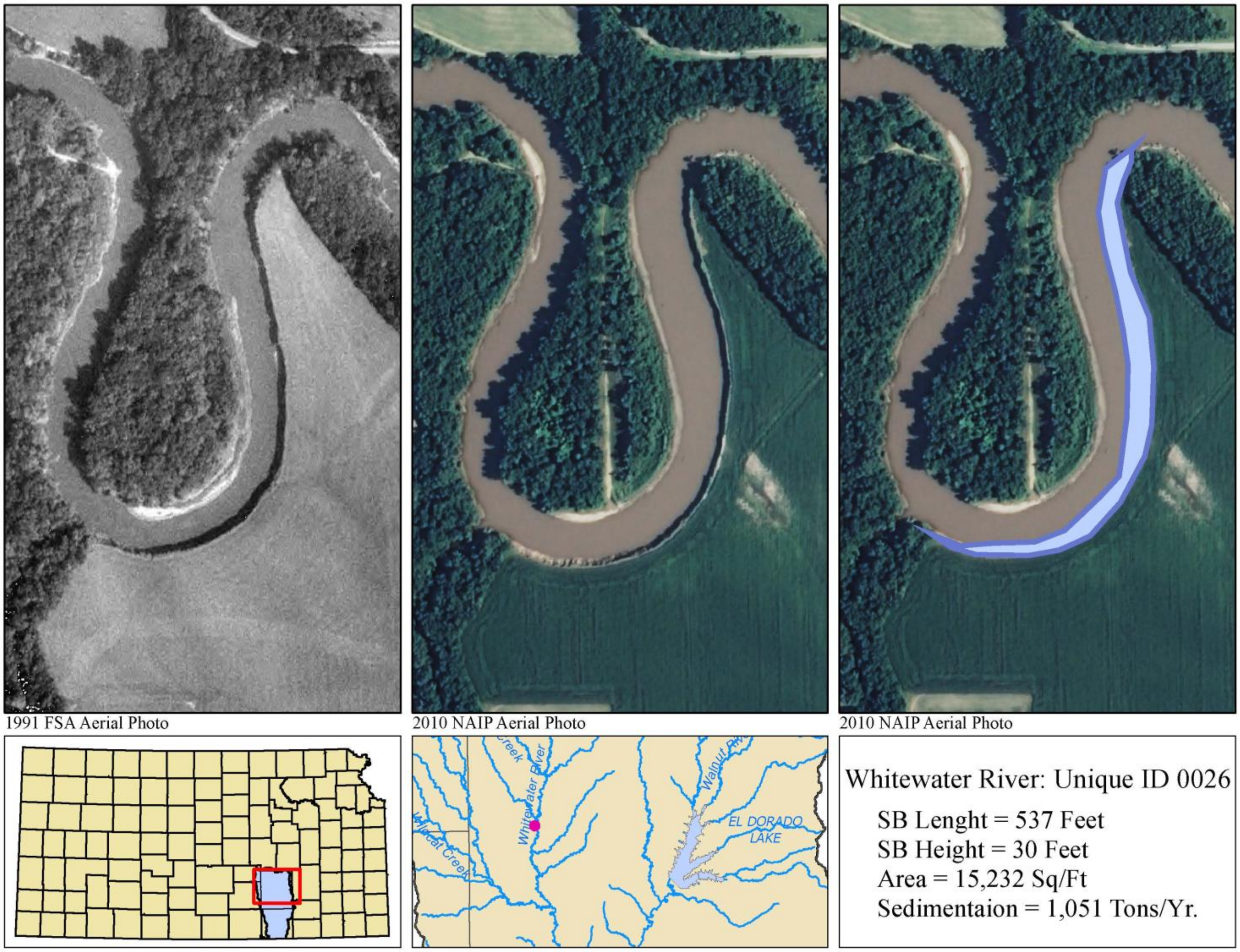
Data Collection Methodology

The Walnut basin, excluding the El Dorado Lake Watershed which was completed by KWO in a previous study (KWO, 2011), streambank erosion assessment was performed using ArcGIS® software. The purpose of the assessment was to identify locations of streambank instability to prioritize restoration needs and slow sedimentation rates to reservoirs through implementation of streambank stabilization projects. ArcMap®, an ArcGIS® geospatial processing program, was utilized to assess color aerial photography from 2010, provided by National Agriculture Imagery Program (NAIP), and compare it with 1991 black and white aerial photography, provided by the Farm Service Agency (FSA).

The streambank erosion assessment was performed by overlaying 2010 NAIP county aerial imagery onto 1991 FSA county aerial imagery (Figure 2). Using ArcMap® tools, only those areas having "aggressive movement" of the streambank between 1991 FSA and 2010 NAIP aerial photos were identified, at a 1:4,000 scale, as a site of streambank erosion. "Aggressive movement" represents an area of roughly 2,500 sq. feet or more of streambank movement based on changes from 1991 FSA and 2010 NAIP aerial photos. Streambank erosion sites were denoted by geographic polygons features "drawn" into the ArcGIS® software program through the ArcMap® editor tool. The polygon features were created by sketching vertices following the 2010 streambank and closing the sketch by following the 1991 streambank at a 1:4,000 scale. Data provided, based on the geographic polygon sites include: basin location, unique ID, stream name, and type of riparian vegetation.

Photo taken by: Katie Hermes, KWO; Walnut River, Butler County

Figure 2: 1991 FSA & 2010 NAIP Streambank Erosion Site, Unique ID 0026, Whitewater River



The streambank erosion assessment data also include approximations of tons of soil loss from the erosion site. This portion of the assessment was performed by utilizing the identified erosion site polygon features. Tons of soil loss was estimated by incorporating perimeter, area and streambank length of the polygons into a regression equation. Perimeter and area were calculated through the *field calculator* application within the ArcGIS® software. The streambank length of identified erosion sites was computed through the application of a regression equation formulated by the KWO. This equation was developed by taking data from the *Enhanced Riparian Area/Stream Channel Assessment for John Redmond Feasibility Study*, a report prepared by The Watershed Institute (TWI) and Gulf South Research Corporation (GSCR), and relating the erosion area (in sq. feet) and perimeter length of that erosion area (in feet) to the unstable stream bank length (in feet). The multiple regression formula of that fit (R-square = 0.999) is:

Estimated SB Length (Feet) = ([Area_SqFt]*-0.00067) + ([Perimtr_ft]*0.5089609)

The intercept of the model was forced to zero.

Tons of soil loss was estimated by first calculating the volume of sediment loss and then applying a bulk density estimate to that volume for the typical soil type of identified sites. The volume of sediment was found by multiplying bank height and surface area lost over the 19 year period between the 1991 and 2010 aerial photos and soil bulk density. This calculated volume is then divided by the 19 year period, to get the average rate of soil loss in mass/year:

Average Soil Loss Rate (Tons/Yr.) =
[Area_SqFt]*[BankHgtFt]*SoilDensity(lbs/ft^3)/2000(lbs/ton)/([NAIP_ComparisonPhotoYear]-[BaseAerialPhotoYear])

Soil Bulk Density was calculated by first determining the moist bulk density of the predominant soil in the basin where erosion sites were identified, using the USDA Web Soil Survey website. The predominant soil type in the Walnut basin is Verdigris-Brewer-Norge Association. These soil series are nearly level sloping, deep soils that have silt loam or silty clay loam surface layer and silty clay subsoil; located on the flood plains and terraces with an average moist bulk density of 1.45 g/cc. This moist bulk density estimate was converted into pounds per cubic foot and reduced by 15% to get a dry bulk density estimate at 77 lbs/ft^3. This number was used for the typical bulk density of the predominant soil within the Walnut basin, and used in the Average Soil Loss Rate equation.

Streambank height measurements were obtained in June 2012 with assistance from the Butler and Cowley County Conservation Districts (CD). Streambank height measurements were obtained from a total of 12 sites on three separate streams throughout the Walnut basin (Figures 3, 4, 5, & 6). Two height measurements were acquired at each field measurement site using a Bushnell Scout 1000 ARC laser rangefinder. The first measurement was completed using the laser rangefinder to estimate the number of yards and angle from a horizontal position at the top of one bank to the *nearest* streambank edge, where the water reaches the streambank. A second measurement was completed to estimate the number of yards and angle from a horizontal position at the top of a bank to the *farthest* streambank edge, also where the water reaches the streambank. The total height from the rangefinder elevation was calculated from each measurement and then the elevation from the rangefinder to the land surface was subtracted from the rangefinder elevation to obtain the streambank height. The remaining 97 streambank erosion sites were then interpolated from the 12 field verified streambank height measurements that were taken and were added to the data. These streambank height measurements were then used in the Average Soil Loss Rate equation.

Figure 3: Fourmile Creek Streambank Heights Measurements (in feet) & Locations

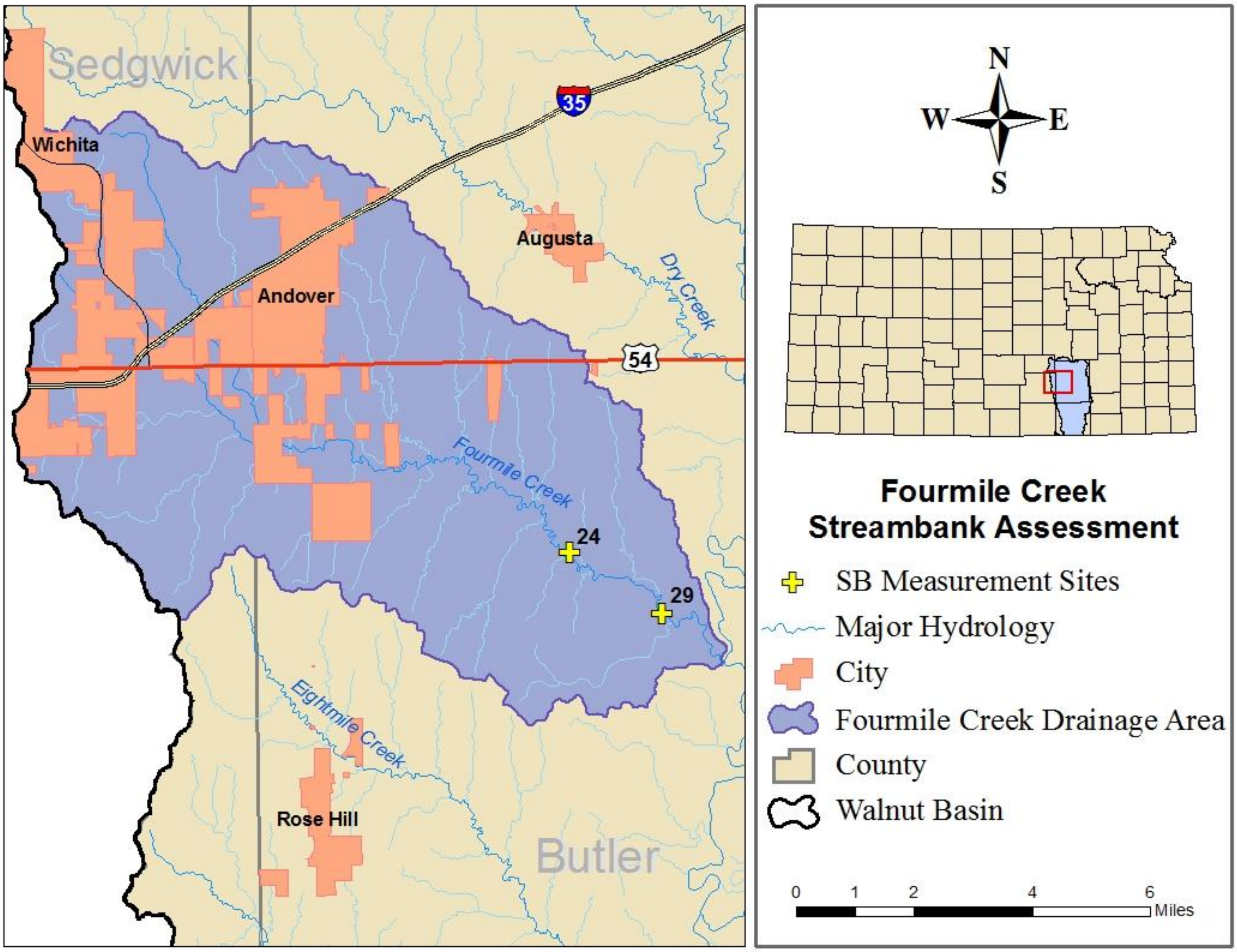


Figure 4: Lower Walnut River Streambank Heights Measurements (in feet) & Locations

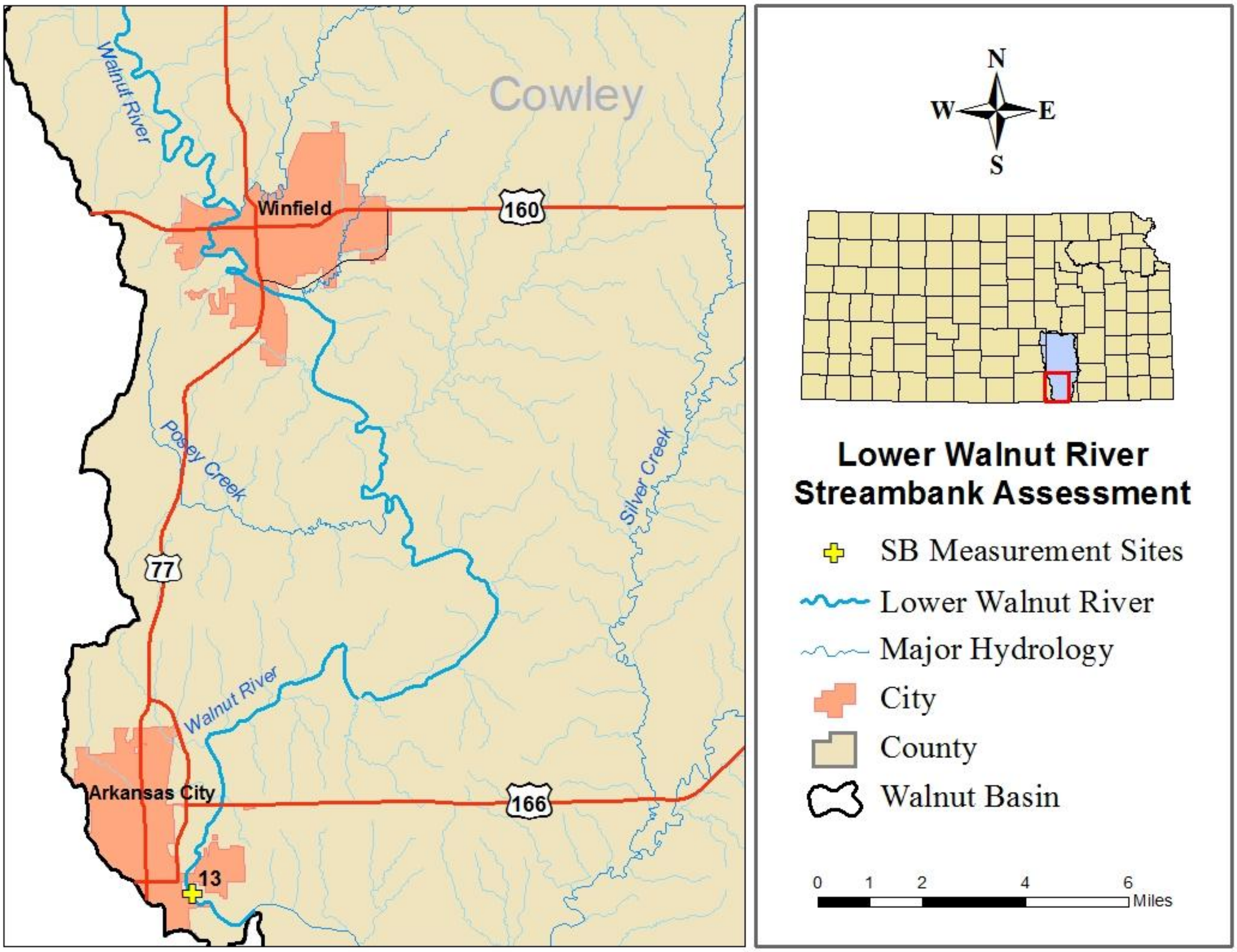


Figure 5: Upper Walnut River Streambank Heights Measurements (in feet) & Locations

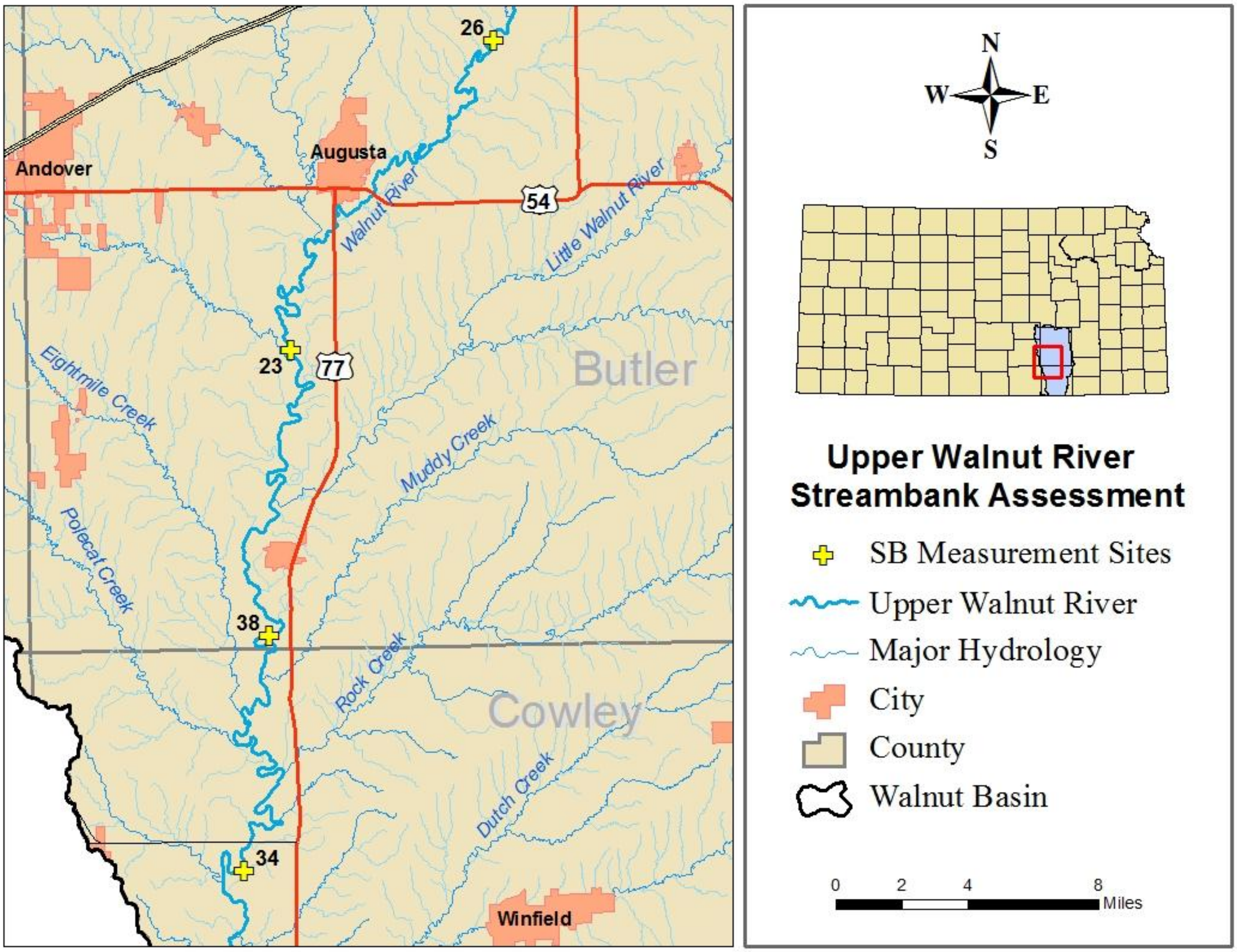
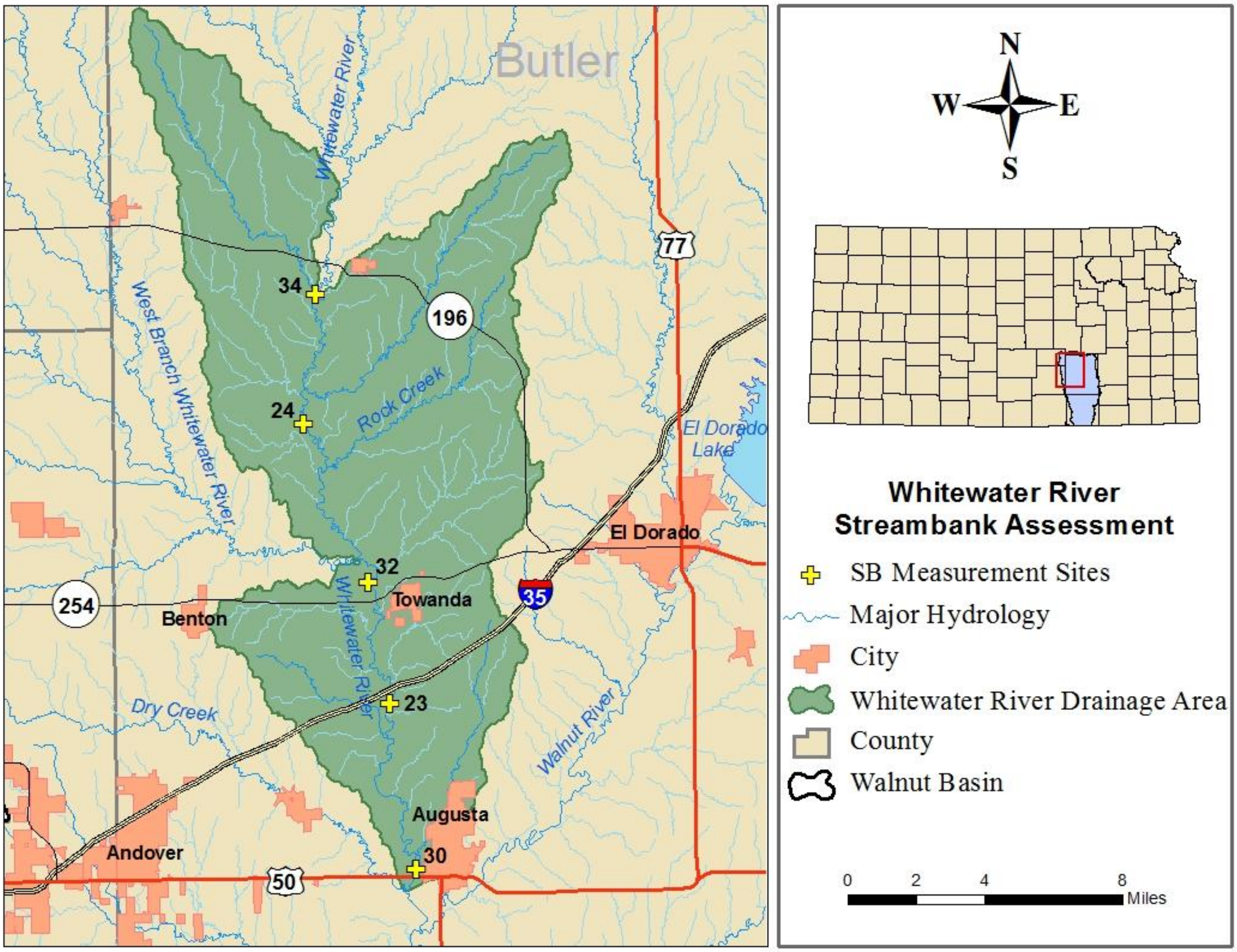


Figure 6: Whitewater River Streambank Heights Measurements (in feet) & Locations



Analysis

To adequately analyze streambank erosion sites, stream reach sections were delineated to better accommodate streambank rehabilitation project focus. Streambank erosion prioritization by stream reaches include: Fourmile Creek, Walnut River and Whitewater River. Streambank erosion sites were analyzed for: streambank length (feet) of the eroded bank; annual soil loss (tons); percent of streambank length with poor riparian condition (riparian area identified as having cropland or grass/crop streamside vegetation; grass/crop buffer includes riparian areas consisting of grasses and rangelands); estimated sediment reduction (through the implementation of streambank stabilization Best Management Practices (BMPs) at an 85% efficiency rate); and streambank stabilization cost estimates for eroded streambank sites. Streambank stabilization costs were derived from an average cost to implement streambank stabilization BMPs, as reported in the TWI

Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment; $71.50 per linear foot was used to calculate average streambank stabilization costs (Figure 7).

Figure 7: TWI Estimated Costs to Implement Streambank Stabilization BMPs

BMP Cost Description	Cost estimate per linear foot (in dollars)
1. Survey and design Rock delivery and placement As-built certification design Bank Shaping	$50 - $75
2. Vegetation (material and planting) Cover Crop Mulch Willow Stakes Bare root seedlings Grass filter strip	$5
3. Contingencies Unexpected site conditions requiring extra materials and construction time	$3 - $5.5
TOTAL	**$58-$85.5**

Results

The KWO 2012 assessment quantifies annual tons of sediment eroding over a 19 year period between 1991 and 2010 within the Walnut basin, excluding the El Dorado Lake Watershed which was completed by KWO in a previous study (KWO, 2011), in southeastern Kansas. A total of 109 streambank erosion sites (Figure 8, 9, 10, & 11) were identified, covering 97,535 feet of unstable streambank and transporting 324,759 tons of sediment downstream per year (Table 1). Fifty-two percent of the identified streambank erosion sites were identified as having a poor riparian condition (riparian area identified as having cropland or grass/crop streamside vegetation). A substantial quantity of the identified eroded sediment in the basin is transported annually from the streambanks of the Walnut River, accounting for approximately 285,791 tons of sediment annually or 88% of sediment eroding from all identified streambank erosion sites (Table 2). These identified reaches account for an estimated 88% or $20,434,057 of total stabilization cost needs in the basin (Figure 12). Based on the average stabilization costs of $71.50 per linear foot (*this is an estimate and may be higher or lower based on location*), conducting streambank stabilization practices for all 109 sites would cost approximately $23,220,197.

It is probable that high flow event runoffs from rangelands and agricultural lands via ephemeral gullies and bridge crossings that are continually undercut by high flow events could also be contributing to the sedimentation load. These occurrences were not a part of this assessment but should be assessed in the future.

Figure 8: Fourmile Creek Streambank Erosion Sites

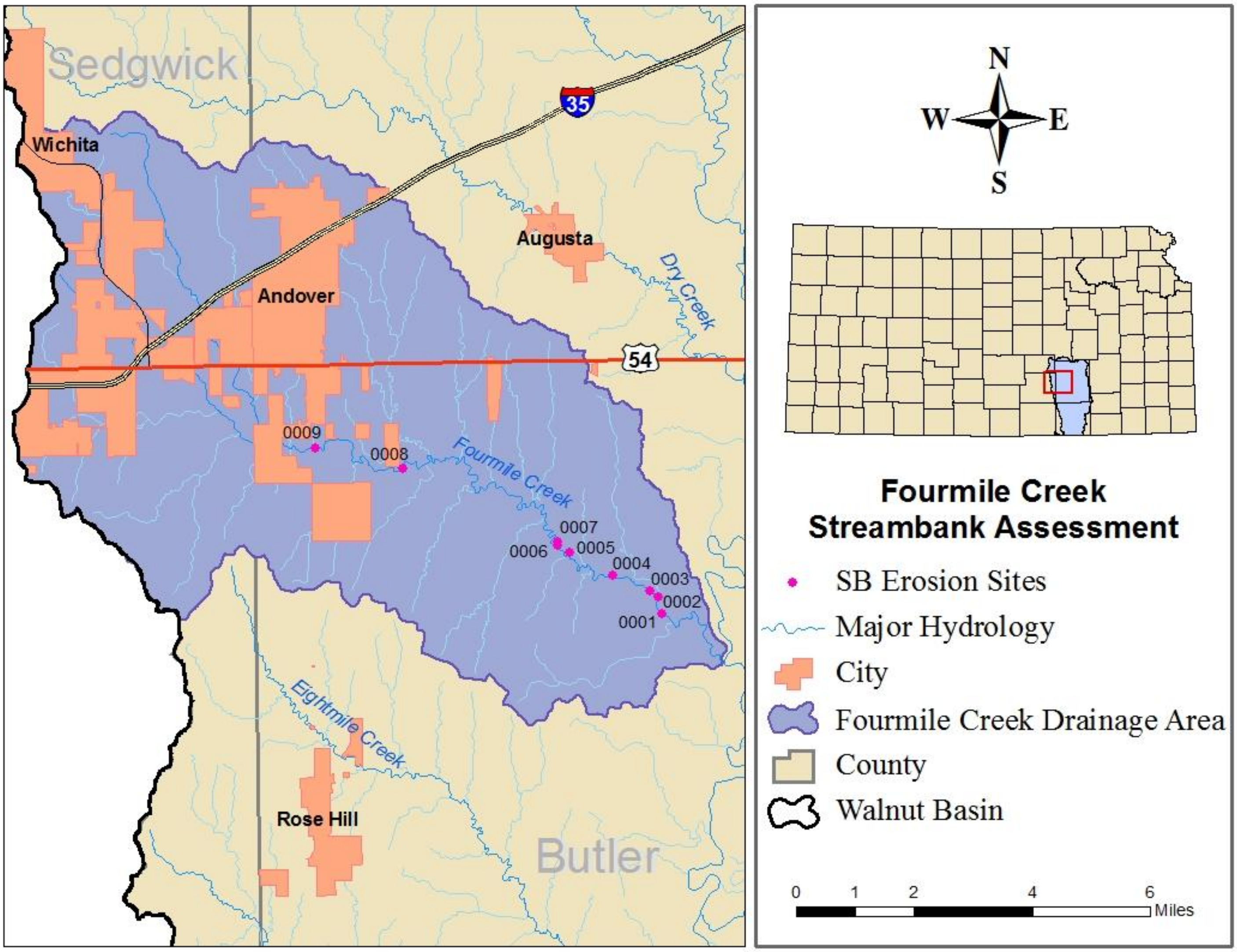


Figure 9: Lower Walnut River Streambank Erosion Sites

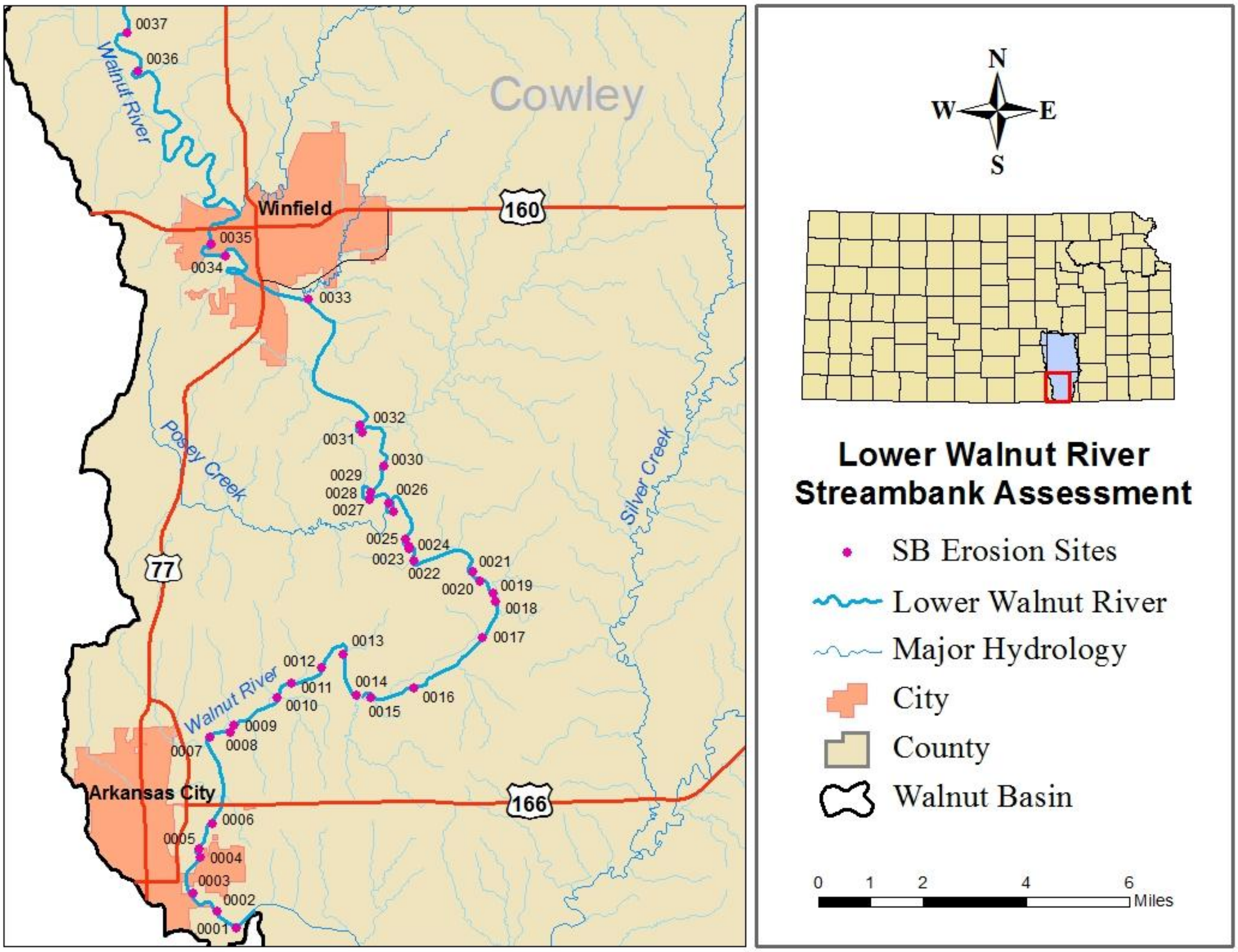


Figure 10: Upper Walnut River Streambank Erosion Sites

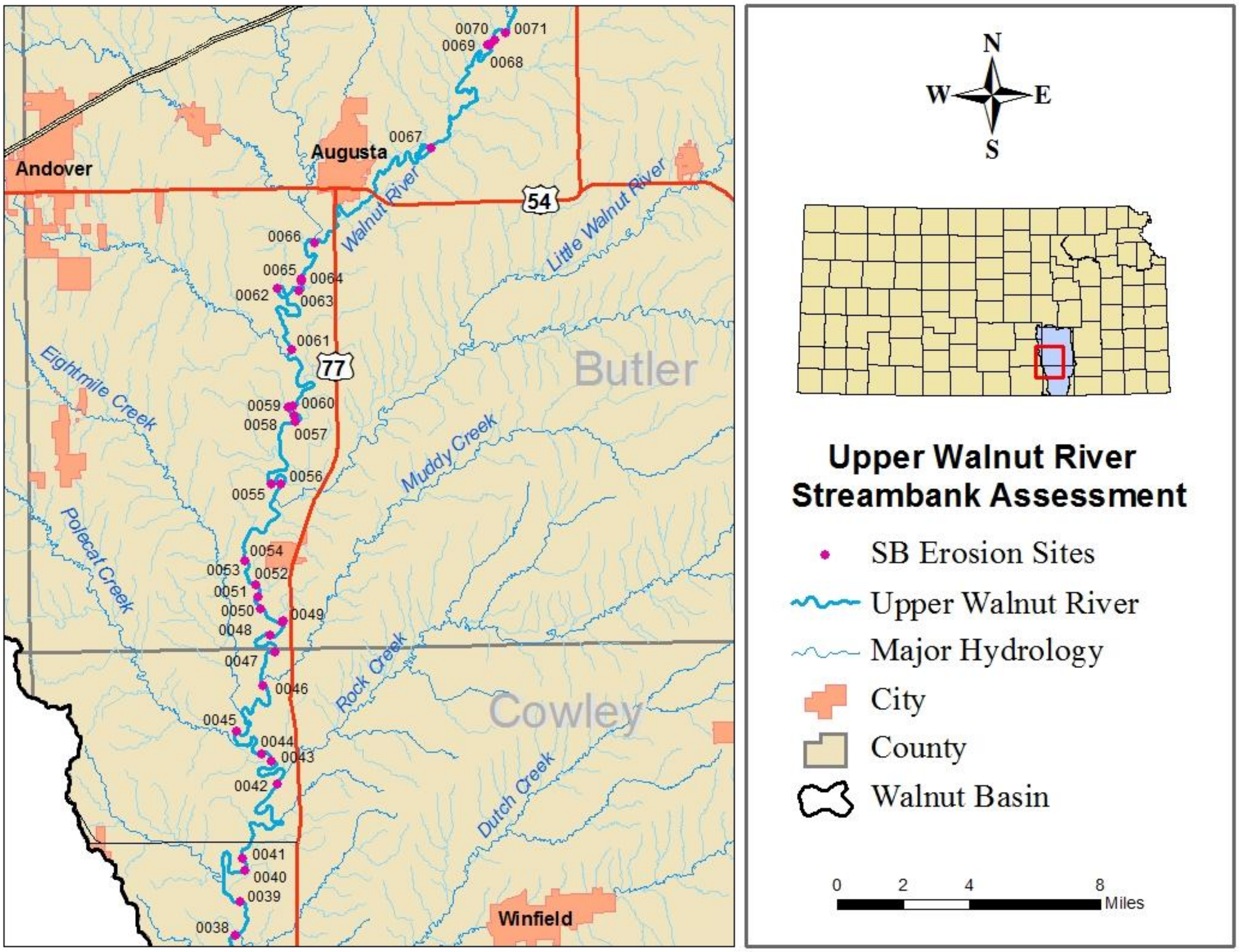


Figure 11: Whitewater River Streambank Erosion Sites

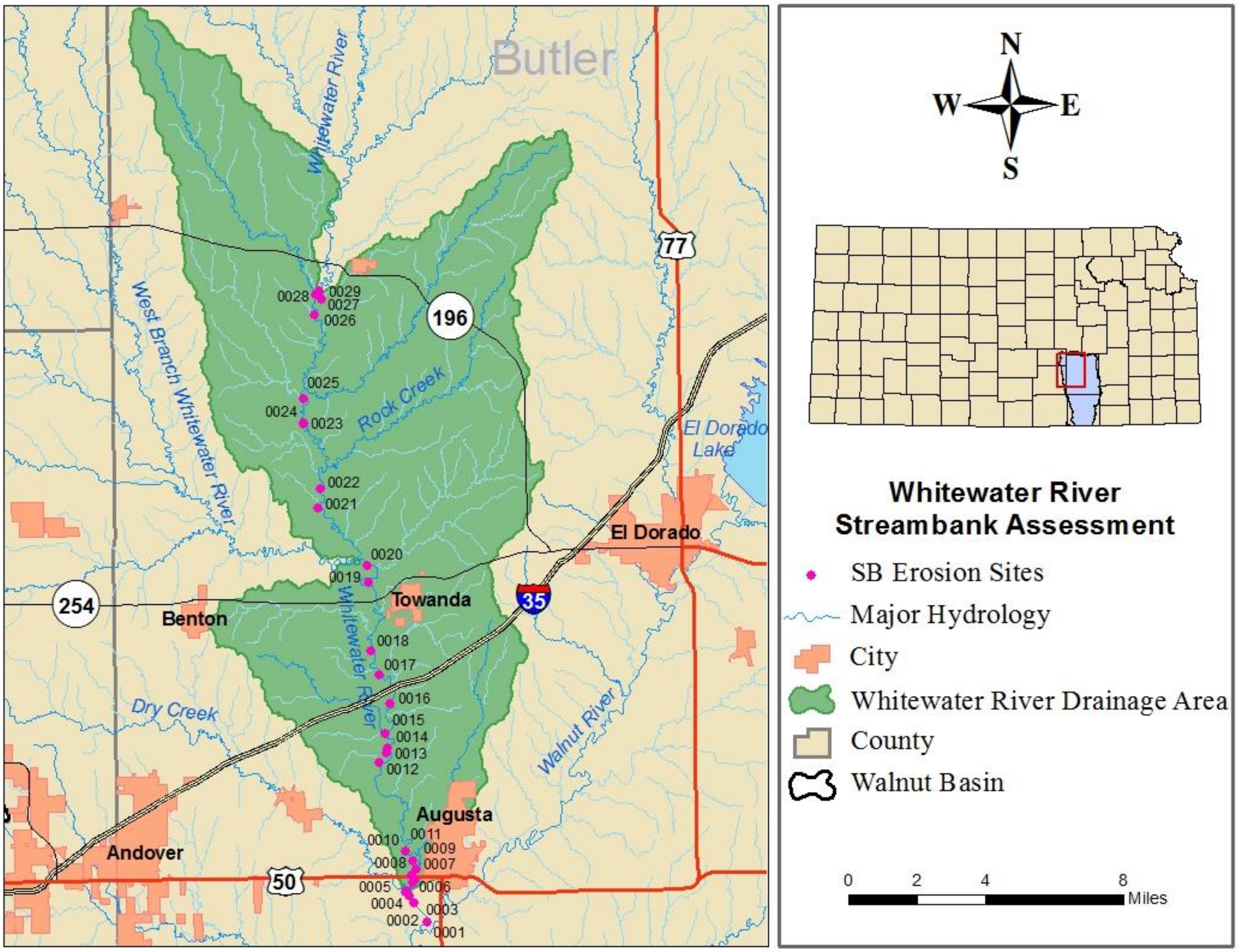


Table 1: Walnut Basin Streambank Erosion Assessment Table by Stream Reach

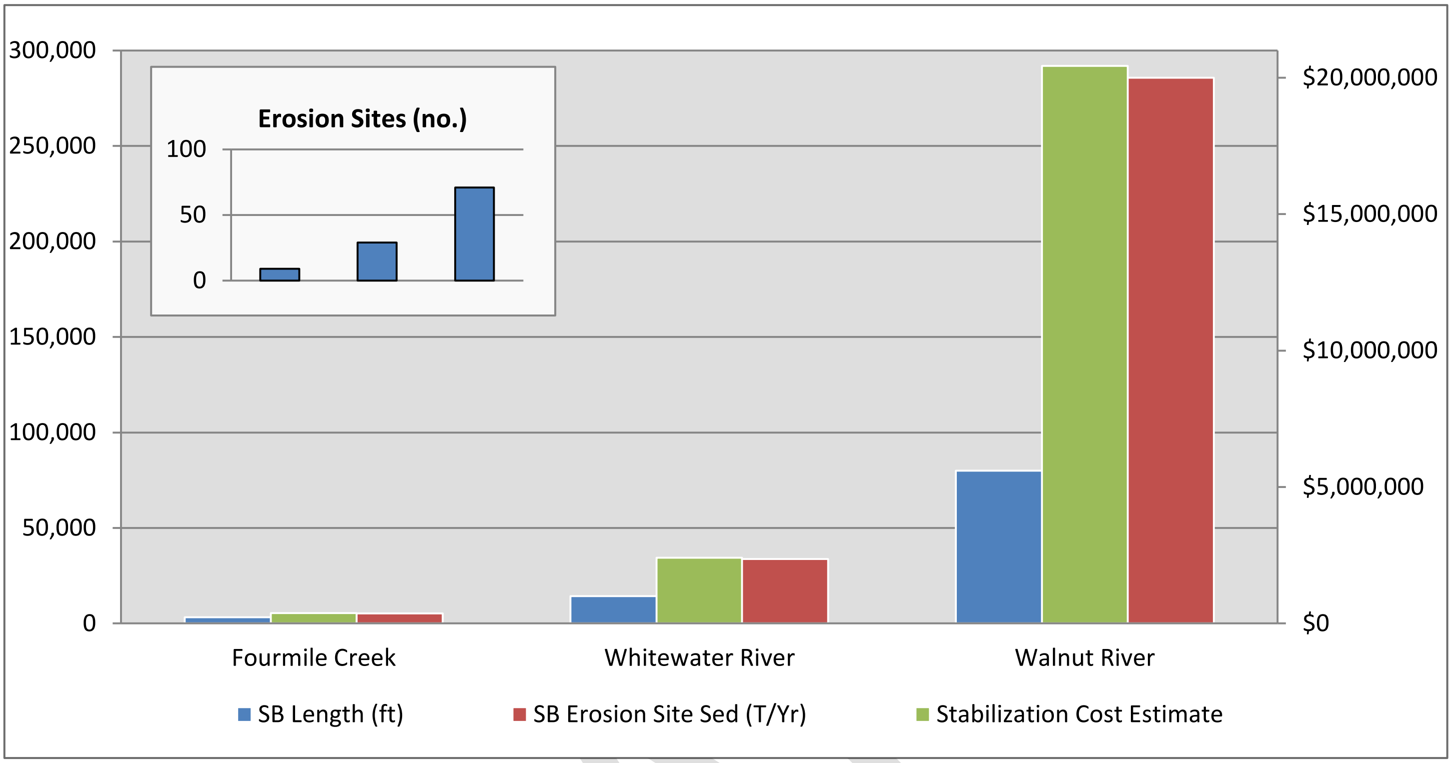
Stream Reach	SB Length (ft)	SB Erosion Site Sed (T/Yr)	Stabilization Cost Estimate	SB Erosion Sites (no.)	Yield Loss/ Bank Length (T/Yr/ft)	Poor Riparian Cond/SB Length (ft)	Est. Sed Reduction (T/Yr)	% SB Length w/ Poor Riparian Cond.
Fourmile Cr	3,301	5,503	$379,093	9	1.6	466	4,678	14.12%
Walnut R	79,917	285,791	$20,434,057	71	3.6	42,544	242,922	53.24%
Whitewater R	14,317	33,665	$2,407,048	29	2.4	7,310	28,615	51.06%
Total	**97,535**	**324,959**	**$23,220,198**	**109**	**7.6**	**50,320**	**276,215**	**51.59%**
Est Stabilization Cost/Linear Ft.			$71.50	**Stabilization/Restoration Efficiency**			0.85	

Table 2: Walnut Basin Streambank Sediment Load by Erosion Site (Tons/Yr.)

Unique ID	Fourmile Cr	Walnut R	Whitewater R
0001	534.2	3,568.8	1,069.1
0002	720.8	14,107.2	1,831.1
0003	1,006.3	21,138.4	675.5
0004	457.1	1,288.4	1,737.8
0005	424.6	1,798.5	1,244.9
0006	546.1	1,457.1	1,279.2
0007	861.8	832.2	701.0
0008	389.0	694.7	1,593.0
0009	362.8	1,244.7	1,203.2
0010		2,570.3	1,468.8
0011		935.7	1,041.1
0012		3,309.9	1,195.7
0013		2,888.0	1,214.1
0014		8,489.6	867.6
0015		4,194.6	1,488.7
0016		1,656.7	1,827.9
0017		4,761.0	1,403.4
0018		3,686.7	1,373.2
0019		5,906.9	1,674.2
0020		7,574.3	1,240.8
0021		6,950.4	1,019.1
0022		6,701.2	419.1
0023		2,512.7	680.9
0024		4,763.2	900.1
0025		12,235.3	790.3
0026		9,805.3	1,051.1
0027		4,040.4	852.5

0028		2,141.7	776.1
0029		18,251.6	1,045.8
0030		5,273.1	
0031		10,119.4	
0032		7,831.5	
0033		3,916.5	
0034		3,657.4	
0035		2,256.6	
0036		3,014.8	
0037		1,497.7	
0038		1,852.2	
0039		2,663.2	
0040		6,911.1	
0041		6,009.1	
0042		2,595.1	
0043		3,069.1	
0044		1,405.9	
0045		1,985.5	
0046		5,030.1	
0047		5,632.7	
0048		819.8	
0049		6,417.8	
0050		1,563.3	
0051		4,294.7	
0052		1,955.1	
0053		4,531.7	
0054		3,238.8	
0055		3,235.6	
0056		3,868.3	
0057		1,305.1	
0058		2,781.0	
0059		1,758.1	
0060		956.3	
0061		856.2	
0062		1,232.8	
0063		1,482.2	
0064		1,128.4	
0065		1,917.7	
0066		1,734.6	
0067		717.5	
0068		894.7	
0069		1,566.5	
0070		1,375.4	
0071		1,903.0	

Figure 12: Walnut Basin Streambank Erosion Assessment Graph by Stream Reach



Conclusion

The KWO 2012 assessment quantifies annual tons of sediment eroding over a 19 year period between 1991 and 2010 within the Walnut basin. A total of 109 streambank erosion sites were identified, covering 97,535 feet of unstable streambank and transporting 324,759 tons of sediment downstream per year. A substantial quantity of the identified eroded sediment in the basin is transported annually from the streambanks of the Walnut River, accounting for approximately 285,791 tons of sediment annually or 88% of sediment eroding from all identified streambank erosion sites. These identified reaches account for an estimated $20,434,057 of total stabilization cost needs in the basin.

The KWO completed this assessment to partially implement the *Reservoir Sustainability Initiative*, established by the Kansas Water Authority, which seeks to integrate all aspects of reservoir input, operations and outputs into an operational plan for each reservoir to ensure water supply storage availability into the future. The Draft and Final Report will be submitted for an internal review. Information contained in the assessment can be used by the KWO and interested parties to target streambank stabilization and riparian restoration efforts toward high priority stream reaches within the Walnut basin.

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