Verdigris Basin Priority Issue
Watershed Restoration and Protection
2010 Update
September 2010

ISSUE

The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Verdigris basin. The Verdigris and Caney rivers drain south into Oklahoma so interstate water quality issues are also important to ensure high quality water crossing the state line.

There are four federal reservoirs: Fall River, Toronto, Elk City and Big Hill, in the Verdigris basin. All are operated by the U.S. Army Corps of Engineers (Corps). All four reservoirs are used for public water supply programs that serve numerous cities and rural water districts in the basin. The reservoirs are also managed by the Corps for flood control and recreation. Additional water supply reservoirs in the basin include Otis Creek Lake (Eureka), Madison City Lake (Madison), Polk Daniels Lake (Howard), Moline New City Lake (Moline), Thayer New City Lake (Thayer), Caney City Lake (Caney), Sedan South City Lake (Sedan) and Boy Scout Lake (PWWSD #23).

Many streams within the basin are experiencing water quality impairments. Fecal coliform bacteria and low levels of dissolved oxygen are the most prevalent stream impairments.

In reservoirs, sedimentation is a major water quantity concern, particularly in reservoirs where the State owns storage for the Water Marketing and Water Assurance district programs. See the Surface Water Management Policy for a description of these programs. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced. Figure 1 shows the estimated percent of multipurpose pool capacity lost, including water supply storage, to sediment deposition in federal reservoirs in the Verdigris basin since construction.

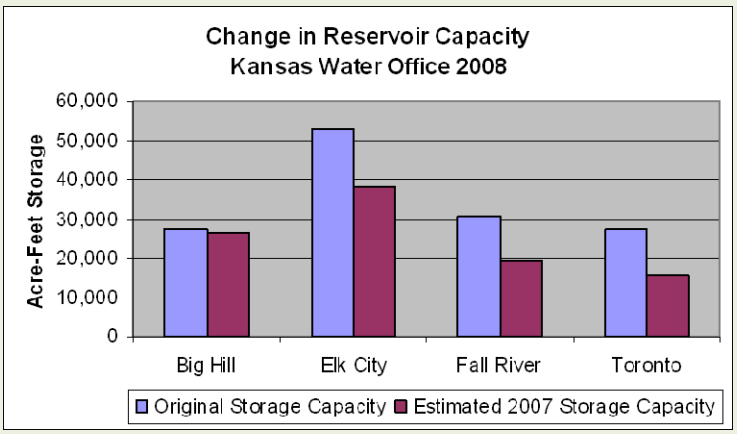

Figure 1. Changes in Verdigris Reservoir Capacity Since Construction

Reservoir sedimentation is a result of soil erosion from the land surface and from stream channels and banks. 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. Growing evidence shows that a significant source of sediment in streams I generated from stream channels and edge of field gullies. Streambank erosion can contribute nutrients, such as phosphorus, which can cause water quality impairments.

When this basin priority issue was approved in January 2009, the following recommendations were made to address watershed restoration and protection needs in the Verdigris basin.

RECOMMENDED ACTIONS

1. Work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans. Coordinate with development of Source Water Protection Plans.

3. Continue coordination efforts with the City of Tulsa to ensure good water quality entering Oklahoma from the Verdigris River in Kansas.

4. Complete assessment projects with particular attention to riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system.

5. Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

6. Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

Since 2009, substantial progress has been made in the implementation of these recommendations, especially in the assessment of streambank condition. This update

provides additional information about recent activities and data acquisition.

Recommendation: Work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.

Water quality protection and improvement is most effectively addressed at the watershed level using regulatory and non-regulatory programs. Surface water quality monitoring is conducted to assess the level of pollutants in the water and the health of the biological community. If monitoring indicates that a river segment or other water body is consistently violating surface water quality standards, the water is deemed water quality impaired. Water bodies not meeting water quality standards for their designated uses are identified on the 303(d) list. The 303(d) list is used to identify those waters targeted for the development of Total Maximum Daily Loads (TMDLs). A TMDL is the maximum amount of a pollutant that a water body can receive without exceeding water quality standards. Since pollution can arrive via point and nonpoint sources, the TMDL process distributes responsibility for the pollutant load reductions among those contributing sources. High Priority TMDL watersheds are used to target technical and financial assistance for implementation of non-point source pollution management practices that can address designated pollutants.

The Kansas Department of Health and Environment (KDHE) completed the first round of TMDLs within the Verdigris basin based on the 1998 303(d) list. There are 20 approved TMDLs within the Verdigris basin that describe the strategies and goals to reduce pollution to achieve water quality standards. The 2008 303(d) list submitted to EPA identifies watersheds associated with six stream chemistry sampling stations and two biological monitoring stations as water quality impaired. There are seven lakes in the Verdigris basin listed as water quality impaired. Among the streams copper causes the greatest number of impairments. Other pollutants of concern in Verdigris streams include zinc, lead, dissolved oxygen deficiency and E. coli bacteria. Among the lakes eutrophic conditions indicative of excessive algae production, dissolved oxygen depletion, and siltation are the causes of impairment.

Each parameter causing impairment requires a TMDL. Many of the stream segments configured in a watershed setting have a TMDL applied to them as a whole. KDHE reviewed and revised Verdigris basin TMDLs and submitted them to EPA in late summer 2008. The following changes were approved: a new high priority eutrophication, dissolved oxygen, and siltation TMDL for Fall River and Toronto reservoirs, a new high priority eutrophication TMDL for Big Hill Reservoir, a new medium priority siltation TMDL for Eureka Lake and a new medium priority eutrophication and siltation TMDL for Elk City Reservoir. The TMDL for Elk City Reservoir will remain a medium priority until a viable Watershed Restoration and Protection Strategy (WRAPS) group is formed in the watershed above it.

KDHE completed a regional study of dissolved oxygen (DO) conditions and causes of low levels during 2007. As a result of this evaluation, KDHE proposed that several DO TMDLs be moved from high priority to medium priority, and the BAC concurred with this recommendation. These priority changes were approved by EPA and are reflected on the map in Figure 2.

Table 1 provides information on rivers and lakes within the basin that are designated a high priority for TMDL implementation, following the recommendations of moving several of the currently listed high priority DO TMDLs to medium priority. Figure 2 shows the location of these watersheds within the basin. (6)

Table 1
Verdigris Basin High Priority TMDLS

MAP ID	WATERBODY	IMPAIRMENTS	HUC 8 WATERSHEDS
STREAM SEGMENTS			
1	Fall River	FCB	11071020
LAKES			
2	Fall River Lake	E, DO, Silt	11070102
3	Toronto Lake	E, DO, Silt	11070101
4	Big Hill Lake	E	11070103

Key:
DO: Low dissolved oxygen in upper 3 meters of water column over deepest location in water body
E: Eutrophication, biological community impacts and excessive nutrient/organic loading
FCB: Fecal Coliform Bacteria
HUC: U.S. Geologic Survey Hydrologic Unit Code
Silt: Observed siltation and/or chronic turbidity that impacts development of trophic state

Surface Water Nutrient Reduction

The impacts of nutrients originating in Kansas have been well documented. These include Gulf of Mexico hypoxia, excessive productivity in Kansas and downstream reservoirs, and taste and odor problems in drinking water originating from reservoirs. Reduction and control of nutrients is needed to begin mitigating those impacts. Nutrient sources within the basin include both point and nonpoint sources. The major point sources in the basin in-

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clude large wastewater treatment plants, which are regulated under the National pollutant Discharge Elimination System (NPDES) Program (Figure 3).

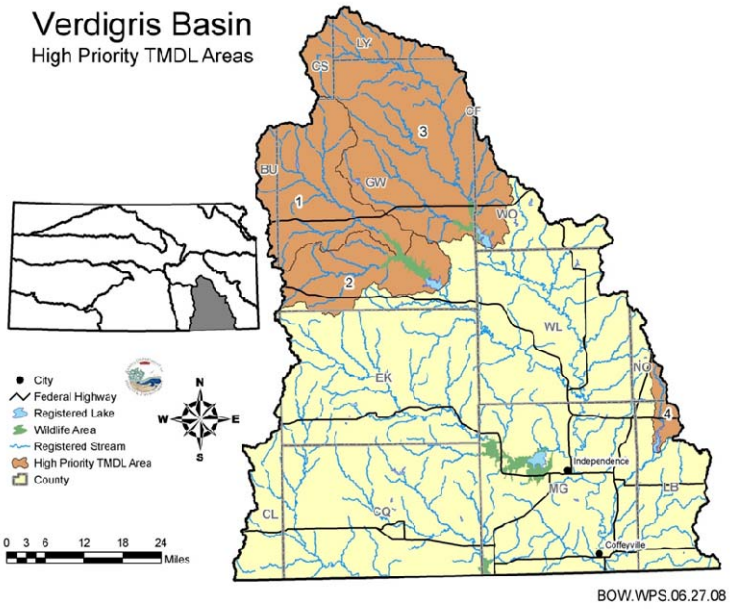

Figure 2. High Priority TMDL Map

Non-point sources of pollution include both agricultural and urban areas. Table 2 shows the relative contribution of point and non-point sources in the Verdigris basin for total phosphorus and total nitrogen leaving the state. The Kansas Surface Water Nutrient Reduction Plan, developed by KDHE, outlines a statewide strategy for reducing the export of total nitrogen (TN) and total phosphorus (TP) in surface waters leaving the state. This involves additional reductions in nutrients from point source discharges through the NPDES Program and reductions in non-point sources through development and implementation of WRAPS. The Nutrient Reduction Plan includes Improvement Potential Index (IPI) maps for Kansas counties for TP and TN reductions (see maps in Water Quality Policy Section). In the Verdigris basin, no counties currently show high improvement potential for TP and TN. However, with the recent development of high priority TMDLs for all four reservoirs in the basin, this could change as the plan is updated. Any actions taken in the basin to reduce nutrients in surface waters will also benefit downstream water users in Oklahoma.[5]

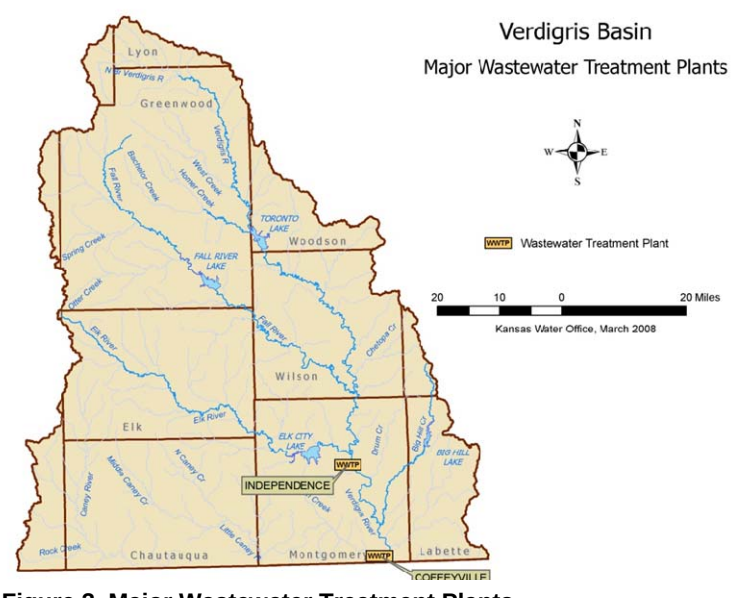

Figure 3. Major Wastewater Treatment Plants

Table 2
Verdigris Nutrient Reduction Data

Statewide Perspective

Parameter	State Total	Verdigris	% of State Total
TN Leaving State (Ton/yr)	51,000	3,468	7
TP Leaving State (Ton/yr)	7,700	385	5
Point Source TN (Ton/yr)	9,215	369	4
Point Source TP (Ton/yr)	1,925	58	3
Nonpoint Source TN (Ton/yr)	41,785	2,925	7
Nonpoint Source TP (Ton/yr)	5,775	347	6

Basin Perspective

Parameter	Total	PS	PS %	NPS	NPS%
TN (Ton/yr)	3,468	441	13	3,027	87
TP (Ton/yr)	385	83	21	314	79

Source: KDHE Bureau of Water - 2/14/06

Source Water Protection

All public water suppliers in the basin completed Source Water Assessments in cooperation with the KDHE in 2004. The next step, which is voluntary, is the development of source water protection plans. For communities using ground water, development of a wellhead protection program is recommended. For communities using surface water, the development of a WRAPS is the best mechanism to ensure water quality protection for their public water supply. No source water or wellhead protection plans have been developed in the Verdigris basin.

Each Source Water Assessment included a susceptibility score which can help communities determine which contaminants pose the most significant threat to their water supply. A susceptibility score was generated from the susceptibility analysis and indicates whether the susceptibility range is low, moderate or high for potential threats of contamination in an assessment area.

KDHE provided public water suppliers susceptibility scores in the following contaminant categories: microbi-

ological, nitrates (applicable for ground water only), pesticides, inorganic compounds, synthetic organic compounds, volatile organic compounds, sedimentation (surface water only), and eutrophication-phosphorus (surface water only).

Of the 24 public water suppliers in the basin which treat raw water, 19 use surface water and 6 use ground water. Most residents in the basin get water from the Verdigris or Fall River, major tributaries or one of the four federal reservoirs in the basin.

Of public water suppliers using ground water in the Verdigris basin, 83 percent had low susceptibility scores and 17 percent had moderate scores. Of public water suppliers using surface water, 74 percent had low scores and 26 percent had moderate scores. The most commonly identified problems with groundwater were inorganic compounds, pesticides, and nitrates. The most commonly identified problems with surface water were pesticides, microbes, and inorganic compounds.

Recommendation: Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans. Coordinate with development of Source Water Protection Plans.

WRAPS are stakeholder-driven watershed management plans designed to address multiple water resource issues within a specific sub-watershed within a river basin. The WRAPS process provides a means to integrate objectives from multiple local, state and federal programs into a comprehensive, coordinated strategy for a specific watershed. This can include TMDL attainment, nutrient reduction, source water protection, reduced reservoir sedimentation, riparian and wetland management, habitat enhancement, and other natural resource objectives.

Watersheds above the four federal reservoirs in the basin that serve public water supply needs have been identified as watersheds of significant state interest for development and implementation of WRAPS. WRAPS projects have been initiated in two (Fall River and Toronto) of the watersheds above the federal. Efforts were made to establish Stakeholder Leadership Teams (SLT) in the watersheds above Elk City and Big Hill reservoirs, and in the watershed below these reservoirs that drain to Oolagah Reservoir in Oklahoma. Financial assistance was provided to assist in organizing local stakeholders. Due to the relatively sparse populations in the watersheds above Elk City and Big Hill, insufficient local interest in the process was demonstrated and no project currently exists in those watersheds. While the cities of Independence and Coffeyville are in the Oolagah reservoir watershed, a stakeholder leadership team was not able to be organized there either. As a result, WRAPS funding for those projects has been withdrawn. The priority status for TMDL's in those watershed has been changed from high to medium until an SLT is formed. However, funding from other sources including the SCC and NRCS is still available for BMP implementation in those watersheds. Watersheds with WRAPS projects currently underway in the basin encompass high priority areas for TMDL implementation, source water assessment areas and priority areas for wetland and riparian protection.

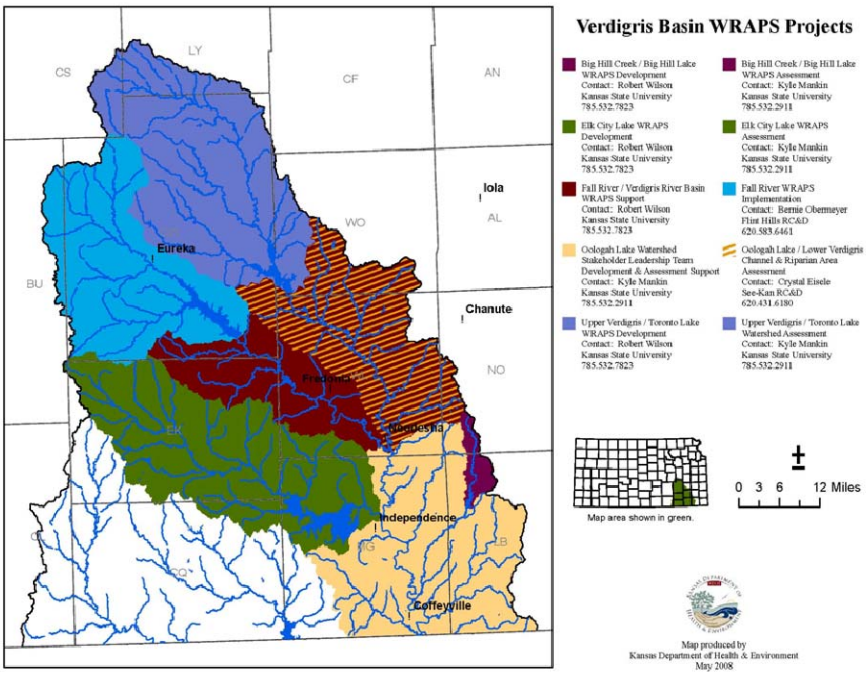

Figure 4. Watershed Restoration and Protection Strategy Groups

The Fall River and Toronto WRAPS groups have been modifying their WRAPS plans to include the EPA Nine Elements into their documents. This is a requirement of EPA in order to continue to receive Section 319 grants for plan implementation. The Toronto Nine Element Plan was the first in the state to be approved by KDHE and EPA. The Fall River Nine Element Plan is under development and on schedule to be approved in early 2011.

Figure 4 shows WRAPS projects coverage and contact information for projects in the basin.

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Recommendation: Complete assessment projects with particular attention to riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system.

Wetland and riparian areas are vital components of proper watershed function that, when wisely managed in context of a watershed system, can moderate and reduce sediment input into reservoirs. There is growing evidence that a substantial source of sediment in streams in many areas of the country is generated from stream channels and edge of field gullies (Balch, 2007). This chapter evaluates streambank erosion contribution to sedimentation in three of the Verdigris basin federal reservoirs.

Streambank erosion is a natural process that contributes a large portion of annual sediment yield, but acceleration of this natural process leads 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 United States Geological Survey (USGS) study in the Perry Reservoir watershed in northeast Kansas showed that stream channels and banks are a large contributor of reservoir sedimentation in addition to land surface erosion (Juracek, 2007) in some watersheds. 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 either aggrading or degrading (Rosgen, 1997). Streams that have been significantly impacted by land use changes in their watersheds or by modifications to stream beds and banks go through an evolutionary process to regain a more stable condition. This process generally involves a sequence of incision (downcutting), widening and re-stabilizing of the stream. Most streams in Kansas are in some stage of this process (SCC, 1999).

Fall River Streambank Erosion. Photo courtesy Deb Baker, KWO

Streambank erosion is often a symptom of a larger more complex problem requiring solutions that frequently involve more than just streambank stabilization (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). This should involve a watershed-based approach to developing stream stabilization plans.

WRAPS plans have been developed for Fall River and Toronto reservoirs. Included in the plans are comprehensive recommendations for Best Management Practices (BMPs) that address the nonpoint source pollution concerns from many land use practices in their watersheds. For Elk City Reservoir, Total Maximum Daily Loads (TMDLs) developed by the Kansas Department of Health and Environment (KDHE) provide guidance for nonpoint source pollution reduction.

Another form of erosion contributing to sedimentation in many watersheds in Kansas is the development of gullies alongside streams. Gullies develop from the wearing away of the surface soil along drainage channels by surface water runoff. Gullies are associated with the loss of vegetation on the soil and down cuts forming deep widening channels. The potential for surface erosion is associated in part with the amount of bare, compacted soil exposed to rainfall and runoff. Increased risk of erosion and sediment delivery is associated with high soil erodability; little ground cover; steep, long, continuous slopes; high intensity storms; high drainage density of the slope; and close proximity to streams.

The primary approach to wetland and riparian area management in the basin focuses on providing technical and financial assistance to landowners to protect and restore these resources in priority watersheds through the implementation of best management practices. Water quality has been a primary focus with implementation efforts

targeted to high priority TMDL watersheds (Figure 3). All conservation districts in the basin have developed wetland and riparian protection plans. An emerging concern is management and maintenance of forested riparian areas to prevent the entry of debris (dead and fallen trees, etc.) into the tributary/river system. Due to recent ice storms and catastrophic flooding, along with unstable streambanks, the potential for woody debris to collect in and clog bridges and culverts has been elevated. Preventing entry of woody debris into the system can help to manage this.

The KWO is proposing a new policy that will provide a systematic approach to the assessment, protection and restoration of wetland and riparian areas and for the restoration of stream channels. The policy promotes a comprehensive evaluation of stream reaches and watershed wetland condition.

As part of the Middle Verdigiris WRAPS, an inventory of riparian area and streambank condition on the mainstem of the Verdigris River has been initiated. A similar assessment of the Fall River and tributaries has been completed. To supplement these efforts, and as part of the Reservoir Roadmap, detailed streambank stability assessments have been completed by the KWO in the watersheds above Fall River, Toronto and Elk City Reservoirs. Results of these assessments are presented below.

Streambank Erosion Hotspot Identification

A streambank erosion assessment was performed using desktop ArcGIS® software and on-the-ground data verification and collection. The purpose of the assessment was to identify locations of streambank instability and estimate erosion rates to prioritize restoration needs along streambanks to slow sedimentation rates in Fall River, Toronto and Elk City reservoirs. ArcMap®, an ArcGIS® geospatial processing program, was utilized to assess color aerial photography from 2006, provided by National Agriculture Imagery Program (NAIP), and compare it with 1991 black and white aerial photography provided by Data Access & Support Center (DASC). Erosion sites identified in this assessment are limited to locations of streambank erosion and do not include gullies, salt scars, or other landscape level sources. No specific attempt was made to locate and characterize gullies within these watersheds during the desktop assessment. However, when completing field measurements of identified streambank hotspots, numerous gullies were found adjacent to streams. It is likely that gullies are also a substantial source of sediment in these watersheds and additional efforts are needed to quantify their contribution.

Data Collection Methodology

The streambank assessment was performed by overlaying 2006 county aerial imagery onto 1991 county aerial imagery. Using ArcMap® tools, streambank erosion sites were indicated by geographic polygon “drawn” into the ArcGIS® software program. Data provided, based on these geographic polygons, include: watershed location, unique ID, stream name, type of stream and type of riparian vegetation.

Unique IDs allow specific streambank locations to be individually identified for each site within the ArcGIS® software. The type of riparian vegetation was assigned to one of four categories of vegetation located on the riparian zone adjacent to the streambank where an erosion site is indicated. The four categories are: woodland, narrow woodland, grass/crop buffer or cropland. The identification of a woodland riparian area indicates the riparian area of the streambank is approximately more than 200 ft. wide with wooded vegetation. Narrow woodland riparian area indicates approximately less than 200 ft. wide of wooded vegetation. A grass/crop buffer indicates a visibly identifiable grass buffer adjacent to an agricultural cropland, rangeland or grassland. Cropland indicates that a cultivated field extends to the streambank itself.

**Measuring Streambank Height on Fall River.
Photo courtesy Deb Baker, KWO.**

For streambank erosion locations, data were compiled for streambank height,tons of soil lost per year, and degraded streambank length. Streambank height measurements were obtained by KWO and WRAPS staff.

Results

Fall River Reservoir

Fall River Reservoir was constructed on Fall River in Greenwood County at river mile 54.2, about 4 miles northeast of the city of Fall River. The watershed drains about 585 square miles and includes portions of Butler, Chase, Elk and Greenwood counties, with the majority in Greenwood County. The Corps, Tulsa District began construction of the reservoir in 1946 for flood control, water supply and water quality control. Gates were closed in early 1949 and the conservation pool filled June 1949.

Major tributaries in the watershed include Oleson, Swing, Ivanpah, Spring, Burnt, Kitty, and Otter Creeks. Headwaters of these tributaries are characterized as high gradient streams with mostly gravel substrate and are bordered to various degrees by deciduous woodlands intermixed with grassland along the alluvial floodplain. Most crops are grown in the floodplains and where this is the case, the native riparian cover has often been converted to cropland, contributing to unstable streambanks.

Geomorphic studies have indicated that over half of the first, second and third order streams in the Upper Fall River watershed have been lost through impoundment and inundation. Tributary channels tend to be slightly entrenched with moderate width to depth ratios and sinuosity and moderately low slopes (< 2%). Most channels are gravel. Studied stream channel segments controlled by watershed structures were shown to be stable and often aggrading as bankfull discharges were diminished by impoundment and the resulting flows lack the power to move larger sediment out of the channel, pools and riffles. Generally, sediment supplies were low, either because of trapping by watershed structures or lack of source material in the Flint Hills ecoregion. There is an implication that diminished sediment supplies from the tributaries could induce main channel erosion along the Fall River as flowing water seeks equilibrium with its transporting sediment load.

Land use in the watershed is typical of the Flint Hills ecoregion where cultivation has been minimal due to shallow, rocky soils, resulting in largely unbroken native tall grass prairie. Grazingland or grassland is the predominant land use, covering 88% of the watershed. Row crop agriculture, which occurs primarily in the floodplains of creeks and the river, makes up six percent of the land use, wooded areas, four percent, urban areas one percent and water resources occupy the remaining one percent of the watershed.

A high priority TMDL for eutrophication/siltation has been developed for the reservoir. The TMDL estimates that 324,000 tons/year of sediment enters the reservoir from the watershed. Bathymetric surveys indicate that storage capacity in the multi-purpose pool which contains the public water supply storage has been reduced by about 38% since the reservoir was filled in 1949.

In 2008, the Fall River Reservoir WRAPS project used US EPA Section 319 funds and State Water Plan funds to perform a GIS based assessment of areas along streams where buffers are lacking or should be installed. The study identified 7,300 acres of streambank where buffers are needed and 19,300 feet of streambanks in need of stabilization.

In 2010, the KWO performed a GIS based analysis of streambank erosion and riparian condition in the Fall River watershed. A total of 64 hotspots covering 19,691feet indicating substantial streambank erosion were identified, corresponding well with the 2008 WRAPS assessment. Of these, nine reaches were selected for field measurements of bank height. Measurements were used to estimate the amount of sediment originating from streambanks.

Several gully erosion problems in areas adjacent to the stream reaches were identified during field reconnaissance of the identified hotspot streambank heights. Gullies were not intentionally identified during the desktop evaluation so it is not known how extensive gullies are in the watershed beyond those encountered during the field work. Gully erosion can contribute a tremendous amount of sediment at the watershed scale and can oc-

Gully Erosion on Fall River. Photo courtesy Deb Baker, KWO

cur in both cropland and grassland. The amount of sediment input is based on rainfall/runoff and gully frequency within a given watershed. In each case, the gullies observed are unstable and will continue to be unless best management practices (BMPs) are implemented. A common BMP for gully erosion is the rock chute. Rock chute designs require bank shaping and the placement of erosion control fabric and sorted rock. Rock chutes are designed to direct flow down through the chute center. The rock creates flow resistance slowing down water velocities.

The assessment estimates annual tons of sedimentation from streambanks within the Fall River Reservoir watershed. Using average streambank erosion rates, an estimated 40,364 tons of sediment originating from unstable streambanks is transported downstream in the Fall River Reservoir watershed annually. This calculated amount accounts for only 12% of the total load estimated from the TMDL.

A substantial majority of the sediment is transported from the main stem Fall River, Otter Creek, West Branch Fall River and Spring Creek contributing approximately 15,940, 12,820, 7,710 and 3,900 tons of sedimentation annually respectively. Based on estimated stabilization costs of $71.50 per linear foot, the stabilization cost for the identified hotspots would be about $1.4 million. The Fall River mainstem accounts for about 34% of the total stabilization cost needs in the watershed totaling $478,370. Costs and percentages for Otter Creek are $391,950 (16%), for West Branch Fall River $302,545 (21%) and for Spring Creek, $235,020 (17%). One project to stabilize 550 feet is currently underway at an estimated cost of $20,000.

Buffer installation costs vary widely. Using an average cost of $500/acre, the 7,300 acres of needed buffers identified the 2008 WRAPS study would cost about $3.6 million to install.

Originally constructed as a watershed district structure for flood control in 1971, Otis Creek Lake also serves as the water supply source for the City of Eureka. The watershed is approximately 8,960 acres and the surface area of the reservoir is about 300 acres. Assessment of streambank stabilization needs for this reservoir were included in the Fall River Assessment but not broken out in this report.

Toronto Reservoir

Toronto Reservoir provides drinking water to the town of Toronto. Authorized uses include flood control and conservation, water supply, water quality, fish and wildlife and recreation. Construction of the dam on the Verdigris River began in 1954 by the Tulsa District U.S. Army Corps of Engineers and the multipurpose pool was filled in 1960. In 1960, the reservoir had a storage capacity of 27,320 acre feet. The estimated current capacity of the latest survey year (1990) is 15,010 acre feet. This represents a loss of capacity of 45% due to sediment that has entered the lake from the watershed with a calculated sedimentation rate of 242 acre feet per year. Toronto Reservoir has the highest percentage of capacity loss of all reservoirs in the State of Kansas. The current maximum depth is approximately 18 feet and the mean depth is 7 feet.

The Toronto Watershed covers 458,395 acres or about 730 mi^2. There are numerous towns and cities in this watershed in addition to developed areas surrounding Toronto Reservoir. Toronto Reservoir covers 2,800 surface acres and is located in the Cross Timbers Region of Kansas, but the watershed drains from the Flint Hills and Osage Cuestas Regions.

Grassland covers 85% of the watershed and can be a major contributor of sediment. Gullies in rangeland are a major source of erosion and sedimentation in this watershed. Numerous factors contribute to gully formation but overgrazing, putting yearling cattle on grass during high flow rain events, noxious weeds and tree growth are overarching themes in range areas of the watershed with large gullies. Brine scar sites are also prevalent in the central region of this watershed. Brine scar sites, a result of historic oil and gas drilling, are areas where natural vegetation has been eliminated and the ground is bare, which leaves the area prone to greater erosion. Sources of sediment originating from cropland (7% of the watershed land use) can originate from overland flow across conventional tilled crop fields and ephemeral gullies that are plowed through each year. Failing and sloughing streambanks with undercuts will also contribute to erosion. Remaining land uses in the watershed is woodlands (4%), water (1%) and other (3%).

Madison City Lake is also in the Toronto watershed and is the sole drinking water supply for the city. Assessment of streambank condition in its watershed was included as part of the streambank assessment but not broken out for this report. In addition to Toronto Reservoir, there are three watershed districts within the study area that build and maintain watershed impoundments for local flood control.

Sediment from the watershed currently entering the lake annually, as calculated in the TMDL, is 96,300 ton/year of TSS. The KWO assessment estimates annual tons of sedimentation from streambanks within the Toronto River Reservoir watershed. Sixty hotspots of actively eroding sites were identified. Ten of these sites were measured and field verified for streambank height. Using average streambank erosion rates, an estimated 30,310 tons of sediment is transported downstream in the Toronto River Reservoir watershed annually from these hotspot areas. This accounts for only about 30% of the load estimated the TMDL. A majority of the sediment is transported from the main stem Verdigris River, Homer Creek, West Creek, North Branch Verdigris River, Duck Creek and Onion Creek contributing approximately 14,782, 4,071, 6,992, 1,571 and 1,116 tons of sedimentation annually respectively.

Based on estimated stabilization costs of $71.50 per linear foot, the streambank stabilization cost for these hotspot areas would be about $1.7 million. The Verdigris River mainstem makes up about 35% of the total stabilization cost needs in the watershed totaling $597,838. Costs and percentages for Homer Creek are $410,550 (24%), West Creek $335,785 (19%), North Branch Verdigris River $191,565 (11%), Duck Creek 75,700 (4%) and Onion Creek $116,420 (7%).

Elk City Reservoir

Elk City Reservoir is important in assuring that the cities of Independence and Coffeyville have sufficient water to supply demand. The reservoir is located on Elk River at river mile 8.7 approximately seven miles east of Elk City in Montgomery County. Authorized purposes include flood control, water supply, water quality, fish and wildlife and recreation. The watershed includes portions of Butler, Chautauqua, Elk, Greenwood, Montgomery and Wilson counties. The reservoir has a surface area of 4,239 acres and the watershed draining into it is 634 square miles. Reservoir construction started in 1962 and the multi-purpose pool was filled in 1967. Since then, approximately 30% of the storage capacity has filled with sediment. The reservoir has medium priority TMDLs for both eutrophication and siltation. The TMDL estimates that approximately 446,028 tons/year of sediment enters the reservoir from the watershed.

The predominant land cover in the watershed around Elk City Lake includes 75% grassland/pasture, 10% forest, and 9% croplands, most of which is grown in the floodplains. The remaining land uses within the watershed contain: 3.5% developed, 1.6 % open water, and less than one percent of wetlands.

The watershed is in the Cross Timbers Ecoregion. The term Cross Timbers describes a strip of land in the United States that runs from southeastern Kansas across Central Oklahoma to Central Texas. Made up of a mix of prairie, savanna, and woodland, it forms part of the boundary between the more heavily forested eastern part of the country and the almost treeless Great Plains, and also marks the western habitat limit of many mammals and insects.

The KWO assessment estimates annual tons of sedimentation from streambanks within the Elk City River Reservoir watershed. Sixty-five hotspots of actively eroding sites were identified. Eight of these sites were measured and field verified for streambank height. Using average streambank erosion rates, an estimated 42,588 tons of sediment is transported downstream in the Elk City River Reservoir watershed annually. This accounts for only 9% of the sediment annual load estimated from the TMDL. A substantial quantity of the sediment originating from streambanks is transported from the mainstem Elk River (27,584 tons/year), Duck Creek (476 tons/year) and Salt Creek 14,528 tons/year).

Elk River. Photo courtesy KWO.

Based on estimated stabilization costs of $71.50 per linear foot, streambank stabilization costs for these hotspots would be about $2.6 million. The Elk River makes up about 35% of the total stabilization cost needs in the watershed totaling $1,580,956. Costs and percentages for Duck Creek are $64,521 (3%), and Salt Creek $940,974 (36%).

Based on this assessment, an estimated $5.7 million is needed to address the hotspot reaches that contribute a total of 113,262 tons/year of sediment into the three reservoirs evaluated during this study. Elk City Reservoir will cost the most at $2.6 million, then Toronto Reservoir at $1.7 million and Fall River Reservoir at $1.4 million. An additional $3.6 million is needed to install buffers in the Fall River watershed. Buffer needs and costs in Toronto and Elk City watersheds are undetermined.

For the Verdigris basin above Fall River, Toronto and Elk City reservoirs, KWO continues to recommend streambank stabilization/riparian restoration projects as an effective method of reducing sediment delivery to these reservoirs from streambank sources. Continued land treatment as described in WRAPS plans and streambank protection with buffers is recommended for all three reservoirs. Additional evaluation of gullies and salt scars is needed to determine sediment contribution from these sources. If a WRAPS group is established for the watershed above Elk City Reservoir, it should use the assessment described above to evaluate streambank stabilization and riparian restoration needs in that watershed. Construction of additional watershed dam structures strategically placed in the watershed may also help to reduce sedimentation. A combination of efforts from landscape BMPs, streambank stabilization, and watershed dam construction are all needed to address sediment sources in this watershed.

Recommendation: Continue efforts to prevent the spread of Zebra mussels from infected water bodies.

Confirmation of Zebra mussel infestation has not yet occurred in any Verdigris basin federal reservoir or other impoundment. However, new occurrences of Zebra mussels in reservoirs in other basins continue to be documented. Zebra mussels cost hundreds of thousands of dollars to control once they become established and begin to build up on water intake and other structures. The most effective mechanism for prevention of future infestations is information and education of boaters and anglers to drain, wash and dry their equipment and boats when leaving any water body and before entering another one. Water quality impacts of Zebra mussels are being monitored, along with changes in biological communities. Efforts are ongoing in the basin to prevent infestation in any water bodies.

Recommendation: Continue coordination efforts with the City of Tulsa to ensure good water quality entering Oklahoma from the Verdigris River in Kansas.

The Verdigris River exits Kansas and is impounded in Oklahoma to form Oolagah Reservoir, a drinking water source for the city of Tulsa. About two-thirds of the watershed for Oolagah Reservoir is in Kansas, so discharge of clean water across the state line is a priority for the Verdigris basin. In 2002**,** the City of Tulsa entered into an agreement with the Tulsa District Corps of Engineers to perform a feasibility study to evaluate watershed pollution potential and possible impacts to the reservoir from water flowing into it. The Soil and Water Assessment Tool (SWAT) model has been calibrated for the watershed draining into the reservoir. In Kansas, the watershed area below the four federal reservoirs is included in the model. Various scenarios are being evaluated to guide the implementation of best management practices throughout the watershed and will be used by the Kansas WRAPS group and other programs to develop recommendations for BMPs implementation. Staff from water resource agencies in both states, including the City of Tulsa, have been meeting to coordinate activities and funding to help ensure high quality water flowing into Oolagah Reservoir. BMP implementation will focus on actions to achieve nutrient and sediment reduction goals.

The Corps is completing their Feasibility Study Report. Once it is complete, it is the intent of local stakeholders to consider and utilize information in the report for future project implementation activities.

Recommendation: Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.

Local Authorities for Water Quality Management

While no counties in the Verdigris basin are projected to substantially increase in population, some communities are experiencing growth and expansion which increases impervious areas. As the amount of impervious surface in a watershed (i.e. rooftops, roads, parking lots, etc.) increases, water resources can be adversely impacted from increases in runoff volume and additional pollutants associated with urban environments, unless efforts are made by local governments and urban residents to minimize these adverse impacts through sound land use planning and stormwater management.

Local land use planning and zoning authorities provide cities and counties effective tools to minimize the poten-

tial impacts of development on water resources. Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs that provide technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role. These programs can be integrated with WRAPS projects to ensure a comprehensive approach to watershed management in urban areas.

An important consideration for watershed restoration and protection in the basin will be the potential for conversion of Conservation Reserve Program (CRP) acreage back to production agriculture as contracts expire. Eight hundred and twenty three contracts on 39,131 acres enrolled in the 12 Kansas counties contained wholly or partly in the Verdigris basin expired on September 30, 2007.[(7)] If land is taken out of permanent grass cover, implementation of best management practices will be needed to minimize potential adverse impacts to water resources within the basin.

Other Watershed Related Activities

- Ten counties either wholly or partly within the basin have adopted local sanitary/environmental codes or participate in the LEPP. Chautauqua County has no local sanitary code and does not participate in LEPP.
- Five counties in the basin have countywide planning and zoning programs.
- All conservation districts in the basin have adopted nonpoint source pollution management plans. Grants under the State Water Quality Buffer Initiative have also been awarded in 4 counties in the basin supporting buffer coordinators and facilitating enrollment of stream buffers in continuous CRP.
- Of cities in the basin, Coffeyville is subject to the Phase II Permitted Municipal Separate Storm Sewer System under the NPDES Stormwater Program.
- As of December 2005, there were 6 contamination sites being investigated or remediated through the State Water Plan Contamination Remediation Program.
- There are 12 organized watershed districts in the basin.

RECOMMENDED ACTIONS

1. Continue work with stakeholder leadership groups to incorporate TMDL implementation, nutrient and sediment reduction, and urban stormwater management goals into applicable WRAPS projects.
2. Target technical and financial assistance programs for water quality protection and restoration to implement TMDLs and WRAPS action plans. Coordinate with development of Source Water Protection Plans. Complete development of nine element plans for all WRAPS documents.
3. Continue coordination efforts with the city of Tulsa to ensure good water quality entering Oklahoma from the Verdigris River in Kansas.
4. Complete assessment projects with particular attention to streambank, riparian and wetland assessments to target resources. Encourage private landowner efforts to maintain riparian areas to prevent introduction of excess woody debris into the tributary and river system. Complete a streambank assessment in the Big Hill Reservoir watershed.
5. Continue public outreach efforts to educate the public and landowners about the benefits of best management practices. Encourage other agencies and entities in partnerships and participation to support WRAPS initiatives, activities and funding.
6. Continue efforts to prevent the spread of Zebra mussels from infected water bodies.
7. Complete an inventory and assessment of gullies and salt scars in the basin, with priority in the federal reservoir watersheds, to determine their contribution to sediment in those watersheds.

RESOURCES

1. KWP. 2006. Water Quality Policy and Institutional Framework Section. KWO.
2. KDHE Bureau of Environmental Remediation. December 2005. *Basin Updates and Site Accomplishments*
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6. KDHE Bureau of Water. 2007. *Watershed Planning and TMDL Program*, www.kdheks.gov/tmdl.
7. USDA Farm Service Agency. 2007. *Summary of Active and Expiring CRP Cropland Acres by County*. www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crt
8. Kansas Water Office. Reservoir Roadmap Volume III. Verdigris Basin. 2010.