KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

ELK CITY LAKE WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2007-0061

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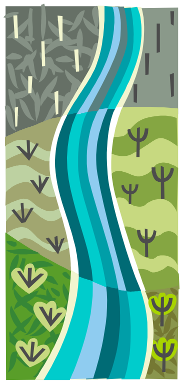

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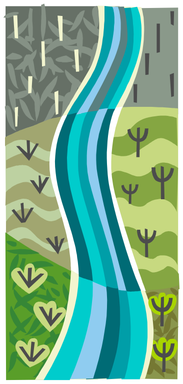
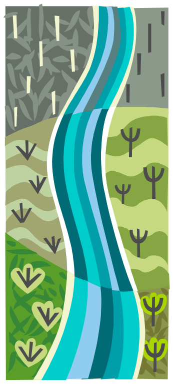


Acknowledgments

This project was made possible with financial support provided by State Water Plan funds administered by the Kansas Department of Health and Environment – Watershed Management Section, granted to K-State Research and Extension through the Kansas WRAPS (Watershed Restoration and Protection Strategy) – Elk City Lake Watershed Assessment project (2007-0061).

The Assessment phase of this project resulted from the dedicated team effort of these KSU personnel:

- Aleksey Y. Sheshukov, Watershed Modeler
- Amir Pouyan Nejadhashemi, Watershed Modeler
- Rohith Gali, Graduate Student, Watershed Modeler
- Josh Roe, Watershed Economist
- Craig M. Smith, Watershed Economist
- Robert M. Wilson, Watershed Planner
- Sue P. Brown, Watershed Communication
- John C. Leatherman, Professor, Agricultural Economics
- William Hargrove, past KCARE Director



Executive Summary

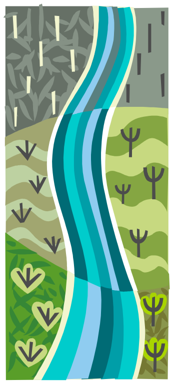
This project served to compile and develop watershed environmental and economic information to assist stakeholders in the Elk City Lake watershed to develop a Watershed Restoration and Protection Strategy (WRAPS) Plan and Report.

Initiated in June 2007, most project activities were completed by May 2009. This WRAPS Assessment Phase project has completed about 60% of its initial goals. The remaining portion of the project will require engagement with the Stakeholder Leadership Team, which has yet to be formed.

Project accomplishments include:

- *Watershed Assessment*: We compiled existing information related to the Elk City Lake watershed, culminating in development and publication of a Watershed Atlas.
- *Watershed Modeling*: We completed a SWAT modeling analysis of baseline watershed conditions.
- *Economic Analysis*: We developed user-friendly decision tools for stakeholder groups to analyze and compare economic and environmental effects of cropland BMPs, vegetative buffer systems, streambank stabilization systems, and tillage systems; and completed an analysis of recreational benefits of Elk City Lake.

Once a Stakeholder Leadership Team is established, further work is needed to engage this team in the process of clarifying WRAPS objectives and assessment needs, refining watershed information and modeling data, reviewing modeling results, and assessing economic and environmental impacts of various management scenarios.



Introduction

Geographic Scope/Location

The Elk City Lake Watershed (HUC 11070104) encompasses parts of Elk, Montgomery, Wilson, and Chautauqua Counties in southeast Kansas. The watershed is primarily the drainage area for Elk River and its tributaries. Major lakes in the watershed include Elk City Lake. Right upstream of the watershed outlet Elk River drains into Elk City Lake and then flows into Verdigris River. Elk City watershed occupies three 10-digit HUC watersheds (1107010401, 1107010402, 1107010403) or 18 12-digit HUC watersheds (110701040101, 110701040102, 110701040103, 110701040104, 110701040105, 110701040201, 110701040202, 110701040203, 110701040204, 110701040205, 110701040301, 110701040302, 110701040303, 110701040304, 110701040305, 110701040306, 110701040307, 110701040308). Main drainage area of the watershed is 449,425 acres or 702 mi^2 (see Figure 1).

Population

The Elk City Lake watershed is a rural agricultural area. There are five small towns in the watershed: Howard, Elk City, Longton, Elk Falls, and Moline (see Figure 2). According to the 2000 census data from the U.S. Census Bureau, population of the largest town Howard is 808 people, with Elk City, Longton, and Moline of 300 to 400 people. The smallest town of Elk Falls is of 112 people (see Table 1). According to the 2000 U.S. Census Bureau, the estimate population within the Elk City Lake watershed is 4081 people (6.4 people/mi^2).

Table 1: Estimate population in the watershed
(http://quickfacts.census.gov/qfd/index.html)

Area	Population
Howard	808
Moline	457
Elk Falls	112
Longton	394
Elk City	305
Watershed	**4,081**

Figure 1: Elk City Lake Watershed Map

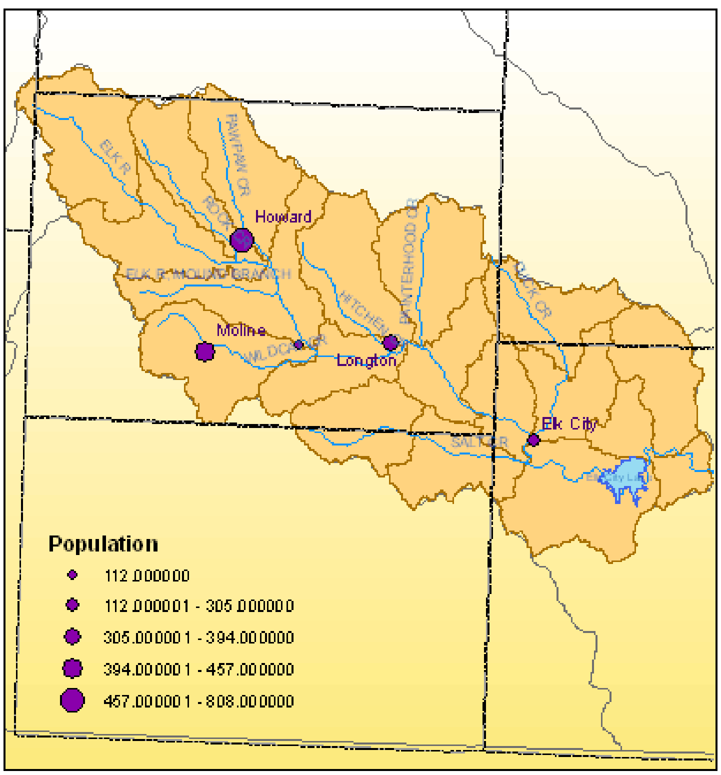


Figure 2: Population in Elk City Lake Watershed

Surface Water Resources

The Elk City Lake is located at the outlet of 110701040306 HUC-12 watershed and collects water from the upstream drainage area of 401,220 acres (627 mi^2). The surface area of the Elk City Lake is 4,400 acres (6.88 mi^2). Elk River is the major stream that feeds the lake. Mean precipitation for the watershed ranges from 36 to 42 inches and mean runoff is 8 inches/year. Maximum depth of the Elk City Lake is 8.0 meters with mean depth of 3.2 meters. Storage volume of the Elk City Lake is 46,053 acre-feet. The lake averages 53.1 inches of evaporation, 365,052 ac-ft/yr outflow, and 381,577 ac-ft/year inflow. Year-to-year variations in inflow and outflow have ranged from 100,000 ac-ft/yr to >800,000 ac-ft/yr.

Designated Uses

Designated uses for the surface water resources in this watershed generally include: expected aquatic life support, food procurement, groundwater recharge, irrigation and livestock watering use, domestic and industrial water supply, and primary contact recreation.

Public Water Supplies

A little more than one-third of the households in Elk County are on septic systems (U.S. Census, 1990). Households that are not served by the public sewer system associated with four municipal NPDES facilities within this watershed are presumably on septic systems.

Land Uses/Activities

Grassland (considered grazing land for livestock) is the predominant land use, covering 75% of the watershed. Row crop agriculture makes up 9%, wooded areas 10%, urban areas 3.5%, less than one percent of wetlands, and water resources occupy the remaining 1.6% of the watershed. The majority of the croplands lie within the flood plain of the Elk River and in the lower portion of the watershed. Areal distribution of farm size in the watershed is shown in Figure 3. General uses of cropland consist of corn, wheat, sorghum, and soybeans (see Figure 4).

Common Cropland BMPs in Elk Watershed

BMPs help reduce the amount of soil and nutrients that run off of cropland fields. Keeping these valuable inputs (soil and nutrients) in the field can be of benefit to both the landowner/producer and to society as a whole. Here are just a couple of the benefits:

1. Top soil savings can result in higher yields and lower fertilizer costs
2. Certain BMPs can offer both water quality protection and wildlife habitat

Below are some of the more popular BMPs in use in the Elk City Lake watershed.

- Contour farming is farming the land, tillage and planting of the crop, on the level around the hill. By doing this, each furrow or ridge left by the different implements acts as miniature dams, trapping water, allowing more to soak into the ground. Each row of crop also slows the water. Combined, less water runs off. Soil is erosion reduced. Crop yields are increased in arid areas.

- Grassed waterways are used as outlets to prevent silt and gully formation. The vegetation cover slows the water flow and minimizes channel surface erosion. They can also be used as outlets for water from terraces.
- Vegetative buffers are areas of land that are maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife. Because of these societal benefits, there are several federal and state programs that encourage the installation and maintenance of vegetative buffers.
- No-till is a form of conservation tillage in which chemicals are used in place of tillage for weed control and seedbed preparation. In other words, the soil surface is never disturbed except for planting or drilling operations in a 100 percent no-till system. Two other forms of tillage, reduced tillage and rotational no-till, involve a light to moderate use of tillage equipment. These forms of tillage also control erosion and nutrient runoff, but are not as effective as 100 percent no-till.
- Terraces are embankments constructed perpendicular to the slope of the field and are designed to reduce the length of a field slope and catch water flowing off the slope. Terraces reduce the rate of runoff and allow soil particles to settle out.
- Streambank stabilization projects can reduce the amount of streambank erosion and help prevent the loss of valuable cropland. Stabilization techniques reduce streambank erosion through diverting and/or slowing the movement of water in a stream channel. Some methods that can be employed include bendway-weirs, stone toes, pools and riffles, stream barbs, and willow post plantings.

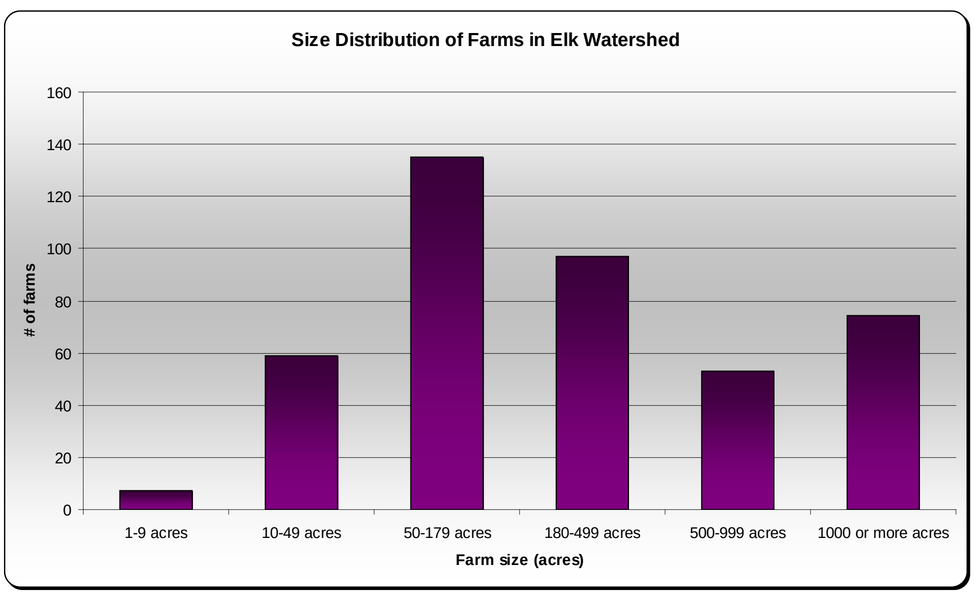


Figure 3: Farm size distribution in Elk City Lake Watershed

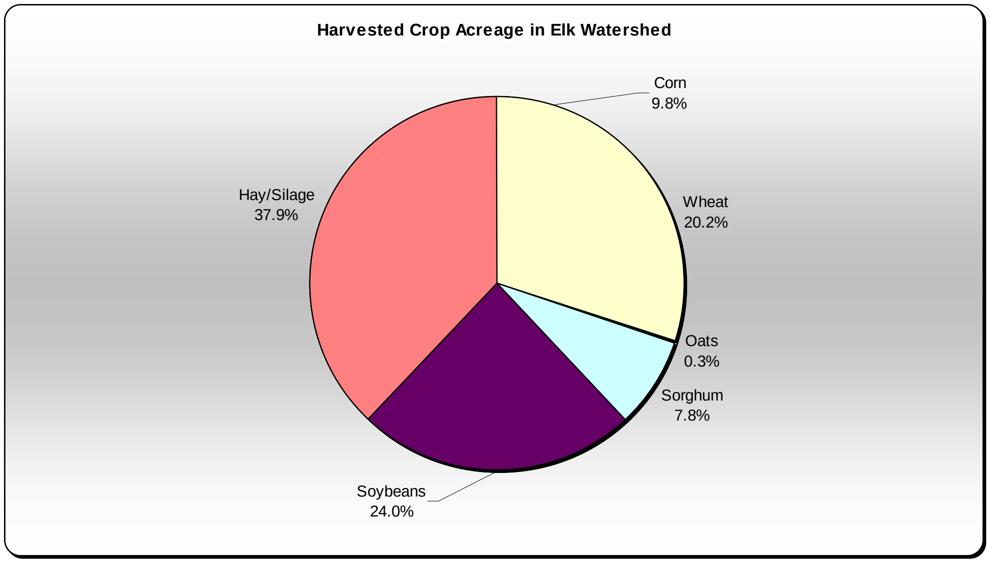


Figure 4: Harvested crop areas in Elk City Lake Watershed

There are 13 certified or permitted confined animal feedlot operations (CAFO) located in the Elk City Lake watershed (see Table 2). The majority of these contains within the lower portion of the watershed near Duck Creek, Elm Branch and the lower portion of the Elk River within Wilson and Montgomery counties. CAFOs are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that is less than 1-5% of the time. Though the potential number of animals associated with the certified confined animal feedlot operations is 27,262 head in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number. However, since the watershed is dominated by grassland and pasture the number of smaller animal feeding operations that are not registered is presumably high, particularly during seasonal feeding months in the winter.

According to the 2006-2007 Kansas Agricultural Farm Facts, there are 29,500 and 33,900 head of cattle in Elk and Montgomery Counties respectively (see Figure 5). In addition, Elk County ranks eleventh in the state for pasture acreage. Grazing densities within the watershed are estimated at approximately 54 head of cattle per square mile. The high percentage of grassland and pasture in the watershed may serve as ideal seasonal grazing lands for livestock during the winter months, which may account for highly variable livestock populations within the watershed from one year to the next.

There are 8 permitted waste treatment facilities located within the Elk City Lake watershed. Of these eight facilities, two are non-overflowing facilities that are prohibited from discharging and two are quarry operations that have minimal discharges. The remaining four facilities are discharging municipal wastewater treatment facilities. The non-overflowing lagoons may contribute to the load under extreme precipitation events; however these events would not occur at a frequency or for a sufficient duration to cause impairment in the watershed.

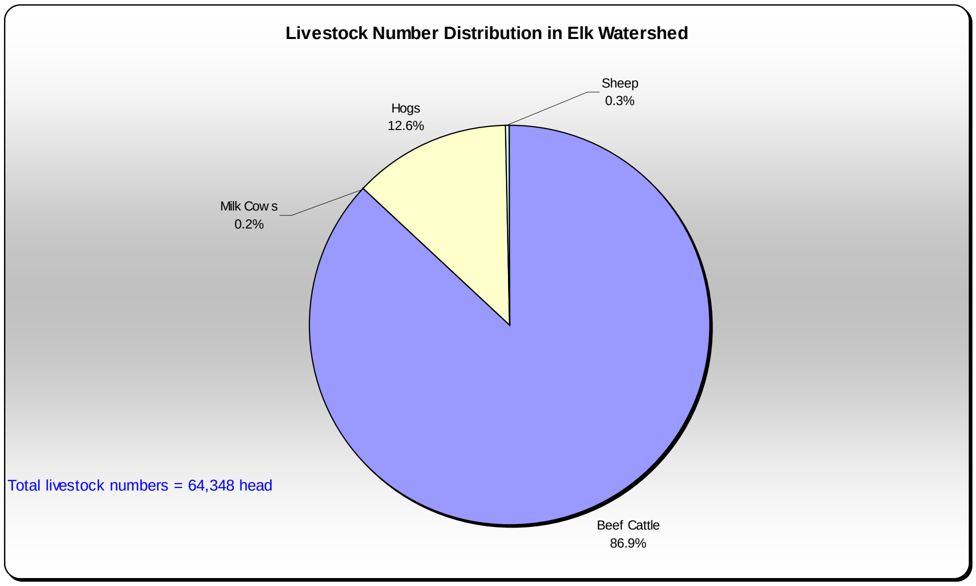


Figure 5: Livestock distribution in Elk City Lake Watershed

Table 2: Permitted waste treatment facilities within the Elk City Lake watershed (Elk City Lake TMDL, 2009)

Permit	Facility	Type	Design Flow (mgd)	Permit Expires
I-VE27-PO02	Harshman Construction	Settling Ponds		2011
I-VE14-PO01	Midwest Minerals - #23 Elk City Qry	Stormwater Runoff/ pit de-watering		2011
I-VE27-NP02	C & M Car Wash	Single-cell Lagoon	Non-Discharging	2011
M-VE23-NO01	KDWP – Elk City State Park	Two-cell Lagoon	Non-Discharging	2012
M-VE27-OO01	City of Moline	Three-Cell Lagoon	0.105	2011
M-VE25-OO01	City of Longton	Three-Cell Lagoon	0.0566	2011
M-VE22-OO02	City of Howard	Three-Cell Lagoon	0.1325	2011
M-VE14-OO01	City of Elk City	Two-Cell Lagoon	0.0344	2011

Wildlife Habitat

Species common to the area included white-tailed deer, ducks, wild turkey, bobwhite quail, cottontail rabbits, fox and gray squirrel, and prairie chicken. Common furbearers include beaver, raccoon, bobcat, coyote, gray fox, opossum, mink and muskrat. Fishable populations in the Elk City Lake are bullhead, crappie, bluegill, channel catfish, flathead catfish, green sunfish, largemouth bass, saugeye, and white bass.

Recreational Areas

Main recreational area in the watershed is Elk City State Park which is located in Montgomery County, approximately 5 miles northwest of Independence, Kansas. The State Park was leased from the U.S. Army Corps of Engineers in 1967 and the lease area involved 857 acres. Camping in the Elk City State Park is permitted in the state park campground and along Table Mound Hiking Trail south of the county road. There are 2 campgrounds, 5 trails (The Green Thumb Nature Trail (1 mile), Table Mound Hiking Trail, Post Oak Self-Guiding Nature Trail, and The Elk River Hiking Trail (scenic 15 mile trail). Elk City Reservoir within the state park offers well to excellent fishing opportunities. In 2007, the U.S. Army Corps of Engineers reported 120,493 visits to Elk City Lake for a total of 1,482,006 visitor-hours from 10/2006 to 9/2007.

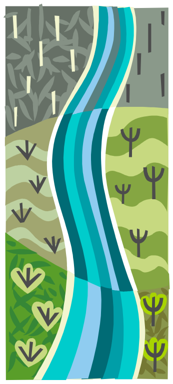
Watershed / Water Quality Conditions

The Clean Water Act sets water quality goals for the U.S. Section 303(d) of the Clean Water Act requires states to submit to the U.S. EPA a list of impaired water bodies (303(d) list). For each water body listed, the state must develop a Total Maximum Daily Load (TMDL), which defines both the water-quality objective and the strategy needed to meet that objective. In Kansas, the Kansas Department of Health and Environment (KDHE), Division of Environment, Bureau of Water, Watershed Planning Section has responsibility to develop the 303(d) list of impaired water bodies and develop TMDLs to address each concern.

Elk City Lake has a medium priority TMDL for eutrophication (approved 9/30/09). Elk River currently has a medium priority TMDL for dissolved oxygen and a medium priority TMDL for fecal coliform bacteria (approved 9/30/02).

- Verdigris Basin TMDL. Waterbody: Elk City Lake. Water Quality Impairment: Eutrophication. <http://www.kdheks.gov/tmdl/ve/Elk_City_TMDL.pdf>
- Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Dissolved Oxygen. <http://www.kdheks.gov/tmdl/ve/ElkR_DO.pdf>
- Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Fecal Coliform Bacteria. <http://www.kdheks.gov/tmdl/ve/ElkR_FCB.pdf>

These impairments can be attributed to agricultural and rural homeowner use activities. Contact recreation in surface waters are being impacted by the presence of fecal coliform bacteria. Public water supplies for rural water districts and private wells are indirectly threatened by water quality impairments. Overgrazing is a problem in certain areas in addition to brush and invasive non-native species introduction. Oil and gas production does occur in this area and therefore brine scars are evident. Flash flooding occurs during storm events primarily in the spring.



Goals, Objectives, and Tasks

Goals

The goal of this project was to provide the watershed environmental and economic information needed for the development of a stakeholder-led Watershed Restoration and Protection Strategy (WRAPS) Plan and Report.

A primary goal of this project was to develop models and tools to evaluate alternative farm and non-farm land use practices in relation to water quality and economics and to document the impact of water restoration and preservation strategies.

Objectives

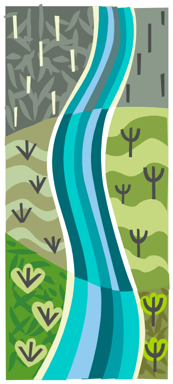
The objectives of this WRAPS Development Phase Project were to

1. characterize watershed conditions,
2. identify needs and opportunities for watershed information to support stakeholder decisions, and
3. understand how the watershed responds to various management scenarios.

Tasks/Activities

The major tasks/activities implemented to achieve project objectives involved:

1. Inform and educate watershed stakeholders.
2. Establish assessment criteria.
3. Inventory existing information.
4. Provide technical information to support implementation decisions.
    a. Watershed Assessment
    b. Watershed Modeling
    c. Economic Analysis
5. Prepare watershed assessment project report.



Summary of Project Activities and Accomplishments

Timeframe

The activities implemented as part of this WRAPS Assessment Phase project were ongoing for approximately two years, starting in May 2007 and ending in July 2009.

Inform and Educate Watershed Stakeholders

The WRAPS Development phase project (beginning January 2006) failed to identify, recruit, and engage a Stakeholder Leadership Team for the Elk City Lake watershed. This outcome was not anticipated at the outset of this WRAPS Assessment phase project, but significantly impacted the final results and impact of the project.

Much of the project effort was geared to anticipating and preparing the watershed assessment information that would be needed by the Stakeholder Leadership Team early in their WRAPS assessment phase.

This Final Report provides the information that will be needed to get a WRAPS Stakeholder Leadership Team started at some time in the future.

Establish Assessment Criteria

Without a Stakeholder Leadership Team, this project assumed that the preliminary assessment information needed for this WRAPS project would be similar to those needed by other similar Stakeholder Leadership Teams.

A future WRAPS project would be needed to review existing data, determine data gaps, and refine assessment needs. These stakeholders should be involved in establishing the assessment criteria that will be given priority, developing potential land management strategies for assessment, and recommending and reviewing monitoring strategies to support assessment and evaluate implementation

Inventory Existing Information

Again, without a Stakeholder Leadership Team, this project assumed that the preliminary assessment information needed for this WRAPS project would be similar to those needed by other similar Stakeholder Leadership Teams.

A future WRAPS project would be needed to identify relevant information regarding watershed conditions, natural resources, culture, customs, institutions, etc.

The project team inventoried watershed informational resources, TMDL needs inventories, previous watershed assessment reports, water-quality studies, USGS monitoring data, wildlife reports, riparian assessments, etc. Details about this process and the data compiled are presented in the *Watershed Assessment* section, below.

Provide Technical Information to Support Implementation Decisions

Watershed Assessment

Watershed Atlas

Extensive information about the watershed and surrounding area was collected, compiled, and published as a Preliminary Assessment Report (often called the "Watershed Atlas"). This information was published as a K-State Research and Extension publication, thus making it available digitally online:

- Elk River Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-143. 56 pages. <http://www.ksre.ksu.edu/library/h20ql2/ep143.pdf>

This publication included the following topics:

- 1.0. Elk River Watershed Assessment
    - 1.1. Watershed Summary
    - 1.2. Overview of Water Quality Issues and Potential Pollution Sources
- 2.0. Climate Mapping System
    - 2.1. Precipitation Map
    - 2.2. 30-Year Average Daily Maximum Temperature Map
    - 2.3. 30-Year Average Daily Minimum Temperature Map
- 3.0. Land Use/ Land Cover
    - 3.1. Land Use (GIRAS 1980s)
    - 3.2. Land Use (NLCD 1992)
    - 3.3. Land Use (NLCD 2001)
- 4.0. River Network
- 5.0. Hydrologic Soil Groups
- 6.0. Water Quality Conditions
    - 6.1. The 303d List of Impaired Waterbodies
    - 6.2. Water Quality Observation Stations
    - 6.3. USGS Gage Stations
    - 6.4. Permitted Point Source Facilities
    - 6.5. Confined Animal Feeding Operations (CAFOs)
    - 6.6. 1990 Population and Sewerage by Census Tract
- 7.0. Agricultural Economy
    - 7.1. Corn Cost-Return Budget
    - 7.2. Soybean Cost-Return Budget
    - 7.3. Wheat Cost-Return Budget
    - 7.4. Grain Sorghum Cost-Return Budget
    - 7.5. Alfalfa Cost-Return Budget
    - 7.6. Common Cropland BMPs in Elk River Watershed
        - 7.6.1. Vegetative Buffer: Economic Analysis and Discussion

        - 7.6.2. Streambank Stabilization: Economic Analysis and Discussion
    - 7.7. Economic Contributions of Recreation at Elk City Lake
    - 7.8. Census Data
- 8.0. Modeling
    - 8.1. Subbasin Map
    - 8.2. Input Data
    - 8.3. Model Outputs

TMDL Reports

The TMDL documents provide a rich source of watershed information:

- Verdigris Basin TMDL. Waterbody: Elk City Lake. Water Quality Impairment: Eutrophication. <http://www.kdheks.gov/tmdl/ve/Elk_City_TMDL.pdf>
- Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Dissolved Oxygen. <http://www.kdheks.gov/tmdl/ve/ElkR_DO.pdf>
- Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Fecal Coliform Bacteria. <http://www.kdheks.gov/tmdl/ve/ElkR_FCB.pdf>

Within these documents are descriptions and discussions of key water quality conditions and sources, and guidance for potential action. Major topics include:

1. Introduction and problem identification – basic waterbody and watershed data
2. Current water quality condition and desired endpoint – summary of available stream and lake data
3. Source inventory and assessment – data on land uses, point sources
4. Allocation of pollutant reduction responsibility – modeling-based load allocations
5. Implementation – potential activities, state and federal educational and funding support programs, milestones
6. Monitoring – plans for future efforts
7. Feedback – process used by KDHE during TMDL development

More information about KDHE's TMDL process can be found at the KDHE, Division of Environment, Bureau of Water, Watershed Planning Section web site:

- Kansas Total Maximum Daily Loads (TMDLs). <http://www.kdheks.gov/tmdl>

Watershed Modeling

There are few water-quality watershed models, simple and complex, that can be used for Elk City Lake watershed assessment. Simple models like STEPL and REGION5 developed by the Environmental Protection Agency (EPA) use mainly empirical equations to model hydrologic and water-quality processes. The complex models like Soil and Water Assessment Tool (SWAT) incorporate multiple submodules which primarily use physically based distributed equations to model various processes in the watershed. The use of complex models requires specific knowledge of physical processes as well as technical skills to run the model.

For Elk City Lake watershed, the project team used STEPL and SWAT and geographic information system (GIS) databases to model the watershed and identify critical areas with higher potential for sediment and nutrients to reach the stream. The results of the STEPL model are presented in the Preliminary Assessment Report and not discussed in this report.

SWAT model

The Soil and Water Assessment Tool (SWAT) model is a physically based, deterministic, continuous, watershed-scale simulation model developed by the USDA Agricultural Research Service (Arnold et al., 1998; Neitsch et al., 2005). ArcGIS interface of ArcSWAT version 9.2 was used. It uses spatially distributed data on topography, soils, land cover, land management, and weather to predict water, sediment, nutrient, and pesticide yields.

The Elk City Lake watershed was divided spatially into subwatersheds using digital elevation data according to the drainage area specified by the user. Subwatersheds are modeled as having non-uniform slope, uniform climatic conditions determined from the nearest weather station, and they are further subdivided into lumped, non-spatial hydrologic response units (HRUs) consisting of all areas within the subwatershed having similar soil, land use, and slope characteristics. The use of HRUs allows slope, soil, and land-use heterogeneity to be simulated within each subwatershed, but ignores pollutant attenuation between the source area and stream within a given HRU, and limits spatial representation of wetlands, buffers, and other BMPs within a subwatershed.

SWAT produces daily results for every subwatershed outlet, each of which can be summed to provide daily, monthly, and annual load estimates.

The model includes subbasin, reservoir, and channel routing components.

- The subbasin component simulates runoff and erosion processes, soil water movement, evapotranspiration, crop growth and yield, soil nutrient and carbon cycling, and pesticide and bacteria degradation and transport. It allows simulation of a wide array of agricultural structures and practices, including tillage, fertilizer and manure application, subsurface drainage, irrigation, ponds and wetlands, and edge-of-field buffers
- The channel component routes flows, settles and entrains sediment, and degrades nutrients, pesticides and bacteria during transport.
- The reservoir component detains water, sediments, and pollutants, and degrades nutrients, pesticides and bacteria during detention.

Throughout the years the SWAT model has been tested for a wide range of regions, conditions, practices, and time scales. Evaluation of monthly and annual streamflow and pollutant outputs indicate SWAT functioned well in a wide range of watersheds.

Data collection

Data for the SWAT model of Elk City Lake watershed were collected from a variety of online and printed data sources and knowledgeable people within the watershed. The primary sources of input data are in the form of thematic GIS layers. Such layers include topography, land use/land cover, and soil spatial distribution. Other input data can also be available in a form of GIS layers, but these were loaded into the model as tables with items manually distributed over subwatersheds or HRUs. Multiple programming utilities have been developed to process the input data, enter it into the SWAT model, and analyze the output results. We used Visual Basic, Visual Basic for Applications and Visual Studio C++ as main programming languages to develop the data processing utilities.

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations vary from 220 m to 511 m above the sea level (see Figure 6). The watershed is delineated into 22 subwatersheds (see Figure 7).

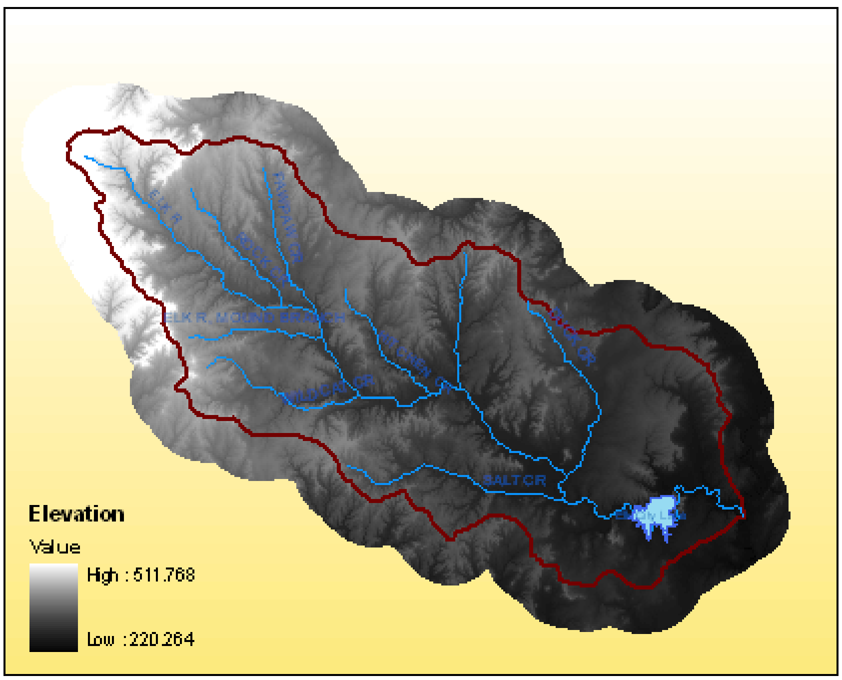


Figure 6: Topography of Elk City Lake Watershed

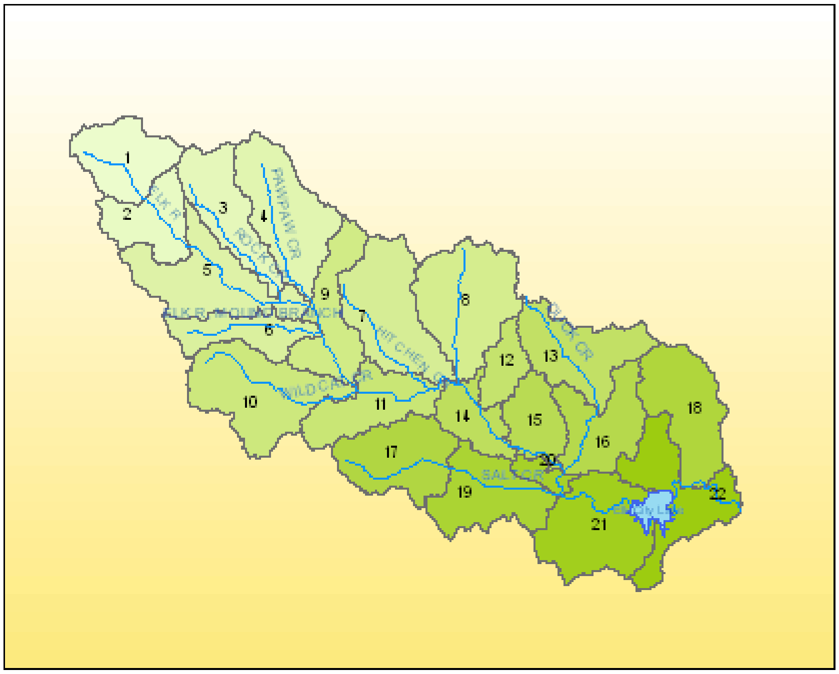


Figure 7: Elk City Lake Watershed showing 22 subwatersheds

The land use dataset used in the model is the USDA National Land Cover Dataset (NLCD) prepared in 2001. NLCD 2001 has 10 standardized categories with 6 main categories presented in Figure 8 and summarized in Table 3 for Elk City Lake watershed.

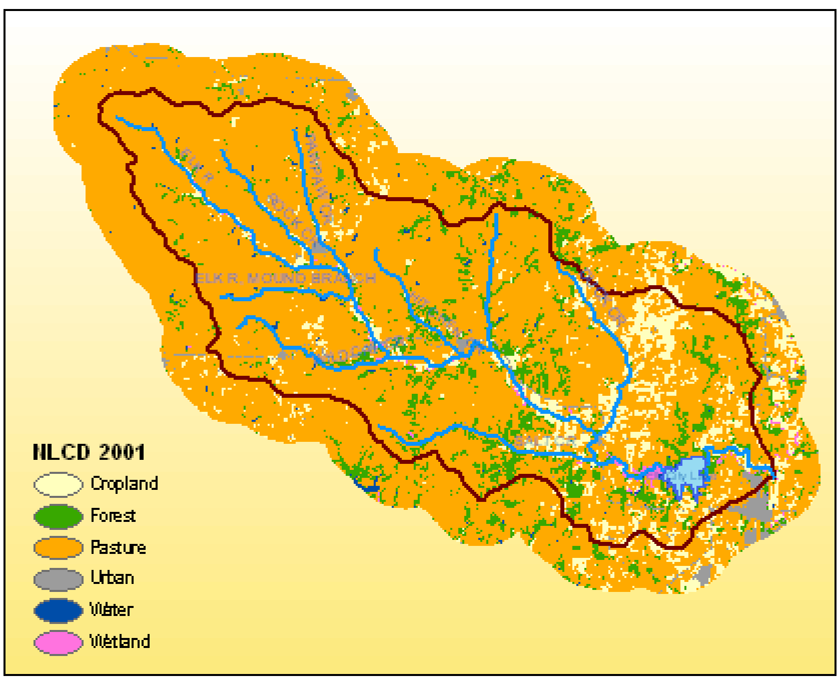


Figure 8: Land Use for Elk City Lake Watershed

Table 3: Areas of land uses and its classification used in SWAT model

Land Use	Area [ha]	Area[acres]	%Wat.Area
Water	2724.30	6731.88	1.50
Residential-Low Density	5620.95	13889.65	3.09
Residential-Medium Density	916.74	2265.31	0.50
Residential-High Density	57.87	143.00	0.03
Industrial	5.40	13.34	0.00
Southwestern US (Arid) Range	162.18	400.75	0.09
Forest-Deciduous	17540.19	43342.69	9.64
Forest-Mixed	858.24	2120.75	0.47
Range-Brush	54.63	134.99	0.03
Range-Grasses	86744.34	214349.60	47.69
Hay	48934.44	120919.45	26.91
Agricultural Land-Row Crops	16716.15	41306.44	9.19
Wetlands-Forested	1473.03	3639.93	0.81
Wetlands-Non-Forested	67.77	167.46	0.04
Total	**181876.23**	**449425.26**	**100.00**

The Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) soils database and its geo-spatial coverage were used as an input for the SWAT model. Groups A, B, C, and D represent different soil textures and commonly vary from sandy soils in Group A to clay soils in Group D. High percentage of C and D group soils present higher soil erosion potential. Figure 9 and Table 4 show 17 soils, their distribution and characteristics in the watershed.

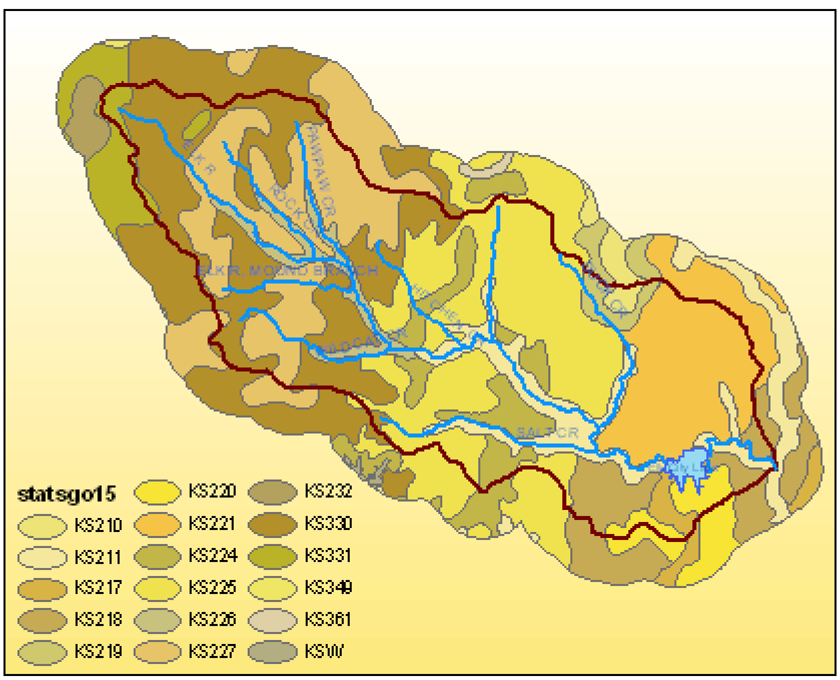


Figure 9: Soil maps for Elk City Lake Watershed

Table 4: Soil characteristics used in SWAT model

Soils	Area [ha]	Area[acres]	%Wat.Area	Soil Hydro Group
KS210	896.67	2215.72	0.49	C
KS211	14189.49	35062.94	7.8	D
KS217	1897.20	4688.08	1.04	C
KS218	7610.22	18805.23	4.18	B
KS219	2313.45	5716.65	1.27	D
KS220	3409.29	8424.53	1.87	D
KS221	22360.14	55253.02	12.29	B
KS224	11373.48	28104.44	6.25	B
KS225	41110.83	101586.92	22.6	D
KS226	6586.02	16274.38	3.62	B
KS227	30779.10	76056.70	16.92	D
KS330	36402.93	89953.46	20.02	C
KS331	1792.44	4429.21	0.99	C
KSW	1154.97	2853.99	0.64	D
Total	**181876.23**	**449425.26**	**100.00**	

Weather data was collected and downloaded from NOAA National Climatic Data Center (NCDC, 2009). There are total 8 weather stations around the watershed; 7 stations with precipitation data and 4 stations with non-precipitation data.

Among other input information entered into the SWAT model, we can list crop rotations, grazing management operations, confined animal feeding operations (CAFO), permitted point source facilities, and septic systems. From prior experience, these data should be confirmed and revised using local stakeholder knowledge and information.

<u>Targeted subwatersheds</u>

The SWAT model was setup to run for 15 years from 1993 to 2008 with the first 5 years dedicated for a model warm-up period, to allow model parameters to adjust from the default initial condition. The results were collected on an annual basis for each subwatershed and then averaged out over the simulation period. Model output variables, such as sediment yield, organic, mineral and soluble phosphorous concentrations, and nitrate and nitrogen concentrations, were collected and combined in the forms of total sediment, phosphorous, and nitrogen loads. Figure 10 presents maps of such loads in a scale of graduated colors (darker color indicates higher load).

Table 5 lists annual loads for each subwatershed calculated by SWAT. Subwatersheds 13, 14, 16, 20, 22 (with highest annual loads) were identified and selected as targeted subwatersheds (see Figure 11). The targeted subwatersheds were selected as subwatersheds that produce top 20% of the nitrogen, phosphorous and sediment loads. Without local knowledge from the Stakeholder Leadership Team, these targeted subwatersheds should be considered as preliminary, representative results.

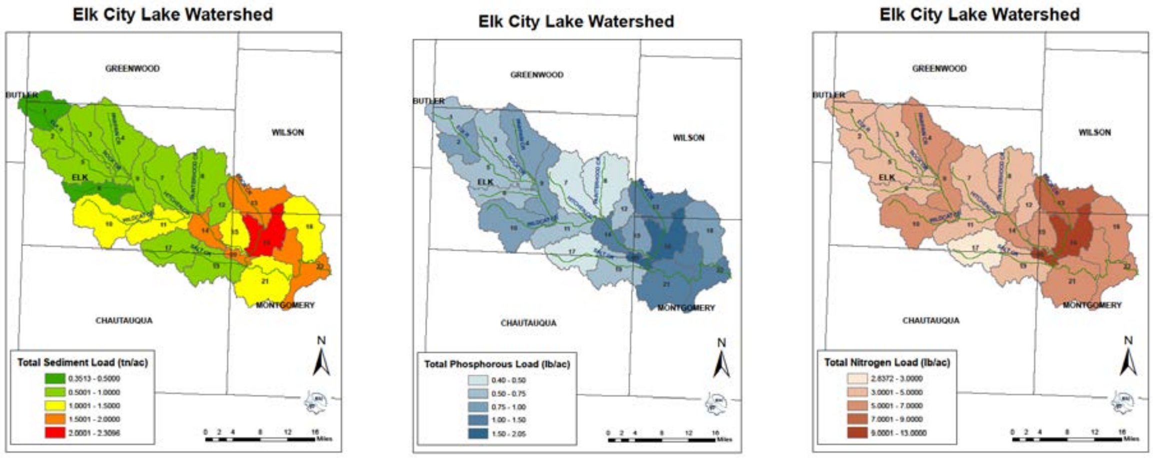


Figure 10: Maps of total sediment, nitrogen, and phosphorous subwatershed loads

Table 5: Total pollutant loads for each subwatershed

Subbasin	Total Sediment (tons/acre)	Total Phosphorous (lbs/acre)	Total Nitrogen (lbs/acre)
1	0.35	0.55	3.71
2	0.69	0.78	4.91
3	0.62	0.69	4.51
4	0.73	0.79	5.19
5	0.62	0.69	4.48
6	0.46	0.59	4.06
7	0.63	0.47	3.19
8	0.75	0.49	3.25
9	0.81	0.85	5.49
10	1.06	0.87	5.60
11	1.04	0.74	4.67
12	0.79	0.62	4.13
13	1.66	1.45	8.89
14	1.51	1.09	6.84
15	1.14	0.97	6.27
16	2.31	1.83	10.84
17	0.76	0.41	2.84
18	1.33	0.97	5.80
19	0.74	0.53	3.37
20	1.81	2.05	12.33
21	1.47	1.06	6.41
22	1.73	1.06	6.35

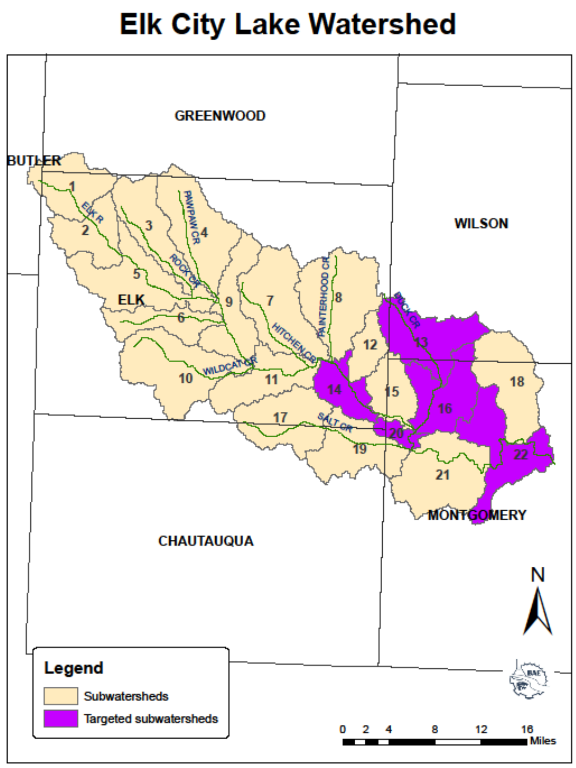


Figure 11: Targeted subwatersheds identified by the SWAT model

Stakeholder engagement

A critical element of the WRAPS watershed modeling process is to engage stakeholders in the collection and verification of watershed data (Mankin, 2008). This process assures that we are modeling "their watershed" using the best local data available. Over a period of several meetings, the watershed modeler meets with stakeholders, presents baseline data, receives feedback and corrections on these data, revises model inputs to represent local data, and re-runs the model using these stakeholder-modified input data.

During the iterative engagement process, the stakeholders develop an understanding of how the assessment data and modeling results can be used to inform, but not dictate, their watershed planning decisions.

Without a Stakeholder Leadership Team, this project was not able to complete the critical stakeholder engagement process needed to make the modeling results truly relevant for the WRAPS planning process.

A future WRAPS project would be needed to work with stakeholders to assure that the watershed model is using appropriate local data and that results address local concerns.

Economic Analysis

General Economic Research

Cost-return budgets have been developed for the Elk City Lake watershed by working with data from the Kansas Farm Management Association (Tables 6 through 10). The budgets are specific to Elk City Lake watershed and vary by inputs and yields. Specific BMP budgets have been developed for vegetative buffers, terraces, streambank stabilization, and reduced/no-till and available in the Elk City Lake watershed atlas.

We compiled lists of financial incentives/programs available through EQIP for both water quality and quantity conservation practices. These lists include both average costs and cost share percentages. We have also identified other programs which offer funding for conservation practices. Since vegetative and riparian forest buffers are supported through multiple funding programs, separate lists have been created to help producers calculate the amount of cost share and annual incentive payments that are available.

Table 6: Cost-return projection for Corn crops in the Elk City Lake watershed

CORN	Yield Level (bu)		
	80	**110**	**140**
INCOME PER ACRE			
A. Yield per acre	80	110	140
B. Price per bushel	$2.70	$2.70	$2.70
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$226.48	$308.39	$390.30
COSTS PER ACRE			
1. Seed	$32.43	$32.43	$36.66
2. Herbicide	33.85	33.85	33.85
3. Insecticide/Fungicide	0.27	0.27	0.27
4. Fertilizer and Lime	37.48	45.4	53.32
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7	7	7
9. Custom Hire / Machinery Expense	90.16	98.83	107.5
10. Non-machinery Labor	10.19	11.17	12.15
11. Irrigation			
12. Land Charge / Rent	34.4	43	51.6
G. SUB TOTAL	$245.77	$271.94	$302.34
13. Interest on ½ Nonland Costs	9.51	10.3	11.28
H. TOTAL COSTS	$255.28	$282.25	$313.63
I. RETURNS OVER COSTS (F-H)	**($28.81)**	**$26.14**	**$76.68**
J. TOTAL COSTS/BUSHEL (H/A)	$3.19	$2.57	$2.24
K. RETURN TO ANNUAL COST (I+13)/G	-7.85%	13.40%	29.09%

Data acquired from: Sarah L. Fogleman and Stewart R. Duncan, Corn Crop Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 7: Cost-return projection for Soybean crops in the Elk City Lake watershed

SOYBEANS	Yield Level (bu)		
	25	**35**	**45**
INCOME PER ACRE			
A. Yield per acre	25	35	45
B. Price per bushel	$6.08	$6.08	$6.08
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$162.48	$224.19	$285.90
COSTS PER ACRE			
1. Seed	$30.60	$30.60	$32.95
2. Herbicide	8.86	8.86	8.86
3. Insecticide/Fungicide			
4. Fertilizer and Lime	16.41	17.7	21.2
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7	7	7
9. Custom Hire / Machinery Expense	73.03	77.25	80.22
10. Non-machinery Labor	8.25	8.75	9.06
11. Irrigation			
12. Land Charge / Rent	34.4	43	51.6
G. SUB TOTAL	$178.55	$193.14	$210.89
13. Interest on ½ Nonland Costs	6.49	6.76	7.17
H. TOTAL COSTS	$185.03	$199.89	$218.06
I. RETURNS OVER COSTS (F-H)	**($22.56)**	**$24.30**	**$67.84**
J. TOTAL COSTS/BUSHEL (H/A)	$7.40	$5.71	$4.85
K. RETURN TO ANNUAL COST (I+13)/G	-9.00%	16.08%	35.57%

Data acquired from: Sarah L. Fogleman and Stewart R. Duncan, Soybean Crop Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 8: Cost-return projection for Wheat crops in the Elk City Lake watershed

WHEAT	Yield Level (bu)		
	35	**45**	**55**
INCOME PER ACRE			
A. Yield per acre	35	45	55
B. Price per bushel	$4.41	$4.41	$4.41
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$164.83	$209.84	$254.85
COSTS PER ACRE			
1. Seed	$9.90	$9.90	$9.90
2. Herbicide	2.75	2.75	2.75
3. Insecticide/Fungicide			
4. Fertilizer and Lime	36.65	43.71	52.06
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7	7	7
9. Custom Hire / Machinery Expense	60.61	63.62	66.63
10. Non-machinery Labor	6.85	7.19	7.53
11. Irrigation			
12. Land Charge / Rent	34.4	43	51.6
G. SUB TOTAL	$158.16	$177.17	$197.47
13. Interest on ½ Nonland Costs	5.57	6.04	6.56
H. TOTAL COSTS	$163.73	$183.20	$204.04
I. RETURNS OVER COSTS (F-H)	**$1.10**	**$26.64**	**$50.81**
J. TOTAL COSTS/BUSHEL (H/A)	$4.68	$4.07	$3.71
K. RETURN TO ANNUAL COST (I+13)/G	4.22%	18.44%	29.06%

Data acquired from: Sarah L. Fogleman and Stewart R. Duncan, Wheat Crop Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 9: Cost-return projection for Grain Sorghum crops in the Elk City Lake watershed

GRAIN SORGHUM	Yield Level (bu)		
	70	**85**	**110**
INCOME PER ACRE			
A. Yield per acre	70	85	110
B. Price per bushel	$2.82	$2.82	$2.82
C. Net government payment	$10.48	$11.39	$12.30
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$207.88	$207.88	$207.88
COSTS PER ACRE			
1. Seed	$12.29	$12.29	$12.29
2. Herbicide	20.34	20.34	20.34
3. Insecticide/Fungicide	5.9	5.9	5.9
4. Fertilizer and Lime	39.68	43.64	50.24
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	7	7	7
9. Custom Hire / Machinery Expense	82.39	86.92	94.47
10. Non-machinery Labor	9.31	9.82	10.68
11. Irrigation			
12. Land Charge / Rent	34.4	43	51.6
G. SUB TOTAL	$211.30	$228.90	$252.51
13. Interest on ½ Nonland Costs	7.96	8.37	9.04
H. TOTAL COSTS	$219.26	$237.27	$261.55
I. RETURNS OVER COSTS (F-H)	**($11.38)**	**$13.82**	**$60.95**
J. TOTAL COSTS/BUSHEL (H/A)	$3.13	$2.79	$2.38
K. RETURN TO ANNUAL COST (I+13)/G	-1.62%	9.69%	27.72%

Data acquired from: Sarah L. Fogleman and Stewart R. Duncan, Grain Sorghum Crop Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Table 10: Cost-return projection for Alfalfa crops in the Elk City Lake watershed

ALFALFA	Yield Level (ton)		
	3	**3.5**	**4**
INCOME PER ACRE			
A. Yield per acre	3	3.5	4
B. Price per bushel	$101.00	$101.00	$101.00
C. Net government payment	$12.30	$13.37	$14.44
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$315.30	$366.87	$418.44
COSTS PER ACRE			
1. Seed	$10.17	$10.17	$10.17
2. Herbicide	2.51	2.51	2.51
3. Insecticide/Fungicide	7.08	7.08	7.08
4. Fertilizer and Lime	19.9	26.89	33.88
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	6.38	6.38	6.38
9. Custom Hire / Machinery Expense	109.42	118.08	126.61
10. Non-machinery Labor	12.36	13.34	14.31
11. Irrigation			
12. Land Charge / Rent	31.6	39.5	47.4
G. SUB TOTAL	$199.43	$223.96	$248.34
13. Interest on ½ Nonland Costs	7.55	8.3	9.04
H. TOTAL COSTS	$206.98	$232.26	$257.38
I. RETURNS OVER COSTS (F-H)	**$108.32**	**$134.61**	**$161.06**
J. TOTAL COSTS/BUSHEL (H/A)	$68.99	$66.36	$64.35
K. RETURN TO ANNUAL COST (I+13)/G	58.10%	63.81%	68.50%

Data acquired from: Sarah L. Fogleman and Stewart R. Duncan, Alfalfa Crop Cost-Return Budget in Southeast Kansas, Kansas State University, October 2006.

Work Products Created (spreadsheet based decision tools)

K-State Watershed Manager Decision-Making Tool is a spreadsheet program that can support the development of watershed management plans. Using this program, watershed stakeholder groups & technical assistance providers can estimate, optimize, and compare the economic and environmental effects of various watershed management scenarios. This includes cost estimates and estimates of (sediment, phosphorus, and nitrogen) load reductions for a variety of cropland Best Management Practices (BMPs). *K-State Watershed Manager* was developed by a group of agricultural economists at Kansas State University. The goal was to provide a user-friendly tool which could aid watershed groups in developing cost-effective watershed management plans. The tool development was funded in part through the Kansas Department of Health and Environment by U.S. EPA Section 319 Funds in support of Kansas Watershed Restoration and Protection Strategies (WRAPS).

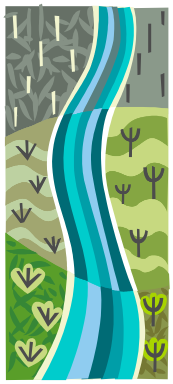
KSU-Vegetative Buffer Decision-Making Tool was developed with assistance and input from KSU Ag Economics faculty, NRCS, and Conservation District personnel (buffer coordinators). This tool allows producers and land-managers across the state of Kansas (including Elk City Lake Watershed) to evaluate the economic benefits and costs of vegetative buffers, and will help them decide if a buffer makes sense for their operation. This tool also incorporates the funding incentives information gathered previously. This tool is on the KSU Agricultural Economics website, AgManager.

KSU-StreambankStabilization Decision-Making Tool was developed with assistance and input from KSU Ag Economics faculty, Watershed Institute, and KAWS.
This tool allows producers and land-managers across the state of Kansas (Elk City Lake Watershed) to evaluate the economic benefits and costs of streambank stabilization projects, and will help them decide if stabilizing an eroding streambank makes sense for their operation. This tool also incorporates the funding incentives information gathered previously. This tool is on the KSU Agricultural Economics website, AgManager.

KSU-Tillage Decision-Making Tool was developed with assistance and input from KSU Ag Economics faculty and Agricultural Extension agents across the state. This tool allows producers and land-managers across the state of Kansas (including Elk City Lake Watershed) to evaluate the economic benefits and costs of alternative tillage management strategies, and helps them decide if reducing tillage is a feasible option for their operation. This tool incorporates enterprise budgets so that the user can make their decision based on a comprehensive analysis. This tool is on the KSU Agricultural Economics website, AgManager.

Non-market valuation and input-output impact analysis

Thorough research was performed for the benefits-cost estimation of watershed management. Initial research has shown sedimentation as the main cause of future economic loss to Elk City Lake, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at Elk City Lake were being estimated using an input-output impact analysis and non-market valuation techniques.



Next Steps / Transition into Planning Phase

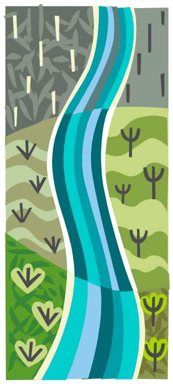
This WRAPS Assessment Phase project is about 60% complete. The remaining portion of the project will require engagement with the Stakeholder Leadership Team.

A key step is to use the assessment information (as revised through collaboration with the Stakeholder Leadership Team) to refine the watershed model. The revised model would then be used to define critical areas, quantify the impacts of potential BMPs on pollutant loads to the streams, and assist the Stakeholder Leadership Team in prioritizing this list of BMPs. The Stakeholder Leadership Team would use model results along with local knowledge about the BMPs that most likely will be accepted by the farmers and implemented on the ground.

The economic aspects of the BMP implementation would also be discussed with the Stakeholder Leadership Team. A variety of decision-making tools that have been developed by K-State would be applied to provide the Stakeholder Leadership Team with the most cost-efficient BMP implementation plan.

For each individual impairment or combination of impairments, a list of recommended BMPs and the cost of implementation would be presented, discussed, and approved by the Stakeholder Leadership Team. The list may include buffers, continuous no-till, nutrient management, and waterways for cropland, riparian and native grass habitat buffers for streambanks, and off-stream watering sites, vegetative filter strips, and relocation of pasture feeding sites for livestock.

To facilitate the transition into the planning phase, an overview of the watershed assessment findings, including the targeted areas, the lists of potential BMPs for each impairment, and the approximate cost of the implementation, should be provided to the Stakeholder Leadership Team.



Evaluation of Project Goal, Objectives, and Tasks

The goal of this project was to characterize watershed conditions, identify needs and opportunities for watershed information to support stakeholder decisions, and understand how the watershed responds to various management scenarios.

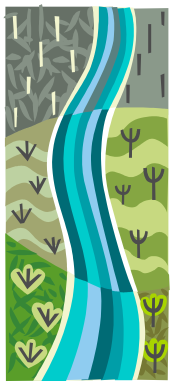
Because a Stakeholder Leadership Team was not successfully established for the Elk City Lake watershed during the WRAPS Development Phase project, this Assessment Phase project did not accomplish all of its objectives. Nonetheless, many objectives toward the project goal were achieved:

- Compiled an inventory of existing information and reports related to Elk City Lake watershed.
- Published a Watershed Atlas online, summarizing watershed climate, soil, topographic, and land use data; economic analyses of agricultural cropping systems and best management practices (BMPs); and STEPL modeling results.
- Set up and completed detailed SWAT modeling analysis of baseline watershed conditions.
- Developed user-friendly decision tools for stakeholder groups to analyze and compare economic and environmental effects of cropland BMPs, vegetative buffer systems, streambank stabilization systems, and tillage systems.
- Completed an analysis of recreational benefits of Elk City Lake Lake.

The following objectives were not achieved, and will require engagement of the Stakeholder Leadership Team so that the resulting information is relevant and applicable to the WRAPS planning process.

- The Stakeholder Leadership Team must clarify WRAPS objectives and assessment needs (an outcome of a successful Development Phase project).
- The Stakeholder Leadership Team must identify informational and data gaps needed to address their objectives and assessment needs.
- Baseline watershed assessment data must be refined using local data in collaboration with the Stakeholder Leadership Team.
- The watershed model must be revised to reflect the refined watershed data.
- The watershed model must be used to assess watershed responses to various management scenarios.
- Watershed model and economic results must be communicated to the Stakeholder Leadership Team.

We have made substantial progress toward accomplishing the project goals. Once a Stakeholder Leadership Team is established, the results of this project will allow rapid progress toward completion of a WRAPS Report.



Conclusions, Recommendations, and Lessons Learned

Conclusions

A solid foundation of watershed assessment information was prepared by this project. From their experience with other successful WRAPS Assessment Phase projects in other watersheds, the project team has a clear understanding of the typical steps remaining to complete the assessment project. It is clear that further progress toward completion of a successful Assessment project, and ultimately a WRAPS Plan and Report, will require establishment of an engaged Stakeholder Leadership Team.

Lessons Learned

Several important lessons were learned through the implementation of this Assessment Phase project:

- Although a WRAPS Assessment Phase project can and should (for timely progress of the overall WRAPS process) begin before the completion of a WRAPS Development Phase project, it cannot be completed until the Stakeholder Leadership Team (that results from the Development project) is in place and fully engaged in the assessment process.
- Watershed data available through various Internet sources should be considered to be “generalized” information and should be confirmed and revised through interactions with stakeholders having local knowledge and data.
- Successful watershed modeling as part of a WRAPS planning process, requires the active engagement of a Stakeholder Leadership Team in a process we have called *Adaptive Watershed Modeling*, where modelers and stakeholders interact iteratively throughout creation of watershed data, development of scenarios, and analysis of results.
- It is helpful to begin discussions of watershed modeling using simple modeling tools (such as STEPL) to allow discussions with stakeholders to focus on important watershed conditions and local information rather than becoming bogged down in discussion of model intricacies.
- Stakeholders benefit from the use of decision tools that integrate economic and environmental impacts of various field and watershed management decisions, and allow them to compare various scenarios.

Recommendations

Watershed modeling is important to the WRAPS Assessment process.

One Kansas individual skeptical of watershed modeling suggested that K-State should instead simply show real data about how various agricultural management practices impact water quality in each locale. He and I discussed how soil types, rainfall patterns, growing seasons, and management practices, among other factors, could impact results, in addition to how expensive it would be to study even a small number of combinations. In a very short time, this individual began to see how models could be used to extend data from specific combinations of these factors to other combinations where water quality data was not available.

Watershed modeling remains highly sophisticated.

The project team has been involved with watershed assessment activities in Kansas for more than 12 years. Over this time, watershed assessment tools and models have evolved. Watershed information can now be accessed in digital format for watershed topography, soils, and land-cover. Watershed models have evolved from dedicated research tools to become more user-friendly both in data input and post-processing of results. However, running watershed models remains a highly sophisticated task; correct results are never guaranteed

Believable watershed modeling requires technical skill and social connection.

The integration of watershed modeling results in the watershed planning process is not a simple endeavor. Once watershed stakeholders lose confidence in the watershed model or modeler, they will not believe the results and will not use these results in their planning. Watershed models generally are not "correct", but their results can be highly instructive and useful to the WRAPS planning process. Helping stakeholders understand how model results should, and should not, be used requires a committed engagement over a long period of time, and often requires an intermediary, like an Extension Agent or Watershed Specialist, who can help the modeler and the stakeholder bridge the communication gap.

In short, watershed environmental and economic modeling is critical to success of a WRAPS project, but requires technical staff with a special set of skills and dedication to the enterprise of stakeholder engagement and partnership.

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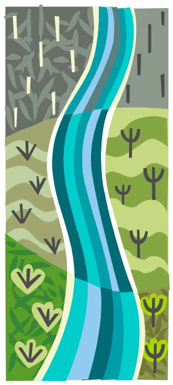

Appendix A

Watershed Atlas

Nejadhashemi, A.P., R.K. Gali, C.M. Smith, K.R. Mankin, R.M. Wilson, S.P. Brown, and J.C. Leatherman. 2009. Elk River Watershed Assessment: Preliminary Report. Kansas State Research and Extension Publication #EP-143. 56 pages.
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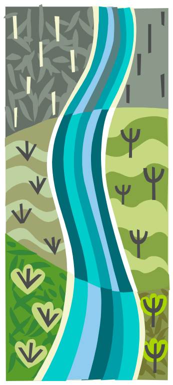


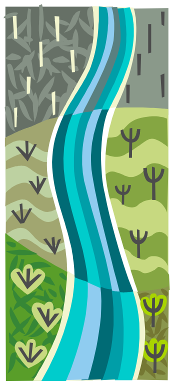
Appendix B

TMDLs

Verdigris Basin TMDL. Waterbody: Elk City Lake. Water Quality Impairment: Eutrophication. < http://www.kdheks.gov/tmdl/ve/Elk_City_TMDL.pdf >

Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Dissolved Oxygen. < http://www.kdheks.gov/tmdl/ve/ElkR_DO.pdf >

Verdigris Basin TMDL. Waterbody: Elk River. Water Quality Impairment: Fecal Coliform Bacteria. < http://www.kdheks.gov/tmdl/ve/ElkR_FCB.pdf >



Appendix C

Financial Summary

Summary of Financial Expenditures and Matching Funds

Category	Budget	Actual	Match	Total
Salaries	24,782.00	32,696.61	7,653.00	40,349.61
Fringe Benefits	5,184.00	3,581.93	1,990.00	5,571.93
Travel	1,750.00	5,096.17		5,096.17
Supplies	2,500.00	1,310.19		1,310.19
Contractual Services	-	-		-
Other	8,550.00	81.10		81.10
Project Indirect Costs	-	-		-
Waived Indirect Costs	-		18,867.00	18,867.00
Total	$ 42,766.00	$ 42,766.00	$ 28,510.00	$ 71,276.00