KANSAS WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS) PROJECT

NEOSHO RIVER WATERSHED ASSESSMENT

FINAL REPORT

KDHE Project No. 2004-0029

March 2012

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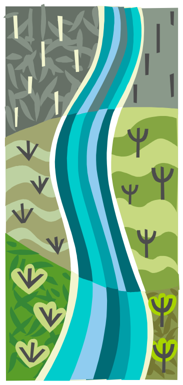

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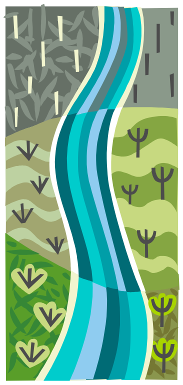

Acknowledgements

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) – Neosho River Basin Assessment project (2004-0029).

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

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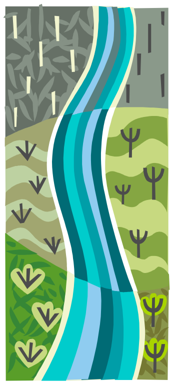
- John C. Leatherman, Professor, Agricultural Economics
- William Hargrove, past KCARE Director



Executive Summary

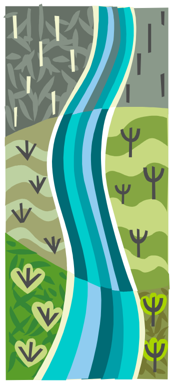
This project served to compile and develop watershed environmental and economic information to assist stakeholders in the Neosho River Basin Watershed (two watersheds downstream from John Redmond Reservoir) to develop a Watershed Restoration and Protection Strategy (WRAPS) Plan and Report. The Neosho River Basin downstream from John Redmond Reservoir is divided into three main watersheds located within Kansas borders: Upper Neosho River watershed, Middle Neosho River watershed, and Spring River watershed. Drainage areas of Upper Neosho River and Middle Neosho River watersheds are exclusively in Kansas.

Initiated in June 2006, this WRAPS Assessment Phase project was completed by July 2009. Project accomplishments include:

- *Watershed Assessment*: We compiled existing information related to the Middle Neosho River Watershed, culminating in development and publication of a Watershed Atlas.
- *Watershed Modeling*: We completed the SWAT modeling analysis of current watershed conditions. General assessment information (limited watershed modeling with STEPL) was conducted for Spring Watershed and Lake O' The Cherokees Watershed.
- *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.

Two stakeholder leadership teams (SLT) were established in 2008 for Upper Neosho River and Middle Neosho River Watersheds and actively participated in a critical review of the assessment activities including modeling findings of targeted areas, discussions on non-point source pollution areas in the watershed that could not be identified with SWAT, like areas with high concentration of livestock produced nutrient contribution to stream pollution.

The SLTs were engaged 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. Groundtruthing of SWAT identified targeted areas assisted in identifying current BMP implementation rates in the targeted areas and provided basis for economic analysis of future BMP implementation scenarios.



Introduction

The Neosho River Basin covers three HUC-8 watersheds below John Redmond Reservoir and above Kansas/Oklahoma state line: Upper Neosho River watershed, Middle Neosho River watershed, and Spring River watershed. Upper Neosho River and Middle Neosho River watersheds are exclusively in Kansas while Spring River watershed lies in Kansas, Oklahoma, and Missouri. In Upper Neosho River and Middle Neosho River watersheds individual Stakeholder Leadership Teams were formed and watershed management and assessment activities were independent from each other. Therefore, in the sections below, Upper Neosho River and Middle Neosho River watersheds will be discussed separately.

Geographic Scope/Location

The Middle Neosho River Watershed (HUC 11070205) is located primarily in Neosho, Crawford, Labette, and Cherokee counties in southeast Kansas, with small drainage areas originating from Allen and Bourbon counties (Figure 1a). The watershed primarily includes Neosho River drainage area, about 912,698 acres and its numerous tributaries. The watershed has upper boundary with an elevation of 677 meters (2,221 feet) and the outlet at the Kansas Oklahoma state line, with 200 meters (656 feet) above sea level. Parsons Lake, Neosho State Fishing Lake, Altamont and Bartlett State Fishing Lakes are some examples of lakes within this watershed. The Middle Neosho Watershed is comprised of six HUC 10 delineations (1107020501, 1107020502, 1107020503, 1107020504, 1107020505 and 1107020506) and 33 HUC 12 (110702050101, 110702050102, 110702050103, 110702050104, 110702050105, 110702050106, 110702050107, 110702050108, 110702050109, 110702050201, 110702050202, 110702050203, 110702050204, 110702050205, 110702050301, 110702050302, 110702050303, 110702050304, 110702050305, 110702050501, 110702050502, 110702050503, 110702050504, 110702050505, 110702050601, 110702050602, 110702050603, 110702050604 and 110702050604) delineations (Figure 2a).

The Middle Neosho Watershed includes areas of mined land and wildlife. The areas mined for coal formed many small depressions and lakes. Kansas Department of Health and Environment (KDHE) and the United States Department of Agriculture (USDA) designated the Middle Neosho Watershed as a Category I watershed indicating that it is in need of restoration in Kansas Unified Watershed Assessment 1999. Also, the Middle Neosho is ranked 24th in the priority watershed list among 92 watersheds in the state.

The Upper Neosho River Watershed is located in Southeast Kansas primarily in Coffey County, Anderson County, Woodson County, Allen County, Wilson County and Neosho County (Figure 1b). The Upper Neosho River watershed has 11070204 HUC 8-digit code number. The watershed area includes five HUC 10 subwatersheds (1107020401, 1107020402, 1107020403, 1107020404, 1107020405) and thirty-one HUC 12 subwatersheds (110702040101, 110702040102, 110702040103, 110702040104, 110702040105, 110702040106, 110702040107, 110702040201, 110702040202, 110702040203, 110702040204, 110702040205, 110702040206, 110702040301, 110702040302, 110702040303, 110702040304, 110702040305, 110702040306, 110702040401, 110702040402, 110702040403, 110702040404, 110702040405, 110702040406, 110702040407, 110702040501, 110702040502, 110702040503, 110702040504, 110702040505) (Figure 2b).

The Upper Neosho River Watershed includes 668 miles of stream and covers 862,080 acres of land. There are numerous towns and cities and no major reservoirs within this watershed. Elevation of the Upper Neosho River Watershed ranges from 200 meters (656 feet) to 677 meters (2,221 feet) above sea level. In 1999 Kansas Unified Watershed Assessment submitted by the Kansas Department of Health and Environment (KDHE) and the United States Department of Agriculture (USDA) had Upper Neosho River Watershed designated as Category I watershed indicating that it is in need of restoration. In addition it was also prioritized for restoration. Among ninety-two watersheds in Kansas State, the Upper Neosho River Watershed is ranked twentieth in priority. Upper Neosho River Watershed with other branches has nutrients, sediment and bacteria contribution into Grand Lake located in North-East Oklahoma.

Population

The Middle Neosho River Watershed has population of 35,158 people and the Upper Neosho River Watershed has population of 35,067 according to the Census 2000 (Table 1). The population density ranges from 0 to 448. Labette County has the highest population density within Middle Neosho River watershed whereas Allen County has the largest population (13,520) in Upper Neosho River watershed. The spatial distribution of the population (based on 2000 census data) is shown in Figure 3.

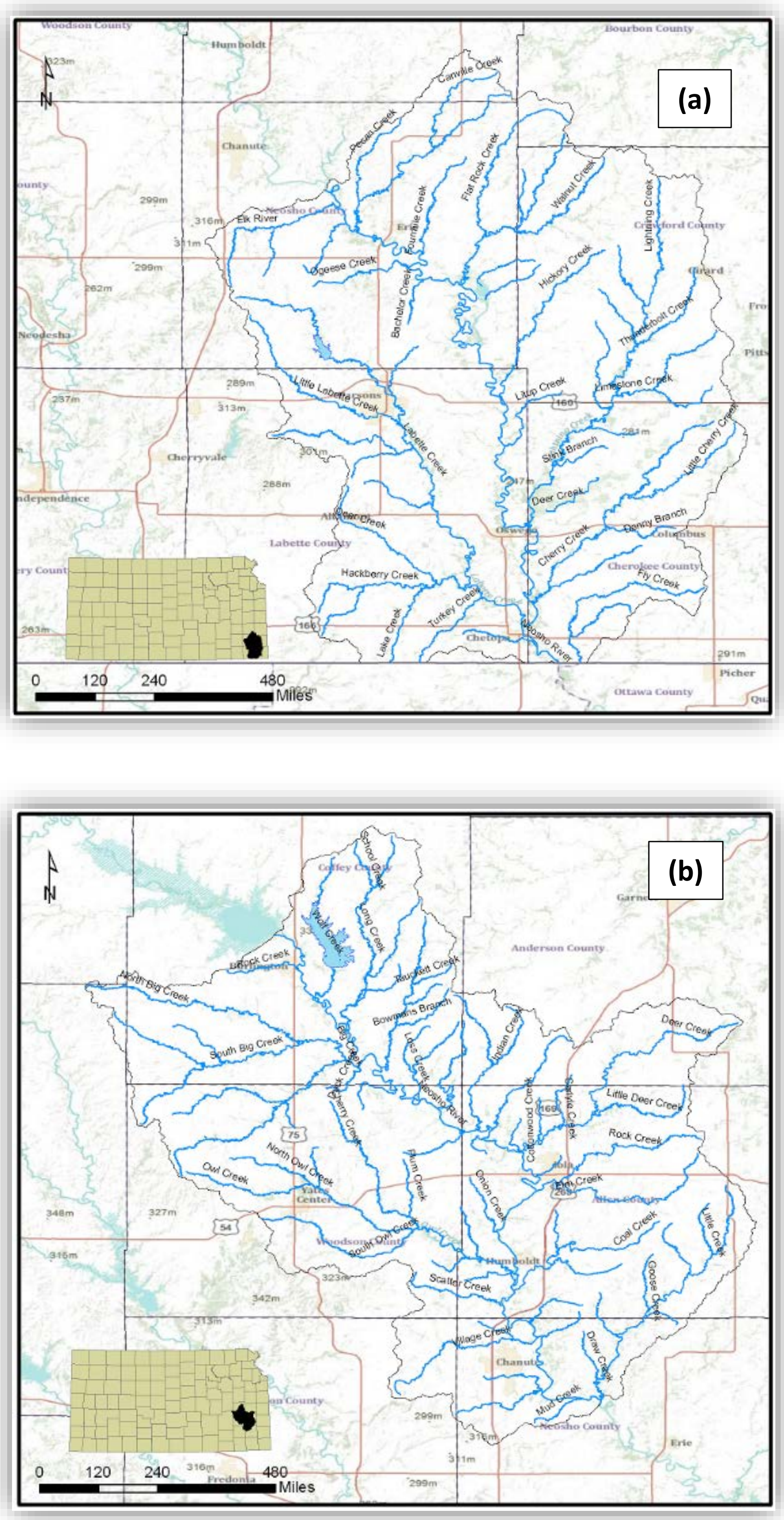


Figure 1 Maps of (a) Middle Neosho and (b) Upper Neosho River Watersheds

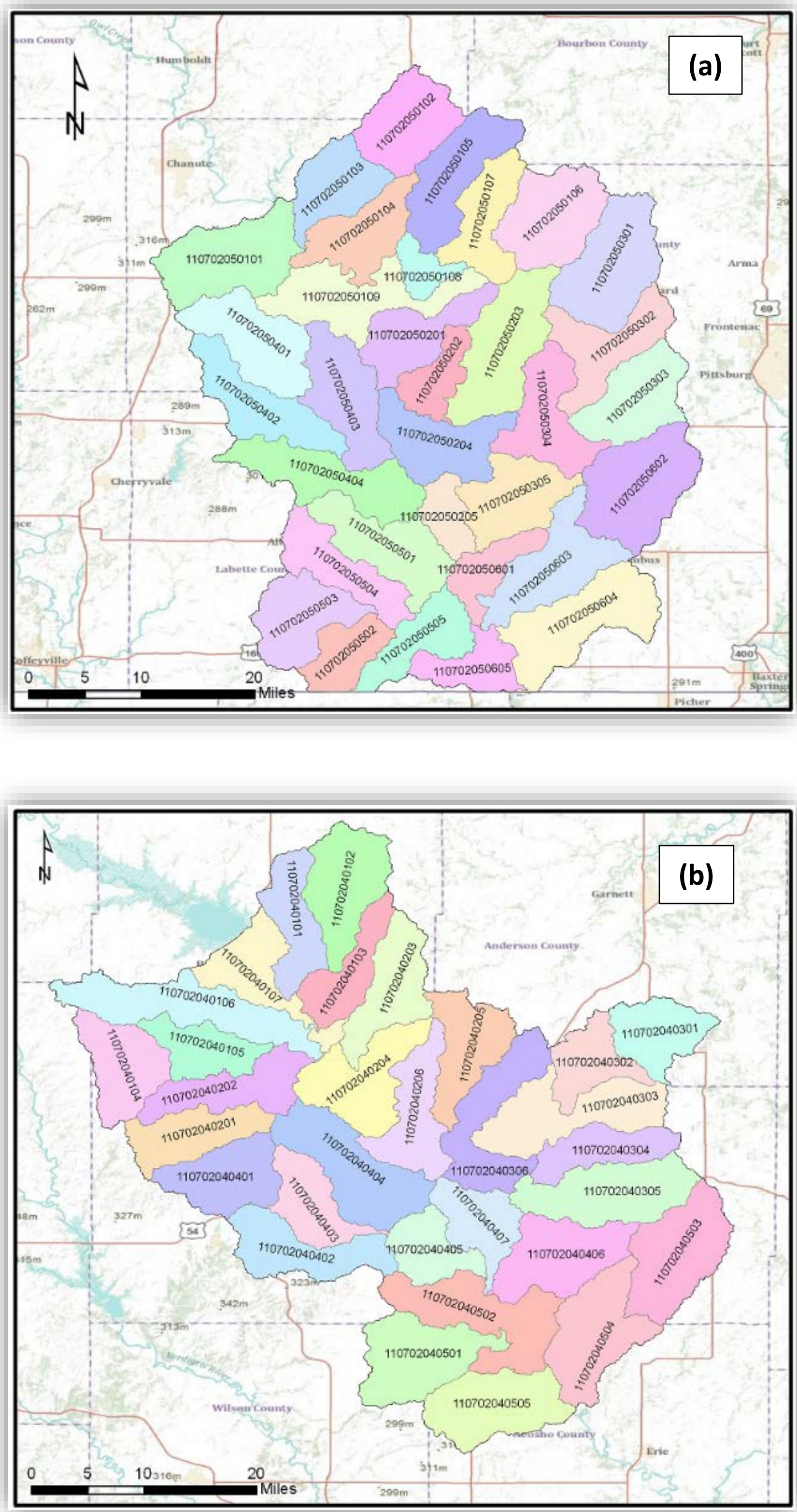
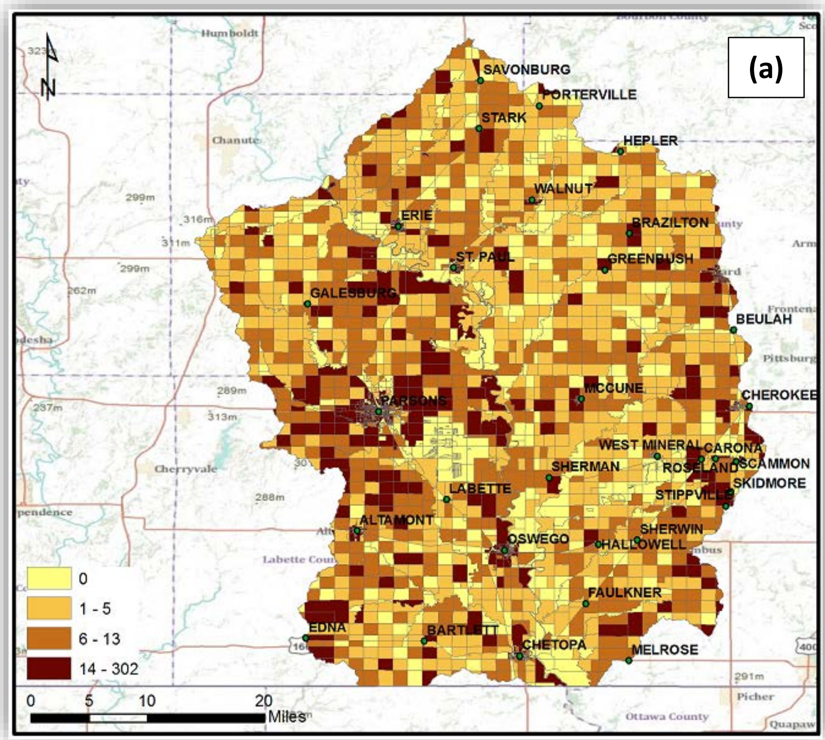


Figure 2 HUC 12 Delineations in (a) Middle Neosho and (b) Upper Neosho River Watersheds

Table 1 Main populated areas in the Neosho River Watershed

COUNTY	POP2000	MALES	FEMALES	HOUSEHOLDS	FAMILIES
Middle Neosho River					
Allen	302	157	145	121	83
Bourbon	79	37	42	29	23
Cherokee	3247	1614	1633	1265	942
Crawford	5905	2932	2973	2271	1621
Labette	20537	10046	10491	8272	5423
Neosho	5088	2544	2544	1926	1421
Total	35158	17330	17828	13884	9513
Upper Neosho River					
Allen	13520	6572	6948	5433	3651
Anderson	1017	493	524	392	301
Coffey	5883	2873	3010	2350	1638
Greenwood	59	30	29	18	13
Lyon	2	1	1	1	1
Neosho	11260	5334	5926	4581	3075
Wilson	347	178	169	137	102
Woodson	2979	1429	1550	1270	838
Total	35067	16910	18157	14182	9619



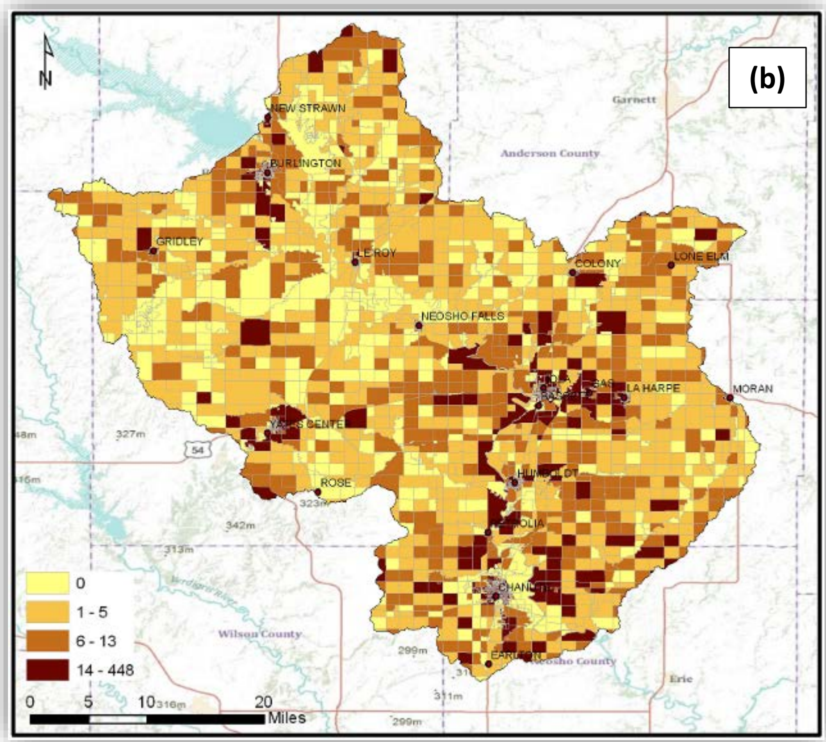
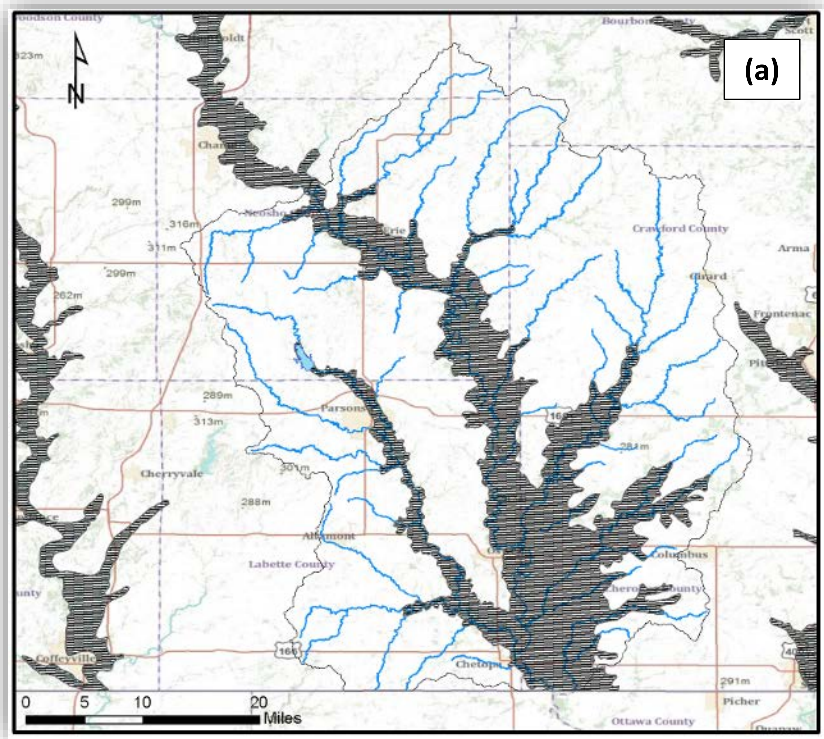


Figure 3 Population density in (a) Middle Neosho and (b) Upper Neosho River Watersheds

Surface Water Resources

The Neosho River along with its tributaries are the primary waterways of Neosho River Watershed. The Neosho River continues further south in Oklahoma State and drains into Grand Lake. The Neosho River Watershed has two aquifers (Figure 4):

- Alluvial Aquifer - The alluvial aquifer is a part of and connected to a river system and consists of sediments deposited by rivers in the stream valleys. The Neosho River has an alluvial aquifer that lies along and below the rivers.
- Ozark Aquifer - The Ozark Aquifer extends from southeastern Kansas and eastern Oklahoma east to St. Louis and south into Arkansas. It is mainly comprised of limestone and dolomite. Historically, water from this aquifer is very hard.



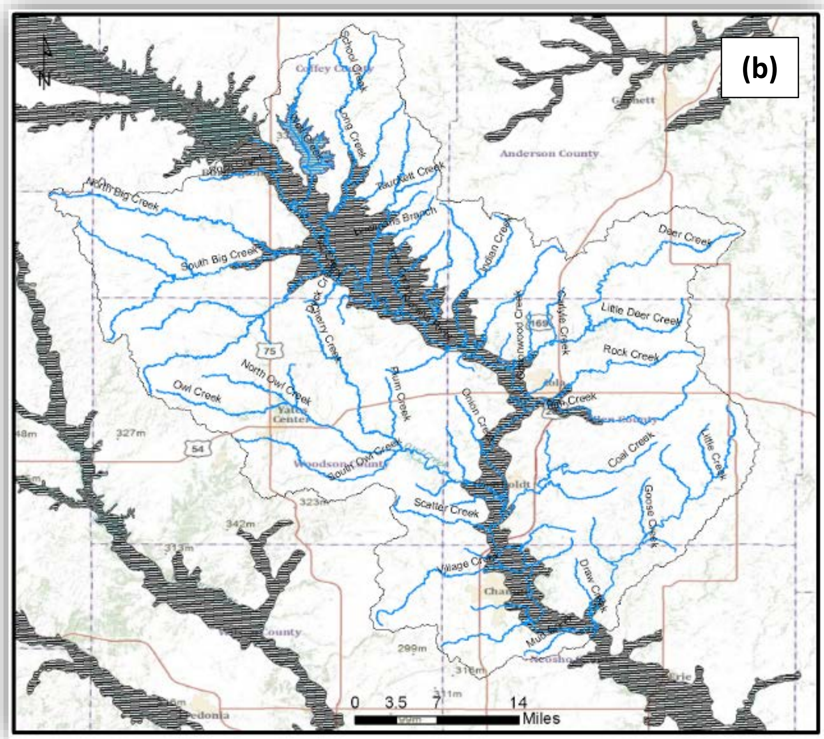


Figure 4 Map of alluvial aquifer underlying (a) Middle Neosho and (b) Upper Neosho River Watersheds

Designated Uses

Neosho River is primarily used for public swimming. Designated uses (Kansas Surface Water Register, KDHE, 2004) other surface waters in this watershed are aquatic life support (fish), human health purposes, domestic water supply, recreation (fishing, boating, swimming), groundwater recharge, industrial water supply, irrigation and livestock watering (Table 2).

Table 2 Designated Water Uses

Stream Name	AL	CR	DS	FP	GR	IW	IR	LW
Middle Neosho River								
Bachelor Creek (seg 396), Center Creek, Denny Branch, Downey Creek, Fourmile Creek, Grindstone Creek, Hackberry Creek, Limestone Creek, Little Cherry Creek, Little Elk Creek, Little Fly Creek, Little Walnut Creek, Litup Creek, Mulberry Creek, Murphy Creek, Ogeese Creek, Pecan Creek, Plum Creek, Rock Creek, Stink Branch, Thunderbolt Creek, Tolen Creek, Town Creek,	E							
Bachelor Creek (seg 40), Canville Creek, Cherry Creek, Deer Creek, Elk Creek, Elm Creek, Flat Rock Creek (seg 14), Hickory Creek, Lake Creek, Lightning Creek, Little Labette Creek, Spring Creek, Walnut Creek,	E			X				
Fly Creek	E	C		X				

Flat Rock Creek	S			X				
Labette Creek (seg 21 and 22) Labette Creek (seg 20), Neosho River Turkey Creek	E S E	C C	X X	X X X	X X	X X	X X	X X X
Unnamed Stream (seg 298, 303, 304, 305), Wolf Creek	E	B	X	X	X	X	X	X
Altamont City Main Lake, Altamont City West Lake, Mined Land Lake #10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, Mined Lake #42 Wetland	E	B		X				
Bartlett City Lake, Timber Lake Harmon Wildlife Area	E E	B A	X	X X		X		
Neosho County SFL	E	B		X				
Neosho Wildlife Area Parsons Lake	S E	 A	 X	X X		 X		
Upper Neosho River								
Badger Cr, Big Cr, N, Carlyle Cr, Charles Br, Draw Cr, Elm Cr, Goose Cr, Indian Cr, Mud Cr, Owl Cr, Plum Cr, School Cr, Scott Cr, Slack Cr, Sutton Cr, Turkey Br, Twiss Cr, Varvel Cr	E							
Big Cr Seg 14 Big Cr Seg 2	E E	C C	X	X X				
Big Cr S, Cherry Cr, Coal Cr, Cottonwood Cr, Crooked Cr, Dinner Cr, Long Cr, Martin Cr, Rock Cr, Spring Cr, Turkey Cr Seg 18, Village Cr	E			X				
Bloody Run, Little Indian Cr, Onion Cr, Owl Cr S, Wolf Cr	S							
Deer Cr Neosho R	E S	C C	X X	X X	X X	X X	X X	X X
Little Turkey C Turkey Cr Seg 32	E E	b b	X	X X	X	X	X	X
Chanute Santa Fe Lake, Iola City Lake, John Redmond Wildlife Area,	E	B		X				
Circle Lake, Leonard's Lake Gridley City Lake	S E	B A		X X				
Neosho Falls City Lake, New Strawn Park Lake	E	B	O	X		O	O	O
Wolf Cr Lake Yates Center Reservoir	E E	B A	 X	X X		X X		

where

AL	Aquatic Life Support
GR	Groundwater Recharge
CR	Contact Recreation Use
IW	Industrial Water Supply

DS	Domestic Water Supply
IR	Irrigation Water Supply
FP	Food Procurement
LW	Livestock Water Supply
A	Primary contact recreation lakes that have a posted public swimming area
B	Primary contact recreation stream segment is by law or written permission of the landowner open to and accessible by the public
b	Secondary contact recreation stream segment is not open to and accessible by the public under Kansas law
C	Primary contact recreation lakes that are not open to and accessible by the public under Kansas law
S	Special aquatic life use water
E	Expected aquatic life use water
X	Referenced stream segment is assigned the indicated designated use
O	Referenced stream segment does not support the indicated beneficial use
Blank	Capacity of the referenced stream segment to support the indicated designated use has not been determined by use attainability analysis

Public Water Supplies (PWS) and National Pollutant Discharge Elimination System (NPDES)

KDHE regulates wastewater treatment facilities fail rate within this watershed. Maximum amount of point source pollutants allowed to be discharged is controlled by National Pollutant Discharge Elimination System (NPDES). The watershed has numerous NPDES and wastewater treatment facilities (Table 3). P water supply diversion points and rural water districts in addition to countless private wells within this watershed are shown in Figure 5. Groundwater is the main source of pollution in public PWS with pollutants like sediment, nutrient and *E. coli*. Other than City of New Strawn, all other water supply points use surface water. City of New Strawn gets PWS from groundwater.

Table 3 NPDES Sites

Facility Name	Ownership	Description	Industrial Classification	City	County
Middle Neosho River					
Kansas Gas & Elect Co Parsons	Pub Pri	Electrical Services	Primary O	Parsons	Labette
Mccune City Of Stp	Public	Sewerage Systems	Municipal	Mccune	Crawford
Girard City Of Wwtp	Public	Sewerage Systems	Municipal	Girard	Crawford
Stark City Of Wwtp	Public	Sewerage Systems	Municipal	Stark	Neosho
Hepler City Of Stp	Public	Sewerage Systems	Municipal	Hepler	Crawford
Us Army-Kansas Army	Federal	National Security	Not On El	Parsons	Labette

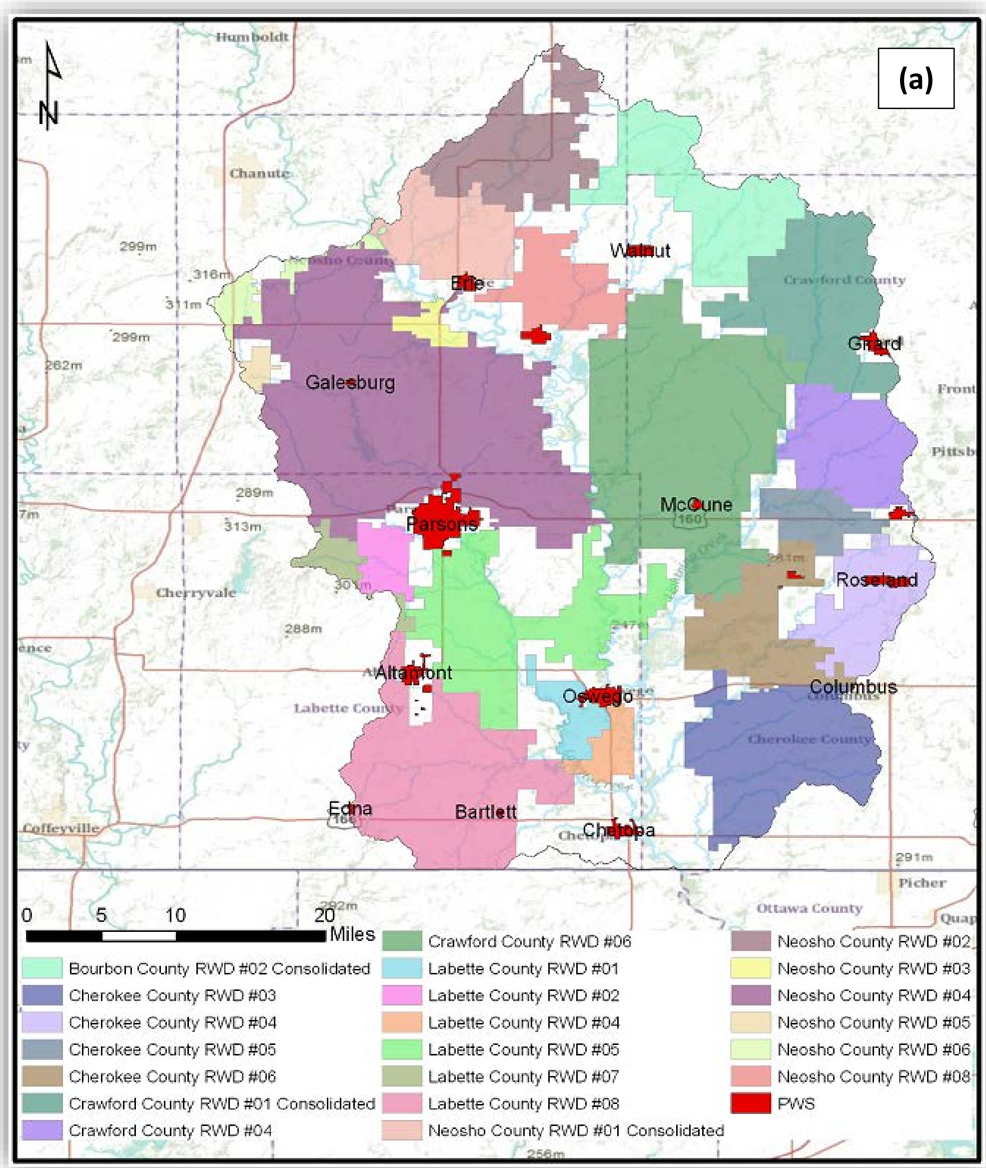
Ammunition					
Chetopa City Of Wwtp	Public	Sewerage Systems	Municipal	Chetopa	Labette
Parsons Water & Sewer Dept	Public	Sewerage Systems	Municipal	Parsons	Labette
Altamont City Of Stp	Public	Sewerage Systems	Municipal	Altamont	Labette
Erie City Of Wwtp	Public	Sewerage Systems	Municipal	Erie	Neosho
Oswego City Of Stp	Public	Sewerage Systems	Municipal	Oswego	Labette
Savonburg City Of Wwtp	Public	Sewerage Systems	Municipal	Savonburg	Allen
Scammon Wastewater Treatment F	Public	Sewerage Systems	Municipal	Scammon	Cherokee
West Mineral City Of Wwtp	Public	Sewerage Systems	Municipal	West Mineral	Cherokee
Bartlett City Of Wwtp	Public	Sewerage Systems	Municipal	Bartlett	Labette
Cherokee Wwtp	Public	Sewerage Systems	Municipal	Cherokee	Crawford
Walnut City Of Wwtp	Public	Sewerage Systems	Municipal	Walnut	Crawford
St. Paul City Of Munic Wwtp	Public	Sewerage Systems	Municipal	Saint Paul	Neosho
Midwest Minerals, Inc. Quarry7	Private	Meat Packing Plants	On Elg	Neosho County	Neosho
Nelson Quarry - Erie/beachner	Pub Pri	Erie	Neosho	0.00000	Nelson Quarry-Erie/beachner
Individual Mausoleum Company	Pub Pri	Parsons	Labette	0.00000	Individual Mausoleum Company
Galesburg	Pub Pri	Galesburg	Neosho	0.00000	Galesburg
Midwest Minerals Inc Quarry 21	Private	Crushed And Broken Limestone	On Elg	Cherokee	Crawford
Midwest Minerals Inc Quarry 3	Private	Crushed And Broken Limestone	On Elg	Parsons	Labette
Upper Neosho River					
Humboldt Wwtf	Public	Sewerage Systems	Municipal	Humboldt	Allen

Iola City Of Stp	Public	Sewerage Systems	Municipal	Iola	Allen
Iola City Of Munic Power Plant	Pub Pri	Electrical Services	Primary O	Iola	Allen
Allen County Sewer Dist 1 Wwtp	Public	Sewerage Systems	Municipal	Iola	Allen
Nelson Quarrystokes Quarry	Private	Crushed And Broken Limestone	On Elg	La Harpe	Allen
Laharpe Mwwtf	Public	Sewerage Systems	Municipal	La Harpe	Allen
Colony Mun Wwtf	Public	Sewerage Systems	Municipal	Colony	Anderson
Wolf Creek Generating Station	Pub Pri	Electrical Services	Primary O	Burlington	Coffey
Burlington - Municipal Plt	Pub Pri			Burlington	Coffey
Gridley City Of Stp	Public	Sewerage Systems	Municipal	Gridley	Coffey
Leroy City Of Stp	Public	Sewerage Systems	Municipal	Le Roy	Coffey
Ash Grove Cement Co Chanute P	Private	Cement, Hydraulic	On Elg	Chanute	Neosho
Chanute Wwtp (New Plant)	Public	Sewerage Systems	Municipal	Chanute	Neosho
Chanute, City Of Power Plnt 3	Public	Electrical Services	On Elg	Chanute	Neosho
Yates Center City Of Stp	Public	Sewerage Systems	Municipal	Yates Center	Woodson

Land Uses / Land Cover

The primary land uses in the Middle Neosho River watershed are grassland (53.7%) and cropland (Figure 6 and Figure 7). Cultivated land within this watershed does not have any buffers and only low percentage of land is used in continuous no-till. With a relatively high annual rainfall amount, the watershed has high potential for erosion and nutrient runoff that originates in cropland areas. Cropland is the major source of pollutant. Grassland can contribute *E. coli* bacteria from grazing livestock manure. The remainder of the land has deciduous forest (10%) and urban open land (4.5%).

The major land use in the Upper Neosho River Watershed is grassland (68.54 %), followed by cropland (Figure 6 and Figure 7). Nutrients and fecal bacteria from livestock, sediment from overgrazed grassing lands and croplands, and fertilizer and manure from cropland can be major pollutants in this watershed. Other land uses consist of deciduous forest (8.3 %) and open developed areas (4.1 %).



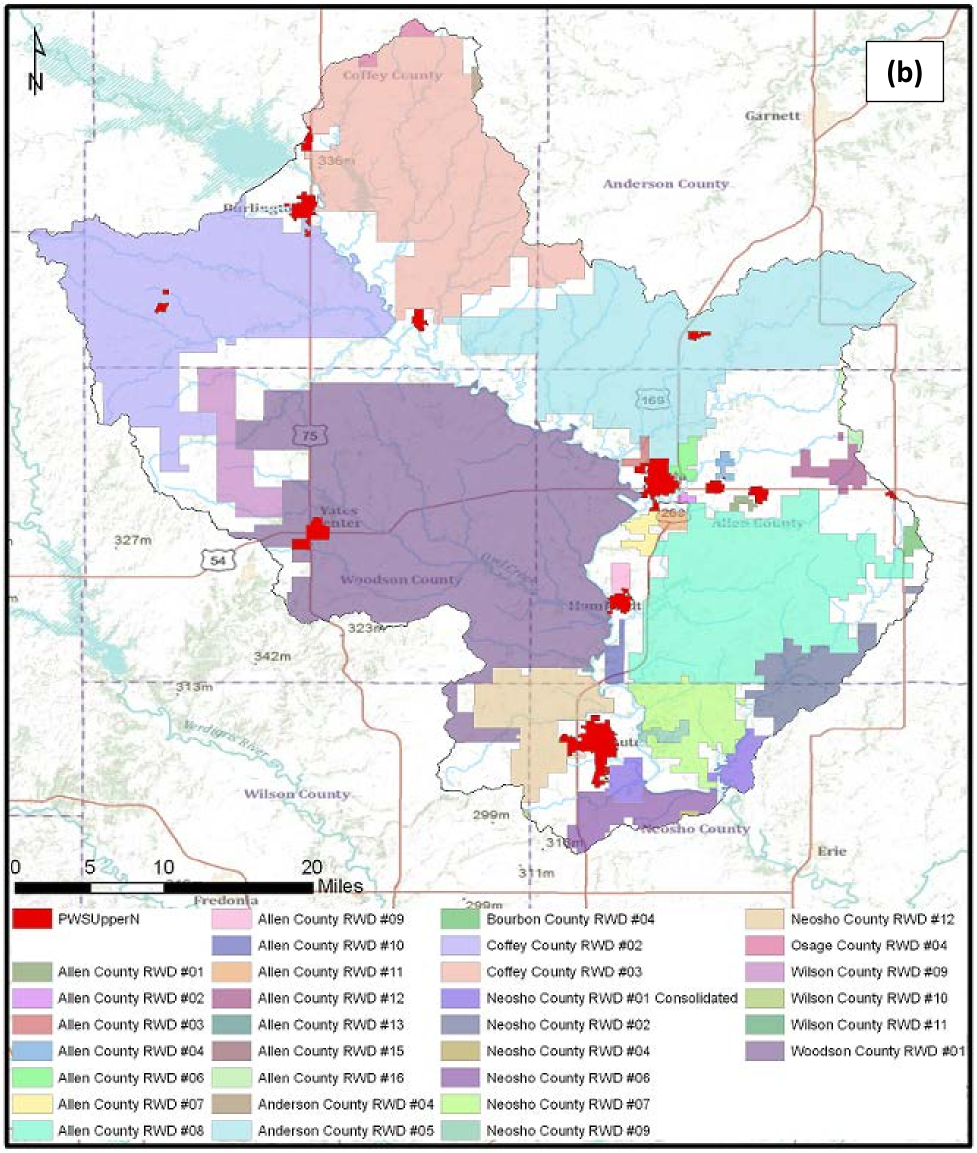
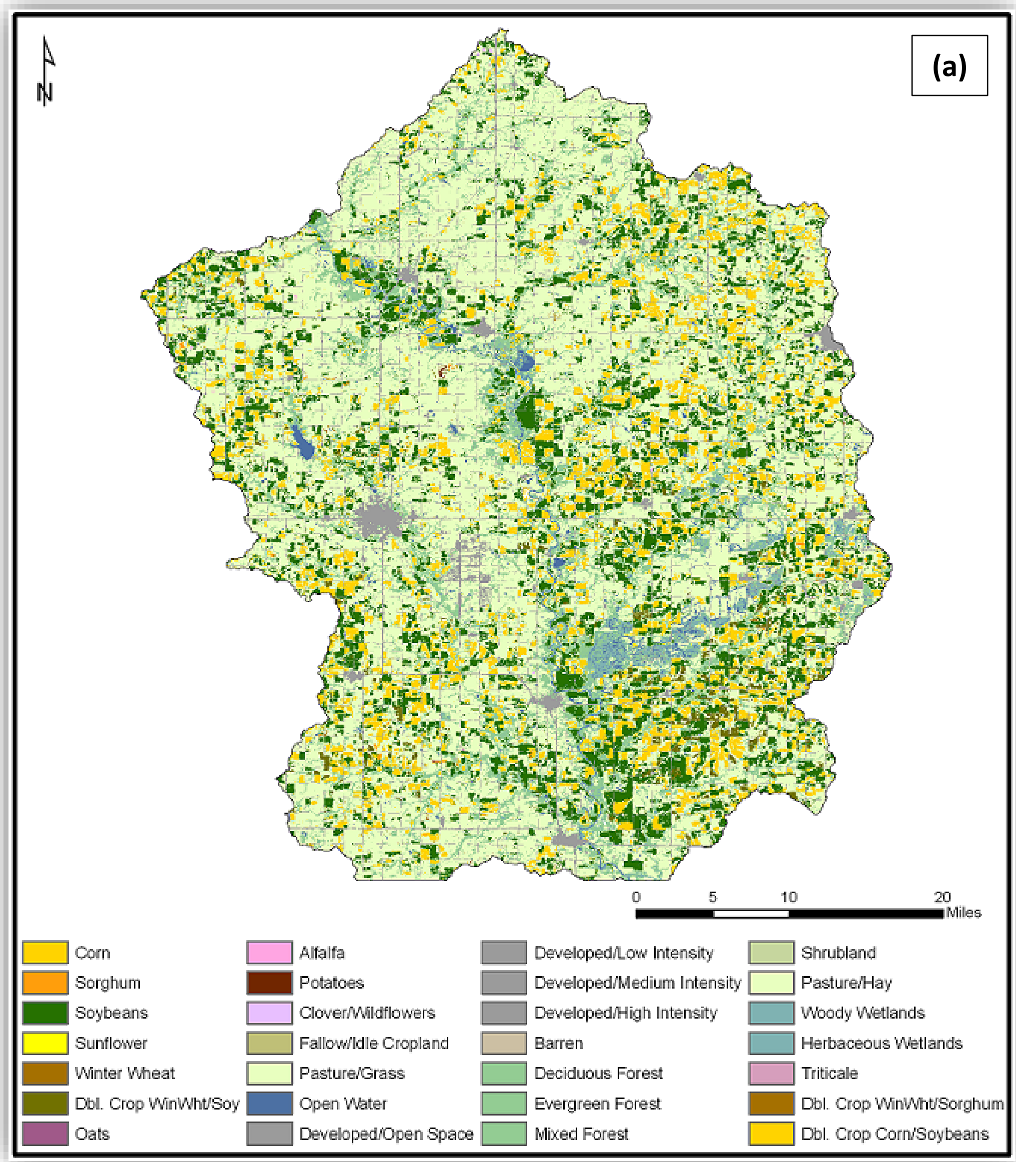


Figure 5 Rural Water Districts (RWD) and Public Water Supply (PWS) Diversion Points in (a) Middle Neosho and (b) Upper Neosho River Watersheds


(a)
N
0
5
10
20
Miles
Corn
Sorghum
Soybeans
Sunflower
Winter Wheat
Dbl. Crop WinWht/Soy
Oats
Alfalfa
Potatoes
Clover/Wildflowers
Fallow/Idle Cropland
Pasture/Grass
Open Water
Developed/Open Space
Developed/Low Intensity
Developed/Medium Intensity
Developed/High Intensity
Barren
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrubland
Pasture/Hay
Woody Wetlands
Herbaceous Wetlands
Triticale
Dbl. Crop WinWht/Sorghum
Dbl. Crop Corn/Soybeans

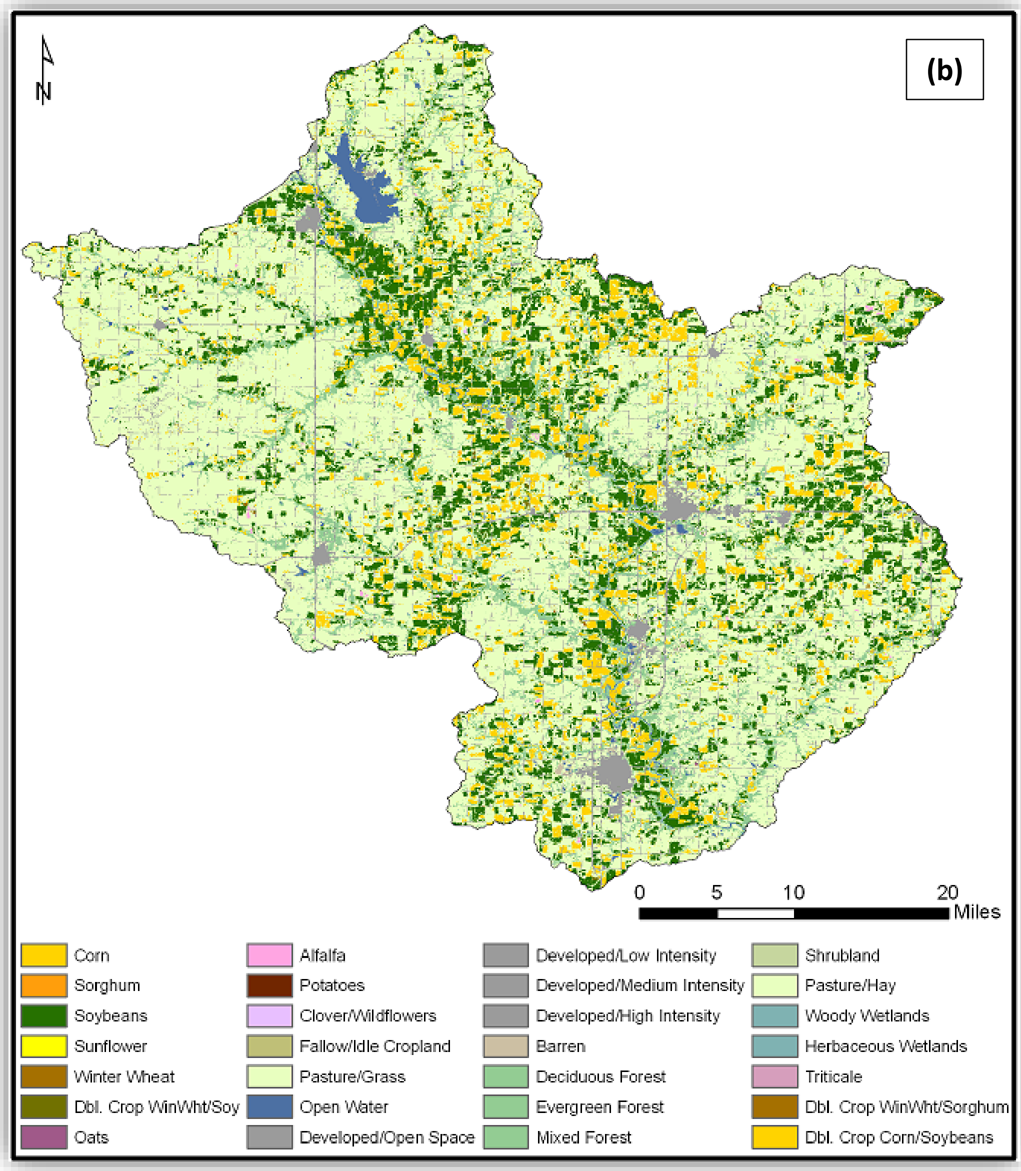


Figure 6 Land cover map (2010 NASS Crop Data Layer) for the (a) Middle Neosho and (b) Upper Neosho River Watersheds

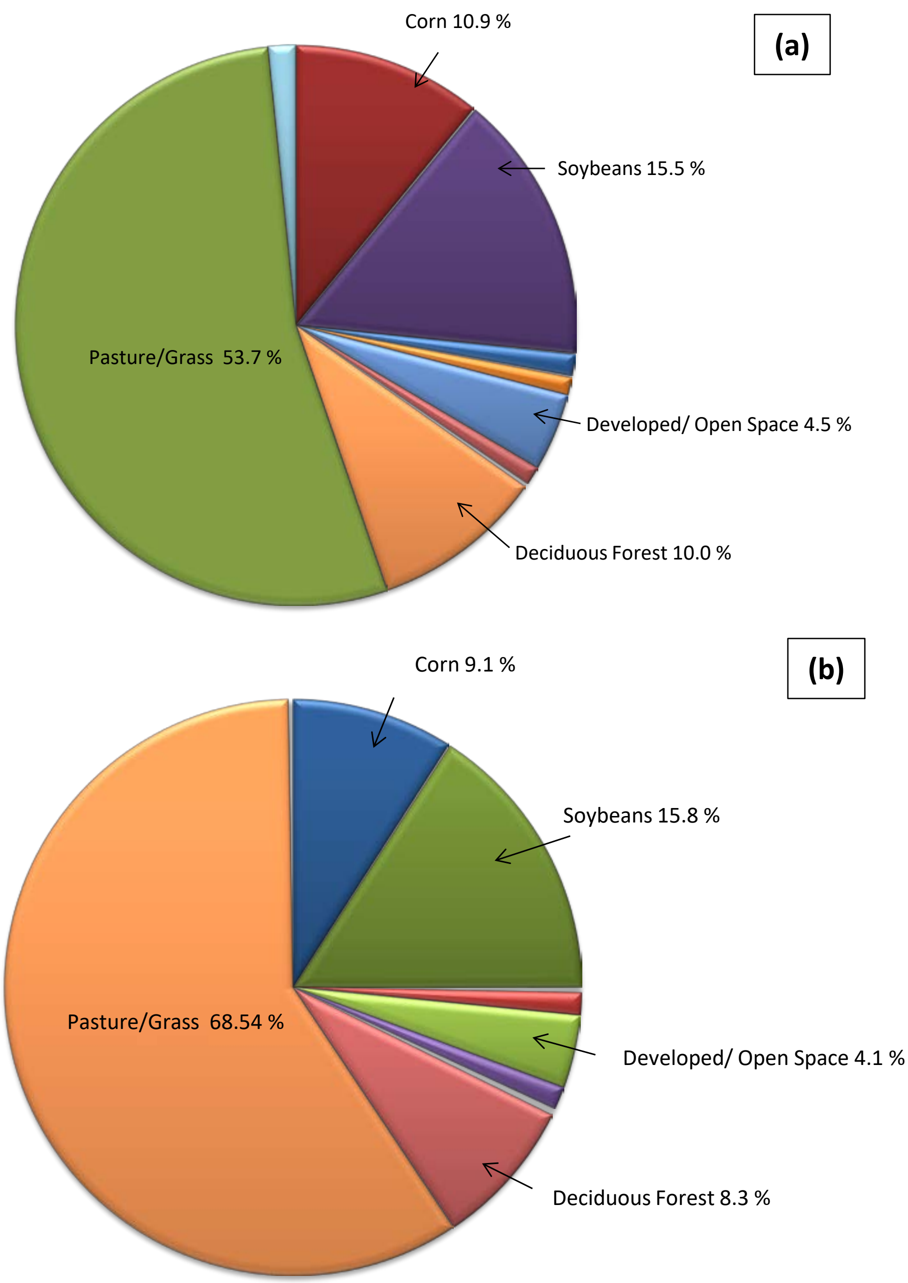


Figure 7 Percentage of individual land uses (Based on 2010 Crop Data Layer) in the (a) Middle Neosho and (b) Upper Neosho River Watersheds

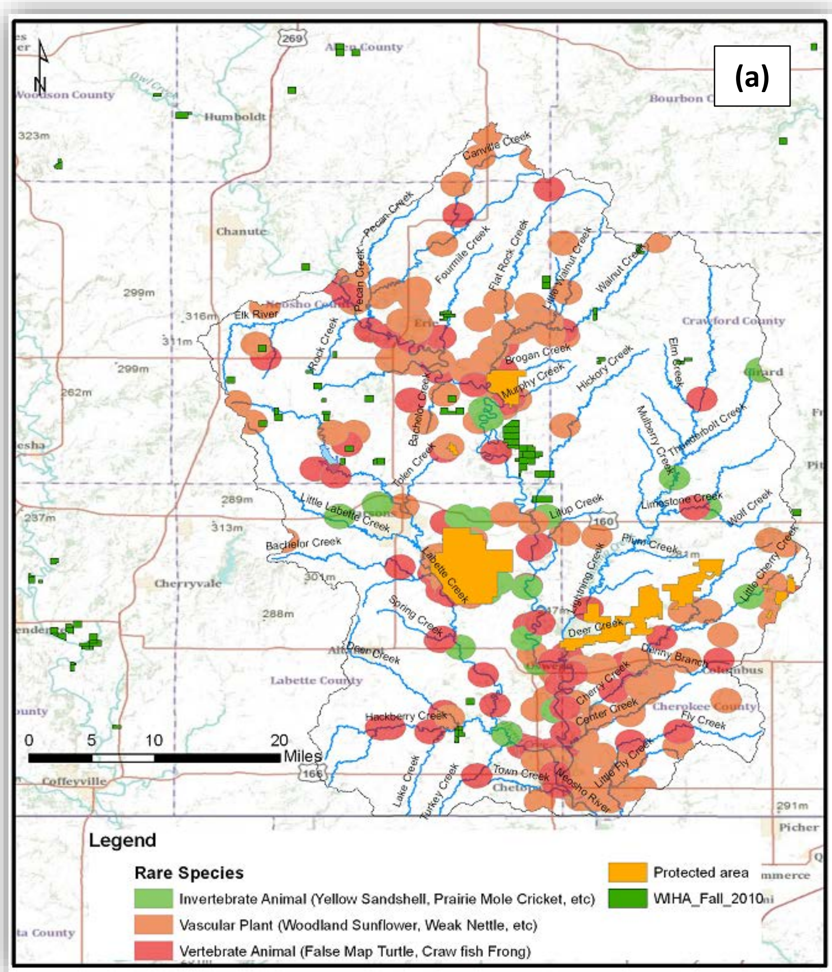
Wildlife Habitat

Middle Neosho River Watershed has numerous game fish and wildlife areas. They are under the jurisdiction of the Kansas Department of Wildlife and Parks and managed for wildlife and songbird habitat. Native plant restoration, prescribed burning, timber management and farming to provide food and habitat for wildlife are some examples of management practices that have been adopted in this area.

Endangered Species

Middle Neosho River Watershed has many rare species not found commonly in the state of Kansas (Figure 8). Labette Creek is listed as special aquatic life use waters (defined as “surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state, or surface waters that contain representative populations of threatened or endangered species”) by the Kansas Department of Wildlife and Parks or the United States Fish and Wildlife Service on this purpose.

The Upper Neosho River Watershed has numerous vertebrate (Spotted Sucker, Neosho Madtom, Bluntnose Darter, Crawfish Frog etc.), invertebrate (Prairie Mole Cricket, Wartyback, Neosho Mucket, Creeper, Spike, Yellow Sandshell, Fawnsfoot, etc.)and vascular plant (Creeping Day-flower, Arkansas Sedge, Marsh Flatsedge, Kansas Arrowhead, Tiny Lease Daisy etc.) rare species (Figure 8). Wolf Creek, Little Indian Creek, Owl Creek South, Bloody Run and Onion Creek are designated as Special aquatic life use waters (“surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state, or surface waters that contain representative populations of threatened or endangered species”) in addition to Neosho River. These special aquatic life use waters are located primarily in cropland area. Pollutants from agricultural land might threaten the health of the rare species within these creeks.



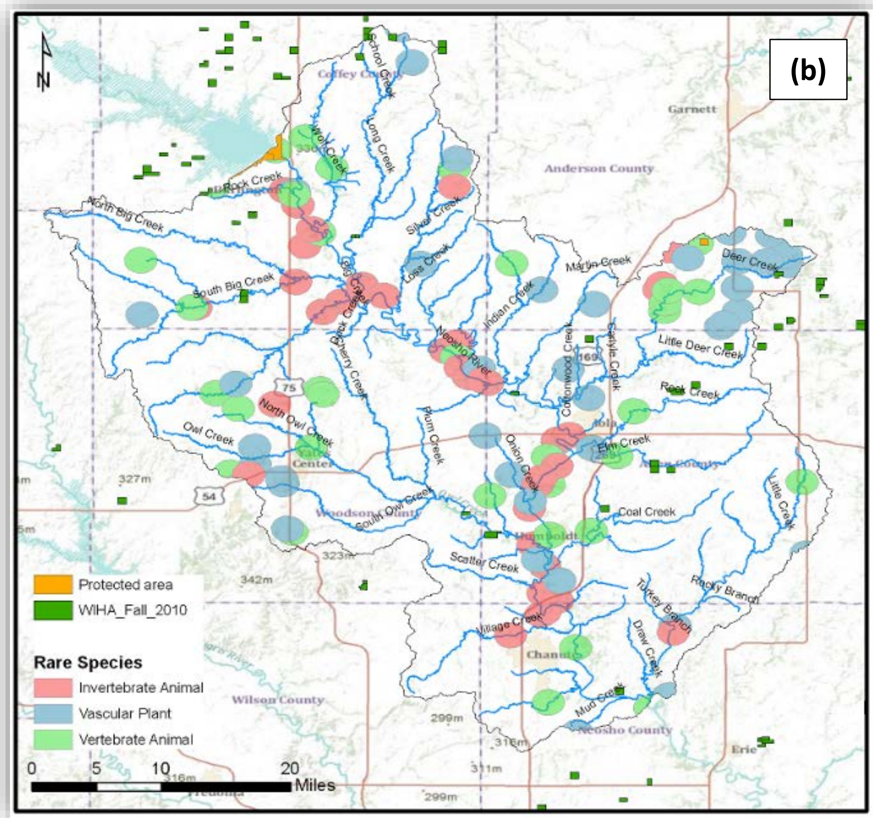


Figure 8 Map of rare species, protected areas, and areas with walk-in hunting access in (a) Middle Neosho and (b) Upper Neosho River Watersheds

Recreational Areas

There are numerous summing, boating, fishing, and walk-in hunting areas within the Neosho River watershed as shown in Figure 8.

Watershed / Water Quality Conditions

When river segments or lakes that are monitored by Kansas Department of Health and Environment (KDHE) have experienced poor quality, a Total Maximum Daily Load (commonly referred to as a TMDL) is established. A TMDL is the maximum amount of pollution that a surface water body can receive and still meet water quality standards.

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. The list of impaired waterways is updated by the states every two years. This can be used to identify specific stream segments and lakes for which, in accordance with their priority ranking, TMDLs may need to be developed.

Total Maximum Daily Loads (TMDLs)

KDHE established streams and lakes experienced poor quality as TMDLs. TMDLs within Upper Neosho River and Middle Neosho River watersheds are mapped in Figure 9 and listed in Table 4. Nearly one-fourth of all water resources in the watershed do not support their designated uses and require TMDLs. Approximately 14% of stream/river miles do not meet water quality standards for low dissolved oxygen, fecal coliform bacteria (FCB), and ammonia. Nearly 64% of the lakes/wetlands in the watershed do not meet water quality standards. Approximately 43% of lakes/wetlands are eutrophic, 14% have low dissolved oxygen, 14% are impaired by FCB, 14% are impaired by silt, 7% have low flow, and 7% are impaired by pH.

Low dissolved oxygen is impairment in numerous creeks and lakes throughout the watersheds. This has resulted in a TMDL aimed at increasing dissolved oxygen concentrations to provide full support of aquatic life. Riparian vegetation restoration, grass buffer strips along streams, proper manure storage and distribution, adequately functioning septic systems, and proper chemical fertilizer rates should help improve water quality and raise dissolved oxygen rates.

Eutrophication is a primary result of excess nutrients entering a waterway. Excess nutrient loading from the watershed creates conditions favorable for algae blooms and plant growth resulting in unfavorable habitat for aquatic life. Surplus nutrients originate from manure and fertilizer runoff in rural and urban areas. Many agricultural producers in the watersheds implement best management practices (known as BMPs) to prevent nutrient runoff. Some common BMPs include: the use of conservation tillage and cover crops, maintaining buffer strips along field edges, and proper timing of fertilizer application.

The Middle Neosho River and Upper Neosho River Watersheds has TMDL for pH. Excursions above pH 8.5 in the Neosho River have been dominated by releases from John Redmond Lake. Nutrients released in the lake water cause photosynthesis by phytoplankton thereby raising the pH of the river water. Activities to reduce nutrient loading in John Redmond Lake should improve pH in the river.

Parsons Lake, Mined Land and Neosho Wildlife Management Areas (WMA), and three of the Mined Land Lakes are impaired by siltation. Silt or sediment accumulation in lakes and wetlands reduces reservoir volume and limits access to the lakes. In addition to the problem of sediment loading in lakes, copper and lead can be attached to the suspended soil particles in water column causing higher than normal concentrations. Reducing erosion is necessary for a reduction in sediment. Agricultural best management practices, such as conservation tillage, grass buffer strips around cropland, and reducing activities within the riparian areas will reduce erosion and improve water quality.

The Mined Land Wildlife Area and Lakes have a TMDL for Sulfate. High sulfate concentrations are derived from exposed sulfur containing bedrock that leaches sulfate into the water. Since no further mining is present and the land has been converted to a wildlife area, reassessment will be made in 2007.

For fecal coliform bacteria, Turkey Creek near Le Roy have high priority, and Big Creek, Deer Creek, and Owl Creek have middle priority. The presence of fecal coliform in aquatic environments may indicate that the water has been contaminated with the fecal material of humans or other animals. Fecal coliform bacteria can enter rivers through direct discharge of waste, from agricultural and storm runoff, and from human sewage. Implementing livestock BMPs and controlling discharges of sewage systems reduce the fecal coliform bacteria concentrations in the streams.

Flat Rock Creek has medium priority for copper, Big Creek near Le Roy, Neosho River near Chanute, and Owl Creek near Humboldt have low priority for copper. The majority of copper loading appears to originate from eroding soil particles that wash into the waterways. The particles contain copper from natural as well as agricultural sources. Implementing BMPs will decrease erosion thereby reducing the amount of copper in the water.

- Neosho Basin TMDLs: http://www.kdheks.gov/tmdl/neosho.htm

Table 4 TMDLs in the Watershed

Water Segment	TMDL Pollutant	Water Quality Standard	Endgoal of TMDL	Priority	Sampling Station
Middle Neosho River					
Bachelor Creek	Dissolved Oxygen	DO >5mg/l	Dissolved oxygen > 5 mg/l	Medium	SC698
Canville Creek	Dissolved Oxygen	DO >5mg/l	Dissolved oxygen > 5 mg/l	Medium	SC612
Cherry Creek	Dissolved Oxygen	DO >5mg/l	BOD < 2.65 mg/l under critical flow and no excursions < 5mg/l dissolved oxygen	High	SC605
Flat Rock Creek	Copper		Copper concentration < acute water quality standard at both low and high flows	Low	SC613
Labette Creek	Dissolved Oxygen	DO >5mg/l	BOD < 2.65 mg/l under critical flow and no excursions < 5mg/l dissolved oxygen	High	SC564, SC571
Altamont City Lake #1, #2, and #3	Eutrophication		Summer chlorophyll a concentrations = or < 12ug/l.	Low	LM068101
Bartlett Lake	Eutrophication		Summer chlorophyll a concentrations = or < 20 ug/l.	Low	LM045401
Mined Land WA Unit #42	Dissolved Oxygen	DO >5mg/l	Dissolved oxygen >5.0 mg/l Total Nitrogen < 0.62 mg/l	Low	LM038841
Neosho Co. SFL	Dissolved Oxygen	DO >5mg/l	Dissolved oxygen > 5.0 mg/l	Medium	LM044601

Neosho Co. SFL	Eutrophication		Summer chlorophyll a concentrations = or < 12ug/l.	Medium	LM044601
Neosho Co. SFL	pH	pH > 6.5 and < 8.5	pH between 6.5 and 8.5	Medium	LM044601
Neosho WMA	Eutrophication		Summer chlorophyll a concentrations = or < 20 ug/l. Total Nitrogen < 0.79 mg/l	Medium	LM 053401
Neosho WMA	pH	pH > 6.5 and < 8.5	pH between 6.5 and 8.5	Medium	LM 053401
Neosho WMA	Siltation		Secchi Disk Depth = 0.2 m	Medium	LM 053401
Neosho WMA	Lead		Lead < 0.0032 mg/l	Medium	LM 053401
Parsons Lake	Eutrophication		Summer chlorophyll a concentrations = or < 12ug/l.	Medium	LM041401
Parsons Lake	Siltation		Secchi Disk Depth = 0.3 m	Medium	LM041401
Mined Land Lakes	Sulfate		Sulfate concentrations = or < 1,000mg.l	Low	LM035901, 048201, 036801, 036901, 034301, 037601, 038841, 048401
Upper Neosho River					
Turkey Creek near LeRoy	Dissolved Oxygen	DO >5mg/l	Average BOD <3.9mg/l and no excursions <5mg/l	High	SC614
Turkey Creek near LeRoy	Fecal Coliform Bacteria	Secondary Contact < 2,000 colonies per 100 ml water	Not to exceed criterion of 2,000 colonies per 100 ml	High	SC614
Chanute Sante Fe Lake	Dissolved Oxygen, Eutrophication, pH	DO > 5mg/L pH > 6.5 and < 8.5	Summer Chlorophyll a </= 20 ug/L pH > 6.5 and < 8.5 Total Nitrogen < 0.79mg	Medium	LM 044401
Gridley City Lake	Dissolved Oxygen, Eutrophication	DO >5mg/l	Summer Chlorophyll a </= 12 ug/L DO >5.0mg/l Total Nitrogen <	Medium	LM045601

			0.62mg		
Big Creek near Le Roy	Fecal Coliform Bacteria	Primary Contact < 200 colonies per 100 ml water Secondary Contact < 2,000 colonies per 100 ml water	Primary Contact <200 colonies/100ml from 5 samples within a 30 day period Secondary Contact by single "not to exceed" criterion of <2,000 colonies/100 ml	Medium	SC615
Deer Creek near Iola	Fecal Coliform Bacteria	Primary Contact < 200 colonies per 100 ml water	Primary Contact <200 colonies/100ml from 5 samples within a 30 day period Secondary Contact by single "not to exceed" criterion of <2,000 colonies/100 ml	Medium	SC609
Owl Creek near Humboldt	Fecal Coliform Bacteria	Secondary Contact < 2,000 colonies per 100 ml water	Secondary Contact by single "not to exceed" criterion of <2,000 colonies/100 ml	Medium	Medium SC610
Neosho River near Chanute	pH	pH range between 6.5 and 8.5	pH >/= 6.5 and </= 8.5	Low	SC271, SC560
Gridley City Lake	Berylium	Be < 0.13ug/L	Be </= 0.13 g/L	Low	LM045601
Big Creek near Le Roy	Copper	Acute Criterion (WQS) = Water Effects Ratio {EXP{(0.9422*(ln(hardness in mg/L)))-1.700}}	Copper Concentration < WQS	Low	SC615
Neosho River near Chanute	Copper	Acute Criterion (WQS) = Water Effects Ratio {EXP{(0.9422*(ln(hardness in mg/L)))-1.700}}	Copper Concentration < WQS	Low	SC560 and SC271
Owl Creek near	Copper	Acute Criterion (WQS) = Water	Copper Concentration <	Low	SC610

Humboldt		Effects Ratio {EXP{(0.9422*(ln(hardness in mg/L)))-1.700}}	WQS		

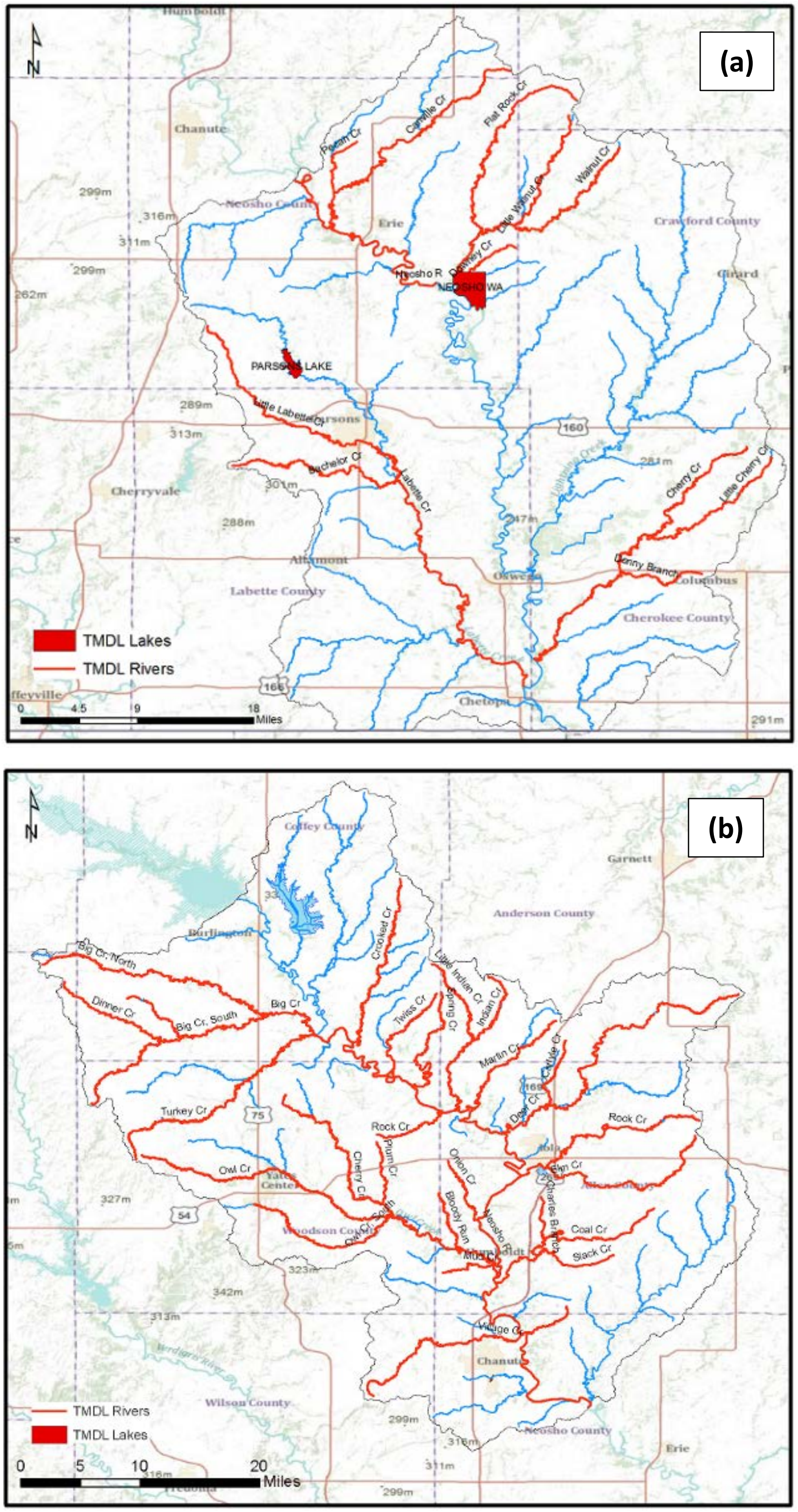


Figure 9 TMDL streams and lakes in the (a) Middle Neosho River and (b) Upper Neosho River Watersheds

The 303d List of Impaired Water Bodies

The Middle Neosho Watershed has numerous impaired lakes and rivers according to KDHE. Current pollutant conditions in the watershed are listed in Table 5. Figure 10 and Table 6 show all impaired streams that are not meeting their designated uses (impaired waters) because of excess pollutants as defined in Section 303(d) of the Clean Water Act. Presence of copper, lead, ammonia, eutrophication, fecal coliform, zinc and siltation are some cause of impairments. Impairment priority rages from low to adequate water quality. The list of impaired waterways is updated by the states every two years. This can be used to identify specific stream segments and lakes for which, in accordance with their priority ranking, TMDLs may need to be developed.

There are high, medium and low priority leveled assigned TMDLs within Upper Neosho Watershed (Table 6). Turkey Creek near LeRoy has high priory level TMDLs for dissolved oxygen and fecal coliform bacteria. Potential sources of fecal coliform bacteria include feedlots, wastewater treatment plants, failing septic systems, and wildlife. Target TMDL endpoint is less than 200 colony forming units per 100 ml water for swimming, and less than 2,000 colony forming units per 100 ml water for boating and fishing.

Low dissolved oxygen is impairment in numerous creeks and lakes throughout the watersheds. This has resulted in a TMDL aimed at increasing dissolved oxygen concentrations to provide full support of aquatic life. Riparian vegetation restoration, grass buffer strips along streams, proper manure storage and distribution, adequately functioning septic systems, and proper chemical fertilizer rates should help improve water quality and raise dissolved oxygen rates.

Eutrophication, pH, beryllium and copper are the other TMDLs pollutants present within this watershed. Copper impairs water quality in Owl Creek, Big Creek and the Neosho River at Chanute. The majority of copper loading appears to originate from eroding soil particles that wash into the waterways. The particles contain copper from natural as well as agricultural sources. Implementing BMPs will decrease erosion thereby reducing the amount of copper in the water.

Table 5 Impaired streams and lakes and water-quality sampling visits and times in the Middle Neosho River Watershed

Watershed and Impairment	Sampling Sites	Sampling Times	Excursions Seen	Baseline Condition
Bachelor Creek DO	Station 698 near Labette	Spring	25%	Nonsupport of impaired designated use
		Summer/Fall	100%	
		Winter	40%	
Canville Creek DO	Station 614 near Shaw	Spring	13%	Nonsupport of impaired designated use
		Summer/Fall	38%	
		Winter	29%	
Cherry Creek DO	Station 605 near Faulkner	Spring	60%	Nonsupport of impaired designated use
		Summer/Fall	43%	
		Winter	22%	
Flat Rock Creek Cu	Station 613 near St. Paul	Current load = 4.673 lb/day		

Labette Creek DO	Station 564 near Labette and Station 571 near Chetopa	Spring	23%	Partial support of impaired designated use
		Summer/Fall	12%	
		Winter	4%	
Altamont City Lake E	Stations LM068001, LM068101, LM068201	Summer Chlorophyll-a = 79.20, 49.90, 12.15 ppb (Hypereutrophic, hypereutrophic and fully eutrophic, respectively) Total phosphorus = 0.07, NA, 0.04 ppm respectively Secchi disk depth = 0.47, 0.47, 0.77 respectively		
Bartlett Lake E	Station LM045401	Chlorophyll-a = 36.5 ppb Total Phosphorus = 211ppb Total Phosphorus in bottom deposits of lake = 390ppb Total Kjeldahl nitrogen in bottom deposits of lake = 764ppm		
Mined Land Lake DO	Station LM038841 in Mined Land Lake #42	DO = 5.2 mg/l Total Phosphorus = 79ppb Chlorophyll a = 12.4ppb		
Neosho Co SFL DO and E	Station LM044601 in Neosho Co SFL	Chlorophyll a = 42.6ppb Total Phosphorus = 310ppb Total Kjeldahl Nitrogen = 1.72ppm pH = 7.70		
Neosho WMA E and pH	Station LM053401 in Neosho WMA	Chlorophyll a = 109ppb Total Phosphorus = 378ppb Total Kjeldahl Nitrogen = 3.53ppm pH = 8.08		
Neosho WMA Silt	Station LM053401 in Neosho WMA	Secchi Disk depth = 14cm Turbidity is 77.7ftu Total suspended solids = 143mg/l Chlorophyll a = 109ppb		
Neosho WMA Lead	Station LM053401 in Neosho WMA	Lead = 0.0125mg/l		
Parsons Lake E	Station LM041401 in Parsons Lake	Chlorophyll a = 6.0ppb Total Phosphorus = 134ppb		
Parsons Lake Silt	Station LM041401 in Parsons Lake	Secchi Disk depth = 22cm Turbidity is 51.4ftu Total suspended solids = 21.7mg/l Chlorophyll a = 6.0ppb Total Phosphorus = 134ppb		
Mined Land Lakes Sulfate	Stations Lake #6 Lake #7 Lake #12 Lake #17 Lake #22 Lake #23 Lake #27 Lake #30 Lake #44 Wetland #42	Lake #6 = 538mg/l Lake #7 = 1,326mg/l Lake #12 = 716mg/l Lake #17 = 1,573mg/l Lake #22 = 1,146mg/l Lake #23 = 983mg/l Lake #27 = 875mg/l Lake #30 = 1,142mg/l Lake #44 = 1,165mg/l Wetland #42 = 756mg/l		

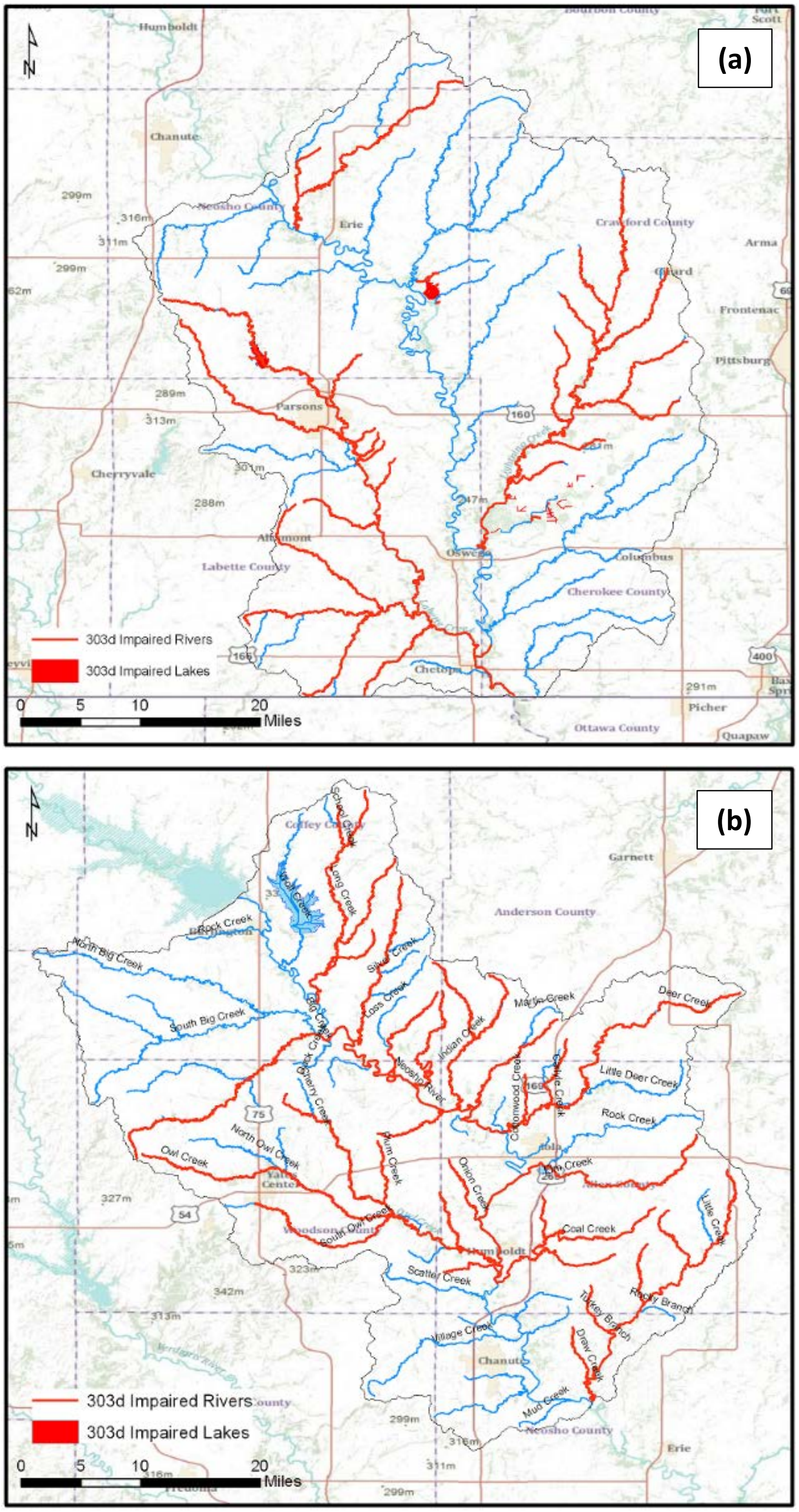


Figure 10 Streams on 303d list in the (a) Middle Neosho and (b) Upper Neosho River Watersheds

Table 6 2008 303d List of Impaired Waters in the Middle Neosho River Watershed

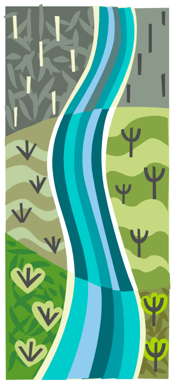
Water Segment	Impairment	Priority	Sampling Station
Middle Neosho River			
Canville Creek near Shaw	Copper	Low	SC612
Labette Creek near Chetopa	Copper	Low	SC571
Neosho WA	Copper	Low	SC571
Mined Land Lake 19	Eutrophication	Low	LM053401
Mined Land Lake 19	Eutrophication	Low	LM053501
Mined Land Lake 24	Eutrophication	Low	LM037001
Mined Land Lake 25	Eutrophication	Low	LM037101
Mined Land Lake 26	Eutrophication	Low	LM037201
Mined Land Lake 31	Eutrophication	Low	LM037701
Mined Land Lake 34	Eutrophication	Low	LM038001
Mined Land Lake 35	Eutrophication	Low	LM038101
Mined Land Lake 36	Eutrophication	Low	LM038201
Mined Land Lake 40	Eutrophication	Low	LM038601
Mined Land Lake 41	Eutrophication	Low	LM038701
Labette Creek near Chetopa	Lead	Low	SC571
Parsons Lake	Lead	Low	LM041401
Mined Land Lake 22	Perchlorate	Low	LM038841
Mined Land Lake WA	Siltation	Low	LM038841
Lightning Creek near Oswego	Temperature	Low	SC565
Labette Creek near Labette	Total Phosphorus	Low	SC564
Labette Creek	Ammonia	No longer impaired	NPDES97560
Labette Creek near Chetopa	Atrazine	Adequate water quality	SC571
Labette Creek near Labette	Copper	Adequate water quality	SC564
Labette Creek	Fecal Coliform bacteria	No longer impaired	NPDES97560
Mined Land Lake 12	pH	Adequate water quality	LM035901
Mined Land Lake 12	Silattion	Adequate water quality	LM035901
Mined Land Lake 17	Silattion	Adequate water quality	LM048201
Mined Land Lake 30	Silattion	Adequate water quality	LM037601
Labette Creek near Labette	Zinc	Adequate water quality	SC564
Upper Neosho River			
Turkey Creek near LeRoy	Copper	Low	SC614
Big Creek near Chanute	Dissolved Oxygen	Low	SC611
Long Creek near Le Roy	Dissolved Oxygen	Low	SC695
Neosho River near Chanute	Lead	Low	SC560

Owl Creek near Humboldt	Lead	Low	SC610
Deer Creek near Iola	Zinc	Low	SC609
Neosho River near Chanute	Zinc	Low	SC560
Owl Creek near Humboldt	Zinc	Low	SC610
Little Turkey Cree	Ammonia	Evaluate for 2012 303d list	NPDES80837
Owl Creek	Ammonia	Evaluate for 2012 303d list	NPDES97446
Big Creek near Chanute	Copper		SC611
Little Turkey Creek	Fecal Coliform Bacteria	Evaluate for 2012 303d list	NPDES80837

Turkey Creek near Le Roy and Neosho River near Chanute water segments have been removed from the 2010 303d list (Table 7). Figure shows the map of 303d Listings in the Watershed.

Table 7 2010 303d Delisted Waters

Water Segment	Impairment	Priority	Sampling Station
Turkey Creek near Le Roy	Lead, Zinc	No longer impaired	SC614
Neosho River near Chanute	pH	No longer impaired	SC271 and SC560



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 Neosho River Watershed project was to develop models and tools to evaluate alternative farm and non-farm land use practices in relation to water quality and to document the impact of water restoration and preservation strategies.

Objectives

The objectives of this WRAPS Assessment Phase project were to:

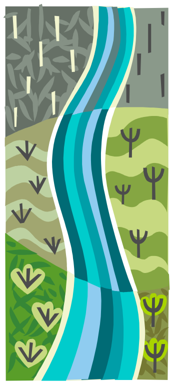
1. characterize watershed conditions,
2. identify needs and opportunities for watershed information to support stakeholder decisions, and
3. understand how the watershed responds to various management scenarios.

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.

The completed activities that address the established goals and objectives are presented in the following sections.



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 January 2007 and ending in July 2009.

Inform and Educate Watershed Stakeholders

Two Stakeholder Leadership Teams were recruited and established in the watershed. Both teams were active during the assessment project and provided critical stakeholder engagement that resulted in modeling results truly relevant for the WRAPS planning process. Watershed modeling and economic analysis results were presented to the SLTs during several meetings, critically discussed, and the final critical areas were approved.

Activities

The following assessment activities took place during the time span of the project:

Date	Type	# Att	# Mater.	Description
2/15/2007	Other	N/A	N/A	We have met with the multistate partners to discuss planning, assessment, and development activities underway within the Grand Lake watershed in each state. The local Oklahoma Grand Lake group is highly active, but only in issues that are in direct proximity to the Lake itself (e.g., septic systems), not with other activities further removed from the Lake but still within the watershed. With a large proportion of the watershed contained within Kansas, much of this work will be addressed in the Kansas WRAPS process. Efforts have been initiated to build communication among the states via a listserve and, potentially, other Web-based information sharing; these interactive efforts are all in a very early stage of development.
2/21/2007	Other	N/A	N/A	Initial contact has been made with Reid Christianson, KSU Extension Assistant in the Biological and Agricultural Engineering Department, whose area of focus is Urban Stormwater BMPs. If the local leadership team identifies urban stormwater as an issue in the Neosho Watershed, then future work will involve the addition of economics to his work on the engineering side.

6/9/2007	PMT Meeting	8	11	No major issues. Development project progressing well. Stakeholder Leadership Team fully established and actively working to develop issues and goals. Assessment Project is coordinating with Development Project to begin work needed to transition into the assessment/modeling phase in the next quarter.
11/14/2007	Public Meeting	N/A	2 PowerPoint presentations	Two meeting were held on November 14, 2007 in Parsons and Iola for the Upper and Middle Neosho Stakeholder groups. In these meetings, watershed modeling was introduced by the watershed modeler as a tool that can be used for watershed assessment and planning. In addition, different types of watershed modeling were discussed. The group was also introduced to economic analysis by the economist that will take place and how the economic analysis will work with the watershed modeling. They were made aware of current decision-making tools that are available to them on the Internet.
2/13/2008	SLT Meeting	20	40	An introduction to watershed modeling was presented by the watershed modeler. Preliminary goals have been identified by the local leadership team. The Preliminary Watershed Assessment Report will serve as a framework for the WRAPS document as a summary of the current watershed conditions. Writing of the formal WRAPS document will commence in the WRAPS Planning phase. An adaptive modeling approach was discussed and approved by the SLT.
9/16/2008	SLT Meeting	20	20	The Middle Neosho SLT Meeting. The STEPL modeling results were presented for entire Neosho basin below John Redmond Reservoir, the STEPL watershed modeling input data were discussed, and revisions recommended. The KSU Assessment team revised the STEPL modeling inputs, re-ran the model, and prepared a presentation summarizing the revised STEPL results.
9/16/2008	SLT Meeting	15	15	The Upper Neosho SLT Meeting. The STEPL modeling results were presented for entire Neosho basin below John Redmond Reservoir, the STEPL watershed modeling input data were discussed, and revisions recommended. The KSU Assessment team revised the STEPL modeling inputs, re-ran the model, and prepared a presentation summarizing the revised STEPL results.
11/3/2008	Workshop	14	0	During 11/03/2008-11/07/2008, Aleksey Sheshukov attended a SWAT/APEX workshop at the Texas A&M University in College Station, TX. The purpose of attending the workshop was to learn about the advanced watershed modeling tools - SWAT and APEX, and train to be proficient applying these tools in the WRAPS projects. This workshop was designed to introduce new version of SWAT (ArcSWAT), review necessary and optional inputs, and familiarize the user with the new ArcGIS interfaces. It also covered sensitivity analysis, model calibration, and uncertainty analysis using the 2005 version of SWAT with an ArcGIS interface.
1/28/2009	SLT Meeting	8	8	The Upper Neosho SLT meeting. The expert team presented the preliminary SWAT modeling results. The detailed discussion and presentation by the watershed modeler is scheduled for the next meeting.

2/26/2009	SLT Meeting	11	11	The Upper Neosho SLT Meeting. The SWAT modeling results were presented by the watershed modeler for Upper Neosho River basin. The watershed modeler presented a watershed assessment summary report including main land characteristics (topography, soil types, and land cover), current TMDL stream concerns, HUC-14 subwatershed map, and county map. The revised STEP-L results were presented to the stakeholders, and the changes from initial STEP-L run were discussed. The modeler presented maps of total sediment and nutrients loadings, and a map with targeted areas (subwatersheds 13, 14, 26 (highest), 3, 29(high)) identified by SWAT. Further steps of what needs to be done including the "groundtruthing" were also suggested and discussed. Discussion of further modeling was taken place, stressing the fact that it would be very helpful to pursue a more detailed analysis within the targeted areas to identify the fields of the greatest potential. The process of publishing the Preliminary Assessment Report (i.e., Watershed Atlas) as a K-State Research and Extension publication has begun, and thus making it available digitally online. This process should take about 3 more months for the whole set of 10 Watershed Atlases. Josh Roe (watershed economist) introduced the concept of cost-effective BMP implementation through targeting. Using past projects as a template, he showed how through the use of watershed modeling and optimization techniques, twice the nutrient and sediment runoff can be prevented using the same amount of funds as randomly installing BMPs throughout the watershed. A handout was made showing ten of the most popular crop land BMPs and the SLT was instructed to begin the process of estimating what the current BMP adoption rates were in the targeted areas identified by the modeling. Josh also spent time in calibrating and installing new features on the Watershed Manager. (BMP cost-effectiveness optimization spreadsheet.)
2/26/2009	SLT Meeting	9	9	The Middle Neosho SLT Meeting. The SWAT modeling results were presented by the watershed modeler for Upper Neosho River basin. The watershed modeler presented a watershed assessment summary report including main land characteristics (topography, soil types, and land cover), current TMDL stream concerns, HUC-14 subwatershed map, and county map. The revised STEP-L results were presented to the stakeholders, and the changes from initial STEP-L run were discussed. The modeler presented maps of total sediment and nutrients loadings, and a map with targeted areas (subwatersheds 13, 14, 26 (highest), 3, 29(high)) identified by SWAT. Further steps of what needs to be done including the "groundtruthing" were also suggested and discussed. Discussion of further modeling was taken place, stressing the fact that it would be very helpful to pursue a more detailed analysis within the targeted areas to identify the fields of the greatest potential. The process of publishing the Preliminary Assessment Report (i.e., Watershed Atlas) as a K-State Research and Extension publication has begun, and thus making it available digitally online. This process should take about 3 more months for the whole set of 10 Watershed Atlases. Josh Roe (watershed economist) introduced the concept of cost-effective BMP implementation through targeting. Using past projects as a template, he showed how through the use of watershed modeling and optimization techniques, twice the nutrient and sediment

				runoff can be prevented using the same amount of funds as randomly installing BMPs throughout the watershed. A handout was made showing ten of the most popular crop land BMPs and the SLT was instructed to begin the process of estimating what the current BMP adoption rates were in the targeted areas identified by the modeling. Josh also spent time in calibrating and installing new features on the Watershed Manager. (BMP cost-effectiveness optimization spreadsheet.)
4/9/2009	SLT Meeting	15	15	The Upper Neosho SLT Meeting. Results of groundtruthing conducted by the SLT were presented. The most appropriate cropland BMPs for areas identified by SWAT model were discussed and selected. Josh presented an optimal set of cropland BMPs and showed the increase in "bang for the buck" that occurs if the BMPs are placed in the targeted area compared to random locations throughout the watershed. The SLT was educated on the cost-effectiveness of 12 cropland BMPs and through a dynamic voting procedure, selected their top five.
4/26/2009	SLT Meeting	9	9	The Middle Neosho SLT Meeting. Results of groundtruthing conducted by the SLT were presented. The most appropriate cropland BMPs for areas identified by SWAT model were discussed and selected. Josh presented an optimal set of cropland BMPs and showed the increase in "bang for the buck" that occurs if the BMPs are placed in the targeted area compared to random locations throughout the watershed. The SLT was educated on the cost-effectiveness of 12 cropland BMPs and through a dynamic voting procedure, selected their top five.

Establish Assessment Criteria

With assistance of two Stakeholder Leadership Teams, one in Upper Neosho River Watershed and one in Middle Neosho River Watershed, the assessment criteria were established based on the pollutant loads calculated with the watershed assessment models and/or monitoring data information in the Neosho River and its tributaries. The assessment criteria were given priorities in the sediment producing agricultural areas and the areas with heavy livestock grazing facilities.

Inventory Existing Information

The watershed assessment team compiled the preliminary assessment information needed for this WRAPS project and revised it with the Stakeholder Leadership Teams. Inventory included topographical information, land uses, soil types, weather data, surface water resources, designated uses, public and rural water supplies, recreational areas, TMDL, agricultural and management practices, etc. This WRAPS project was able 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 Atlas

Extensive information about the Neosho River 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:

Neosho River Watershed Assessment: Preliminary Report. K-State Research & Extension Publication #EP-135. 68 pages. http://www.ksre.ksu.edu/library/h20ql2/ep135.pdf

This publication included the following topics:

- 1.0. Upper and Middle Neosho 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 Neosho 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 Neosho River
  - 7.8. Census Data
- 8.0. Modeling
  - 8.1. Subbasin Map
  - 8.2. Input Data

        8.2.1. Upper Neosho
        8.2.2. Middle Neosho
    8.3. Model Output
        8.3.1. Upper Neosho
        8.3.2. Middle Neosho
9.0. Acknowledgment
10.0. Footnotes/Bibliography

TMDL Reports

The TMDL documents provide a rich source of watershed information. Priority categories and detailed list of impairments were provided in Table 4.

- Upper Neosho River Basin TMDL
    - Turkey creek: http://www.kdheks.gov/tmdl/ne/TurkeyCr_DO.pdf
    - Neosho river: http://www.kdheks.gov/tmdl/ne/NeoshoR_pH.pdf
    - Chanute city lake: http://www.kdheks.gov/tmdl/ne/ChanuteE.pdf
    - Gridley city lake: http://www.kdheks.gov/tmdl/ne/GridleyE.pdf
    - Big creek: http://www.kdheks.gov/tmdl/ne/BigCr_FCB.pdf
    - Deer creek: http://www.kdheks.gov/tmdl/ne/DeerCr_FCB.pdf
    - Owl creek: http://www.kdheks.gov/tmdl/ne/OwlCr_FCB.pdf
    - Turkey creek: http://www.kdheks.gov/tmdl/ne/TurkeyCr_FCB.pdf

- Middle Neosho River Basin
    - http://www.kdheks.gov/tmdl/ne/BachelorCreek_DO.pdf
    - http://www.kdheks.gov/tmdl/ne/CanvilleCr_DO.pdf
    - http://www.kdheks.gov/tmdl/ne/CherryCr_DO.pdf
    - http://www.kdheks.gov/tmdl/ne/AltamontE.pdf
    - http://www.kdheks.gov/tmdl/ne/BartlettE.pdf
    - http://www.kdheks.gov/tmdl/ne/Wetland42DO.pdf
    - http://www.kdheks.gov/tmdl/ne/NeoshoCoSFL.pdf
    - http://www.kdheks.gov/tmdl/ne/NeoshoWMAE.pdf
    - http://www.kdheks.gov/tmdl/ne/NeoshoWMASilt.pdf
    - http://www.kdheks.gov/tmdl/ne/NeoshoWMAPb.pdf
    - http://www.kdheks.gov/tmdl/ne/ParsonsE.pdf
    - http://www.kdheks.gov/tmdl/ne/ParsonsSILT.pdf
    - http://www.kdheks.gov/tmdl/ne/MinedLandSO4.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

Soil and Water Assessment Tool (SWAT)

The Neosho River Watershed was assessed using the Soil and Water Assessment Tool (SWAT) by Kansas State University Department of Biological and Agricultural Engineering. SWAT was used as an assessment tool to estimate annual average pollutant loadings such as nutrients and sediment that are coming from the land into the stream. At the end of simulation runs the average annual loads are calculated for each sub watershed. Some subbasins have higher loads than the others. All subbasins are ranked based on the values of an average annual load, sorted from highest to lowest, and form the ranking list. Subbasins within the top 20 to 30 percent of the list are selected as critical (targeted) areas for cropland and livestock BMPs implementation.

The SWAT model was developed by USDA- Agricultural Research Service (ARS) from numerous equations and relationships that have evolved from years of runoff and erosion research in combination with other models used to estimate pollutant loads from animal feedlots, fertilizer and agrochemical applications, etc. 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. The model directly accounts for many types of common agricultural conservation practices, including terraces and small ponds; management practices, including fertilizer applications; and common landscape features, including grass waterways. The model incorporates various grazing management practices by specifying the amount of manure applied to the pasture or grassland, grazing periods, and the amount of biomass consumed or trampled daily by the livestock. Septic systems, NPDES discharges, and other point-sources are considered as combined point-sources and applied to inlets of sub watersheds. These features made SWAT a good tool for assessing rural watersheds in Kansas.

The SWAT model is a physically based, deterministic, continuous, watershed scale simulation model developed by the USDA-ARS. 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. A modeled watershed is divided spatially into sub watersheds using digital elevation data according to the drainage area specified by the user. Sub watersheds 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 sub watershed having similar soil, land use, and slope characteristics. The use of HRUs allows slope, soil, and land-use heterogeneity to be simulated within each sub watershed, but ignores pollutant attenuation between the source area and stream and limits spatial representation of wetlands, buffers, and other BMPs within a sub watershed.

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

1. 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. Sediment yield is estimated for each subbasin with the Modified Universal Soil Loss Equation (MUSLE). The hydrology model supplies estimates of runoff volume and peak runoff rates. The crop

management factor is evaluated as a function of above ground biomass, residue on the surface, and the minimum C factor for the crop that is provided in the crop database.

2. The reservoir component detains water, sediments, and pollutants, and degrades nutrients, pesticides and bacteria during detention. This component was not used during the simulations.
3. The channel component routes flows, settles and entrains sediment, and degrades nutrients, pesticides and bacteria during transport. SWAT produces daily results for every sub watershed outlet, each of which can be summed to provide daily, monthly, and annual load estimates. The sediment deposition component is based on fall velocity, and the sediment degradation component is based on Bagnold's stream power concepts. Bed degradation is adjusted by the USLE soil erodibility and cover factors of the channel and the floodplain. This component was utilized in the simulations but not used in determining the critical areas.

Data Collection

Data for the Neosho River SWAT model were collected from a variety of reliable online and printed data sources and knowledgeable agency personnel within the watershed. The primary sources of input data were 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 had been developed to process the input data, enter it into the SWAT model, and analyze the output results: Visual Basic, Visual Basic for Applications and Visual Studio C++ were used as main programming languages to develop the data processing utilities.

Input data and their online sources were:

1. 30 meters DEM (USGS National Elevation Dataset)
2. 30m NLCD 2001 Land Cover data layer (USDA-NRCS)
3. STATSGO soil dataset (USDA-NRCS)
4. NCDC NOAA daily weather data (NOAA National Climatic Data Center)
5. Point sources (KDHE on county basis)
6. Septic tanks (US Census)
7. Crop rotations (local knowledge)
8. Grazing management practices (local knowledge)

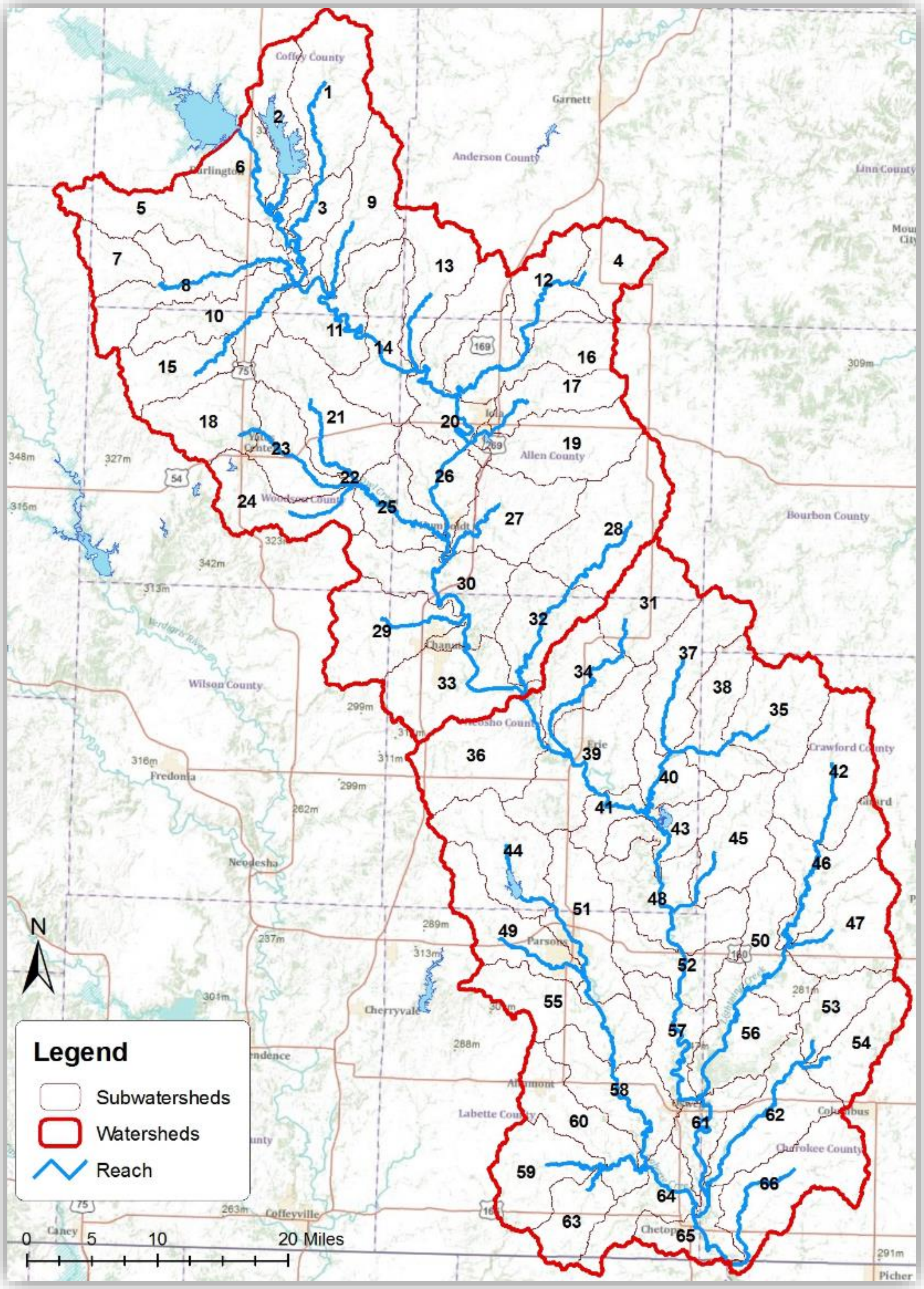


Figure 11 Neosho River Basin delineated with SWAT

Topography

The digital elevation map (DEM) for the basin was downloaded from the USGS National Elevation Dataset (NED). Elevations varied from 191 m to 497 m above the sea level (see Figure 12). The watershed was delineated into 66 subwatersheds (see Figure 11).

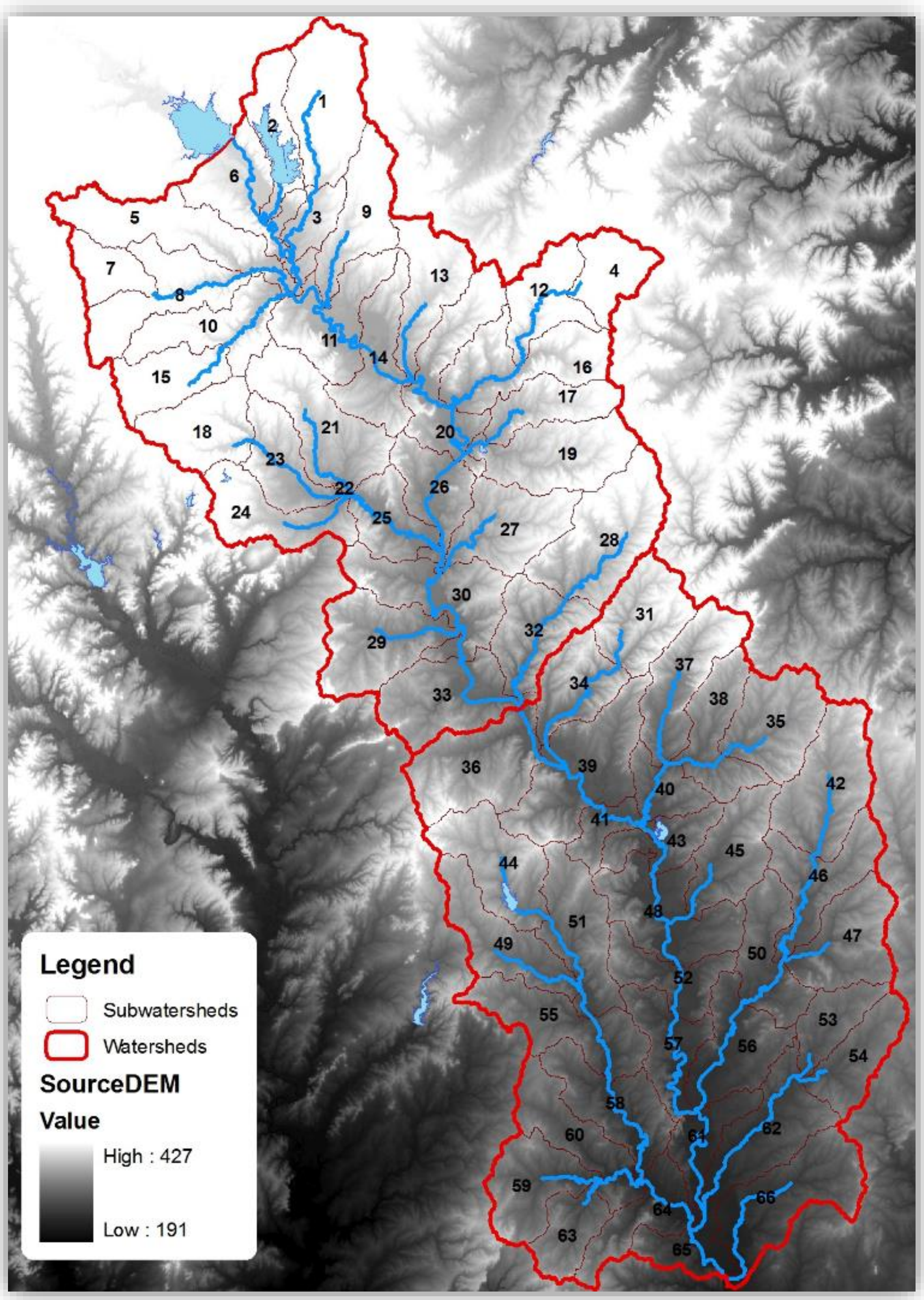


Figure 12 Topography map

Land Use

The land use dataset used in the model was the USDA National Land Cover Dataset (NLCD) prepared in 2001. NLCD 2001 has 10 standardized categories with 7 main categories presented in Figure 13 and summarized in Table 8 for the Neosho River Basin including Upper Neosho and Middle Neosho Watersheds.

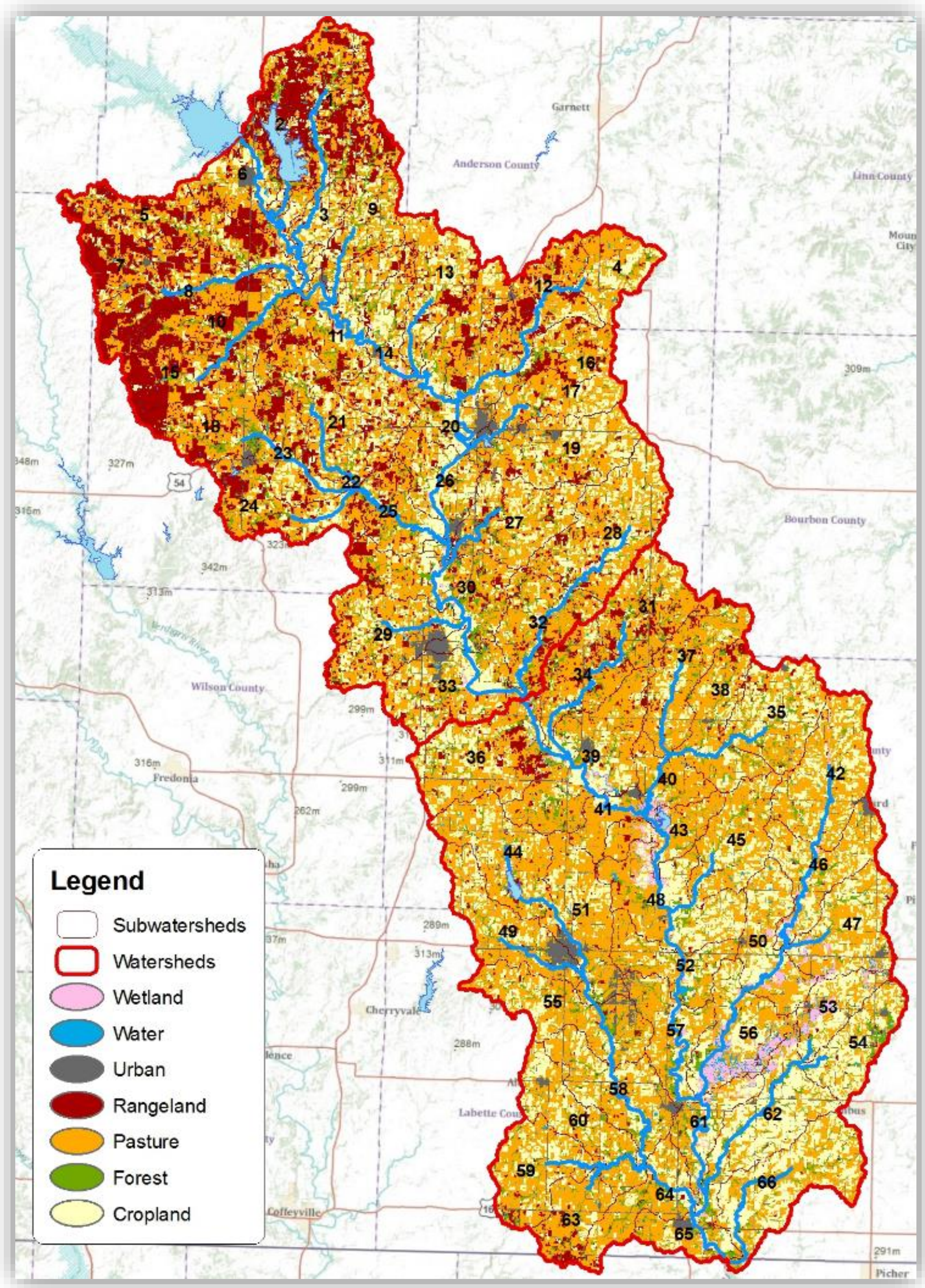


Figure 13 Land use map utilized in the SWAT model

Table 8 Areas of land uses and its classification used in SWAT model

LANDUSE:	Area [ha]	Area[acres]	%Wat.Area
Water	9,296.68	22,972.56	1.29
Residential-Low Density	31,312.80	77,375.49	4.34
Residential-Medium Density	8,201.41	20,266.10	1.14
Residential-High Density	1,261.15	3,116.37	0.17
Southwestern US (Arid) Range	756.21	1,868.62	0.10
Forest-Deciduous	50,385.02	124,503.91	6.98
Forest-Mixed	1,539.88	3,805.11	0.21
Range-Brush	214.16	529.19	0.03
Range-Grasses	81,961.36	202,530.61	11.35
Hay	321,149.97	793,577.64	44.48
Agricultural Land-Row Crops	201,082.52	496,884.95	27.85
Wetlands-Forested	14,179.22	35,037.55	1.96
Wetlands-Non-Forested	254.59	629.10	0.04
Industrial	335.24	828.40	0.05
Forest-Evergreen	26.56	65.63	0.01
Total	**721,956.76**	**1,783,991.25**	**100.00**

Soils

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 14 and Table 9 show 14 soils, their distribution and characteristics in the watershed.

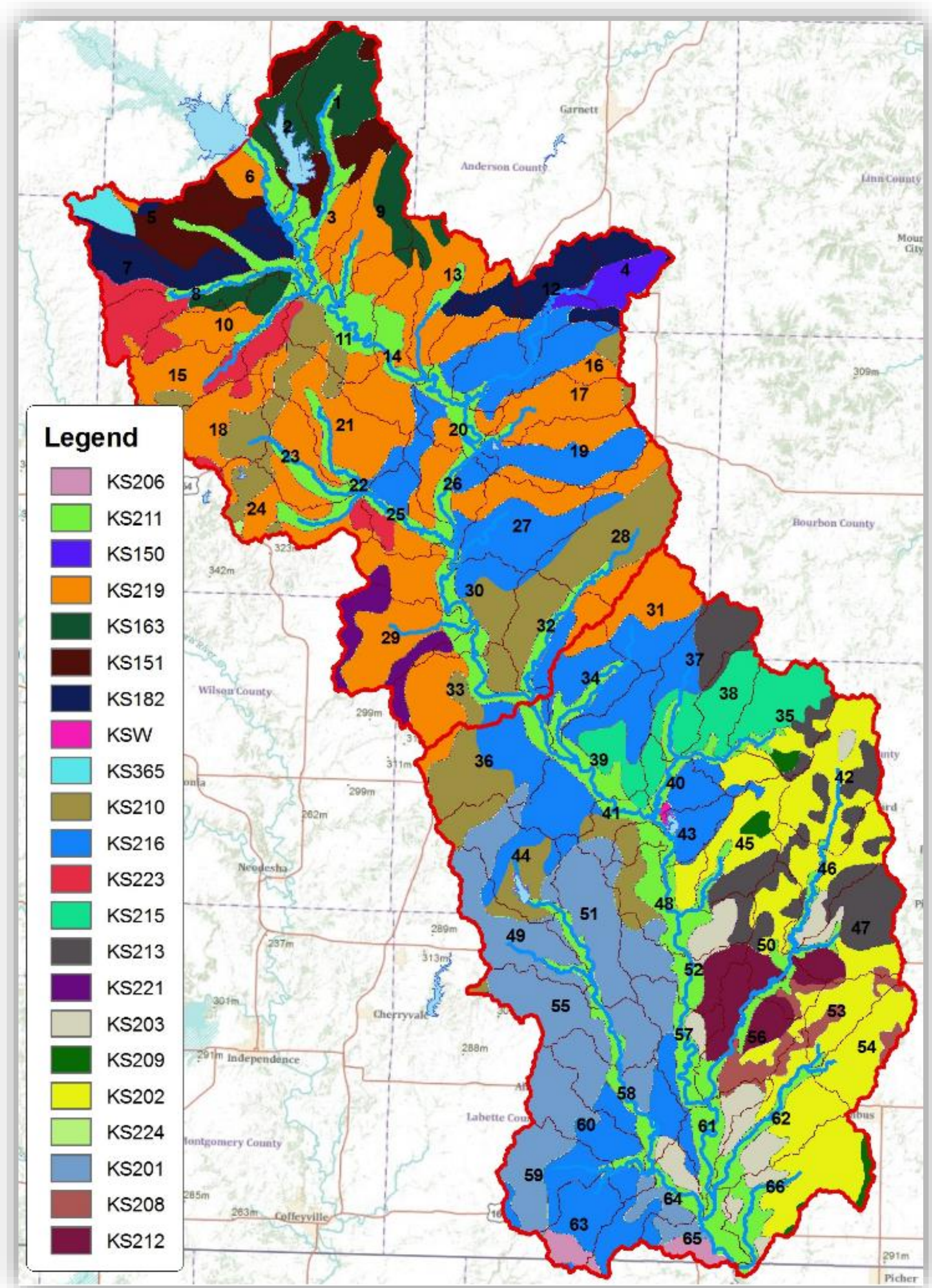


Figure 14 Soil map used in the SWAT model

Table 9 Soil characteristics used in the SWAT model

Soil	Area [ha]	Area [acres]	%Wat. Area
KS151	18,547.58	45,832.01	2.57
KS163	24,707.37	61,053.13	3.42
KS211	98,862.19	244,293.42	13.69
KS219	134,843.51	333,205.06	18.68

KS182	23,748.51	58,683.77	3.29
KS150	5,700.40	14,085.97	0.79
KS210	59,141.52	146,141.66	8.19
KS216	109,009.33	269,367.50	15.10
KS365	2,893.06	7,148.89	0.40
KSW	813.14	2,009.32	0.11
KS223	15,048.95	37,186.71	2.08
KS224	191.90	474.18	0.03
KS221	6,697.18	16,549.08	0.93
KS213	27,445.98	67,820.38	3.80
KS202	63,598.87	157,155.99	8.81
KS209	2,818.44	6,964.50	0.39
KS215	21,822.00	53,923.27	3.02
KS201	66,351.56	163,958.03	9.19
KS203	15,050.96	37,191.68	2.08
KS208	7,475.51	18,472.37	1.04
KS212	13,518.51	33,404.91	1.87
KS206	3,670.28	9,069.44	0.51
Total	**721,956.76**	**1,783,991.25**	**100.00**

Other inputs

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.

In every watershed, there are specific locations that contribute a greater pollutant load due to soil type, proximity to a stream and land use practices. By focusing BMPs in these areas; pollutants can be reduced at a more efficient rate. Through research at the University of Wisconsin, it has been shown that there is a “bigger bang for the buck” with streamlining BMP placement in contrast to a “shotgun” approach of applying BMPs in a random nature throughout the watershed. Therefore, the SLT has targeted areas in the watershed to focus BMP placement for sediment runoff, nutrients and *E. coli* bacteria from livestock production and stream bank erosion. Targeting for this watershed will be accomplished in three different areas:

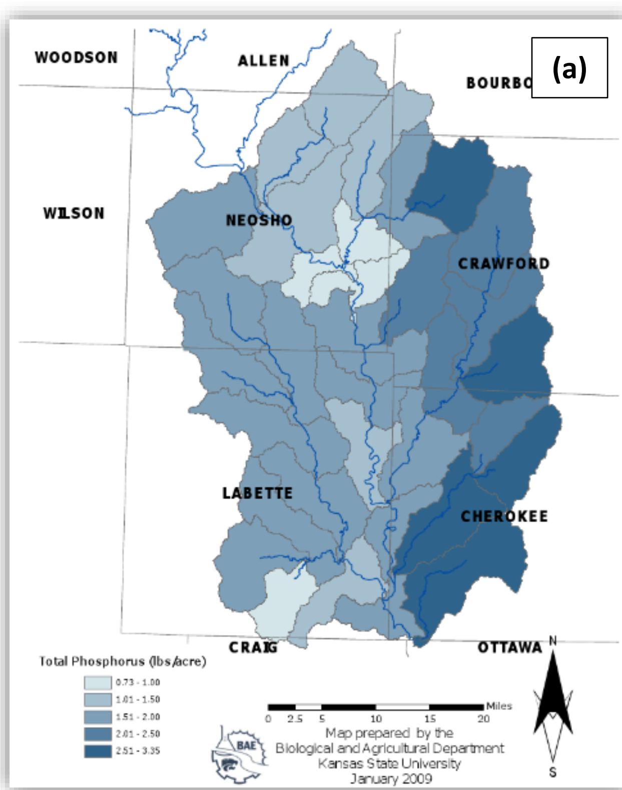
1. Cropland will be targeted for sediment,
2. Rangeland will be targeted for sediment and the same geographic area will be targeted for livestock related phosphorus, and
3. Stream banks will be targeted for sediment.

After locating initial critical targeted areas, the area was groundtruthed. Groundtruthing is a method used to determine what BMPs are currently being utilized in the targeted areas. It involves conducting windshield surveys throughout the targeted areas identified by the watershed models to determine which BMPs are currently installed. These surveys are conducted by local agency personnel and members of the SLT that are familiar with the area and its land use history. Groundtruthing provides the current adoption rate of BMPs, pictures of the targeted areas, and may bring forth additional water quality concerns not captured by watershed modeling. In 2009, the groundtruthing provided the current adoption rates for five common BMPs (buffers, no-till, terraces, conservation crop rotation and grassed waterways) in the cropland targeted area of the watershed averaged across counties.

The results are as follows:

- Vegetative buffer strips – current adoption rate of 30 percent
- No-till cultivation – current adoption rate of 20 percent
- Grassed terraces – current adoption rate of 70 percent
- Conservation Crop Rotation – current adoption rate of 95 percent
- Grassed waterways – current adoption rate of 10 percent The SWAT model was revised using the groundtruthing information.

This allows the SWAT model to develop a more accurate determination of appropriate targeted areas. The SWAT model then determined number of acres needed to be implemented for each BMP. The maps produced by the modeling are displayed below. It is noted that the areas are characterized by different color with darker colors indicating higher loads.



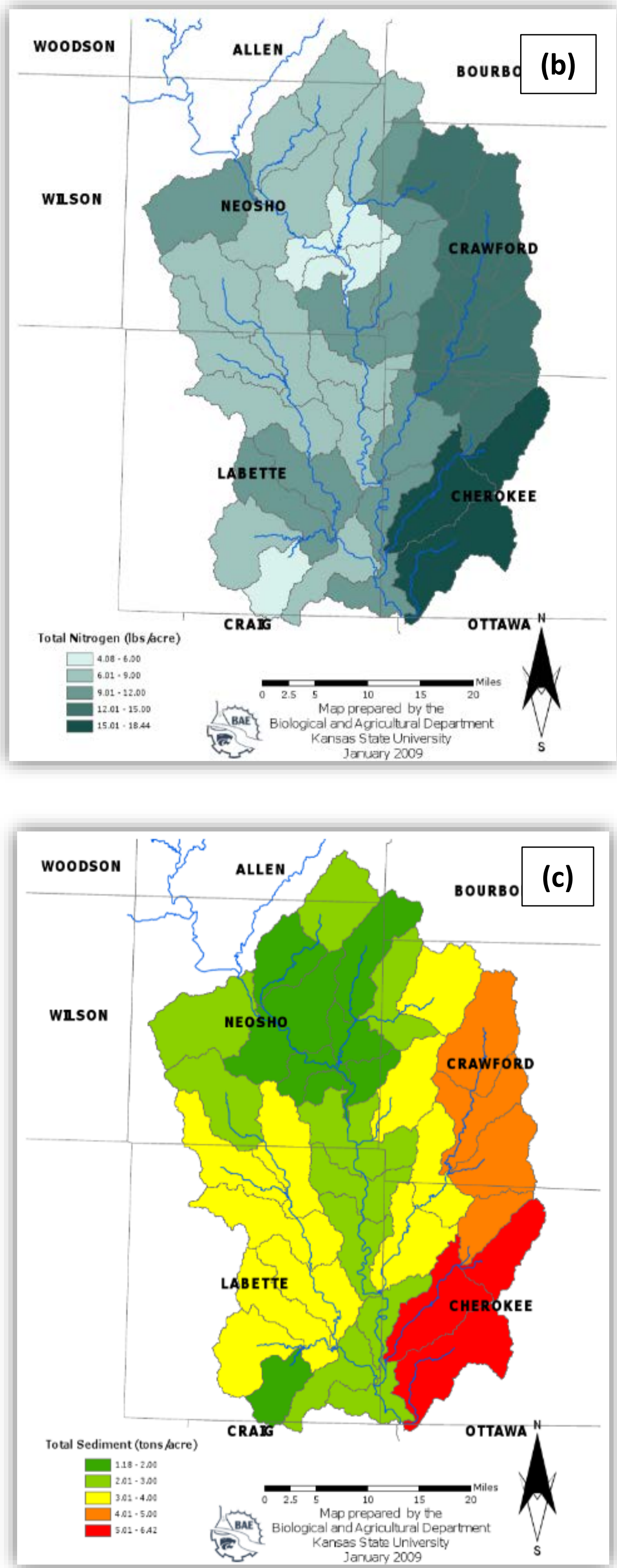
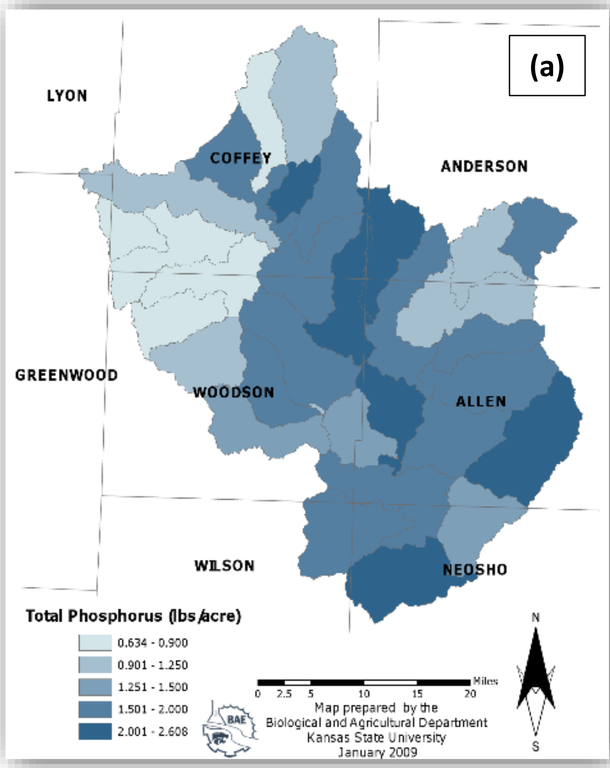


Figure 15 Maps of (a) total phosphorous, (b) total nitrogen, and (c) sediment yields in 17 subbasins of the Middle Neosho River Watershed


(a)
LYON
COFFEY
ANDERSON
GREENWOOD
WOODSON
ALLEN
WILSON
NEOSHO
Total Phosphorus (lbs/acre)
0.634 - 0.900
0.901 - 1.250
1.251 - 1.500
1.501 - 2.000
2.001 - 2.608
0 2.5 5 10 15 20 Miles
Map prepared by the
Biological and Agricultural Department
Kansas State University
January 2009
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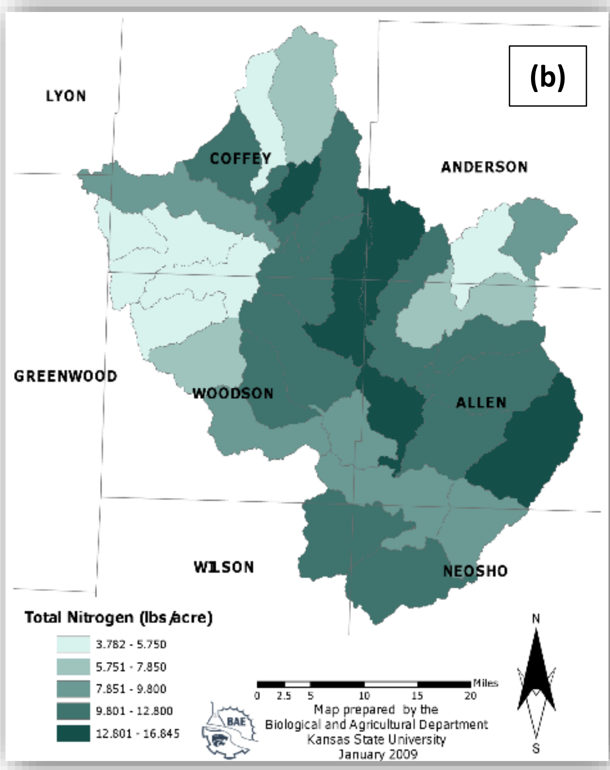
(b)
LYON
COFFEY
ANDERSON
GREENWOOD
WOODSON
ALLEN
WILSON
NEOSHO
Total Nitrogen (lbs/acre)
3.782 - 5.750
5.751 - 7.850
7.851 - 9.800
9.801 - 12.800
12.801 - 16.845
0 2.5 5 10 15 20 Miles
Map prepared by the
Biological and Agricultural Department
Kansas State University
January 2009
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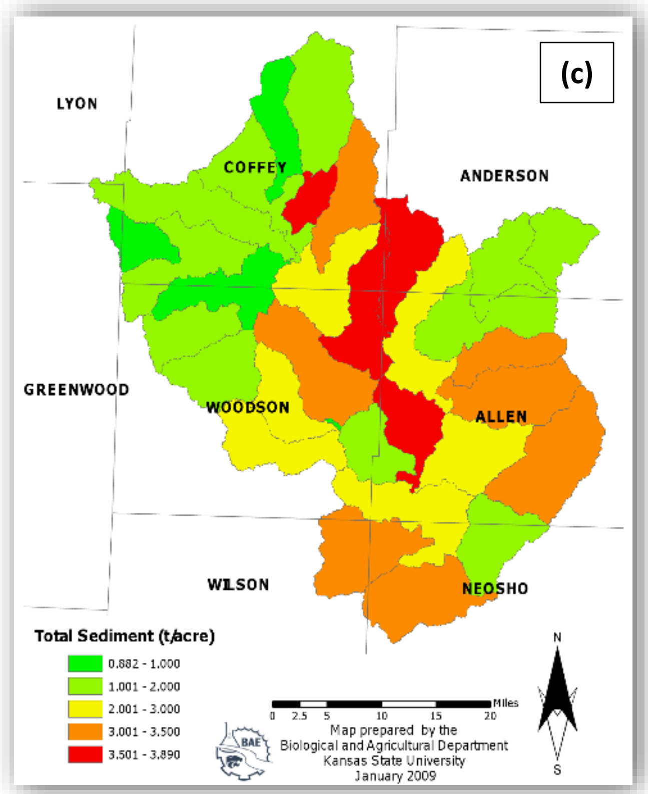


Figure 16 Maps of (a) Phosphorous (lb/acre), (b) Nitrogen (lb/acre), and (c) Sediment (tons/acre) Yields as Determined by SWAT in the Upper Neosho River Watershed

Pollutant Yields

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 organic nitrogen concentrations, were collected and combined in the forms of total sediment, phosphorous, and nitrogen loads. Figure 15 and Figure 16 present maps of the loads for Middle Neosho and Upper Neosho River Watersheds in a scale of graduated colors (darker color indicates higher load).

Average annual yields for each subwatershed are listed in Table 10. In Middle Neosho River Watershed, the subwatersheds 42, 46, 47, 54, 62, 53 and 66 produced the highest annual yields, whereas the subwatersheds 3, 9, 13, 14, 21, 26, 17, and 29 were the highest producing loads watersheds in the Upper Neosho River Watershed, with at least 20% or higher of the total watershed nitrogen, phosphorous, and sediment yields.

Table 10 Total pollutant loads for each subwatershed

Subbasin	Total Sediment Yield (tn/ac)	Total Phosphorous Yield (lb/ac)	Total Nitrogen Yield (lb/ac
1	1.694	1.051	6.82
2	0.998	0.741	4.909
3	3.628	2.608	16.845
4	1.69	1.713	9.345
5	1.628	1.18	7.877
6	1.974	1.508	9.82
7	0.905	0.634	3.782
8	1.038	0.76	4.811
9	3.327	1.9	12.041
10	0.989	0.738	4.861
11	2.754	1.894	11.958
12	1.372	0.974	5.682
13	3.808	2.389	14.954
14	3.89	2.337	15.024
15	1.115	0.827	5.444
16	1.705	1.148	6.953
17	3.401	1.993	12.549
18	1.596	1.075	6.862
19	3.106	1.92	11.529
20	2.784	1.734	10.829
21	3.236	1.882	12.002
22	0.882	1.228	8.453
23	2.733	1.804	11.55
24	2.046	1.416	9.069
25	1.818	1.359	8.641
26	3.761	2.371	14.567
27	2.958	1.797	10.708
28	3.319	2.278	12.808
29	3.418	1.901	11.712
30	2.324	1.572	9.612
31	2.676	1.359	8.615
32	1.968	1.383	8.16
33	3.01	2.022	12.181
34	1.59	1.007	6.279
35	3.251	2.507	13.811
36	2.556	1.8	10.157

37	1.602	1.294	7.894
38	2.435	1.682	9.386
39	1.411	1.189	6.945
40	1.182	0.959	5.719
41	1.386	0.969	5.672
42	4.149	2.363	13.39
43	1.22	0.89	5.079
44	2.795	1.632	8.41
45	3.767	2.207	11.801
46	4.398	2.443	12.898
47	4.131	2.593	14.67
48	2.585	1.902	10.559
49	3.316	1.72	8.839
50	3.716	2.322	12.258
51	3.291	1.571	8.285
52	2.965	1.598	8.65
53	4.659	2.463	12.871
54	6.42	3.205	16.34
55	3.296	1.668	8.748
56	3.19	1.749	9.106
57	2.201	1.39	7.922
58	3.178	1.841	9.716
59	3.356	1.716	8.863
60	3.229	1.906	9.645
61	2.216	1.732	9.923
62	5.394	3.11	15.775
63	1.178	0.733	4.076
64	2.176	1.287	7.214
65	2.404	1.665	9.808
66	6.3	3.35	18.441

STEPL Modeling

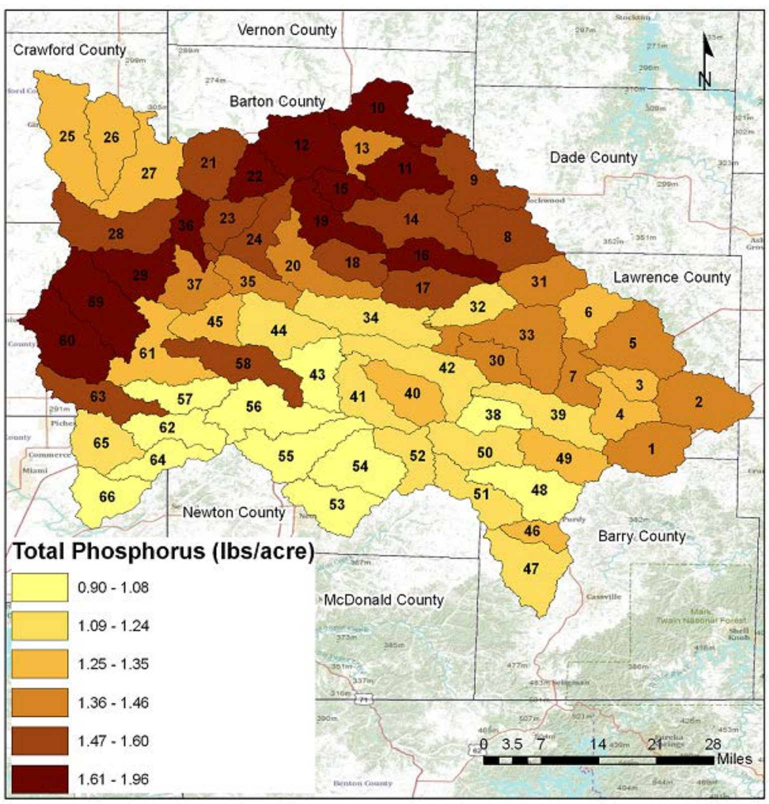
The Spreadsheet Tool for Estimating Pollutant Load (STEPL) model

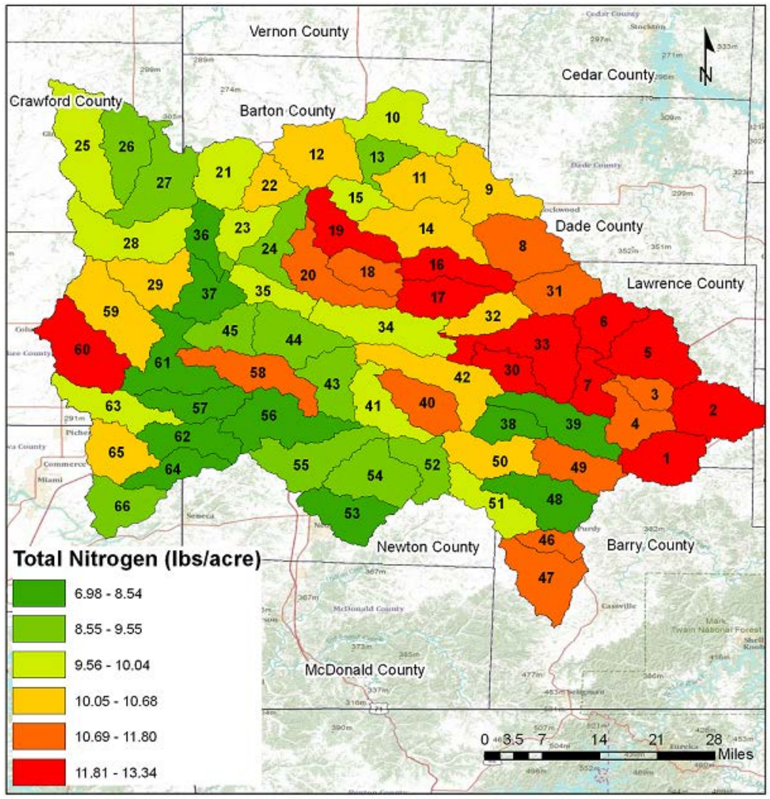
Spreadsheet Tool for Estimating Pollutant Load (STEPL) employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs) (Tetra Tech Inc, 2006). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5);

and sediment delivery based on various land uses and management practices. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

Spring Watershed

The STEPL model was employed for limited assessment of annual pollutant yields in Spring Watershed (HUC 11070207). Input datasets for delineated subareas (HUC 12 Units), land use, soil groups, number of animals, septic systems, etc, were downloaded from the STEPL Model Input Data Server (STEPL Data Server, 2011). The results were generated with default parameters and no BMP implementation. Model output contained annual sediment yield, total phosphorous and total nitrogen concentrations. Figure 17 presents maps of pollutant loads in a scale of graduated colors (darker color indicates higher load). Table 11 lists load values for each HUC 12 subwatershed within Spring Watershed. Figure 18 presents charts for total loads for individual land use calculated with the STEPL model.





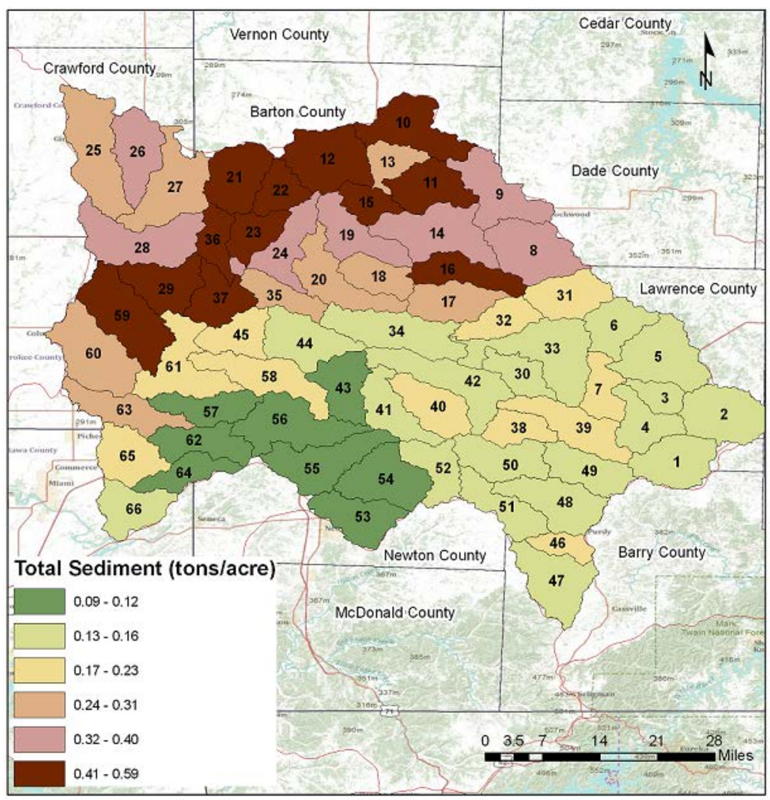


Figure 17 Maps of (a) Phosphorous (lb/acre), (b) Nitrogen (lb/acre), and (c) Sediment (tons/acre) Yields as Determined by SWAT in the Upper Neosho River Watershed

Table 11 Pollutant loads for each HUC-12 subwatershed

	HUC 12 watershed	Total Nitrogen (lbs/acre/yr)	Total Phosphorus (lbs/acre/yr)	Total sediment (tons/acre/yr)
1	**110702070101**	9.642	1.288	0.302
2	**110702070102**	9.885	1.617	0.454
3	**110702070103**	8.985	1.350	0.340
4	**110702070104**	10.380	1.630	0.438
5	**110702070105**	8.637	1.247	0.283
6	**110702070106**	9.551	1.361	0.310
7	**110702070107**	9.797	1.584	0.448
8	**110702070201**	10.057	1.554	0.405
9	**110702070202**	10.343	1.618	0.450
10	**110702070203**	10.683	1.767	0.546
11	**110702070204**	9.740	1.619	0.504
12	**110702070205**	12.966	1.829	0.394
13	**110702070206**	9.442	1.485	0.365
14	**110702070301**	9.685	1.504	0.367
15	**110702070302**	10.524	1.585	0.375
16	**110702070303**	8.328	1.628	0.593
17	**110702070304**	9.590	1.595	0.440
18	**110702070305**	11.180	1.548	0.346
19	**110702070306**	10.810	1.425	0.274
20	**110702070307**	13.339	1.959	0.447
21	**110702070308**	11.160	1.463	0.301
22	**110702070309**	10.451	1.871	0.539
23	**110702070310**	8.417	1.444	0.432
24	**110702070311**	10.381	1.712	0.429
25	**110702070401**	11.481	1.397	0.194
26	**110702070402**	9.912	1.362	0.280
27	**110702070403**	11.998	1.526	0.305
28	**110702070404**	10.416	1.236	0.171
29	**110702070405**	11.957	1.351	0.160
30	**110702070501**	12.514	1.701	0.312
31	**110702070502**	9.674	1.186	0.140
32	**110702070503**	8.734	1.119	0.134
33	**110702070504**	8.954	1.257	0.213
34	**110702070505**	8.536	1.250	0.229
35	**110702070506**	12.341	1.368	0.143
36	**110702070507**	12.584	1.402	0.129
37	**110702070508**	11.882	1.357	0.144

38	**110702070601**	10.584	1.194	0.136
39	**110702070602**	8.924	1.063	0.122
40	**110702070603**	11.235	1.507	0.172
41	**110702070604**	12.329	1.441	0.198
42	**110702070605**	9.955	1.139	0.131
43	**110702070606**	11.801	1.298	0.166
44	**110702070607**	10.044	1.458	0.308
45	**110702070608**	10.922	1.274	0.158
46	**110702070701**	11.327	1.293	0.149
47	**110702070702**	13.268	1.423	0.136
48	**110702070703**	7.313	1.050	0.097
49	**110702070704**	6.978	0.952	0.088
50	**110702070705**	8.481	1.107	0.170
51	**110702070706**	8.318	1.070	0.171
52	**110702070801**	8.445	1.049	0.104
53	**110702070802**	10.227	1.226	0.203
54	**110702070803**	8.702	1.031	0.103
55	**110702070804**	10.514	1.214	0.138
56	**110702070805**	12.931	1.455	0.142
57	**110702070806**	8.735	1.101	0.140
58	**110702070901**	11.020	1.294	0.146
59	**110702070902**	8.948	1.080	0.116
60	**110702070903**	7.658	0.899	0.114
61	**110702070904**	9.863	1.151	0.142
62	**110702071001**	8.262	0.968	0.135
63	**110702071002**	8.940	0.960	0.145
64	**110702071003**	7.788	1.038	0.107
65	**110702071004**	11.627	1.260	0.173
66	**110702071005**	11.413	1.203	0.131

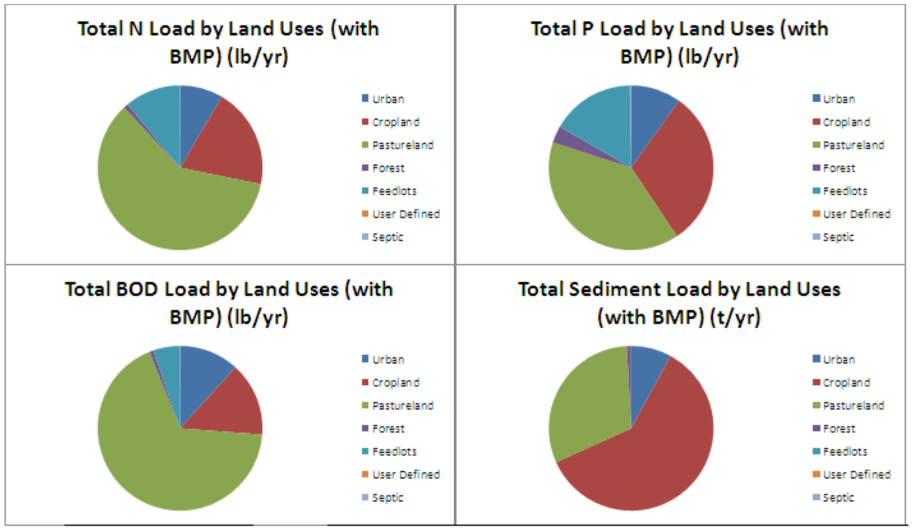
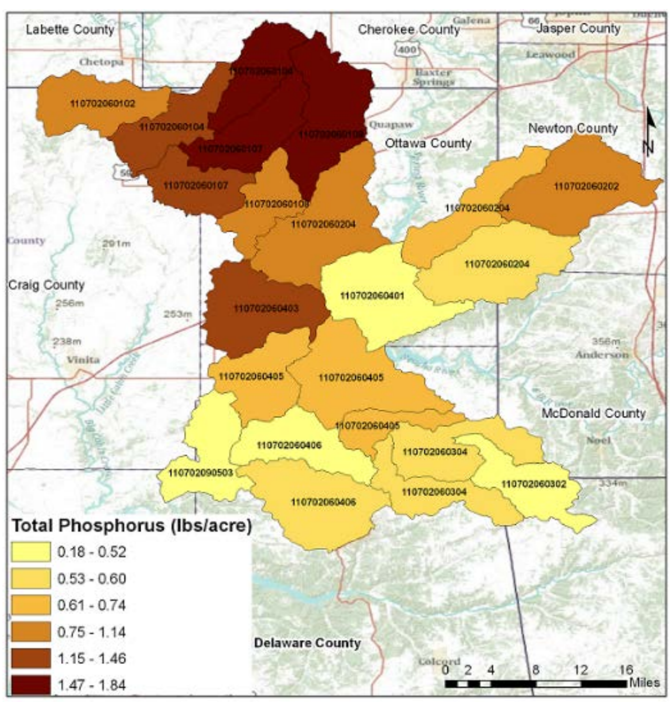


Figure 18 Total loads per each land use for Spring Watershed calculated with the STEPL model.

Lake O' The Cherokees Watershed

The STEPL model was employed for limited assessment of annual pollutant yields in Lake O' The Cherokees Watershed (HUC 11070206). Input datasets for delineated subareas (HUC 12 Units), land use, soil groups, number of animals, septic systems, etc, were downloaded from the STEPL Model Input Data Server (STEPL Data Server, 2011). The results were generated with default parameters and no BMP implementation. Model output contained annual sediment yield, total phosphorous and total nitrogen concentrations. Figure 19 presents maps of pollutant loads in a scale of graduated colors (darker color indicates higher load). Table 12 lists load values for each HUC 12 subwatershed within Lake O' The Cherokees Watershed. Figure 20 presents charts for total loads for individual land use calculated with the STEPL model.



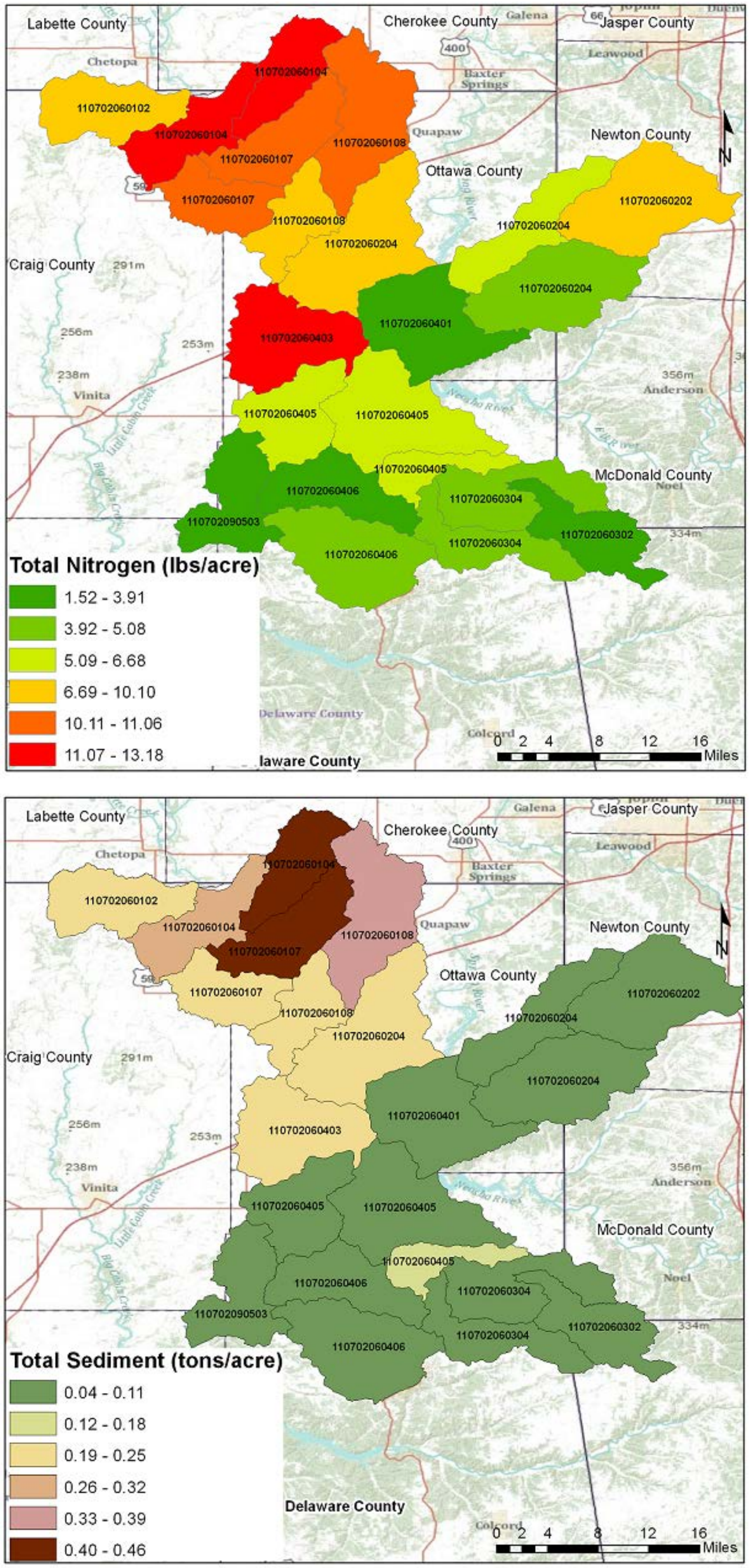


Figure 19 Maps of (a) Total phosphorous, (b) Total nitrogen, and (c) Total sediment yields in 22 subbasins of the Lake O' The Cherokees Watershed

Table 12 Pollutant loads for each HUC-12 subwatershed

HUC 12 Watershed	Total Nitrogeen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Sediment (tons/yr)
110702060101	13.183	1.461	0.238
110702060102	3.915	0.494	0.075
110702060103	9.458	1.139	0.223
110702060104	4.789	0.583	0.079
110702060105	4.683	0.560	0.088
110702060106	5.584	0.686	0.120
110702060107	3.764	0.519	0.059
110702060108	3.402	0.451	0.073
110702060201	5.202	0.664	0.094
110702060202	6.679	0.737	0.090
110702060203	10.924	1.154	0.207
110702060204	10.105	1.107	0.179
110702060301	10.977	1.686	0.364
110702060302	11.060	1.594	0.388
110702060303	11.528	1.433	0.289
110702060304	8.069	0.917	0.184
110702060401	11.677	1.839	0.457
110702060402	8.331	0.985	0.090
110702060403	5.977	0.703	0.107
110702060404	5.078	0.603	0.083
110702060405	5.058	0.561	0.094
110702060406	1.524	0.178	0.038

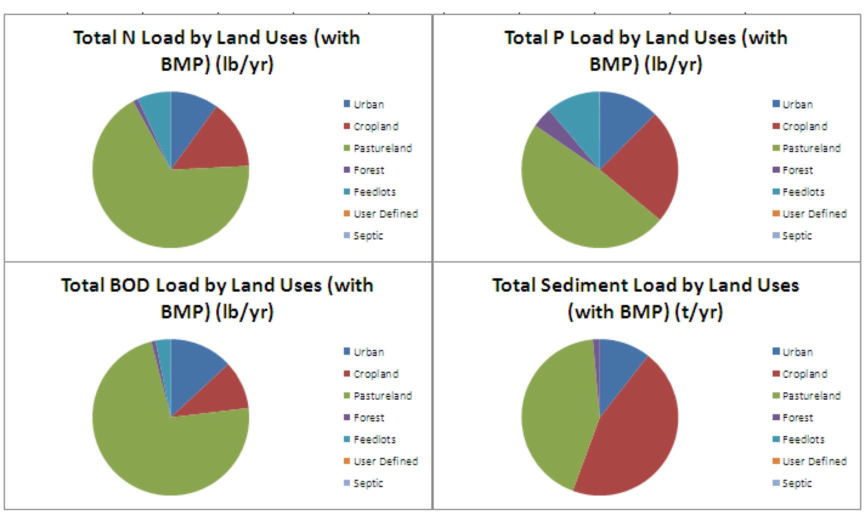


Figure 20 Total loads per individual land use for Lake O' The Cherokees Watershed calculated with the STEPL model

Critical Targeted Areas

Middle Neosho River Watershed

The pollutant yields maps produced by the modeling are displayed above. The subwatersheds 42, 46, 47, 54, 62, 53 and 66 at west side of the basin show the highest potential for erosion, phosphorous, and nitrogen runoff. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices. This is the area of the watershed with the greatest percentage of cropland, which leads to a higher potential for erosion compared to areas that are mainly composed of grassland.

The critical cropland, livestock and poultry targeted areas are displayed above. An identification of poultry and livestock critical areas was conducted by the SLT.

Cropland Erosion

The SWAT delineated (primary ranked) targeted area of this project is to be used for the determination of BMP placement for sediment (overland origin) and nutrients. Four subbasins were included as targeted areas. The targeted area contains the following HUC-12 numbers:

- Sub basin #46: 110702050302
- Sub basin #47: 110702050303
- Sub basin #54: southern half of 110702050602 (Little Cherry Creek drainage)
- Sub basin #66: 110702050604

Rangeland and Livestock Targeted Areas

The Livestock Targeted Area of this project was determined primarily by SWAT, but some additional areas were added through the watershed knowledge of the SLT. These areas will be used for the determination of BMP placement for nutrients as determined by phosphorus. The HUC 12s that are included in these sub basins are:

- Sub basin #35: 110702050106
- Sub basin #38: 110702050107
- Sub basin #42: 110702050301
- Sub basin #44: 110702050401
- Sub basin #51: 110702050403
- Sub basin #55: 110702050404
- Sub basin #58: 110702050501
- Sub basin #64: 110702050505

Poultry Targeted Areas

In addition to livestock targeted areas, the Poultry Targeted Area of this project was determined by the knowledge of the watershed by the SLT. These areas will be used for the determination of BMP placement for nutrients as determined by phosphorus. Sub basins 46, 47, 54, and 66 are also included in the cropland targeted area. The HUC 12s that are included in these sub basins are:

- Sub basin #46: 110702050302

- Sub basin #47: 110702050303
- Sub basin #53: northern half of 110702050602 (Cherry Creek drainage)
- Sub basin #54: southern half of 110702050602 (Little Cherry Creek drainage
- Sub basin #62: 110702050603
- Sub basin #66: 110702050604

Upper Neosho River Watershed

The pollutant yields maps produced by the modeling are displayed above. The subwatersheds 3, 9, 13, 14, 21, 26, 17, and 29 at the northern end of the basin and along the Cherry and Rock creeks show the highest potential for erosion, phosphorous, and nitrogen runoff. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices. This is the area of the watershed with the greatest percentage of cropland, which leads to a higher potential for erosion compared to areas that are mainly composed of grassland.

The critical Tier 1 and Tier 2 cropland erosion and livestock producing targeted areas are displayed below. An identification of livestock critical areas was conducted by the SLT, whereas the division of cropland areas to Tier 1 and Tier 2 was developed by the assessment team with consultation with the SLT.

Tier 1 Cropland Erosion

The SWAT delineated (primary ranked) Cropland Targeted Area Tier 1 of this project will be used for the implementation of sediment and nutrient reduction agricultural BMPs. The area in Tier 1 group includes a portion of the Long Creek, Crooked Creek, Spring Creek with Neosho River, Indian Creek, Rock Creek, Cherry Creek, Onion Creek and Village Creek (HUC-12 numbers I brackets):

- Sub basin 3: Long Creek (110702040103)
- Sub basin 9: Crooked Creek (110702040203)
- Sub basin 13: Indian Creek (110702040205)
- Sub basin 14: Spring Creek / Neosho River (110702040206)
- Sub basin 16: Onion Creek (110702040407)
- Sub basin 17: Rock Creek (110702040304)
- Sub basin 21: Cherry Creek (110702040404)
- Sub basin 29: Village Creek (110702040404)

Tier 2 Cropland Erosion

The SWAT delineated Cropland Targeted Area Tier 2 of this project is to be used for the determination of BMP placement for sediment (overland origin) and nutrients after all Tier 1 projects have been completed. This area includes a portion of the Duck Creek and Neosho River, Martin Creek and Neosho River, Coal Creek, Headwaters Big Creek, and Turkey Creek and Neosho River. This area contains HUC-12 numbers:

- sub basin 11: Duck Creek Neosho River (110702040204)
- sub basin 20: Martin Creek Neosho River (110702040306)
- sub basin 27: Coal Creek (110702040406)
- sub basin 28: Headwaters Big Creek (110702040503)

- sub basin 33: Turkey Creek Neosho River (110702040505)

Livestock Targeted Areas

The SLT has determined an area for targeting livestock related sediment, phosphorus pollutants and bacteria. Livestock BMPs will be placed in this area. Creeks included in this area are Deer Creek, Big Creek Turkey Creek and Owl Creek. The HUC 12 areas and correlated SWAT delineated areas are:

- sub basin 4: Upper Deer Creek (110702040301
- sub basin 5: Big Creek (110702040106
- sub basin 10: Outlet Turkey Creek (110702040202
- sub basin 12: Middle Deer Creek (110702040302
- sub basin 15: Headwaters Turkey Creek (110702040201
- sub basin 16: Lower Deer Creek (110702040303
- sub basin 18: Upper Owl Creek (110702040401
- sub basin 23: Middle Owl Creek (110702040403)

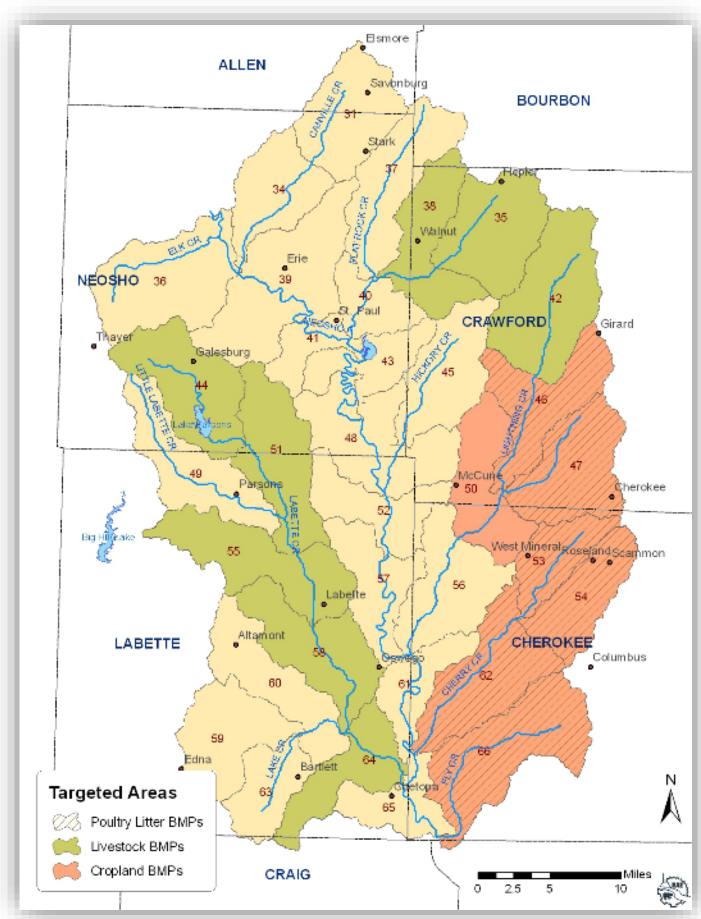


Figure 21 Critical targeted subwatersheds in Middle Neosho River Watershed

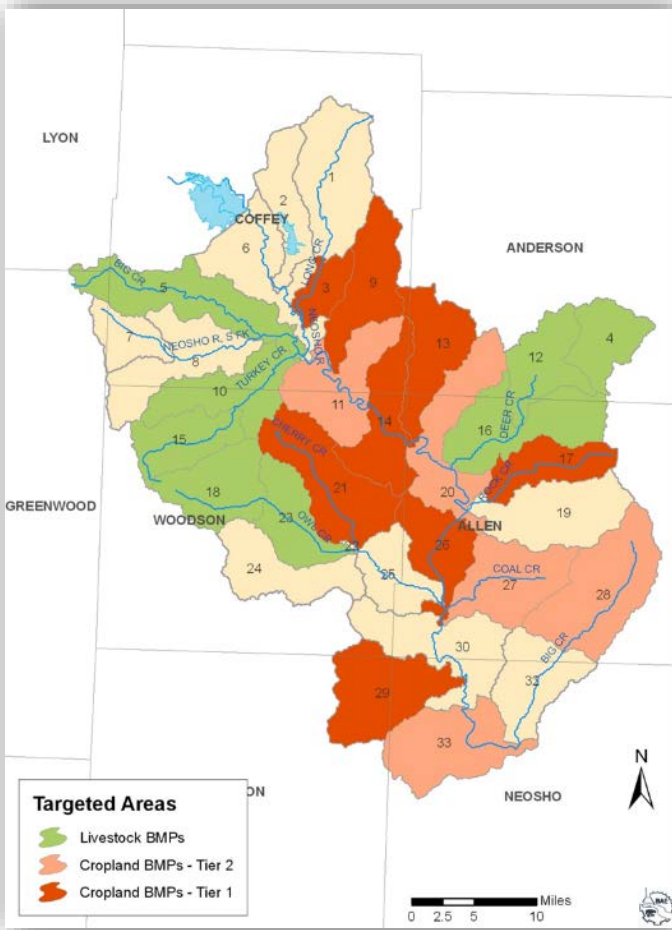


Figure 22 Critical targeted subwatersheds in Upper Neosho River Watershed

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.

Economic Analysis

General Economic Research

Cost-return budgets have been developed for the Middle Neosho and Upper Neosho River Watersheds by working with data from the Southeast Kansas Farm Management Association.

The budgets are specific to either Upper Neosho or Middle Neosho River Watersheds and vary by inputs and yields. Specific BMP budgets have been developed for vegetative buffers, terraces, stream bank stabilization, and reduced/no-till and available in the Neosho River Watershed Atlas. The cost-return budgets are compiled for corn, soybean, wheat, grain, and alfalfa crops and presented in the Watershed Atlas (see Appendix A: 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.

Work Products

The following spreadsheet based decision tools were created to assist with economic analysis in support of the development of watershed management plans.

K-State Watershed Manager Decision-Making Tool

This 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

This 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 Neosho River 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-Streambank Stabilization Decision-Making Tool

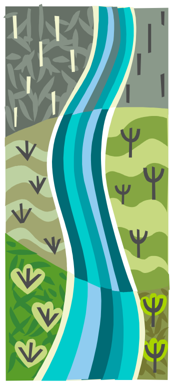
This tool was developed with assistance and input from KSU Ag Economics faculty, Watershed Institute, and KAWS. This tool allows producers and land-managers across the state of Kansas (Neosho River Watershed) to evaluate the economic benefits and costs of streambank stabilization projects, and will help 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

This 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 Neosho River 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 Neosho River, so this will be the main focus of the economic analysis. The economic impacts and benefits of recreation at the Neosho River were being estimated using an input-output impact analysis and non-market valuation techniques.



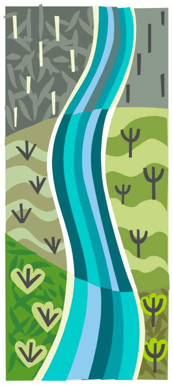
Next Steps / Transition into Planning Phase

This WRAPS Assessment Phase project was completed and all tasks were finished. For transition into the Planning phase, the identified critical areas (cropland, livestock, and stream bank targeted areas) and calculated pollutant loads to the streams will be used to quantify the impacts of potential, 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.

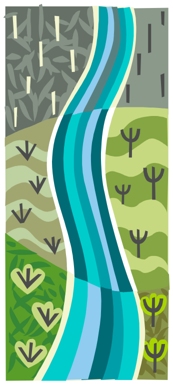


Evaluation of Project Goal, Objectives, and Tasks

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.

This Assessment Phase project accomplished all of its objectives, in particular:

- The Stakeholder Leadership Team clarified WRAPS objectives and assessment needs in the watershed and identified informational and data gaps needed to address the objectives and assessment needs
- The assessment team compiled an inventory of existing information and reports related to Neosho River watershed.
- The assessment team 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.
- The assessment team set up and completed detailed SWAT modeling analysis of baseline and SLT revised using local knowledge watershed conditions.
- The assessment team 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.
- The assessment team completed an analysis of recreational benefits of Neosho River.
- Watershed model and economic results were delivered, discussed, and approved by the Stakeholder Leadership Team.



Conclusions, Recommendations, and Lessons Learned

Conclusions

Watershed assessment information was prepared by this project including watershed inventory, watershed modeling, identification of critical areas, and economic analysis. A Stakeholder Leadership Team was created and fully engaged in all activities throughout the assessment phase of the WRAPS project. The identified targeted areas were divided into three categories: cropland BMPs, livestock BMPs, and stream bank BMPs. This division was based on the restoration needs and specifics of the watershed. SLT contribution along with the assessment management team was instrumental in identification of livestock and stream bank erosion sites.

Lessons Learned

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

- 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.

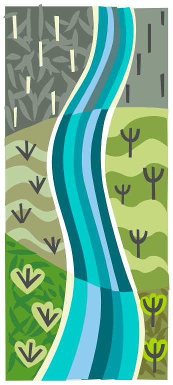
- One Kansas individual skeptical of watershed modeling suggested that K-State should instead simply show real data about how various agricultural management practices impact water quality in each locale. He and I discussed how soil types, rainfall patterns, growing seasons, and management practices, 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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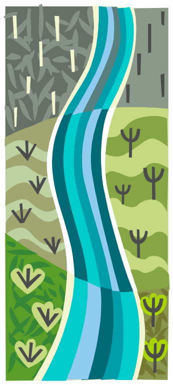
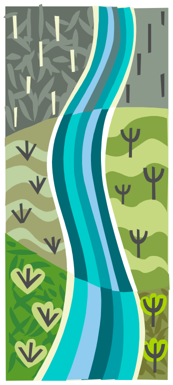


Appendix A: Watershed Atlas

Nejadhashemi, A.P., S.A. Perkins, C.M. Smith, K.R. Mankin, R.M. Wilson, S.P. Brown, and J.C. Leatherman. 2009. Upper and Middle Neosho Watersheds Assessment: Preliminary Report. Kansas State Research and Extension Publication #EP-135. 68 pages. http://www.ksre.ksu.edu/library/h20ql2/EP135.pdf

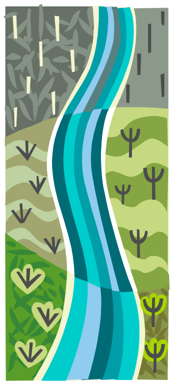


Appendix B: TMDLs

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT, 2000.

- Upper Neosho River Basin TMDL
    - Turkey creek: http://www.kdheks.gov/tmdl/ne/TurkeyCr_DO.pdf
    - Neosho river: http://www.kdheks.gov/tmdl/ne/NeoshoR_pH.pdf
    - Chanute city lake: http://www.kdheks.gov/tmdl/ne/ChanuteE.pdf
    - Gridley city lake: http://www.kdheks.gov/tmdl/ne/GridleyE.pdf
    - Big creek: http://www.kdheks.gov/tmdl/ne/BigCr_FCB.pdf
    - Deer creek: http://www.kdheks.gov/tmdl/ne/DeerCr_FCB.pdf
    - Owl creek: http://www.kdheks.gov/tmdl/ne/OwlCr_FCB.pdf
    - Turkey creek: http://www.kdheks.gov/tmdl/ne/TurkeyCr_FCB.pdf

- Middle Neosho River Basin TMDL
    - Bachelor Creek: http://www.kdheks.gov/tmdl/ne/BachelorCreek_DO.pdf
    - Canville Creek: http://www.kdheks.gov/tmdl/ne/CanvilleCr_DO.pdf
    - Cherry Creek: http://www.kdheks.gov/tmdl/ne/CherryCr_DO.pdf
    - Altamont City Lake: http://www.kdheks.gov/tmdl/ne/AltamontE.pdf
    - Bartlett Lake: http://www.kdheks.gov/tmdl/ne/BartlettE.pdf
    - Mined Land Wetland: http://www.kdheks.gov/tmdl/ne/Wetland42DO.pdf
    - Neosho County State Lake: http://www.kdheks.gov/tmdl/ne/NeoshoCoSFL.pdf
    - Neosho Wildlife Area: http://www.kdheks.gov/tmdl/ne/NeoshoWMAE.pdf
    - Neosho Wildlife Area: http://www.kdheks.gov/tmdl/ne/NeoshoWMASilt.pdf
    - Neosho Wildlife Area: http://www.kdheks.gov/tmdl/ne/NeoshoWMAPb.pdf
    - Parsons Lake: http://www.kdheks.gov/tmdl/ne/ParsonsE.pdf
    - Parsons Lake: http://www.kdheks.gov/tmdl/ne/ParsonsSILT.pdf
    - Mined Land Lake: http://www.kdheks.gov/tmdl/ne/MinedLandSO4.pdf



Appendix C: Financial Summary

Summary of Financial Expenditures and Matching Funds				
Category	**Budget**	**Actual**	**Match**	**Total**
Salaries	138,960.00	140,797.00	30,639.93	171,436.93
Fringe Benefits	33,899.00	30,222.00	6,626.18	36,848.18
Travel	4,000.00	4,767.00	-	4,767.00
Supplies	3,500.00	4,378.00		4,378.00
Contractual Services	-	4,883.00		4,883.00
Other	8,900.00	1,387.00	13,876.20	15,263.20
Project Indirect Costs	18,926.00	18,644.00	-	18,644.00
Waived Indirect Costs	-	-	85,055.29	85,055.29
Total	$ 208,185.00	$ 205,078.00	$ 136,197.60	$ 341,275.60