JOHN REDMOND RESERVOIR

Watershed Restoration and Protection Strategy

Neosho Headwaters Watershed

Final Draft Plan May 11, 2011
Approved by KDHE October 4, 2010

ant

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October 4, 2010

Robert Wilson
Office of Local Government
K-State Research and Extension
10E Umberger Hall
Manhattan KS 66506

Dear Mr. Wilson

I am pleased to inform you that the Kansas Department of Health and Environment has completed the review process for **The Watershed Restoration and Protection Strategy for the Neosho Headwaters (Final Draft Plan, March 10, 2010)**. The plan has met the KDHE requirements and is hereby approved for future funding consideration. Applications for WRAPS funding to implement components of the plan may be submitted to KDHE during the grant application period. Decisions on funding of plan components will be made as part of the grant application process.

Please provide two hardcopies and one digital copy of the final plan to:

> **Kansas Department of Health and Environment**
> **Bureau of Water, Watershed Management Section**
> **1000 SW Jackson St., Suite 420**
> **Topeka, KS 66612-1367**

I want to express my sincere appreciation to you and the Stakeholder Leadership Team in putting together a quality plan that will guide future watershed restoration and protection activities in your watershed. Thank you for all your efforts in protecting and restoring Kansas watersheds.

Sincerely,

Kerry Wedel
Chief, Watershed Management Section
Bureau of Water, Kansas Department of Health and Environment

cc: Ann D'Alfonso

BUREAU OF WATER – WATERSHED MANAGEMENT SECTION
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Glossary of Terms

Best Management Practices (BMP): Environmental protection practices used to control pollutants, such as sediment or nutrients, from common agricultural or urban land use activities.

Biological Oxygen Demand (BOD): Measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements.

Biota: Plant and animal life of a particular region.

Chlorophyll a: Common pigment found in algae and other aquatic plants that is used in photosynthesis

Dissolved Oxygen (DO): Amount of oxygen dissolved in water.

E. coli bacteria: Bacteria normally found in gastrointestinal tracts of animals. Some strains cause diarrheal diseases.

Eutrophication (E): Excess of mineral and organic nutrients that promote a proliferation of plant life in lakes and ponds.

Fecal coliform bacteria (FCB): Bacteria that originate in the intestines of all warm-blooded animals.

Municipal Water System: Water system that serves at least 25 people or has more than 15 service connections.

NPDES (National Pollutant Discharge Elimination System) Permit: Required by Federal law for all point source discharges into waters.

Nitrates: Final product of ammonia's biochemical oxidation. Primary source of nitrogen for plants. Originates from manure and fertilizers.

Nitrogen(N or TN): Element that is essential for plants and animals. TN or total nitrogen is a chemical measurement of all nitrogen forms in a water sample.

Nutrients: Nitrogen and phosphorus in water source.

Phosphorus (P or TP): Element in water that, in excess, can lead to increased biological activity in water. TP or total phosphorus is a chemical measurement of all phosphorus forms in a water sample.

Riparian Zone: Margin of vegetation within approximately 100 feet of waterway.

Sedimentation: Deposition of slit, clay or sand in slow moving waters.

Secchi Disk: Circular plate 10-12" in diameter with alternating black and white quarters used to measure water clarity by measuring the depth at which it can be seen.

Stakeholder Leadership Team (SLT): Organization of watershed residents, landowners, farmers, ranchers, agency personnel and all persons with an interest in water quality.

Total Maximum Daily Load (TMDL); Maximum amount of pollutant that a specific body of water can receive without violating the surface water-quality standards, resulting in failure to support their designated uses

Total Suspended Solids (TSS): Measure of the suspended organic and inorganic solids in water. Used as an indicator of sediment or silt.

1.0 Preface

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for Neosho Headwaters Watershed is to outline a plan of restoration and protection goals and actions for the surface waters of the watershed. Watershed goals are characterized as “restoration” or “protection”. Watershed restoration is for surface waters that do not meet Kansas water quality standards, and for areas of the watershed that need improvement in habitat, land management, or other attributes. Watershed protection is needed for surface waters that currently meet water quality standards, but are in need of protection from future degradation.

The WRAPS development process involves local communities and governmental agencies working together toward the common goal of a healthy environment. Local participants or stakeholders provide valuable grass roots leadership, responsibility and management of resources in the process. They have the most “at stake” in ensuring the water quality existing on their land is protected. Agencies bring science-based information, communication, and technical and financial assistance to the table. Together, several steps can be taken towards watershed restoration and protection. These steps involve building awareness and education, engaging local leadership, monitoring and evaluation of watershed conditions, in addition to assessment, planning, and implementation of the WRAPS process at the local level. Final goals for the watershed at the end of the WRAPS process are to provide a sustainable water source for drinking and domestic use while preserving food, fiber, timber and industrial production. Other crucial objectives are to maintain recreational opportunities and biodiversity while protecting the environment from flooding, and negative effects of urbanization and industrial production. The ultimate goal is watershed restoration and protection that will be “locally led and driven” in conjunction with government agencies in order to better the environment for everyone.

This report is intended to serve as an overall strategy to guide watershed restoration and protection efforts by individuals, local, state, and federal agencies and organizations. At the end of the WRAPS process, the Stakeholder Leadership Team (SLT) will have the capability, capacity and confidence to make decisions that will restore and protect the water quality and watershed conditions of the Neosho Headwaters Watershed.

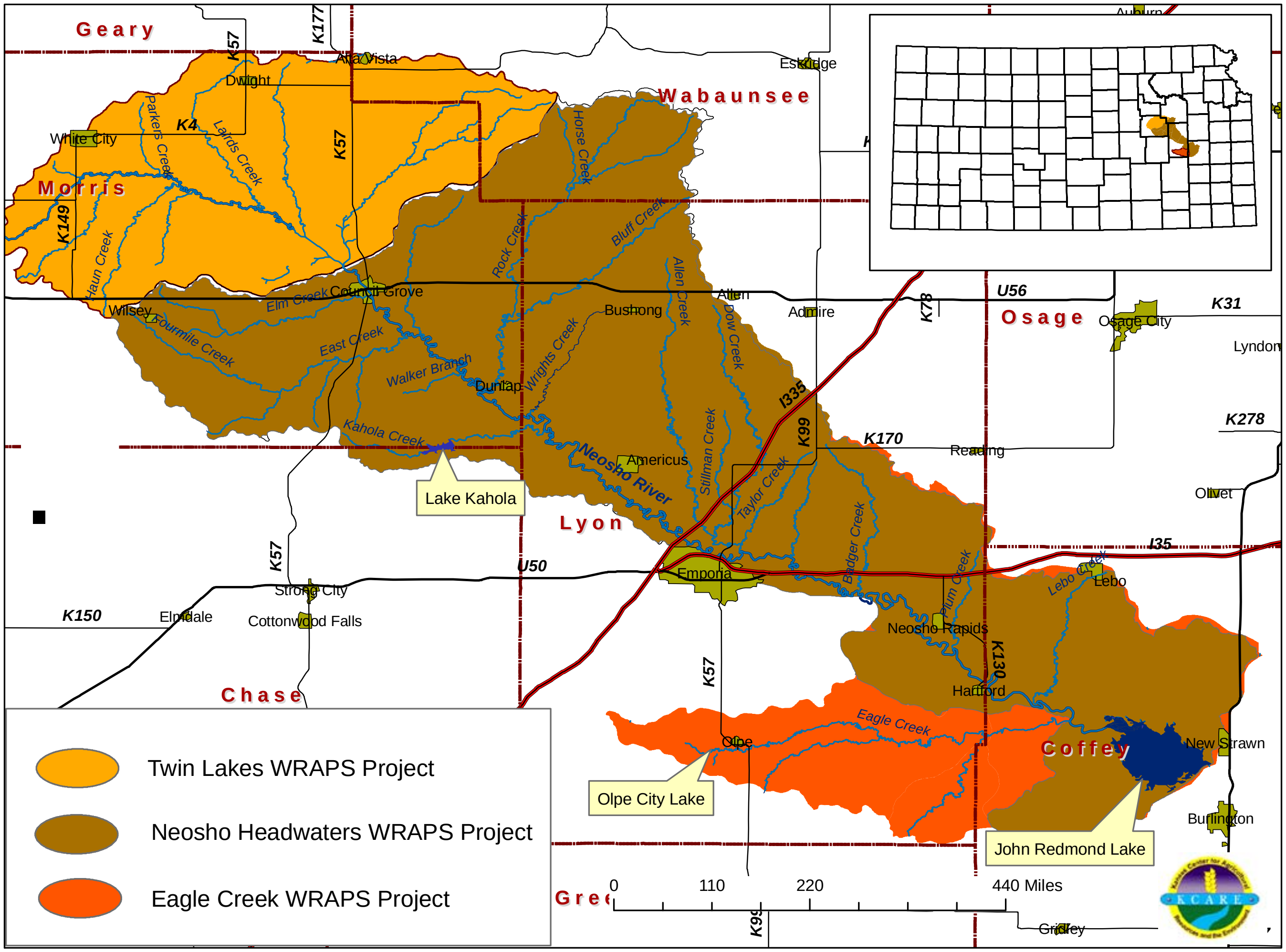


Figure 1. Map of Neosho Headwaters Watershed.

NOTE: The geographic scope of the watershed referred to in this WRAPS process as "Neosho Headwaters" does not include the entire Neosho Headwaters HUC8 watershed. Two other WRAPS projects exist in the watershed. They are Twin Lakes WRAPS that covers the drainage area of Council Grove Lake and Eagle Creek WRAPS which covers the drainage area of Eagle Creek. For this report, all references and data referred to "Neosho Headwaters" will not include the two other WRAPS geographic areas unless specified.

2.0 Priority Issues and Goals of the Stakeholder Leadership Team

The Stakeholder Leadership Team (SLT) was formed out of concern for the health and lifespan of John Redmond Reservoir, which is the geographic endpoint of this WRAPS plan. Construction of the dam began in 1959 by the US Corps of Engineers (COE) and the multipurpose pool was filled in 1964. In 1963, the reservoir had a storage capacity of 82,230 acre feet. The capacity of the latest survey year (2007) is 50,227 acre feet. Estimated current capacity is 48,010 acre feet. This represents a loss of 41.61% due to sediment that has entered the reservoir from the watershed with a calculated sedimentation rate of 739 acre feet per year. John Redmond Reservoir is ranked third of all Kansas reservoirs in percentage of capacity loss.

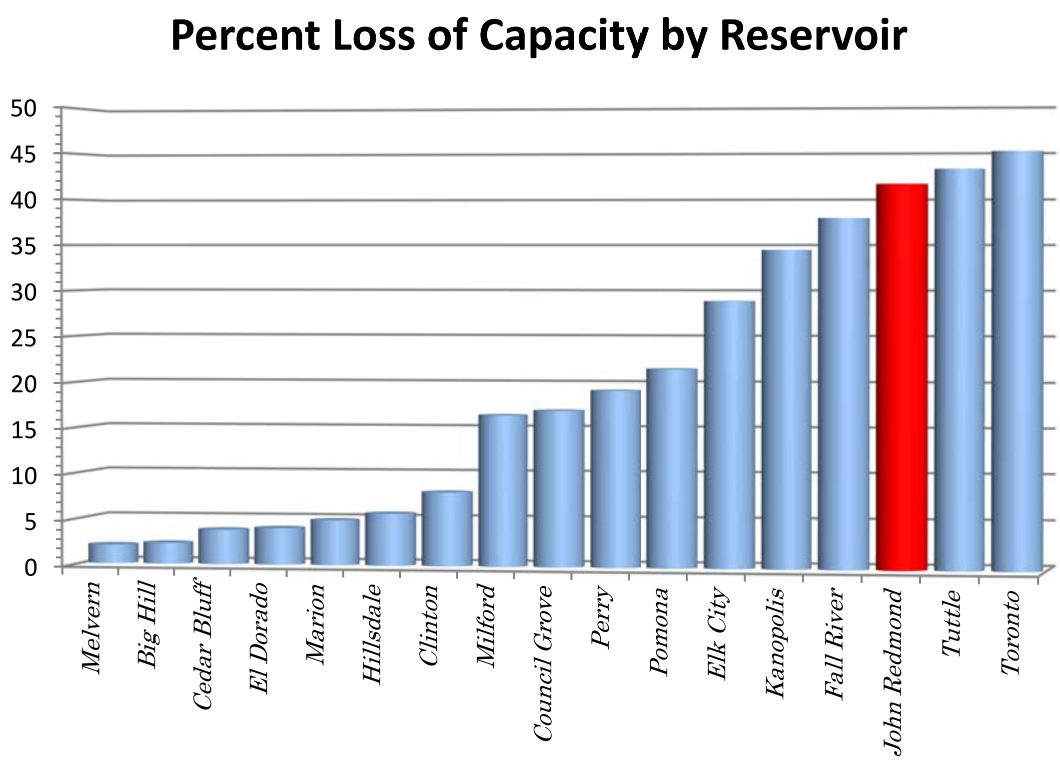


Figure 2. Percent of Reservoir Loss Due to Sedimentation (1990). [1]

The SLT hopes to slow this rate of sedimentation by improving conditions in the watershed. Watershed-wide additional benefits will be an improvement of water quality, an increase in yields in agricultural production and an increase in the health of wildlife and natural ecosystems.

The SLT has been meeting since 2008 and they have set their priority issues as (in no particular order):

1. Sedimentation and eutrophication in Redmond Reservoir.
2. Streambank erosion.
3. Rangeland/gully erosion.
4. Cropland erosion.
5. Floodplain erosion.
6. Riparian area degradation.
7. Bacteria levels in streams.
8. Low dissolved oxygen levels in streams.

The Watershed goals as set by the SLT are:

1. Protection of long-term water storage capacity and water quality in John Redmond Reservoir.
2. Protection of water quality in Neosho River and tributary streams.
3. Restoration and protection of riparian areas along Neosho River and tributary streams.
4. Protection of native tallgrass prairie.
5. Protection from flooding.
6. Protection of productivity of agricultural lands.
7. Protection of public drinking water and industrial water supplies.

In this report, the term BMP (Best Management Practice) will be used frequently. A BMP is defined as an environmental protection practice used to control pollutants, such as sediment or nutrients, from common agricultural or urban land use activities. Common agricultural BMPs are buffer strips, terraces, grassed waterways, utilizing no-till or minimum tillage, conservation crop rotation and nutrient management plans. Definitions of each of these BMPs are found in the appendix of this report.

3.0 Watershed Review

There are twelve river basins located in Kansas. The scope of this WRAPS project is a portion of the Neosho Basin in south-east Kansas. The entire basin drains the Neosho River and its tributaries into Oklahoma and eventually empties into the Gulf of Mexico. Two other WRAPS projects presently exist in the Neosho Headwaters Watershed. The scope of these projects is not included in this WRAPS. They are the Twin Lakes WRAPS and the Eagle Creek WRAPS. The extent of the WRAPS area is the Neosho River and its tributaries upstream of and including John Redmond Reservoir. The dam at John Redmond Reservoir is the geographical endpoint of this WRAPS project.

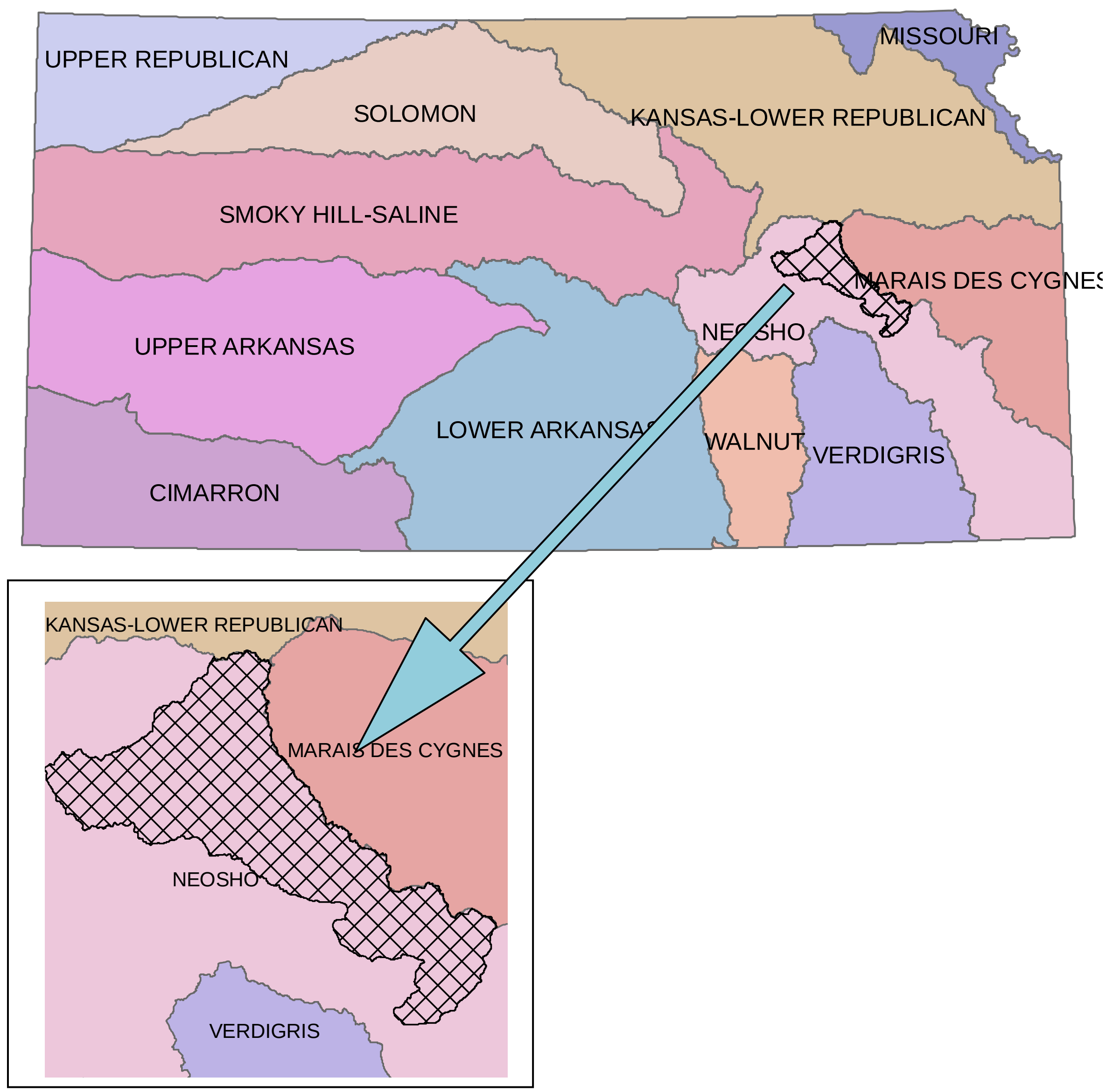


Figure 3. Location of Watershed in State

A watershed is an area of land that catches precipitation and funnels it to a particular creek, stream, and river and so on, until the water drains into an ocean. A watershed has distinct elevation boundaries that do not follow political “lines” such as county, state and international borders. Watersheds come in all shapes and sizes, with some only covering an area of a few acres while others are thousands of square miles across.

HUC is an acronym for **H**ydrologic **U**nit **C**odes. HUCs are an identification system for watersheds. Each watershed has a unique HUC number in addition to a common name. As watersheds become smaller, the HUC number will become larger. For example, the Neosho Basin is one of twelve basins in the state of Kansas. Within the Neosho Basin are seven HUC 8 classifications. HUC 8s can further be split into smaller watersheds that are given HUC 10 numbers and HUC 10 watersheds can be further divided into smaller HUC 12s. The geographic scope of the Neosho Headwaters Watershed WRAPS process is comprised of eighteen HUC 12 delineations.

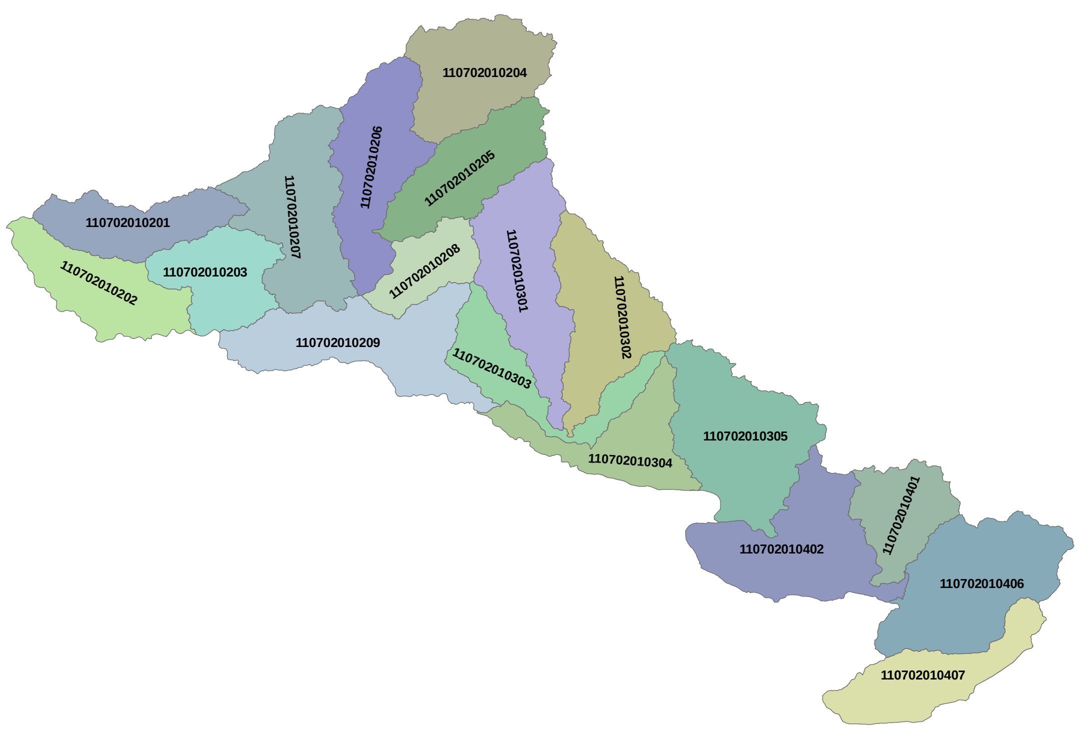


Figure 4. HUC 12 Delineations in the Neosho Headwaters Watershed.

The Neosho Headwaters Watershed is designated as Category I watershed indicating that it is in need of restoration as defined by the Kansas Unified Watershed Assessment 1999 submitted by the Kansas Department of Health and Environment (KDHE) and the United States Department of Agriculture (USDA)[2]. A Category I watershed does not meet state water quality standards or fails to achieve aquatic system goals related to habitat and ecosystem health. Category I watersheds are also assigned a priority for restoration. The Neosho Headwaters is ranked thirty-eighth in priority out of ninety-two watersheds state wide.

The Neosho Headwaters Watershed covers 421,946 acres. There are numerous towns and cities in this watershed in addition to developed areas surrounding John Redmond Reservoir.

3.1 Land Cover/Land Uses

Land use activities have a significant impact on the types and quantity of pollutants in the watershed. The major land use in the watershed is grassland (68%). Grassland can contribute fecal coliform bacteria from livestock access to streams and ponds. Erosion can occur from pathways made by livestock in creeks or gullies in pastures. Cropland is the second most prominent land use at 20 percent. Cropland can contribute nutrients from fertilizer and sediment from bare crop ground that will erode during heavy rainfall events. The rest of the land uses (12%) in the watershed are woodlands, water and other.

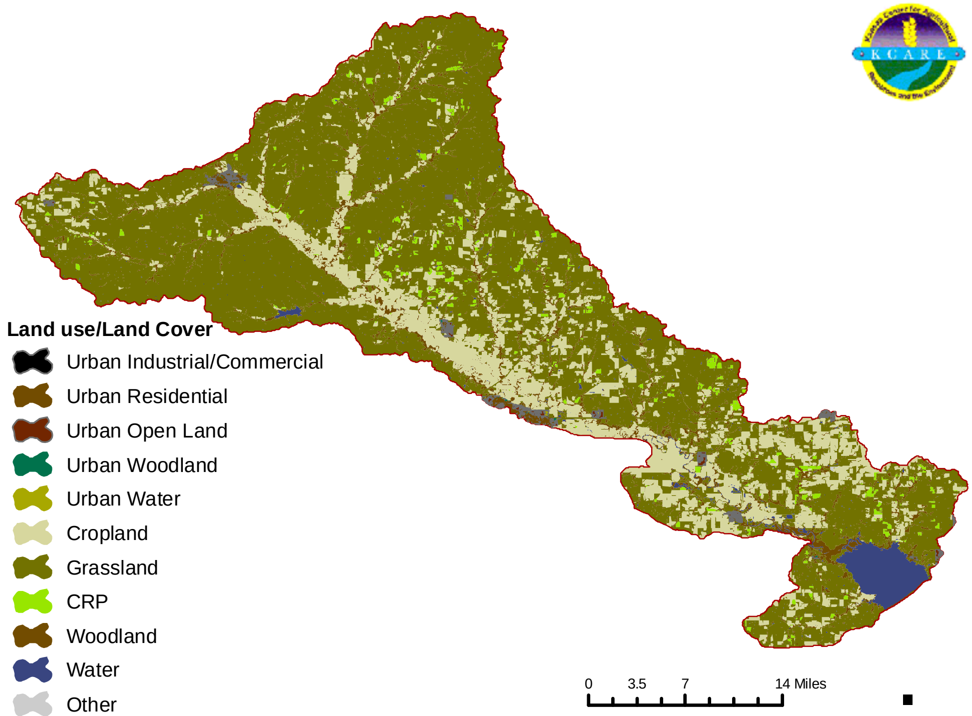


Figure 5. Land Cover and Land Use of the Neosho Headwaters Watershed. [3]

Table 1. Land Use in the Watershed, 2005. [3] *Calculated from Kansas Applied Remote Sensing Program, 2005. Kansas Land Cover Patterns, Kansas Geospatial Community Commons.*

Land Use	*Acres*	*Percentage*
Neosho Headwaters Watershed		
Urban Industrial/Commercial	483	0.10
Urban Residential	2,001	0.42
Urban Open Land	2,695	0.57
Urban Woodland	257	0.05
Urban Water	78	0.02
Cropland	94,393	19.94
Grassland	323,354	68.31
CRP	8,658	1.83
Woodland	28,453	6.01
Water	12,895	2.72
Other	91	0.02
Total	**473,358**	**99.99**

3.2 Designated Uses

Surface waters in this watershed are generally used for aquatic life support (fish), human health purposes, domestic water supply, recreation (fishing, boating, swimming), groundwater recharge, industrial water supply, irrigation and livestock watering. These are commonly referred to as “designated uses” as stated in the Kansas Surface Water Register, 2004, issued by KDHE.

Table 2. Designated Water Uses for the Neosho Headwaters Watershed. [4] ***Kansas Surface Water Register, 2004, KDHE.***

Designated Uses Table								
Stream or Lake Name	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Allen Cr, Badger Cr, Bluff Cr, Dows Cr, Elm Cr, Four mile Cr, Fourmile Cr, Munkers Cr E Br, Rock Cr,	E			X				
Big John Cr, Eagle Cr S, East Cr, Horse Cr, Kahola Cr, Lebo Cr, Plum Cr, Plumb Cr, Rock Cr E Br, Spring Cr, Stillman Cr, Taylor Cr, Unnamed St, Walker Br, Wolf Cr, Wrights Cr	E							
Crooked Cr, Lanos Cr	E		X					
Neosho R	E	C	X	X	X	X	X	X
John Redmond Reservoir	E	A		X		X		
Lake Kahola	E	A	X	X		X		
Flint Hills NWR	E			X				
Jones Park Lake	E	B	O	X		O	O	O
Key provided on following page.								

open

nder

nsas

not

3.3 Special Aquatic Life Use Waters

Special aquatic life use waters are 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". The Neosho Headwaters Watershed has a special aquatic life use designation for the Neosho River due to the existence in the river of the Neosho Madtom.

(Photo courtesy of US Fish and Wildlife)

The Neosho Madtom is a small catfish that is found only in riffles and gravel bars in clear moderately large rivers. It is on the threatened species list. Habitat destruction (dams, dredging, an increase in water demand and manure runoff) has contributed to population decline. [5]

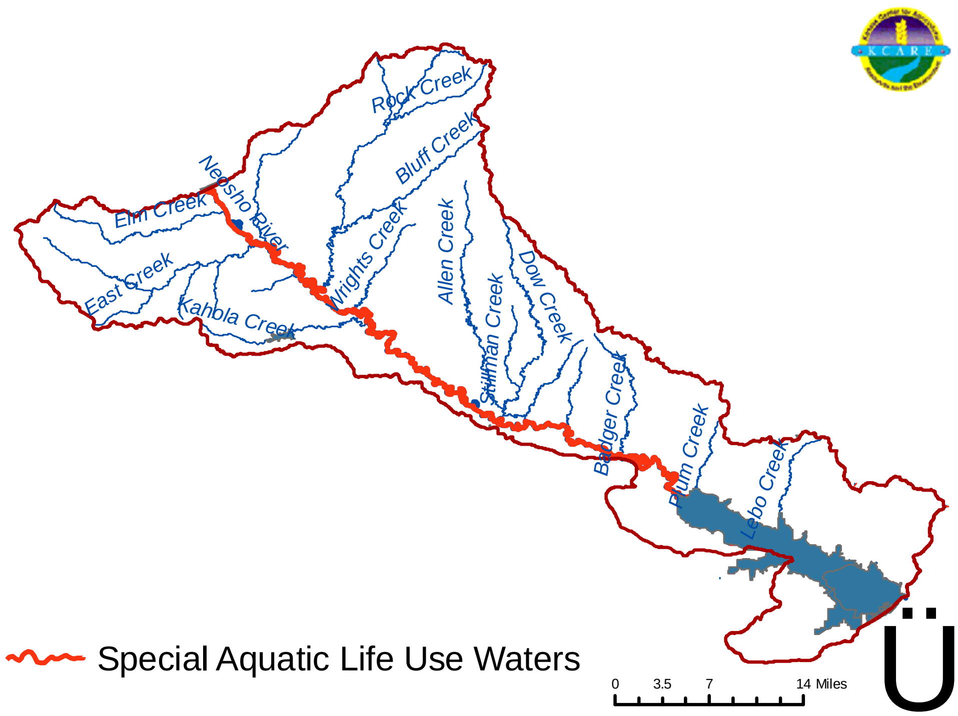


Figure 6. Special Aquatic Life Use Waters in the Watershed. [6] Kansas Department of Health and Environment.

The special aquatic life use waters are located in an area that is primarily surrounded by grassland, however, cropland lies adjacent to the river in the flat floodplains. Pollutants that might threaten the health of these waters would be from cropland. Sediment from ephemeral gullies, nutrients from fertilizer and applied manure and fecal coliform bacteria from livestock are some of the potential pollutants.

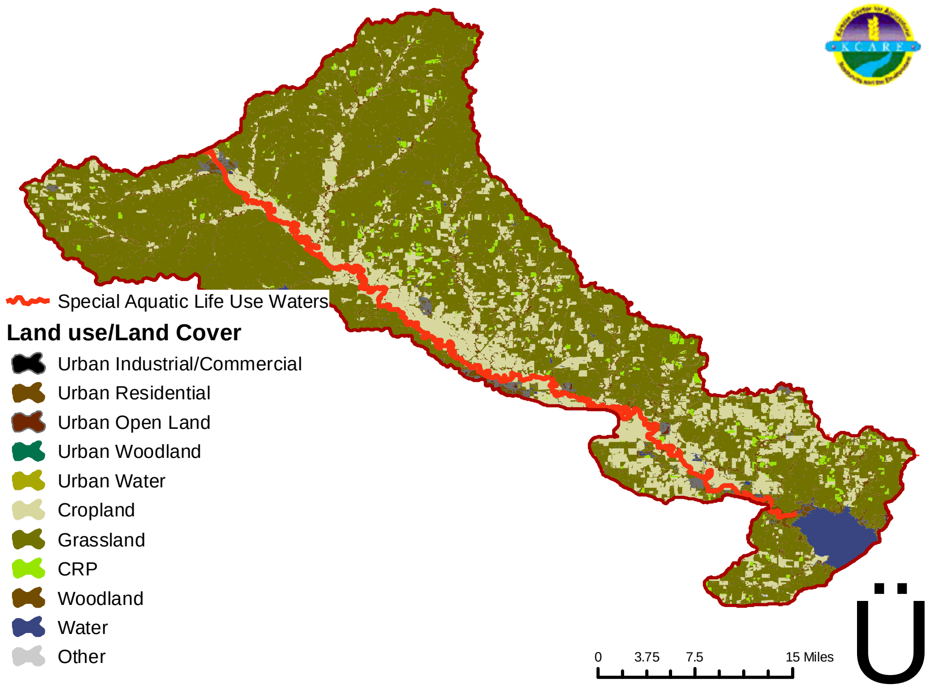


Figure 7. Special Aquatic Life Use Waters with Land Cover.

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

A public water supply (PWS) that derives its water from a surface water supply can be affected by sediment – either in difficulty at the intake in accessing the water or in treatment of the water prior to consumption. Reservoirs can be affected by sediment due to capacity reduction. Nutrients and fecal coliform bacteria will also affect surface water supplies causing excess cost in treatment prior to public consumption. The table below lists the public water supplies in the Neosho Headwaters Watershed.

Table 3. Public Water Supplies in the Neosho Headwaters Watershed [7]

Municipality	Source	Serves (Secondary Users)	Purchase From	County	Population Served
Burlington	Neosho	Coffey County RWD No. 2	None	Coffey	2852
	Neosho	Coffey County RWD No. 3			
	Neosho (pond)	New Strawn			
Council Grove	Neosho	Morris County RWD No. 1		Morris	2541
Emporia	Neosho	Coffey County RWD No. 2	None	Lyon	26662
	Cottonwood	Lyon County RWD No. 1			
	Neosho	Lyon County RWD No. 2			

Public Water Supplies, Cont.					
Municipality	**Source**	**Serves (Secondary Users)**	**Purchase From**	**County**	**Population Served**
Emporia	Neosho	Lyon County RWD No. 4			
	Neosho	Lyon County RWD No. 5			
		Hartford			
Hartford	Groundwater	None	Emporia	Lyon	600
	Neosho River				
	Neosho River				
	Groundwater				
	Neosho River				
New Strawn	Groundwater			Coffey	430
	Groundwater				
Wilsey	Groundwater			Morris	188

Wastewater treatment facilities are permitted and regulated through KDHE. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. Having these point sources located on streams or rivers may impact water quality in the waterways. For example, municipal waste water can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds or bacteria. Waste water will be treated to remove solids and organic materials, disinfected to kill bacteria and viruses, and discharged to surface water. Treatment of municipal waste water is similar across the country. Industrial point sources can contribute toxic chemicals or heavy metals. Treatment of industrial waste water is specific to the industry and pollutant discharged. [8] Any pollutant discharge from point sources that is allowed by the state is considered to be Wasteload Allocation.

Table 4. Permitted Point Source Facilities. [9] Municipalities that have both NPDES and PWS sites are highlighted in tan.

Facility Name	Owner	Description	City	County
IBP, Inc	Private	Meat Packing Plants	Emporia	Lyon
Emporia, City Of	Public	Sewerage Systems	Emporia	Lyon
Modine Manufacturing Company	Private	Motor Vehicle Parts & Accessor	Emporia	Lyon
Didde Web Press Corp.	Private	Commercial Printing	Emporia	Lyon
Country Park Mhc Wwtp	Private	Oper Of Res Mobile Home Sites	Lyon County	Lyon
Thunderbird Estates	Private	Oper Of Res Mobile Home Sites	Emporia	Lyon
Hartford City Of Stp	Public	Sewerage Systems	Hartford	Lyon

Permitted Point Source Facilities, Cont.				
Facility Name	**Owner**	**Description**	**City**	**County**
Council Grove City Of Stp	Public	Sewerage Systems	Council Grove	Morris
Americus City Of Stp	Public	Sewerage Systems	Americus	Lyon

Numerous onsite wastewater systems exist in the watershed. There is no accurate accounting number of these systems and their functional condition is generally unknown. Best guess is that ten percent of onsite wastewater systems are either failing or inadequately constructed. [10] All counties in the watershed have sanitary codes.

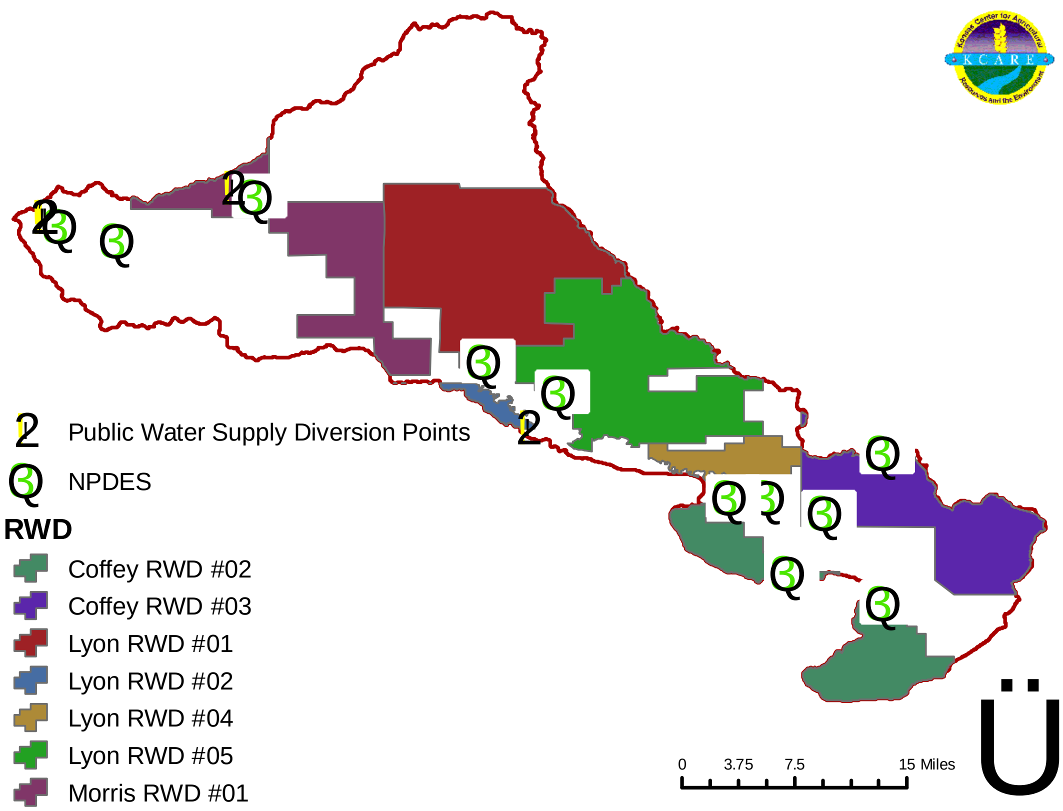


Figure 8. Rural Water Districts, Public Water Supply Diversion Points and NPDES Waste Water Treatment Plants (WTP). [11] Kansas Department of Health and Environment. Rural Water Districts, 2006 and Public Water Supply source water wells and surface water intakes, 1994. These sites include those that are currently in use and those that have been functional in the past. NPDES Treatment Facilities, Kansas Department of Health and Environment, 1994.

3.5 Aquifers

One aquifer underlies the watershed:

- 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 river.

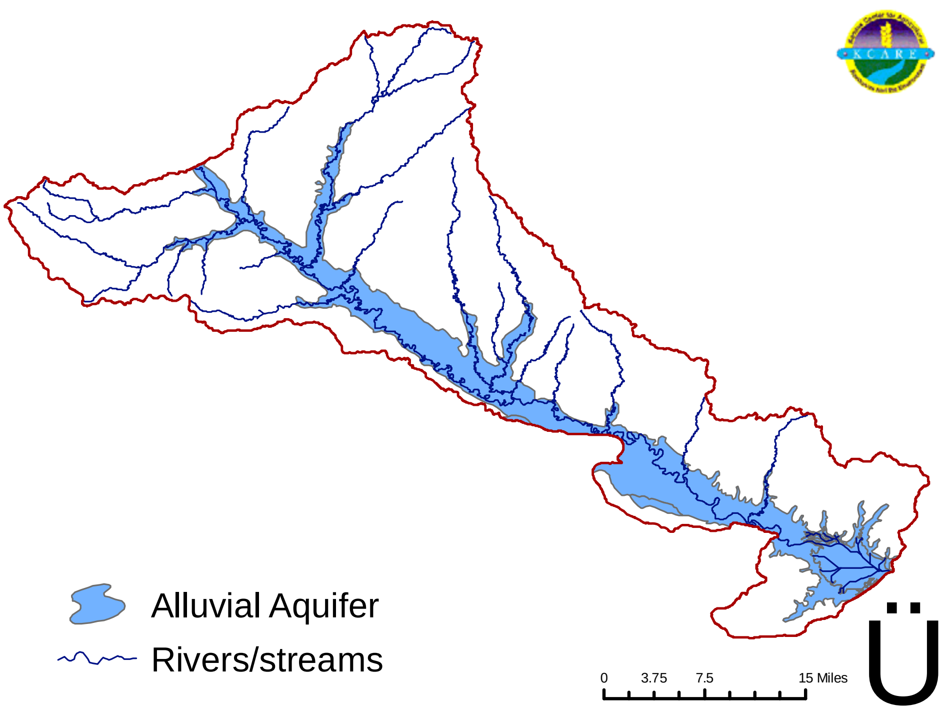


Figure 9. Aquifers in the Watershed. [12]. Kansas Geospatial Community Commons.

3.6 Total Maximum Daily Loads in the Watershed

A Total Maximum Daily Load (TMDL) designation sets the maximum amount of pollutant that a specific body of water can receive without violating the surface water-quality standards, resulting in failure to support their designated uses. TMDLs provide a tool to target and reduce point and nonpoint pollution sources. TMDLs established by Kansas may be done on a watershed basis and may use a pollutant-by-pollutant approach or a biomonitoring approach or both as appropriate. TMDL establishment means a draft TMDL has been completed, there has been public notice and comment on the TMDL, there has been consideration of the public comment, any necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. The desired outcome of the TMDL process is indicated, using the current situation as the baseline. Deviations from the water quality standards will be documented. The TMDL will state its objective in meeting the appropriate water quality standard by quantifying the degree of pollution reduction expected over time. Interim objectives will also be defined for midpoints in the implementation process. [13] In summary, TMDLs provide a tool to target and reduce point and nonpoint pollution sources. The goal of the WRAPS process is to address high priority TMDLs.

KDHE reviews TMDLs assigned in each of the twelve basins of Kansas every five years on a rotational schedule. The table below includes the review schedule for the Neosho Basin.

Table 5. TMDLs Review Schedule for the Neosho Basin. [14]

Year Ending in September	Implementation Period	Possible TMDLs to Revise	TMDLs to Evaluate
2013	2014-2023	2002, 2004, 2005	2002, 2004, 2005
2018	2019-2028	2000, 2004, 2005, 2008	2000, 2004, 2005, 2008

Pollutants are assigned "categories" depending on stage of TMDL development:

- Category 5 – Waters needing TMDLs
- Category 4a – Waters that have TMDLs developed for them and remain impaired
- Category 3 – Waters that are indeterminate and need more data or information
- Category 2 – Waters that are now compliant with certain water quality standards

(http://www.kdheks.gov/tmdl/download/2008_303d_List.pdf)

TMDLs in the watershed are listed in the table below.

Table 6. TMDLs in the Watershed[15] The shaded lines indicate high, medium or low priorities. The TMDLs in bold print indicate ones that will be targeted by this WRAPS plan.

Category	Water Segment	TMDL Pollutant	Endgoal of TMDL	Priority	Sampling Station
High Priority					
4a – Has TMDL and remains impaired	**Allen/Dows Creek near Emporia**	**Dissolved Oxygen**	**Average BOD < 3.2 mg/L**	**High**	**SC628**
Medium Priority					
4a – Has TMDL and remains impaired	**Allen/Dows Creek near Emporia**	**Fecal Coliform Bacteria**	**No exceedances > 2,000 colonies per 100ml water (secondary contact recreation)**	**Medium**	**SC628**

TMDLs in the Watershed, Cont.					
Category	**Water Segment**	**TMDL Pollutant**	**Endgoal of TMDL**	**Priority**	**Sampling Station**
4a – Has TMDL and remains impaired	John Redmond Reservoir	Eutrophication	Summer chlorophyll a concentrations < 12ug/L Total N concentration < 0.62 mg/L	Medium	LM026001
4a – Has TMDL and remains impaired	**John Redmond Reservoir**	**Siltation**	**65,000 acre-feet storage capacity in 2014**	**Medium**	**LM026001**
Low Priority					
4a – Has TMDL and remains impaired	Jones Park Pond	Eutrophication	Summer chlorophyll a concentrations < 12ug/L	Low	LM068701
4a – Has TMDL and remains impaired	Allen Creek near Emporia	Copper	Total Cu concentration < acute Water Quality Standard	Low	SC628

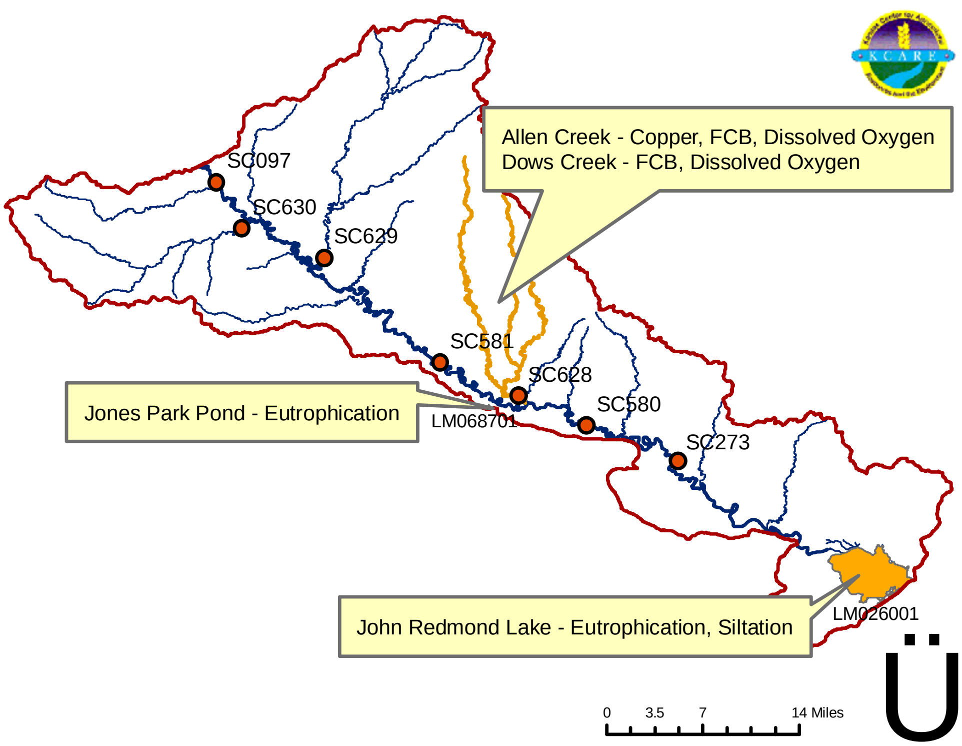


Figure 10. TMDLs in the Watershed. [16]. Kansas Geospatial Community Commons. Kansas Department of Health and Environment.

Table 7. Current Pollutant Conditions in the Watershed. [17]

Watershed and Impairment	Sampling Sites	Sampling Times	Excursions Seen	Baseline Condition
Allen and Dows Creek FCB	628	Spring	29%	Partial support of designated uses
		Summer/Fall	13%	
		Winter	None	
Allen and Dows Creek DO	628	Spring	29%	Non-support of designated uses
		Summer/Fall	38%	
		Winter	13%	
Watershed and Impairment	Sampling Sites	Criteria	Concentrations	
John Redmond Reservoir Eutrophication	026001	Chlorophyll a	6.53 ppb	
		Trophic Index	48.98	
		Total Phosphorus	175 ppb	
		Total Nitrogen	0.84 mg/L	
John Redmond Reservoir Sediment	026001	Secchi Disc depth	12 cm	
		Turbidity	50.4 ftu	
		Total Suspended Solids	46 mg/L	
		Trophic Index	Argillotrophic	
		Sedimentation Rate	693 acre ft/year	
Jones Park Pond Siltation	068701	Chlorophyll a	16.4 ppb	
		Total Phosphorus	118 ppb	

3.7 303d Listings in the Watershed

The Neosho Headwaters Watershed has numerous new listings on the 2008 “303d list”. A 303d list of impaired waters is developed biennially and submitted by KDHE to EPA. To be included on the 303d list, samples taken during the KDHE monitoring program must show that water quality standards are not being met. This in turn means that designated uses are not met. TMDL development and revision for waters of the Neosho Headwaters Watershed is scheduled for 2013. TMDLs will be developed over the subsequent two years for “high” priority impairments. Priorities are set by work schedule and TMDL development timeframe rather than severity of pollutant. If it will be greater than two years until the pollutant can be assessed, the priority will be listed as “low”. (http://www.kdheks.gov/tmdl/download/2008_303d_List.pdf)

Table 8. 2010 303d List of Impaired Waters in the Neosho Headwaters Watershed[18] The impairments in bold print indicate ones that will be affected by this WRAPS plan.

Category	Water Segment	Impairment	Priority	Sampling Station
		Low Priority		
5 – Waters needing TMDL	Neosho River at Neosho Rapids	Biology	Low	SC273
5 – Waters needing TMDL	Rock Creek near Dunlap	Dissolved Oxygen	Low	SC629

2010 303d List of Impaired Waters in the Neosho Headwaters Watershed, Cont.				
Category	**Water Segment**	**Impairment**	**Priority**	**Sampling Station**
5 – Waters needing TMDL	**Flint Hills NWR**	**Siltation**	**Low**	**LM072401**
5 – Waters needing TMDL	Neosho River at Neosho Rapids	Total Phosphorus	Low	SC273
5 – Waters needing TMDL	Four Mile Creek near Council Grove	Zinc	Low	SC630

Table 9. 2010 303d Delisted Waters. [19]

Category	Water Segment	Impairment	Comment	Sampling Station
2 – Waters now compliant	Neosho River near Emporia	Dissolved Oxygen	No longer impaired	SC580
2 – Waters now compliant	Lake Kahola	Siltation	Adequate water quality	LM043401

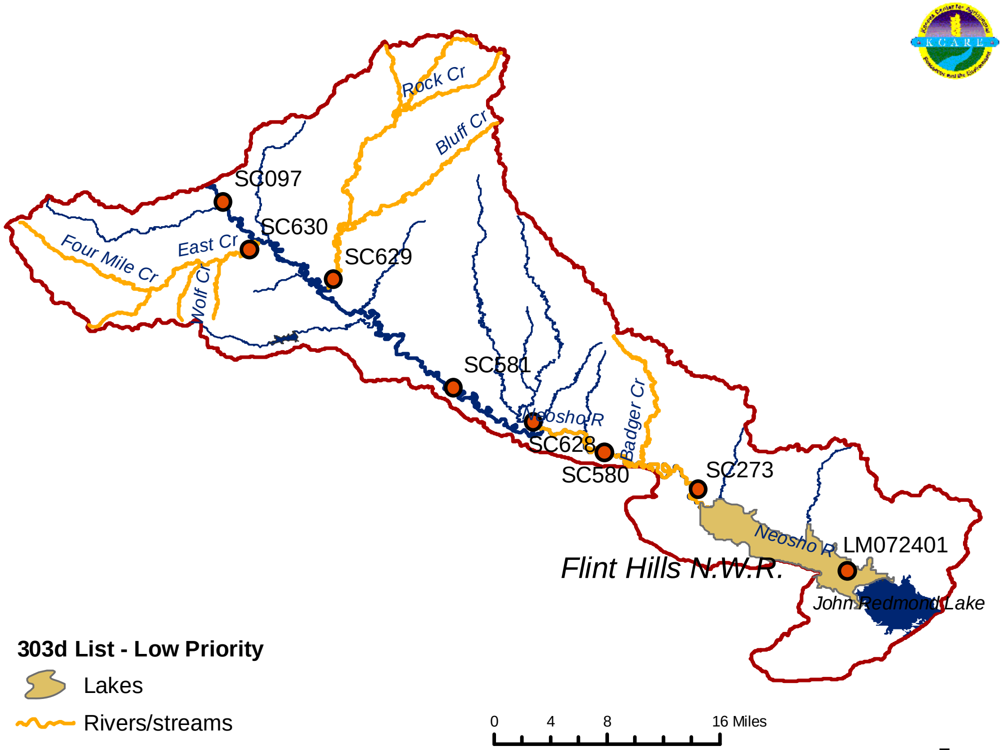


Figure 11. 303d Listings in the Watershed. [16] Kansas Geospatial Community Commons. Kansas Department of Health and Environment.

3.8 TMDL Load Allocations [20]

TMDL loading is based on several factors. A total load is derived from the TMDL. Part of this total load is wasteload allocation. This portion comes from point sources in the watershed: NPDES facilities, CAFOs or other regulated sites. Some TMDLs will have a natural or background load allocation, which might be atmospheric deposition or natural mineral content in the waters. After removing all the point source and natural contributions, the amount of load left is the TMDL Load Allocation. This is the amount that originates from nonpoint sources (pollutants originating from diffuse areas, such as agricultural or urban areas that have no specific point of discharge) and is the amount that this WRAPS project is directed to address. All BMPs derived by the SLT will be directed at this Load Allocation by nonpoint sources.

Load Allocations for Neosho Headwaters Watershed Summary:

1) **Total Suspended Solids nonpoint source load allocation = 29,760 tons/year**
2) **Total Phosphorus nonpoint source load allocation = 28,641 lbs/year**

KDHE has determined by analyzing river and creek samples the degree to which each of the sub watersheds contribute to the load. Cottonwoods Watershed (the Cottonwood River from headwaters to confluence with the Neosho River) is attributed for 80% of the impairment allocation. Eagle Creek Watershed (Eagle Creek to the confluence with Neosho River) is attributed for 10% of the impairment allocation. This leaves Neosho Headwaters with a responsibility of 10% of the total load allocations.

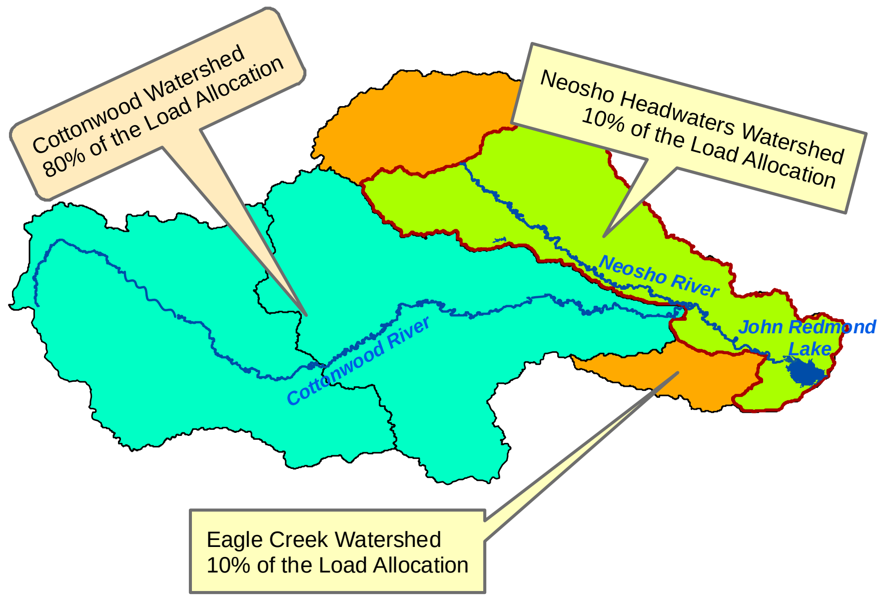


Figure 12. Load Allocation Responsibilities Assigned in Neosho Headwaters, Eagle Creek and Cottonwoods Watersheds

3.8.1 Siltation

KDHE has set a load reduction goal for siltation for John Redmond Reservoir originating from nonpoint sources. This amount is 297,600 tons per year. It is derived from subtracting the total silt load capacity from the silt current condition. This is the amount that the Neosho Headwaters, Eagle Creek and the Cottonwood Watersheds will need to remove through BMP installations and conservation practices. In addition to naming a load reduction for the reservoir, KDHE has determined that the Neosho Headwaters Watershed is responsible for 10% of the load allocation or 29,760 tons of sediment.

Table 10. Siltation Load Allocations for Neosho Headwaters Watershed. [21]

John Redmond Siltation TMDL	
Silt Current Condition (tons)	888,623
Less Total Silt Load Capacity (tons)	591,000
Required Load Reduction from Nonpoint Sources (tons) for John Redmond Reservoir	**297,600**

Siltation Load Allocations for Neosho Headwaters Watershed, Cont.	
Required Annual Load Reductions by Watersheds (tons/yr) to meet TMDL	
Cottonwood (80% of total load reduction)	238,080
Eagle Creek (10% of total load reduction)	29,760
Required Load Reduction for Neosho Headwaters from Nonpoint Sources (10% of Total Load for John Redmond Reservoir)	**29,760**
Total Load Reduction for John Redmond Reservoir	**297,600**

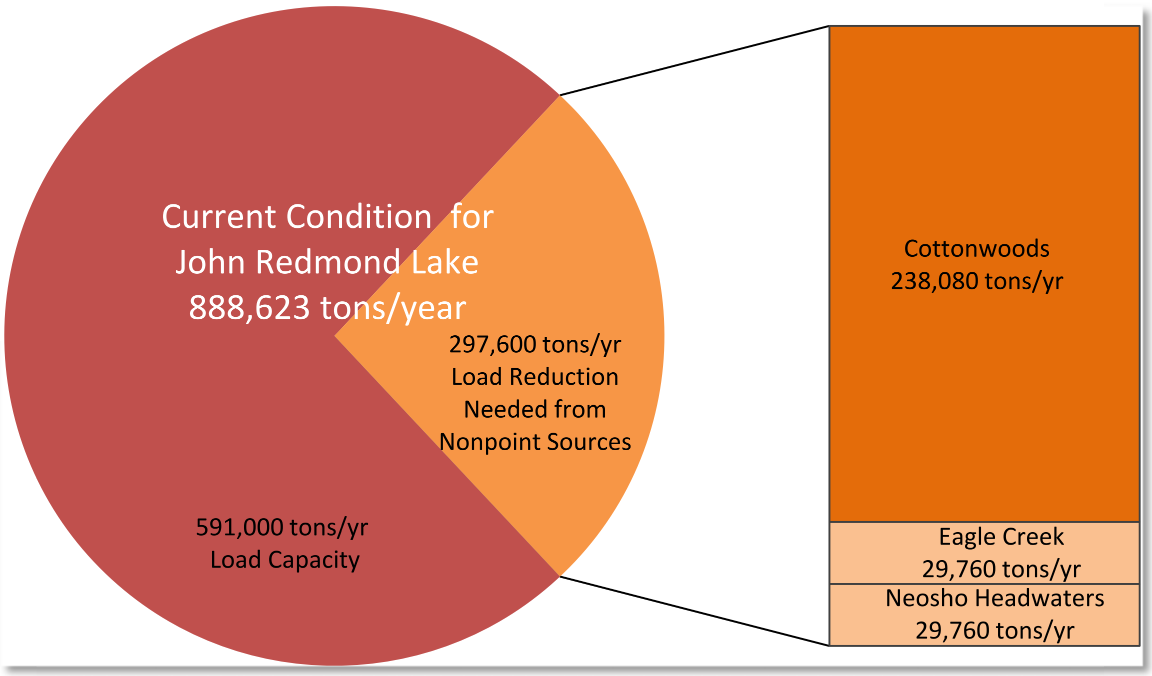


Figure 13. Sediment Load Allocations for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds. Total sediment load in John Redmond Reservoir is 888,623 tons per year.

3.8.2 Phosphorus

The same principal has been applied to phosphorus loads. KDHE has set a load reduction goal for phosphorus in John Redmond Reservoir originating from nonpoint sources. This amount is 286,408 pounds per year. It is derived from subtracting the total phosphorus load capacity from the current condition of phosphorus concentration in the reservoir. This is the amount that the Neosho Headwaters, Eagle Creek and the Cottonwood Watersheds will need to remove through BMP installations and conservation practices. In addition to naming a load reduction for the reservoir, KDHE has determined that the Neosho Headwaters Watershed is responsible for 10% of the load allocation or 28,641 pounds of phosphorus.

Table 11. Phosphorus Load Allocations for the Watershed. [22]

John Redmond Phosphorous TMDL	
Total P Current Condition (lbs)	1,352,982
less Total P Load Capacity (lbs)	1,066,574
Required Load Reduction from Nonpoint Sources (lbs)	**286,408**
Required Annual Load Reductions by Watersheds (lbs/yr) to meet TMDL	
Cottonwood (80% of total load reduction)	229,126
Eagle Creek (10% of total load reduction)	28,641
Required Load Reduction for Neosho Headwaters from Nonpoint Sources (10% of Total Load for John Redmond Reservoir)	**28,641**
Total Load Reduction for John Redmond Reservoir	**286,408**

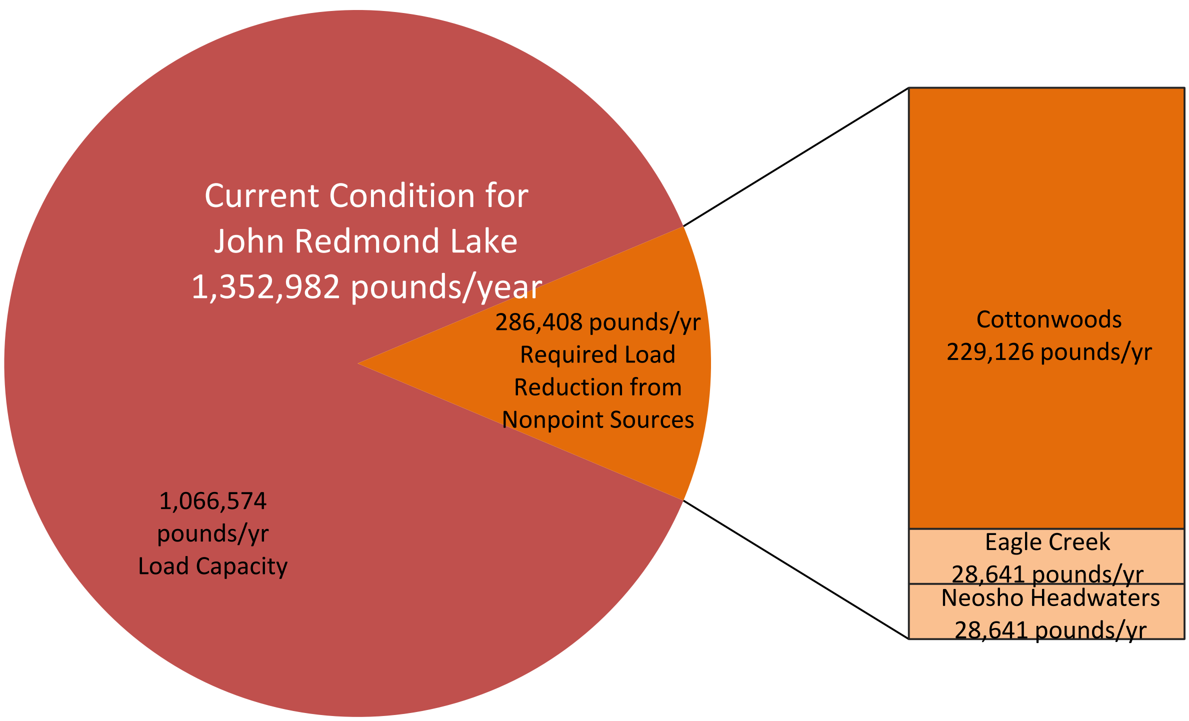


Figure 14. Phosphorus Load Allocations for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds. Total phosphorus load in John Redmond Reservoir is 1,352,982 pounds per year.

4.0 Critical Targeted Areas

4.1 Cropland and Livestock Targeted Areas

The Neosho Headwaters Watershed was assessed for sediment from cropland and livestock related pollutants 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 average annual 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 top 20% to 30% of the list are selected as critical (targeted) areas for cropland and livestock BMPs implementation.

The SWAT model was developed by USDA-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 amount of manure applied to the pasture or grassland, grazing periods, and 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 Agricultural Research Service. 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 the crop provided in the 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 for the Neosho Headwaters SWAT model were collected from a variety of reliable online and printed data sources and knowledgeable agency personnel within the watershed. Input data and their online sources are:

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)

The maps produced by the modeling are displayed below. The darker colors on the map indicate a greater potential for runoff of sediment and nutrients. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices.

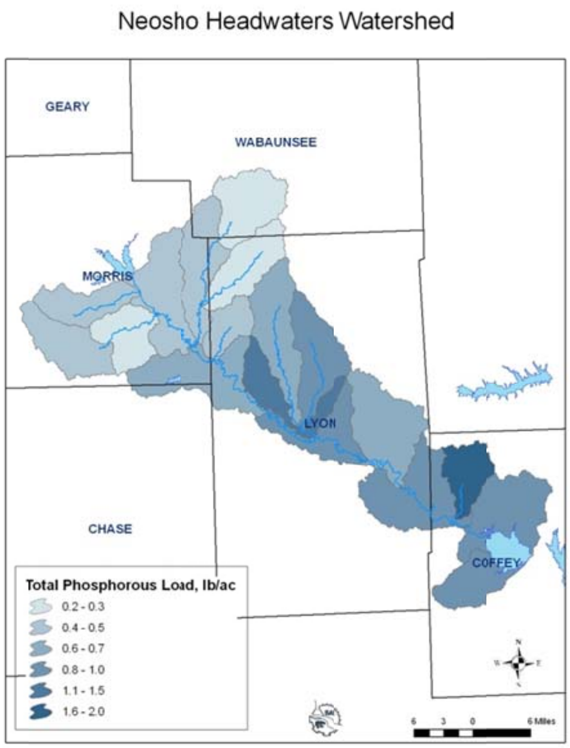


Figure 15. Total Phosphorus Load, pounds/acre as Indicated by SWAT.

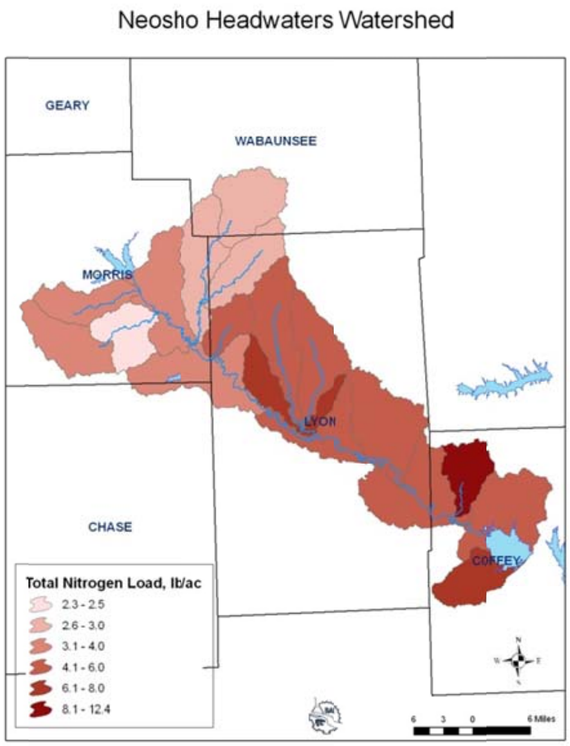


Figure 16. Total Nitrogen Load, pounds/acre as Indicated by SWAT.

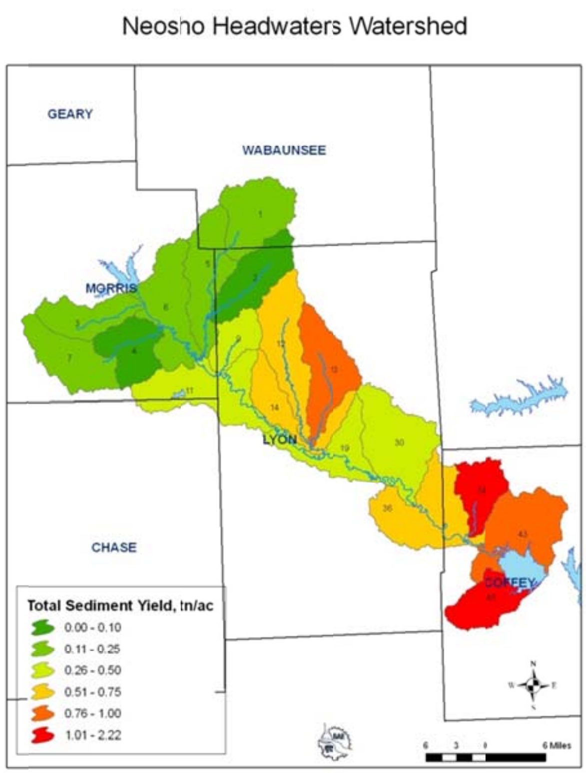


Figure 17. Total Sediment Yield, tons/acre as Indicated by SWAT.

After locating initial sediment 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 stakeholder leadership team 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 (waterways, no-till, buffers, terraces and minimum tillage) in the cropland targeted area of the watershed averaged across counties. The results are as follows:

- Grassed waterways – current adoption rate of 17%
- No-till cultivation – current adoption rate of 14%
- Vegetative buffer strips – current adoption rate of 2%
- Grassed terraces – current adoption rate of 34%
- Minimum tillage – current adoption rate of 28%

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. This information is provided in Tables 15 and 23.

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. Targeting for this watershed will be accomplished in two different areas:

1. Cropland and streambank areas will be targeted for sediment, and
2. Livestock, cropland and streambank areas will be targeted for eutrophication (represented as phosphorus).

Cropland targeted areas were determined by SWAT. Livestock targeted areas were determined by the SLT along with KDHE water sample input. They are included in the map below.

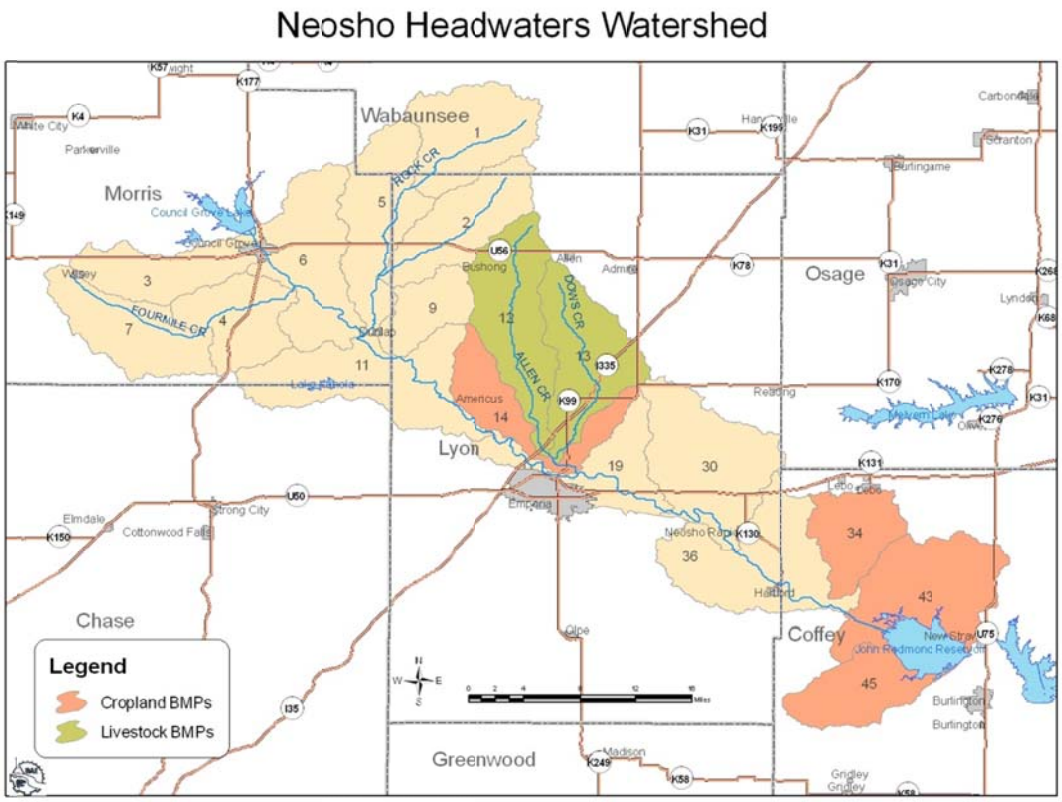


Figure 18. Cropland and Livestock Targeted Areas

4.1.1 Cropland Targeted Area

The SWAT model has indicated an area of the watershed that is susceptible to cropland erosion. This area is seen in the map below and includes the following HUC 12s;

- 110702010303 (subbasin 14),
- 110702010401(subbasin 34),
- 110702010406 (subbasin 43) and
- 110702010407 (subbasin 45).

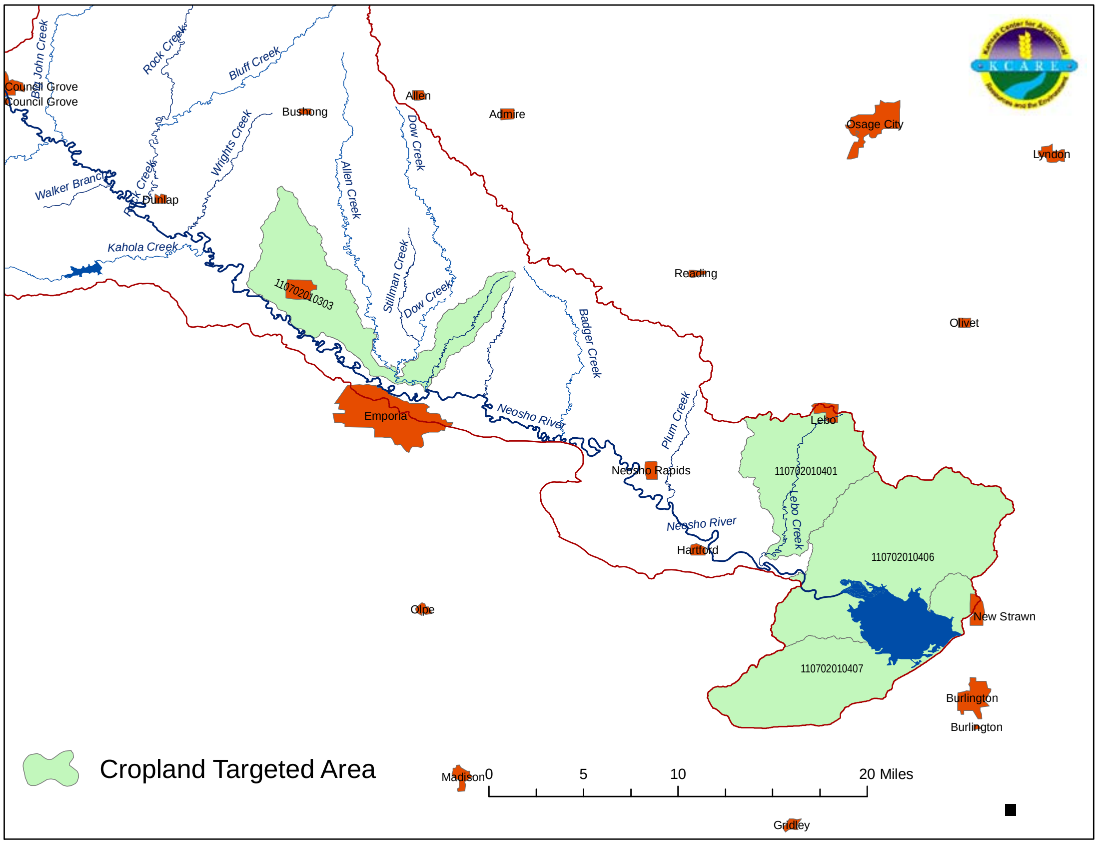


Figure 19. SWAT Targeted Area for Cropland in the Watershed.

Table 12. Land Use by Sub Watershed for Cropland Targeted Area

Landuse Breakdown (acres)						
Subbasin	**Pasture or Hay**	**Percent Pasture or Hay**	**Cultivated**	**Percent Cultivated**	**Percent Other Land Uses**	**Total**
110702010303	8,216	40.90	9,739	48.47	10.63	20,091
110702010401	7,338	41.88	7,980	45.54	12.58	17,523
110702010406	22,021	59.19	4,646	12.49	28.32	37,205
110702010407	12,988	57.81	3,544	15.77	26.42	22,467
Total	50,563		25,909			97,286

4.1.2 Livestock Targeted Area

The SLT has determined an area for targeting livestock related (E. coli and nutrients) pollutants in the watershed. This area will be targeted for livestock BMPs. These two sub watersheds focus on Dow and Allen Creeks because they have TMDLs for fecal coliform bacteria. This makes them important in controlling livestock runoff.

HUC 12 numbers for the livestock targeted area are:

- 110702010301 (subbasin 12) and
- 110702010302 (subbasin 13).

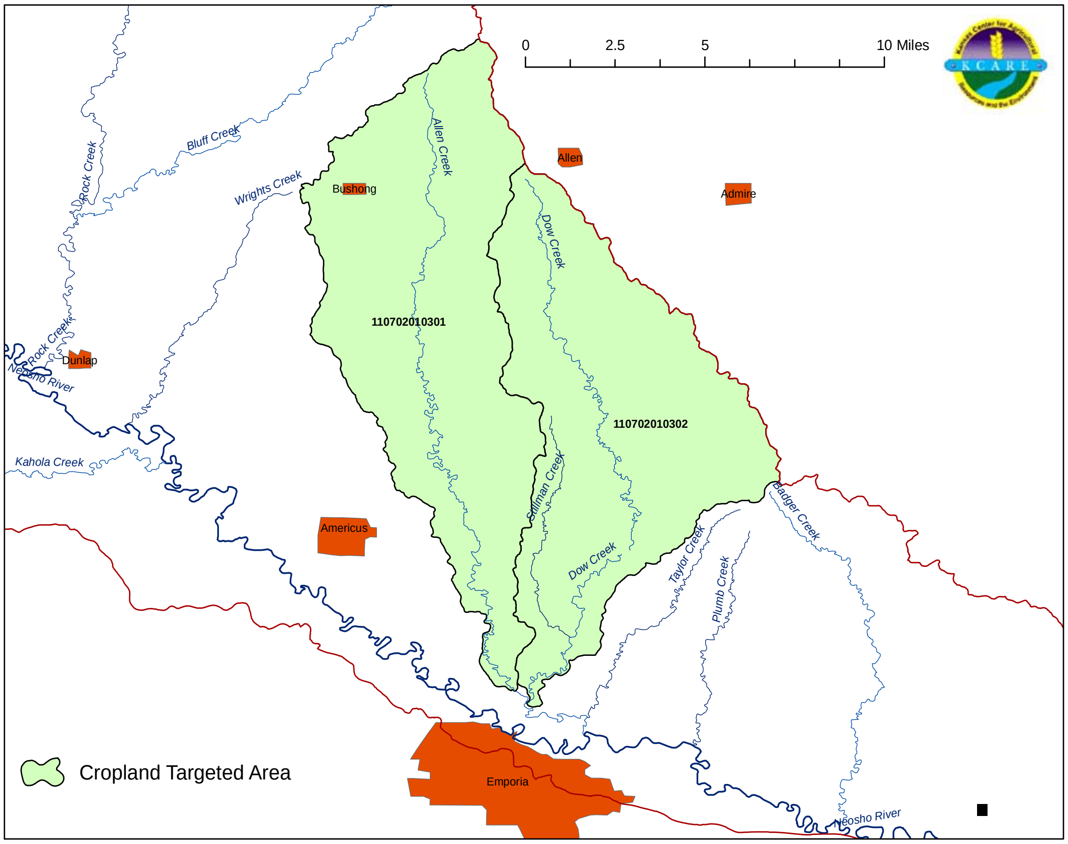


Figure 20. Targeted Area for Livestock in the Watershed.

Table 13. Land Use by Sub Watershed for Livestock Targeted Area

Landuse Breakdown (acres)						
Subbasin	Pasture or Hay	Percent Pasture or Hay	Cultivated	Percent Cultivated	Percent Other Land Uses	Total
110702010301	24,140	76.55	5,336	16.92	6.53	31,534
110702010302	20,928	72.39	6,247	21.61	6.00	28,907
Total	45,068		11,583			60,441

Flint Hills RC&D is conducting a livestock assessment for Allen and Dow Creek watersheds. They will do an aerial survey of all CAFOs and will submit a report of total livestock, people and wildlife units within those two sub watersheds.

4.1.3 Streambank Targeted Area

The Kansas Water Office contracted the Watershed Institute, Inc. (TWI) to complete a riparian area and stream channel assessment for the John Redmond Reservoir. This assessment along the main channel of the Neosho River determined the targeted area for streambank restoration. Sediment transport and stability of streambanks were characterized by USGS and TWI. The study estimated annual erosion rates from surveys at representative channel locations, as well as characterizing "hotspots" of channel erosion based on aerial photography. [23] After consultation with landowners, NRCS, SCC, and Flint Hill RC&D, an 8.3-mile reach of the Neosho River has been selected for streambank stabilization and riparian restoration. [24] Thirty one hotspots were identified and ranked into a three tier system. Priority or Tier One will include restoring thirteen hotspots and be funded through the American Reinvestment and Recovery Act (ARRA). Construction will begin in 2010. Priority Two will include six hotspots and Priority Three will include the final twelve hotspots. Priorities Two and Three will be addressed at a later date as funding allows.

Table 14. Erosion Summary from Thirty One Hotspots along the Neosho River. [25]

Priority	Neosho River "Hotspot" Erosion Summary						
	Site ID	Erosion Area (Sq Ft)	Length	Bank Height	Erosion/ Year	Tons/ Year	Tons/ Ft/Year
Tier One	13	150,996.0	773	21	13.02	9,407.05	12.17
	14	132,570.0	1,347	21	6.56	8,259.11	6.13
	15	19,616.2	657	21	1.99	1,222.09	1.86
	16	26,707.0	1,063	21	1.67	1,663.85	1.57
	17	29,489.0	1,021	21	1.93	1,837.16	1.80
	18	51,344.5	1,997	21	1.71	3,198.76	1.60
	19	70,701.5	1,367	21	3.45	4,404.70	3.22
	20	41,178.6	1,083	21	2.53	2,565.43	2.37
	21	35,697.9	1,052	21	2.26	2,223.98	2.11
	22	32,744.1	1,231	21	1.77	2,039.96	1.66
	23	80,755.6	1,466	21	3.67	5,031.07	3.43
	24	81,797.5	1,935	21	2.82	5,095.98	2.63
	25	44,219.2	1,371	21	2.15	2,754.86	2.01
Tier Two	26	43,223.1	1,265	21	2.28	2,692.80	2.13
	27	60,855.8	2,252	21	1.80	3,791.32	1.68
	28	46,369.4	1,219	21	2.54	2,888.81	2.37
	29	52,704.0	1,654	21	2.12	3,283.46	1.99
	30	76,831.0	2,567	21	2.00	4,786.57	1.86
	31	148,461.0	2,385	21	4.15	9,249.12	3.88

Neosho River "Hotspot" Erosion Summary, Cont.							
	Site ID	Erosion Area (Sq Ft)	Length	Bank Height	Erosion/ Year	Tons/Year	Tons/ Ft/Year
Tier Three	1	23,508.3	828	21	1.89	1,464.57	1.77
	2	28,069.2	797	21	2.35	1,748.71	2.19
	3	19,174.3	380	21	3.36	1,194.56	3.14
	4	14,754.0	407	21	2.42	919.17	2.26
	5	13,925.3	400	21	2.32	867.55	2.17
	6	37,499.9	1,020	21	2.45	2,336.24	2.29
	7	23,304.2	697	21	2.23	1,451.85	2.08
	8	21,084.7	732	21	1.92	1,313.58	1.79
	9	28,898.3	827	21	2.33	1,800.36	2.18
	10	21,017.3	631	21	2.22	1,309.38	2.08
	11	26,410.9	753	21	2.34	1,645.40	2.19
	12	33,926.5	1,095	21	2.07	2,113.62	1.93
	Total	**1,517,834.3**	**36,272**	**-**	**-**	**94,561.08**	**-**
	Average	**48,962.4**	**1,170**	**21**	**2.85**	**3,050.36**	**2.66**

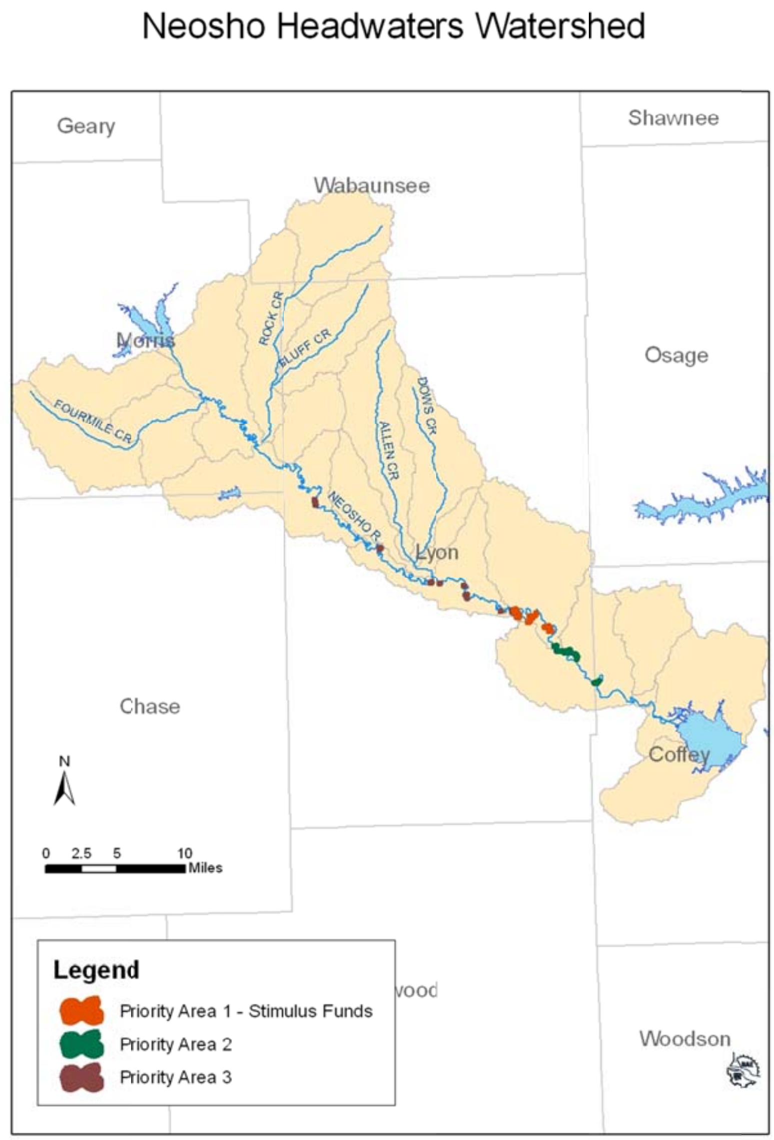


***Figure 21. Streambank targeted areas along the Neosho River*.**

4.2 Load Reduction Estimate Methodology

4.2.1 Cropland

Baseline loadings are calculated using the SWAT model delineated to the HUC 12 watershed scale. Best management practice (BMP) load reduction efficiencies are derived from K-State Research and Extension Publication MF-2572. [26] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

4.2.2 Livestock

Baseline nutrient loadings per animal unit are calculated using the Livestock Waste Facilities Handbook.[27] Livestock management practice load reduction efficiencies are derived from numerous sources including K-State Research and Extension Publication MF-2737 and MF-2454.[28] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

NOTE: The SLT of the Neosho Headwaters Watershed has determined that the focus of this WRAPS process will be on two key concerns of the watershed listed in order of importance:

1. **Sedimentation,**
    a. **Cropland erosion and**
    b. **Streambank erosion**
2. **Eutrophication**
    a. **Livestock (nutrients and fecal coliform bacteria),**
    b. **Cropland (nutrients) and**
    c. **Streambank (sediment with attached nutrients)**

All goals and best management practices will be aimed at restoring water quality or protecting the watershed from further degradation. The following sections in this report will address these concerns.

5.0 Impairments Addressed by the SLT

5.1 Sediment

John Redmond Reservoir has a TMDL for **siltation (sedimentation)**. The Flint Hills National Wildlife Refuge, which is located on the upstream end of John Redmond Reservoir, is listed on the 303d list for siltation.

Silt or sediment accumulation in lakes and wetlands reduces reservoir volume and therefore, limits public access to the lakes because of inaccessibility to boat ramps, beaches and the water side. Also, a decrease in storage in the lake affects domestic and industrial uses of the lake water. In addition to the problem of sediment loading in lakes, pollutants can be attached to the suspended soil particles in the water column causing additional impairments. Sediment can originate from streambank erosion and sloughing of the sides of the river and stream due to erosion and a lack of riparian cover. Sheet and rill erosion from cropping and pasture systems contributes sediment in the ecosystem. Therefore, reducing erosion is necessary for accomplishing a reduction in sediment. Agricultural best management practices (BMPs) such as no-till, conservation tillage, grass buffer strips around cropland, terraces, grassed waterways and reducing activities within the riparian areas will reduce erosion and improve water quality.

Activities performed on the land affects sediment that is transported downstream to the lakes. Physical components of the terrain are important in sediment movement. The slope of the land, its propensity to generate runoff and soil type is important. Animal movement, such as livestock that regularly cross the stream, can cause pathways that will erode. Another source of sediment is silt that is present in the stream from past activities and is gradually moving downstream with each high intensity rainfall event.

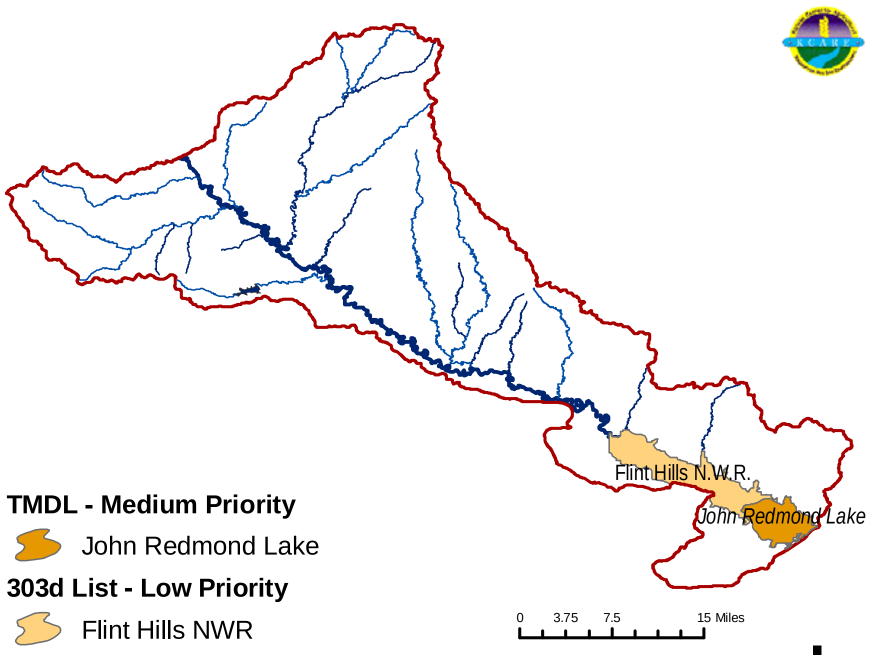


Figure 22. TMDL and 303d Listings for Siltation in the Watershed. [16] Kansas Department of Health and Environment.

5.1.1 Cropland Erosion

Cropland erosion BMPs have been targeted by SWAT modeling analysis. The lower portion of the targeted area is located near John Redmond Reservoir and the upper portion is located along the Neosho River near Emporia. Causes of erosion are discussed in more detail in the rest of this section.

5.1.1.A Land Use

Land use activities have a significant impact on the types and quantity of sediment transfer in the watershed. Construction projects in the watershed and in communities can leave disturbed areas of soil and unvegetated roadside ditches that can wash in a rainfall event. In addition, agricultural cropland that is under conventional tillage practices as well as a lack of maintenance of agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion. The primary land uses in the watershed are grasslands (68%), cropland (19%), woodlands (6%), water (3%) and other (3%). The primary land uses in the cropland targeted area of the watershed are cropland (27%) and grassland (52%).

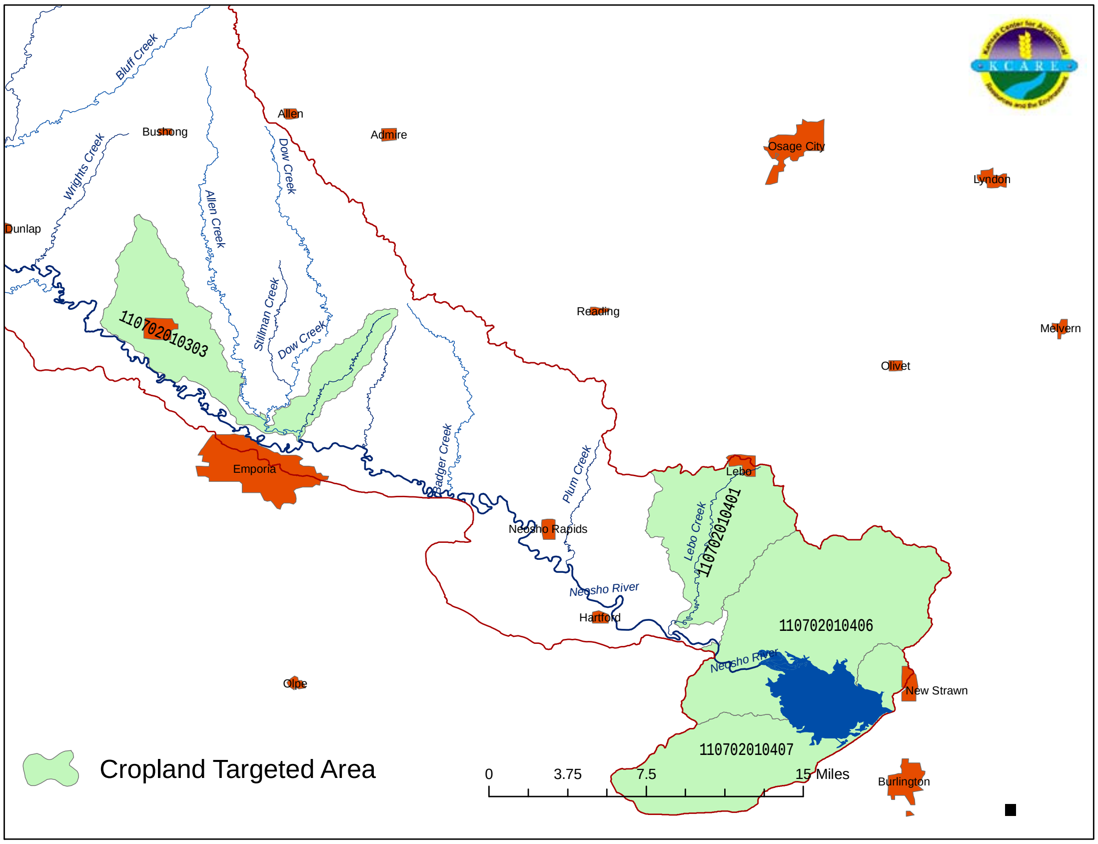


Figure 23. Targeted Area for Cropland in the Watershed as determined by SWAT Analysis.

Table 15. Land Use in the Targeted Area 2005. *Calculated from Kansas Applied Remote Sensing Program, 2005 :Kansas Land Cover Patterns, Kansas Geospatial Community Commons.*

Land Use	*Acres*	*Percentage*
Targeted Cropland		
Urban Industrial/Commercial	63	0.06
Urban Residential	353	0.36
Urban Open Land	639	0.66
Urban Woodland	37	0.04
Urban Water	8	0.01
Cropland	25,909	26.63
Grassland	50,563	51.97
CRP	2,933	3.02
Woodland	6,734	6.92
Water	9,966	10.24
Other	80	0.08
Total	97,285	100.00

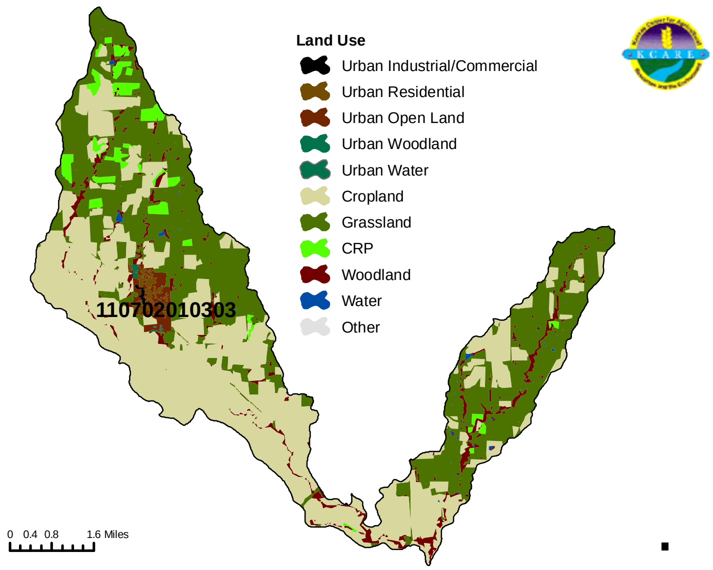


Figure 24. Land Cover of the Upper Portion of the Cropland Targeted Area of the Watershed, 2005 (HUC 110702010303). 3 *Kansas Applied Remote Sensing Program, Kansas Geospatial Community Commons.*

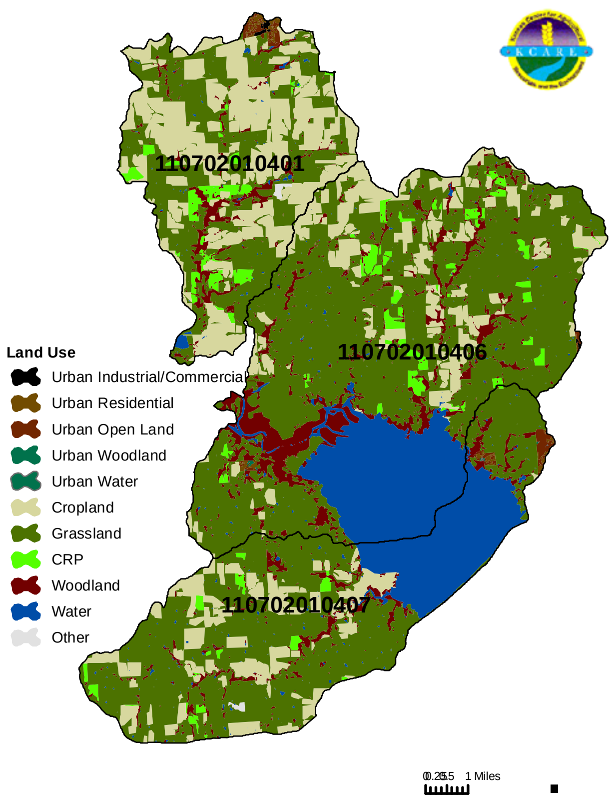


Figure 25. Land Cover of the Lower Portion of the Cropland Targeted Area of the Watershed, 2005 (HUC 110702010401, 110702010406 and 110702010407). 3 *Kansas Applied Remote Sensing Program, Kansas Geospatial Community Commons.*

5.1.1.B Soil Erosion Caused by Wind and/or Water

NRCS has established a "T factor" in evaluating soil erosion. T is the soil loss tolerance factor. It is defined as the maximum rate of annual soil loss that will permit crop productivity to be sustained economically and indefinitely on a given soil. It is assigned to soils without respect to land use or cover and ranges from 1 ton per acre for shallow soils to 5 tons per acre for deep soils that are not as affected by loss of productivity by erosion. T factor represents the goal for maximum annual soil loss in sustaining productivity of the land use. Erosion is considered to be greater than T if either the water (sheet and rill) erosion or the wind erosion rate exceeds the soil loss tolerance rate. [29]

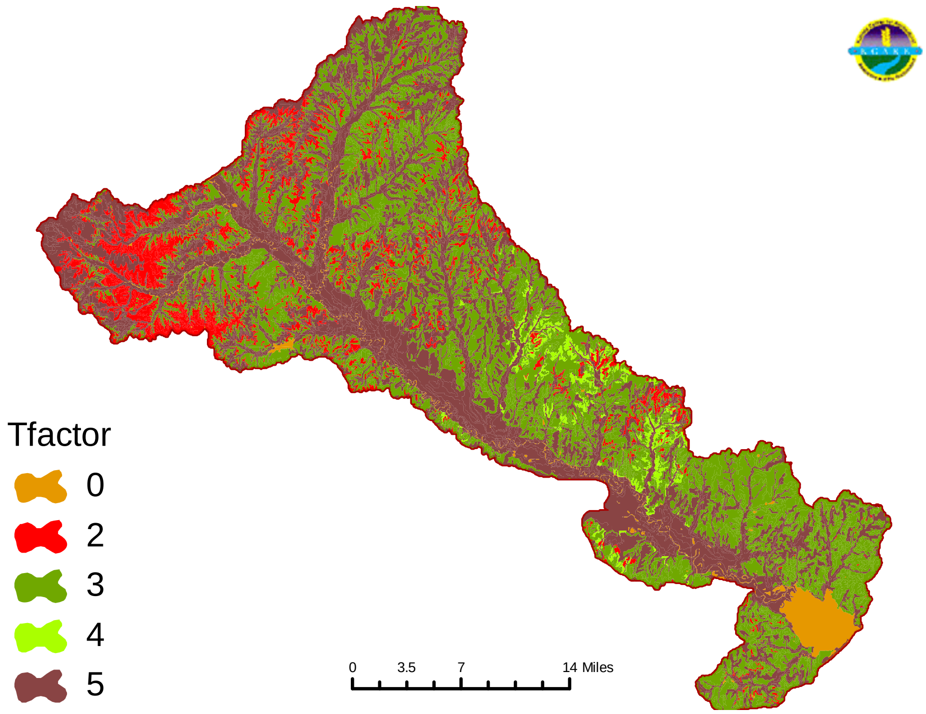


Figure 26. T Factor of the Watershed. [30] *Data derived from SSURGO NRCS Soil Data Mart.*

The primary percentage ranking T Factor for this watershed is 5, which constitutes the deepest soils. This demonstrates the need for conservation practices in the watershed to protect against soil erosion.

Table 16. T Factor in the Watershed. Calculated from SSURGO NRCS Soil Data.

T Factor	Acres	Percent of Watershed
0	11,916	2.52
2	43,814	9.26
3	196,498	41.52
4	8,664	1.83
5	212,358	44.87

5.1.1.C Soil Erosion Influenced by Soil Type and Runoff Potential

Soil type has an influence on runoff potential and erosion throughout the watershed. Soils are classified into four hydrologic soil groups (HSG). The soils within each of these groups have the same runoff potential after a rainfall event if the same conditions exist, such as plant cover or storm intensity. Soils are categorized into four groups: A, B, C and D.

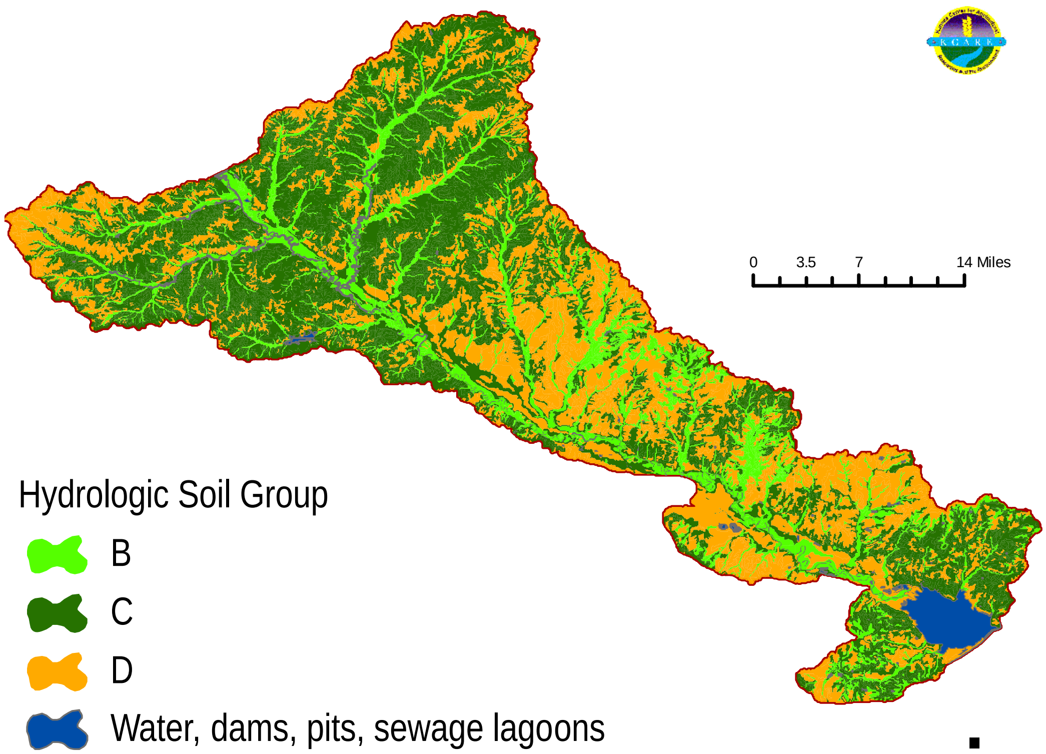


Figure 27. Hydrologic Soil Groups of the Watershed with the Cropland. Targeted Area Highlighted. [31] *Data derived from SSURGO NRCS Soil Data Mart.*

Almost half of the watershed (48 percent) is characterized as soil group C. Thirty two percent are categorized as soil group D, which is the soil group with the highest potential for runoff. Conservation practices and BMP installations will help to protect this fragile soil.

Table 17. Hydrologic Soil Groups of the Watershed. *Calculated from SSURGO Soil Data Mart.*

Hydrologic Soil Group	Definition	Acres of Watershed in HSG	Percentage of Watershed in HSG
A	Soils with low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep well drained to excessively well-drained sands or gravels.	0	0

Hydrologic Soil Groups of the Watershed, Cont.			
Hydrologic Soil Group	**Definition**	**Acres of Watershed in HSG**	**Percentage of Watershed in HSG**
B	Soils having moderate infiltration rates even when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well drained to sell drained soils with moderately fine to moderately coarse textures.	78,094	16.5
C	Soils having slow infiltration rates even when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures.	227,922	48.2
D	Soils with high runoff potential. Soils having very slow infiltration rates even when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material.	155,271	32.8
Other	Water, dams, pits, sewage lagoons	11,964	2.5
Total		473,250	100

5.1.2 Streambank Erosion

Sediment can originate from streambank erosion and sloughing of the sides of the river and stream bank. A lack of riparian cover can cause washing on the banks of streams or rivers and enhance erosion.

5.1.2.A Riparian Quality

An adequately functioning and healthy riparian area will reduce sediment flow from cropland and rangeland. Riparian areas can be vulnerable to runoff and erosion from livestock induced activities in pastureland and overland flow from bare soil on cropland. Buffers and filter strips along with additional forested riparian areas can be used to impede erosion and streambank sloughing. Livestock restriction along the stream will prevent livestock from entering the stream and degrading the banks. Cropland needs buffer and filter strips adjacent to the stream in order to impede the flow of sediment off of fields. Conservation tillage practices are also effective for slowing the flow of rain water off of crop fields.

This WRAPS project has streambank stabilization projects that will deal with sediment generated along the Neosho River. However, all implemented cropland and livestock BMPs will also reduce sediment.

5.1.2.B Rainfall and Runoff

Rainfall amounts and subsequent runoff can affect sediment delivery from agricultural areas and urban areas into streams and John Redmond Reservoir. High rainfall events can cause cropland erosion, rangeland gully erosion and sloughing of streambanks. High intensity rainfall events (rainfall rates that overwhelm soil adsorptive capacity) usually occur in late spring and early summer. Extended duration of rainfall events that causes soil saturation and subsequent runoff also usually occurs in late spring and early summer. For these reasons it is important to utilize conservation practices such as no-till that provide a "cover" on bare soil during the spring and into the summer.

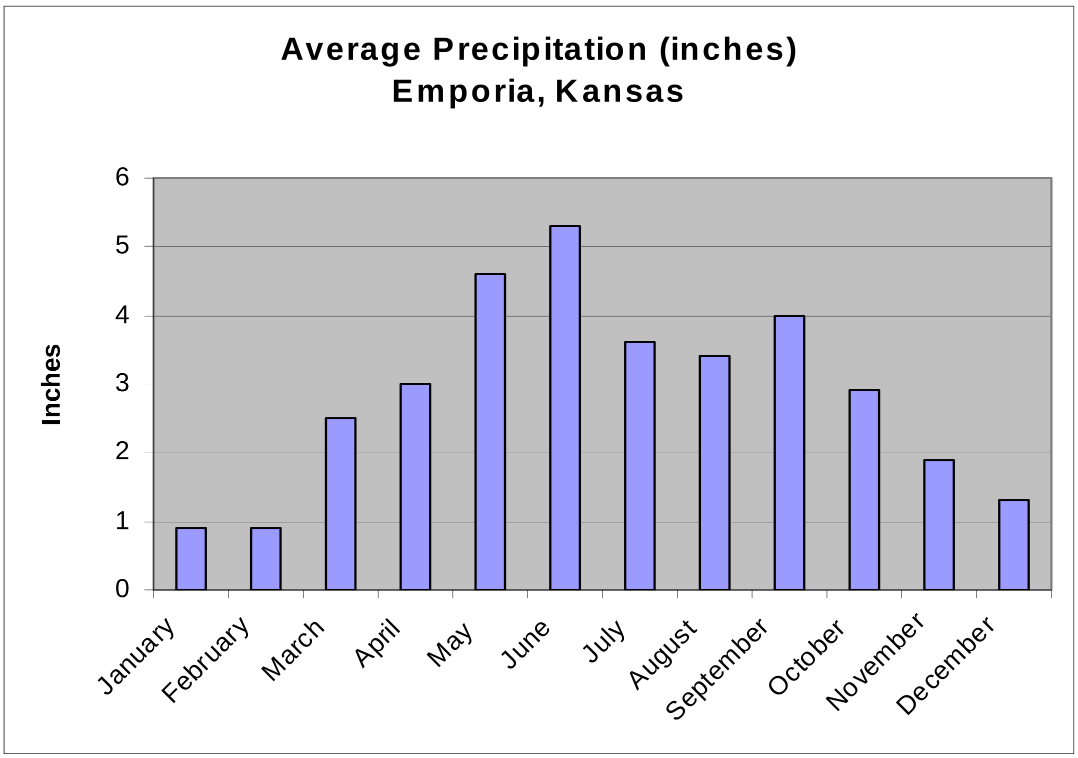
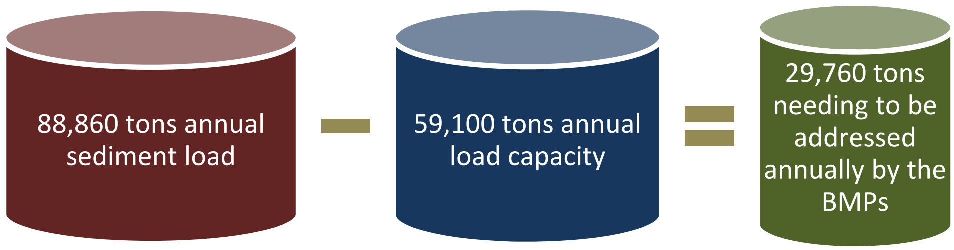


***Figure 28. Average precipitation by month**.* [32] Emporia, Kansas.

5.1.3 Sediment BMPs with Acres or Projects Needed

The current estimated sediment load in the Neosho Headwaters Watershed is 88,600 tons per year according to the TMDL section of KDHE. **The total annual load reduction allocated to Neosho Headwaters needed to meet the sediment TMDL is 29,760 tons of sediment**. This amount does not include the river restoration projects along the Neosho River that are being funded by the ARRA in the year 2010. The sediment load reduction will be met in the first year of the River restoration projects. However, the SLT believes that it is important to have BMPs that will be used as protection of the watershed from sediment deposition in the future.



The SLT has laid out specific BMPs that they have determined will be acceptable to watershed residents as listed below. **These BMPs will be implemented in the cropland and streambank targeted areas.** Cropland BMPs that will be implemented to address nutrient/phosphorus runoff are included in this section. Even though the ARRA projects will meet the sediment reduction goal, an added bonus is that the cropland BMPs aimed at nutrient/phosphorus reduction will also address sediment runoff. Therefore, their sediment load reduction is included. The nutrient/phosphorus BMPs are also listed in Section 5.2.4 of this plan. Specific acreages or projects that need to be implemented per year have been determined through modeling and economic analysis and approved by the SLT.

Table 18. BMPs and Acres or Projects Needed to Reduce Sediment Contribution Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List.

Protection Measures	Best Management Practices and Other Actions	Acres or Projects Needed to be Implemented		
		Cropland Groundtruthing Determined by Adoption Rates		
1. Prevention of sediment contribution from **cropland**	1.1 Establish grassed waterways in crop fields	Current adoption rate = 17%	Adoption rate goal = 40%	1,654 acres
	1.2 Encourage no-till cultivation practice	Current adoption rate = 14%	Adoption rate goal = 37%	3,309 acres
	1.3 Establish buffers along crop fields	Current adoption rate = 2%	Adoption rate goal = 13%	1,654 acres
	1.4 Installation of terraces	Current adoption rate = 34%	Adoption rate goal = 42%	1,654 acres
	1.5 Encourage minimum till	Current adoption rate = 28%	Adoption rate goal = 74%	3,309 acres
2. Prevention of sediment contribution from **streambank** erosion	2.1 Tier One streambank restoration projects along the Neosho River	13 sites		
	2.2 Tier Two streambank restoration projects along the Neosho River	6 sites		

BMPs to Reduce Sediment Contribution, Cont.		
Protection Measures	**Best Management Practices and Other Actions**	**Acres or Projects Needed to be Implemented**
2. Streambank erosion, cont.	2.3 Tier Three streambank restoration projects along the Neosho River	12 sites

5.1.4 Sediment Load Reductions

The table below lists the cropland BMPs and acres implemented with the associated load reductions attained by implementing all of these BMPs.

Table 19. Estimated Sediment Load Reductions for Implemented BMPs on Cropland Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List.

Additive Annual Soil Erosion Reduction (tons), Cropland BMPs						
Year	**Waterways**	**No-Till**	**Buffers**	**Terraces**	**Minimum Tillage**	**Total Load Reduction**
	1,654 acres	**3,309 acres**	**1,654 acres**	**1,654 acres**	**3,309 acres**	
1	83	312	104	62	156	718
2	167	625	208	125	312	1,436
3	250	937	312	187	468	2,155
4	333	1,249	416	250	625	2,873
5	416	1,561	520	312	781	3,591
6	500	1,874	625	375	937	4,309
7	583	2,186	729	437	1,093	5,028
8	666	2,498	833	500	1,249	5,746
9	749	2,810	937	562	1,405	6,464
10	833	3,123	1,041	625	1,561	7,182
11	916	3,435	1,145	687	1,718	7,901
12	999	3,747	1,249	749	1,874	8,619
13	1,083	4,060	1,353	812	2,030	9,337
14	1,166	4,372	1,457	874	2,186	10,055
15	1,249	4,684	1,561	937	2,342	10,773
16	1,332	4,996	1,665	999	2,498	11,492
17	1,416	5,309	1,770	1,062	2,654	12,210
18	1,499	5,621	1,874	1,124	2,810	12,928
19	1,582	5,933	1,978	1,187	2,967	13,646
20	1,665	6,245	2,082	1,249	3,123	14,365

The table below demonstrates the streambank load reductions attained by restoring the 31 stabilization sites along the Neosho River. The first year of stabilization projects will meet the TMDL requirement.

Table 20. Estimated Sediment Load Reductions for Restoration Projects along the Neosho River Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List..

Annual Sediment Reduction (tons), Streambank Restoration				
Priority Area	**Number of Sites**	**Average Length (ft)**	**Average Erosion (tons/ft/year)**	**Streambank Reduction (tons)**
1	13	1,259	3.50	49,704
2	6	1,890	2.48	26,692
3	12	714	2.33	18,185

The following table delineates sediment reduction by year to the ten year life of the plan. (The life of the streambank portion of the WRAPS plan is only ten years.) Priority One stabilization projects will be completed in year one and will provide a sediment reduction of 49,704 tons. Since stabilization projects in Priority Areas 2 and 3 will be dependent on funding, the total anticipated sediment reductions for the entire ten year period were summed and divided by the remaining nine years of the plan to give an average annual load reduction per year of 4,986 tons.

Table 21. Estimated Sediment Load Reductions for Implemented BMPs on Streambanks Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List.

Annual Sediment Reduction (tons), Streambank Restoration	
Year	**Streambank Reduction (tons)**
1	49,704
2	54,688
3	59,672
4	64,656
5	69,640
6	74,624
7	79,608
8	84,592
9	89,576
10	94,560

The table below shows the combined load reduction for sediment that is attained by implementing all cropland and streambank BMPs annually. The percent of TMDL achievement is illustrated in the right column. Due to the implementation of ARRA funded Tier One streambank restoration projects, the TMDL will be met by the first year. At the end of year one, the sediment focus will be directed to “prevention” instead of restoration.

Table 22. Combined Cropland and Streambank Load Reductions Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List.

Cumulative Combination of Cropland and Streambank* BMPs to Meet the Sediment TMDL				
Year	**Streambank Reduction (tons)**	**Cropland Reduction (tons)**	**Total Reduction (tons)**	**% of TMDL**
1	49,704	718	50,422	169%
2	54,688	1,436	56,124	189%
3	59,672	2,155	61,827	208%
4	64,656	2,873	67,529	227%
5	69,640	3,591	73,231	246%
6	74,624	4,309	78,933	265%
7	79,608	5,028	84,636	284%
8	84,592	5,746	90,338	304%
9	89,576	6,464	96,040	323%
10	94,560	7,182	101,742	342%
11	94,560	7,901	102,461	344%
12	94,560	8,619	103,179	347%
13	94,560	9,337	103,897	349%
14	94,560	10,055	104,615	352%
15	94,560	10,773	105,333	354%
16	94,560	11,492	106,052	356%
17	94,560	12,210	106,770	359%
18	94,560	12,928	107,488	361%
19	94,560	13,646	108,206	364%
20	94,560	14,365	108,925	366%

Sediment reduction goal is met.

* *Load reduction to meet sediment TMDL = 29,760 tons.*

Table 23. Sediment Load Reduction by Category Aimed at Meeting the Siltation TMDL for John Redmond Reservoir and the Siltation Impairment for Flint Hills NWR on the 303d List.

Best Management Practice Category	**Total Load Reduction (tons)**	**% of Sediment TMDL**
Cropland	14,365	48.3%
Streambank	94,560	317.7%
Total	**108,925**	**366.0%**

Refer to Section 7, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

5.2 *Eutrophication and Nutrients*

5.2.1 Livestock Related Pollutants

Livestock can cause certain pollutants in the water. E. coli bacteria is present in livestock manure and can be transported into waterways if livestock have access to streams. Nutrients, primarily phosphorus, are also present in manure. Soluble phosphorus can easily be transported in runoff from fields where livestock gather. Other nutrient issues can arise from fertilizers applied to non-native pastures. Nitrogen and phosphorus can originate from fertilizer runoff caused by either excess application or a rainfall event immediately after application. ***It must be noted that not all E. coli bacteria can be attributed to livestock. Wildlife has a contribution to E. coli loads. In addition, failing septic systems can be a source of E. coli bacteria from humans. A similar notation is that not all phosphorus and nitrogen contributions can be attributed to agricultural practices. Excess fertilization of lawns, golf courses and urban areas can easily transport nitrogen and phosphorus downstream. However, for this WRAPS process, targeting will be for livestock.***

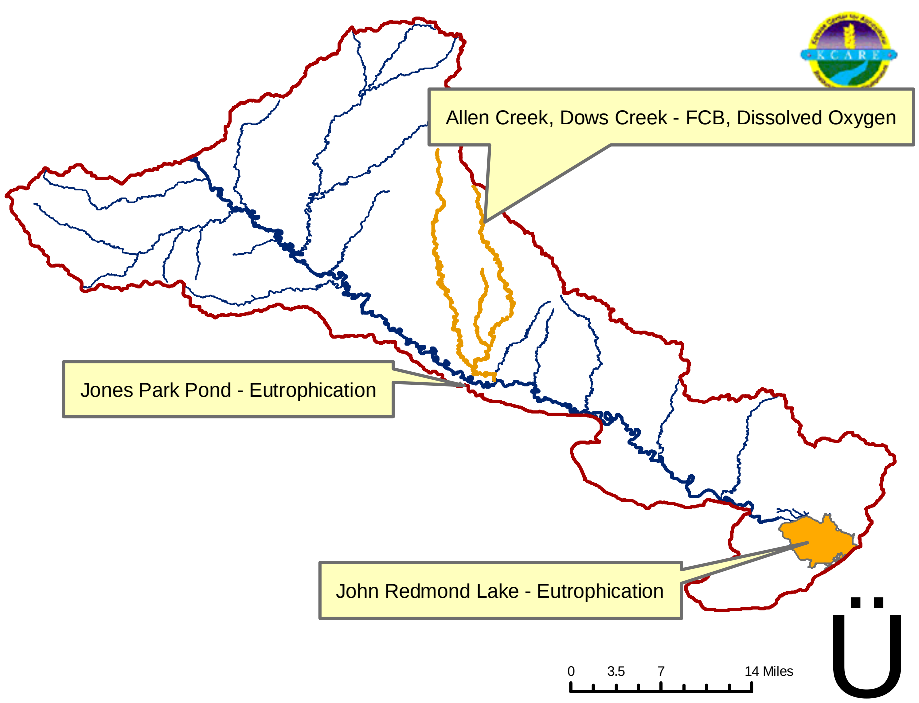


Figure 29. Livestock Related TMDLs in the Watershed.

As mentioned earlier in this report, targeting has been assigned for livestock related pollutants. It includes Dow Creek and Allen Creek watersheds. These two creeks have TMDLs for fecal coliform bacteria and dissolved oxygen. These are both animal and nutrient related issues.

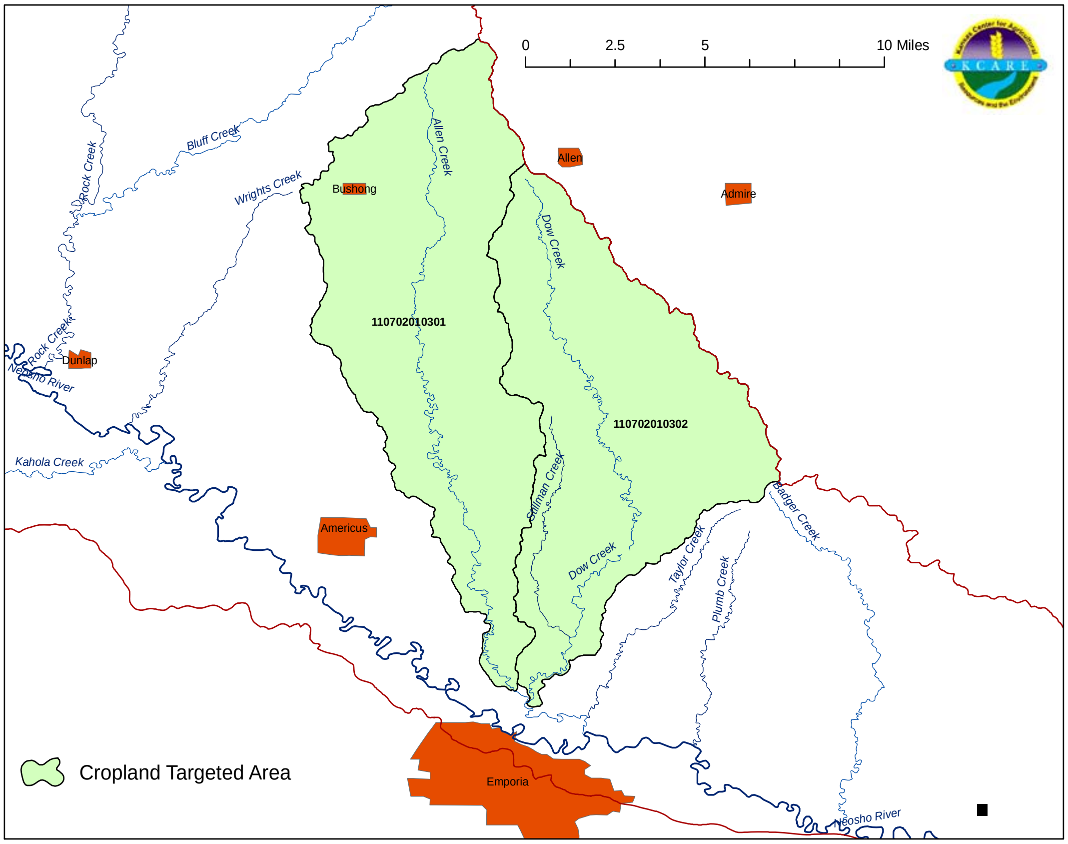


Figure 30. Targeting for Livestock BMPs in the Watershed.

5.2.1.A. Manure Runoff from Fields and Livestock Operations

Allen and Dows Creeks are listed with TMDLs for **fecal coliform bacteria (FCB)**. FCB are a broad spectrum of bacteria species which includes E. coli bacteria. Since FCB is present in the digestive tract of all warm blooded animals including humans and animals (domestic and wild), its presence in water indicates that the water has been in contact with human or animal waste. FCB is not itself harmful to humans, but its presence indicates that disease causing organisms, or pathogens, may also be present. A few of these are Giardia, Hepatitis, and Cryptosporidium. In the past, KDHE has measured FCB in determination of issuance of a TMDL. In the past, KDHE has used FCB as an indicator of pathogen impairment. Currently, however, KDHE is transitioning to the use of E. coli as it is a more reliable indicator of human health risk. Consequently, the new methodology for assessing E. coli levels in water bodies requires the average of five samples taken over a month's time to exceed the criteria level. This is much more stringent than the former FCB methodology which required a single exceedance to indicate impairment. Presence of E. coli in waterways can originate from

- improper manure disposal from livestock production areas,

- failing septic systems,
- close proximity of any mammals to water sources, and
- manure application during adverse weather events to agricultural fields.

E. coli can originate in both rural and urban areas. It can be caused by both point and nonpoint sources.

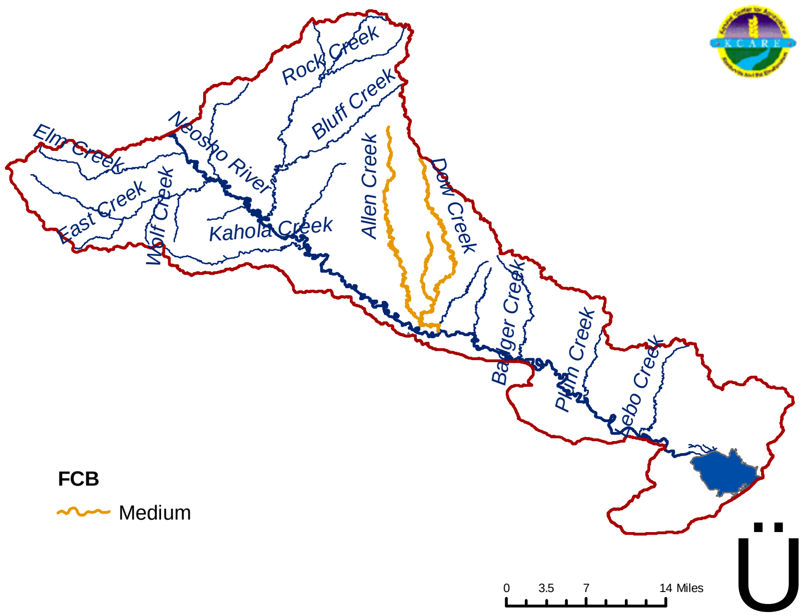


Figure 31. Fecal Coliform Bacteria TMDLs in the Watershed. [15] Kansas Department of Health and Environment.

In Kansas, animal feeding operations (AFOs) with greater than 300 animal units must register with KDHE. Confined animal feeding operations (CAFOs), those with more than 999 animal units, must be permitted with EPA. An animal unit or AU is an equal standard for all animals based on size and manure production. For example: 1 AU= 1,000 pounds of live animal weight (steer = 1 AU, dairy cow = 1.4 AU, swine = 0.4 AU). The watershed contains several CAFOs. (This data is derived from KDHE, 2003. It may be dated and subject to change). CAFOs are not allowed to release manure from the operation. However, they are allowed to spread manure on cropland fields for distribution. If this application is followed by a rainfall event or the manure is applied on frozen ground, it can run off into the stream. Smaller operations are not regulated by the state. Many of these operations are located along streams because of historic preferences by early settlers. Movement of feeding sites away from the streams and providing alternate watering sites is logistically important to prevention of FCB entering the stream. Grazing density is an important factor in manure runoff due to the common practice of cattle loafing in ponds and streams during the hot summer months and frequently defecating directly into the water source. Also, overgrazed pastures do not retain manure as well as moderately grazed pastures. This allows for runoff to a greater extent. Manure management is an key component in the WRAPS plan for addressing low dissolved oxygen concentrations and high concentrations of fecal coliform bacteria in Allen and Dows Creeks.

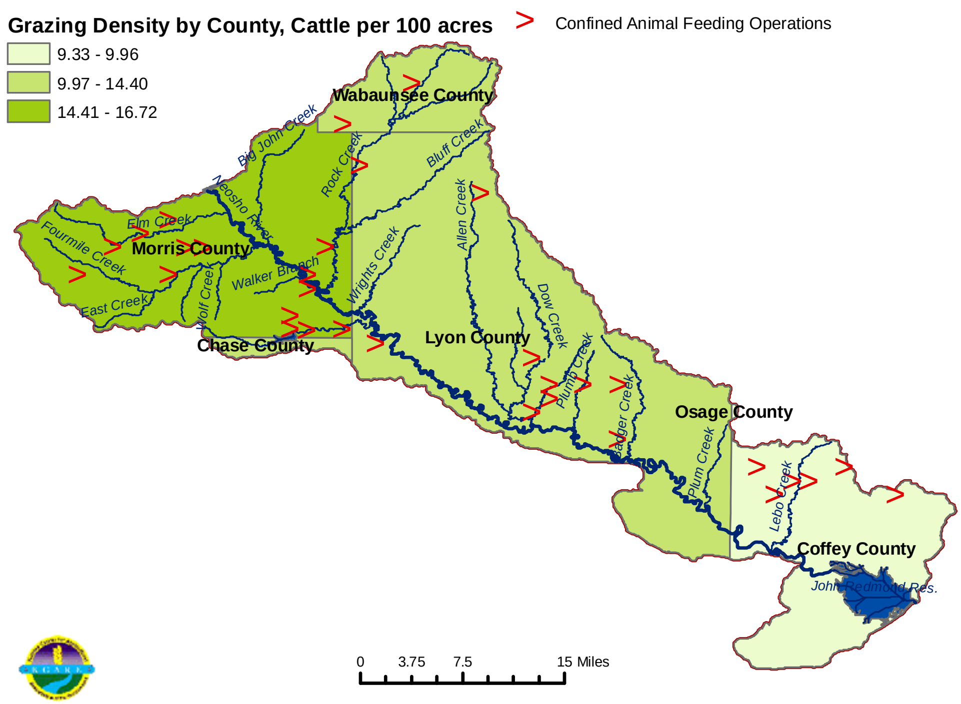


Figure 32. Confined Animal Feeding Operations and Grazing Density in the Watershed.[33]
CAFO data provided by Kansas Department of Health and Environment, 2003. Data may be dated and subject to change. Grazing density USDA National Agricultural Statistics Service, 2002.

5.2.1.B Land Use

Land use activities have a significant impact on the types and quantity of livestock related nonpoint source pollutants in the watershed. Agricultural activities and lack of maintenance of agricultural structures can have cumulative effects on land transformation. Manure runoff from grasslands close to waterways can add to FCB in the waterways. The primary land uses in the livestock targeted area of the watershed are grassland (72%) and cropland (19%).

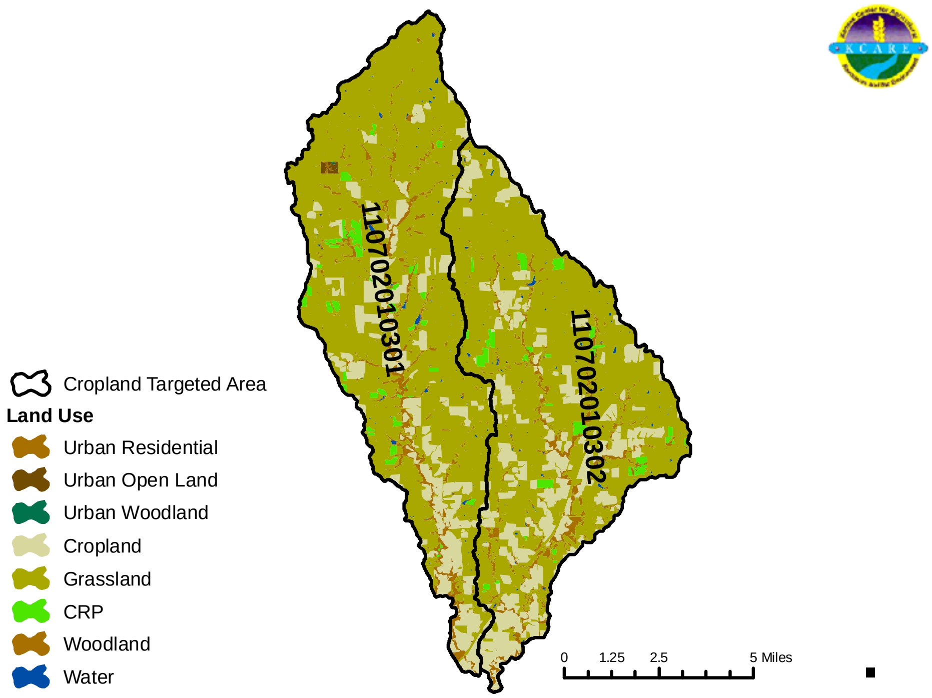


Figure 33. Land Cover of the Livestock Targeted Area of the Watershed, 2005. [34] *Kansas Applied Remote Sensing Program, Kansas Geospatial Community Commons*

Table 24. Land Use in the Livestock Targeted Area. *Calculated from Kansas Applied Remote Sensing Program, Kansas Geospatial Community Commons.*

Livestock Targeted Area		
Land Use	***Acres***	***Percentage***
Urban Residential	15	0.02
Urban Open Land	74	0.12
Urban Woodland	4	0.01
Cropland	11,583	19.16
Grassland	43,629	72.18
CRP	1,440	2.38
Woodland	3,416	5.65
Water	281	0.46
Total	60,442	100.00

5.2.1.C Population and Wastewater Systems

Failing, improperly installed or lack of an onsite wastewater system can contribute FCB to the watershed. There is no way of knowing how many failing or improperly constructed systems exist in the watershed. Thousands of onsite wastewater systems may exist in this watershed and the functional condition of these systems is generally unknown. However, best guess would be that ten percent of wastewater systems in the watershed are failing or insufficient. [35] Therefore, the exact number of systems is directly tied to population.

Table 25. Population in the Watershed by County.*[36] *US Census Bureau, 2008.

County	Population	Persons per square mile	Population Change (2000 to 2008), %
Coffey	8,409	14.1	-5.1
Lyon City of Emporia	35,562 26,188	42.2	-1.0 -2.3
Marion	12,100	14.2	-9.4
Wabaunsee	6,922	8.6	0.5
Total for Watershed without Emporia	**36,805**	**Average: 12.3**	**Average: -4.1**
Total for Watershed	**Total: 62,993**	**Average: 19.8**	**Average: -3.8**

Most of the watershed would be considered low population. The only major urban area is the city of Emporia. The Kansas average population density represented as persons per square mile is 32.9, whereas, the average for the watershed is 19.8. If the city of Emporia is excluded from the count, the average population density would be 12.3 persons per square mile.

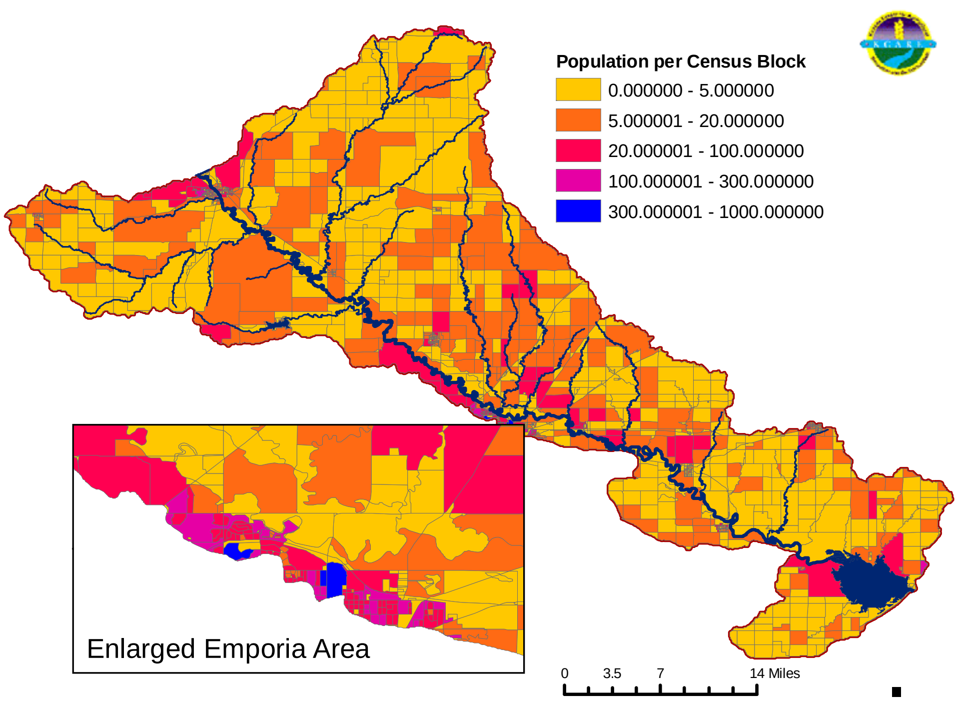


Figure 34. Census Count 2000.[37] *Data from US Census Bureau, 2000.*

5.2.1.D Rainfall and Runoff

Rainfall amounts and subsequent runoff along with flooding outside the stream channel can affect FCB concentrations in rivers and John Redmond Reservoir. Manure in streams can originate from livestock that are allowed access to wade or loaf directly in the stream. Manure from cropland can originate from fields where the manure that has been applied either before a rainfall event or on frozen ground. Manure and livestock management is important in preventing FCB or phosphorus runoff from the targeted area.

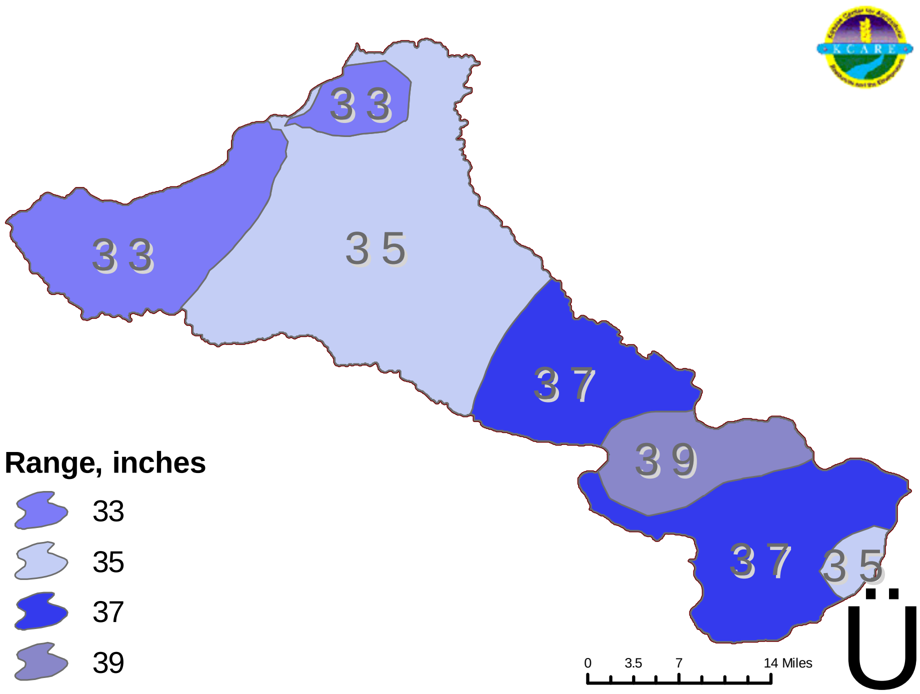


Figure 35. Average Yearly Precipitation in the Watershed. [38] *USDA/NRCS National Water and Climactic Center.*

5.2.2 Cropland Related Nutrient Pollutants

Allen and Dows Creeks have TMDLs for low dissolved oxygen. Targeting for phosphorus will be the watersheds of Allen and Dows Creeks; however, reduction of manure and phosphorus in these areas will have a positive effect on water quality downstream in the Neosho River and John Redmond Reservoir. The Neosho River is listed on the 303d list for total phosphorus and biology. John Redmond Reservoir has a TMDL for eutrophication.

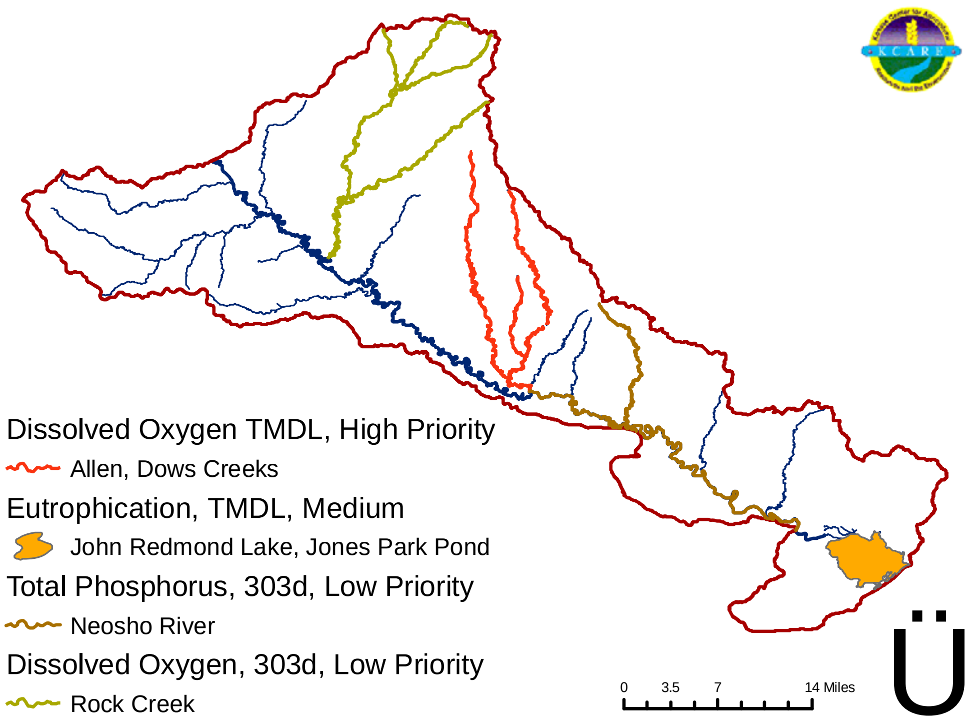


Figure 36. Nutrient Related TMDLs Included on the 303d list in the Watershed, 2008.[39]
Kansas Department of Health and Environment, 2008.

Eutrophication is a natural process that occurs when a water body receives excess nutrients. These excess nutrients, primarily nitrogen and phosphorus, create optimum conditions that are favorable for algal blooms and plant growth. John Redmond Reservoir and Jones Park Pond have TMDLs for eutrophication. Proliferation of algae and subsequent decomposition depletes available dissolved oxygen in the water profile. This lack of oxygen is devastating for aquatic species and can lead to fish kills. Allen Creek and Dows Creek have TMDLs for low dissolved oxygen. Desirable criteria for a healthy water profile include dissolved oxygen rates greater than 5 milligrams per liter and biological oxygen demand (BOD) less than 3.5 milligrams per liter. BOD is a measure of the amount of oxygen removed in water while stabilizing biodegradable organic matter. It can be used to indicate organic pollution levels. Excess nutrients can originate from failing septic systems, manure runoff and fertilizer runoff in rural and urban areas.

For more information concerning each, refer to the KDHE website, Watershed Management Section. http://www.kdheks.gov/tmdl/index.htm

An excess in nutrients can be caused by any land practice that will contribute to nitrogen or phosphorus in surface waters. Examples are (but not limited to):

- Fertilizer runoff from agricultural and urban lands,
- Manure runoff from domestic livestock and wildlife in close proximity to streams and rivers,
- Failing septic systems, and
- Phosphorus recycling from lake sediment.

Activities performed on the land affects nutrient loading in the lakes of the watershed. Land use in this watershed is primarily agricultural related; therefore, agricultural BMPs are necessary for reducing nitrogen and phosphorus. Some examples of nitrogen and phosphorus BMPs include:

- Soil sampling and appropriate fertilizer recommendations,
- Minimum and no-till farming practices,
- Filter and buffer strips installed along waterways,
- Reduce contact to streams from domestic livestock,
- Develop nutrient management plans for manure management, and
- Replace failing septic systems.

5.2.2.A Land Uses

Land use activities have a significant impact on the types and quantity of nutrient runoff in the watershed. Agricultural cropland in the watershed lies along and adjacent to the river and tributaries. If this cropland is under conventional tillage practices and/or lacks maintenance of agricultural BMP structures, there can be an increase in runoff which will carry nitrogen and phosphorus into streams and lakes. Cropland in the Neosho Headwaters Watershed consists of approximately twenty percent of the land use. Cropland in the watershed consists of mainly wheat, soybeans, corn and sorghum.

Figure 37. Cropland in the Watershed, 2005. [34] *Kansas Applied Remote Sensing Program, Kansas Geospatial Community Commons*

Figure 38. Farm Crops*.* Total farm crops in the counties of the watershed by percentage. 2007 Census of Agriculture, USDA NASS. [40]

5.2.2.B Confined Animal Feeding Operations

The watershed contains numerous CAFOs. (This data is derived from KDHE, 2003. It may be dated and subject to change). Number of and location of CAFOs is important in nutrient reduction because of the manure that is generated and must be disposed of by the CAFOs. Most farmers haul manure to cropland and incorporate it to be used as fertilizer for the crops. However, due to hauling costs, fields close to the feedlot tend to receive more manure over the course of time than fields that are at a more distant location. These close fields will have a higher concentration of soil phosphorus and therefore, a higher incidence of runoff potential as phosphorus can be attached to the soil particles. Prevention of erosion is a part of reduction of phosphorus in surface water. Refer to Section 5.2.1.A.

5.2.2.C Rainfall and Runoff

Rainfall amounts and subsequent runoff can affect nutrient runoff from agricultural areas. Manure runoff from livestock that are allowed access to stream or manure applied before a rainfall or on frozen ground is affected by the amount and timing of rainfall events. Manure management is a part of reduction of phosphorus in surface water. Refer to Section 5.2.1.D.

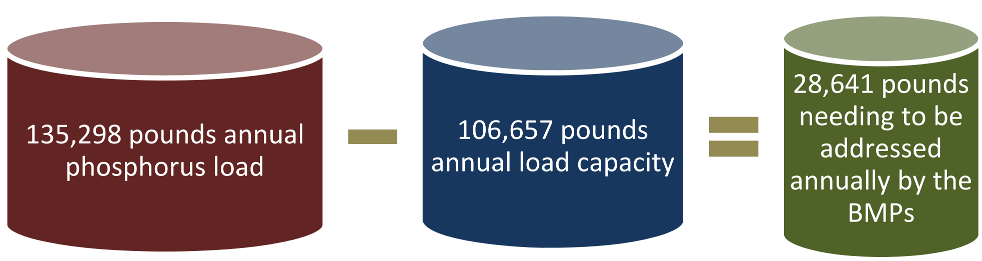
5.2.3 Streambank Related Phosphorus Pollutant

Stable streambanks are important to reduction in phosphorus in the waterways of the watershed. Soil that is lost from the streambanks can have attached phosphorus particles. This soil will then gradually release the phosphorus as it travels downstream.

The Neosho Headwaters Watershed has in progress (2010) stabilization of sections of the Neosho River funded through the ARRA. In addition to these major stabilization projects, all smaller streams and creeks need good riparian areas along their banks. This will prevent upstream erosion that also contributes to the sediment and phosphorus loading in the reservoir. All livestock related BMPs that the SLT has agreed upon will be beneficial to soil loss and ultimately also help reduce phosphorus concentrations in the reservoir.

5.2.4 Phosphorus BMPs with Projects Needed

The current estimated phosphorus load in the Neosho Headwaters Watershed is 286,408 pounds per year according to the TMDL section of KDHE. **The total load reduction allocated to Neosho Headwaters needed to meet the phosphorus TMDL is 28,641 pounds of phosphorus**.



The SLT has laid out specific BMPs that they have determined will be acceptable to watershed residents as listed below. **These BMPs will be implemented in the livestock, cropland and streambank targeted areas.** Specific acreages or projects that need to be implemented per year have been determined through modeling and economic analysis and approved by the SLT.

Table 26. BMPs and Number of Projects to be Installed as Determined by the SLT Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

<table>
<tr><th>Protection Measures</th><th>Best Management Practices and Other Actions</th><th colspan="3">Annual Projects Installed</th></tr>
<tr><td rowspan="5">1.0 Reduce nutrient contribution from livestock</td><td>1. Establish vegetative filter strips</td><td colspan="3">1 filter strip</td></tr>
<tr><td>2. Fence off streams to restrict access to waterways</td><td colspan="3">1 fenced off stream</td></tr>
<tr><td>3. Relocate Pasture Feeding Sites</td><td colspan="3">2 feeding sites</td></tr>
<tr><td>4. Promotion of Off Stream Watering Sites</td><td colspan="3">2 off-stream watering sites</td></tr>
<tr><td>5. Promotion of Rotational Grazing</td><td colspan="3">1 rotational grazing system every 2 years</td></tr>
<tr><td></td><td></td><td colspan="2">Cropland Groundtruthing Determined by Adoption Rates</td><td></td></tr>
<tr><td rowspan="5">2.0 Reduce nutrient contribution from cropland</td><td>2.1 Establish grassed waterways in crop fields</td><td>Current adoption rate = 17%</td><td>Adoption rate goal = 40%</td><td>1,654 acres</td></tr>
<tr><td>2.2 Encourage no-till cultivation practices</td><td>Current adoption rate = 14%</td><td>Adoption rate goal = 37%</td><td>3,309 acres</td></tr>
<tr><td>2.3 Establish buffers along crop fields</td><td>Current adoption rate = 2%</td><td>Adoption rate goal = 13%</td><td>1,654 acres</td></tr>
<tr><td>2.4 Installation of terraces</td><td>Current adoption rate = 34%</td><td>Adoption rate goal = 42%</td><td>1,654 acres</td></tr>
<tr><td>2.5 Encourage minimum till</td><td>Current adoption rate = 28%</td><td>Adoption rate goal = 74%</td><td>3,309 acres</td></tr>
<tr><td rowspan="3">3.0 Reduce nutrient contribution from streambank erosion</td><td>3.1 Tier One streambank restoration projects along the Neosho River</td><td colspan="3">13 sites</td></tr>
<tr><td>3.2 Tier Two streambank restoration projects along the Neosho River</td><td colspan="3">6 sites</td></tr>
<tr><td>3.3 Tier Three streambank restoration projects along the Neosho River</td><td colspan="3">12 sites</td></tr>
</table>

5.2.5 Phosphorus Load Reductions

The table below lists the livestock BMPs installed with the associated load reductions attained by implementing all of these livestock related BMPs.

Table 27. Estimated Phosphorus Load Reductions for Installed BMPs for Livestock Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

Annual Phosphorus Load Reductions (lbs)						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Load Reduction
1	638	90	153	153		1,034
2	1,276	180	306	306	45	2,112
3	1,914	270	459	459	45	3,146
4	2,552	360	611	611	90	4,224
5	3,189	450	764	764	90	5,258
6	3,827	540	917	917	135	6,337
7	4,465	630	1,070	1,070	135	7,370
8	5,103	720	1,223	1,223	180	8,449
9	5,741	810	1,376	1,376	180	9,483
10	6,379	900	1,529	1,529	225	10,561
11	7,017	990	1,682	1,682	225	11,595
12	7,655	1,080	1,834	1,834	270	12,673
13	8,292	1,170	1,987	1,987	270	13,707
14	8,930	1,260	2,140	2,140	315	14,786
15	9,568	1,350	2,293	2,293	315	15,819
16	10,206	1,440	2,446	2,446	360	16,898
17	10,844	1,530	2,599	2,599	360	17,932
18	11,482	1,620	2,752	2,752	405	19,010
19	12,120	1,710	2,905	2,905	405	20,044
20	12,758	1,800	3,057	3,057	450	21,122

The table below demonstrates the phosphorus reduction attained by implementing the cropland BMPs that were outlined in Section 5.1.

Table 28. Estimated Phosphorus Load Reductions for Implemented BMPs for Cropland Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

Annual Phosphorous Reduction (lbs), Cropland BMPs						
Year	Waterways	No-Till	Buffers	Terraces	Minimum Tillage	Total Load Reduction
1	85	170	42	64	106	467

Annual Phosphorous Reduction (lbs), Cropland BMPs, Cont.						
Year	Waterways	No-Till	Buffers	Terraces	Minimum Tillage	Total Load Reduction
2	170	339	85	127	212	934
3	255	509	127	191	318	1,400
4	339	679	170	255	424	1,867
5	424	849	212	318	530	2,334
6	509	1,018	255	382	637	2,801
7	594	1,188	297	446	743	3,267
8	679	1,358	339	509	849	3,734
9	764	1,528	382	573	955	4,201
10	849	1,697	424	637	1,061	4,668
11	934	1,867	467	700	1,167	5,135
12	1,018	2,037	509	764	1,273	5,601
13	1,103	2,207	552	827	1,379	6,068
14	1,188	2,376	594	891	1,485	6,535
15	1,273	2,546	637	955	1,591	7,002
16	1,358	2,716	679	1,018	1,697	7,468
17	1,443	2,886	721	1,082	1,803	7,935
18	1,528	3,055	764	1,146	1,910	8,402
19	1,612	3,225	806	1,209	2,016	8,869
20	1,697	3,395	849	1,273	2,122	9,335

The table below demonstrates the streambank load reductions attained by restoring the 31 stabilization sites along the Neosho River.

Table 29. Estimated Phosphorus Load Reductions for Implemented BMPs on Streambanks Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

Annual Phosphorus Reduction (pounds), Streambank Restoration	
Year	Streambank Reduction (pounds)
1	2,982
2	3,281
3	3,580
4	3,879
5	4,178
6	4,477
7	4,776
8	5,076
9	5,375
10	5,674

The table below shows the combined load reduction for phosphorus that is attained by implementing all livestock, cropland and streambank BMPs annually. The percent of TMDL achievement is illustrated in the right column. The timeframe for attaining the TMDL is sixteen years

Table 30. Combined Livestock, Cropland and Streambank Phosphorus Reductions Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

Combination of Cropland and Streambank* BMPs to Meet the Phosphorous TMDL					
Year	Streambank Reduction (lbs)	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of TMDL
1	2,982	467	1,034	4,483	16%
2	3,281	934	2,112	6,327	22%
3	3,580	1,400	3,146	8,127	28%
4	3,879	1,867	4,224	9,971	35%
5	4,178	2,334	5,258	11,770	41%
6	4,477	2,801	6,337	13,615	48%
7	4,776	3,267	7,370	15,414	54%
8	5,076	3,734	8,449	17,259	60%
9	5,375	4,201	9,483	19,058	67%
10	5,674	4,668	10,561	20,903	73%
11	5,674	5,135	11,595	22,403	78%
12	5,674	5,601	12,673	23,948	84%
13	5,674	6,068	13,707	25,449	89%
14	5,674	6,535	14,786	26,994	94%
15	5,674	7,002	15,819	28,495	99%
16	5,674	7,468	16,898	30,040	105%
17	5,674	7,935	17,932	31,540	110%
18	5,674	8,402	19,010	33,086	116%
19	5,674	8,869	20,044	34,586	121%
20	5,674	9,335	21,122	36,132	126%

* *Load reduction to meet phosphorus TMDL = 28,641 pounds*

Phosphorus reduction goal has been met.

Table 31. Phosphorus Load Reduction by Category Aimed at Meeting the Dissolved Oxygen TMDL in Dows and Allen Creeks and, Simultaneously, Having a Positive Effect on Meeting the Fecal Coliform Bacteria TMDL.

Best Management Practice Category	Total Load Reduction (pounds)	% of Phosphorous TMDL
Cropland	9,335	32.6%
Livestock	21,122	73.7%
Streambank	5,674	19.8%
Total	**36,131**	**126.1%**

Refer to Section 7, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

6.0 Information and Education in Support of BMPs

6.1 Information and Education Activities and Events

Table 32. Information and Education Activities and Events as Requested by the SLT in Support of Meeting the TMDLs.

BMP	Target Audience	Information/Education Activity/Event	Time Frame	Estimated Costs	Sponsor/Responsible Agency
Cropland BMP Implementation					
Riparian Buffers	**Landowners and Farmers**	Demonstration Projects	Annual – Spring	$5,000 per project	• Flint Hills RC&D, • Conservation Districts
		Tour/Field Day highlighting grassed buffers	Annual - Summer	$1,000 per tour	• Flint Hills RC&D, • Conservation Districts
		Tour/Field Day highlighting forestry-BMPs	Annual – Summer	$1,700 per tour	• Kansas Forest Service
		One-on-One Technical Assistance for Landowners	Annual - Ongoing	No cost	• NRCS Conservation Technician
No-Till	**Farmers and Rental Operators**	Scholarships for 5 farmers to attend No-Till Winter Conference	Annual – Winter	$750 ($150 per person)	• No-till on the Plains
		Tour/Field Day	Annual – Summer	$1,500	• No-till on the Plains
		One on One Technical Assistance for Farmers	Annual - Ongoing	$5,000 per year	• No-till on the Plains
		Seasonal Informational Meetings (planting)	Annual – spring (plant) summer (harvest)	$5,500 ($2,750/meeting)	• No-till on the Plains
Terraces	**Farmers**	Tour/Field Day	Annual – Summer	$1,500 per tour	• Conservation Districts
Grassed Waterways					

Continued on next page.

Information and Education Activities, Cont.					
BMP	Target Audience	Information/Education Activity/Event	Time Frame	Estimated Costs	Sponsor/Responsible Agency
Livestock BMP Implementation					
Vegetative Filter Strips	**Landowners and Ranchers**	Demonstration Projects	Annual – Spring	Combined with riparian buffer demonstrations	• Flint Hills RC&D, • Conservation Districts
		Tour/Field Day	Annual - Summer	Combined with riparian buffer tour	• Flint Hills RC&D, • Conservation Districts
		One-on-One Technical Assistance for Landowners	Annual - Ongoing	No cost	• NRCS Conservation Technician
Fenced Off Streams	**Landowners and Ranchers**	Demonstration Projects	Annual - Summer	$2,000 per project	• Kansas Rural Center
		Tour/Field Day	Annual - Summer	$2,000 per tour	• Kansas Rural Center
Relocate Pasture Feeding Sites	**Ranchers**	Demonstration Project	Annual – Spring	$5,000 per project	• Kansas Rural Center
		Tour/Field Day	Annual - Summer	$500 per tour	• Kansas Rural Center
		Informational Meeting/ Workshop	Annual - Fall	$500 per meeting	• Kansas Rural Center
Off Stream Watering System	**Ranchers**	Demonstration projects for pond construction and spring developments	Annual - Fall	$10,000 per project	• Kansas Rural Center
		Tour/Field Day	Annual - Summer	$500 per tour	• Kansas Rural Center
		Informational Meeting/ Workshop	Annual - Fall	Combine with relocating pasture feeding sites meeting	• Kansas Rural Center
Rotational Grazing	**Ranchers**	Tour/Field Day	Annual – Spring	$500 per tour	• Kansas Rural Center

Continued on next page.

Information and Education Activities, Cont.					
BMP	Target Audience	Information/Education Activity/Event	Time Frame	Estimated Costs	Sponsor/Responsible Agency
Streambank BMP Implementation					
Streambank Stabilization	**Landowners**	One-on-One Technical Assistance for Landowners	Annual – Ongoing	Varies by project	• Consulting firms/agencies providing engineering/design services (TBD)
		Tour highlighting completed stabilization projects	Annual - Summer	$2,000 per tour	• Kansas Alliance for Wetlands and Streams

Continued on next page.

Information and Education Activities, Cont.					
BMP	Target Audience	Information/Education Activity/Event	Time Frame	Estimated Costs	Sponsor/Responsible Agency
General / Watershed Wide Information and Education					
Education Activities Targeting Youth	**Students and Educators**	Day on the Farm	Annual – Spring	$500 per event	• County Farm Bureaus • Kansas FFA Organization
		Poster, essay, speech contests promoting WQ	Annual – Spring	$200	• Conservation Districts
		Envirothon	Annual - Spring	$250	• Conservation Districts
		Curriculum workshopfor K-12 educators	Annual - Summer	$2,000 per workshop	• KACEE
		Environmental education	Ongoing	$5,000 per year	• Project EARTH
		Service learning project	Ongoing	$5,000 per year	• Water Link
Education Activities Targeting Adults	**Farmers and Landowners**	River Friendly Farms assessment Info meetings	Annual - Ongoing	$150 per meeting	• Kansas Rural Center
	Watershed Residents	Newspaper/newsletter articles	Annual – Ongoing	No cost	• Conservation Districts, • Kansas State Research and Extension
		Presentation about water quality issues & WRAPS update at annual meetings	Annual – Winter	No cost	• Conservation Districts, • Kansas State Research and Extension • Flint Hills RC&D
		Educational campaign about leaking/failing septic systems	Ongoing	$1,500 per year	• Local Environmental Protection Programs
		Healthy Ecosystems – Healthy Communities	Ongoing	$15,000 per year	• Kansas PRIDE Program
Total Cost per Year for All Information and Education Activities				**$74,550**	

6.2 Evaluation of Information and Education Activities

All service providers conducting Information and Education (I&E) activities funded through the Neosho Headwaters WRAPS will be required to include an evaluation component in their project proposals and Project Implementation Plans. The evaluation methods will vary based on the activity.

At a minimum, all I&E projects must include participant learning objectives as the basis for the overall evaluation. Depending on the scope of the project, development of a basic logic model identifying long-term, medium-term, and short-term behavior changes or other outcomes that are expected to result from the I&E activity may be required.

Specific evaluation tools or methods may include (but are not limited to):

- Feedback forms allowing participants to provide rankings of the content, presenters, useful of information, etc.
- Pre and post surveys to determine amount of knowledge gained, anticipated behavior changes, need for further learning, etc.
- Follow up interviews (one-on-one contacts, phone calls, e-mails) with selected participants to gather more in-depth input regarding the effectiveness of the I&E activity.

All service providers will be required to submit a brief written evaluation of their I&E activity, summarizing how successful the activity was in achieving the learning objectives, and how the activity contributed to achieving the long-term WRAPS goals and/or objectives for pollutant load reductions.

7.0 Costs of Implementing BMPs and Possible Funding Sources

The SLT has reviewed all the recommended BMPs listed in the Section 5 of this report for each individual impairment. It has been determined by the SLT that specific BMPs will be the target of implementation funding for each category (cropland, livestock and streambank). Most of the BMPs that are targeted will be advantageous to more than one impairment, thus being more efficient.

Summarized Derivation of Cropland BMP Cost Estimates

Grassed Waterway: $2,200 per acre was arrived at using average cost of installation figures from the conservation districts within the watershed and updated costs of brome grass seeding from Josh Roe.

No-Till: After being presented with information from K-State Research and Extension (Craig Smith and Josh Roe) on the costs and benefits of no-till, the SLT decided that a fair price to entice a producer to adopt no-till would be to pay them $10 per acre for 10 years, or a net present value of $77.69 per acre upfront assuming the NRCS discount rate of 4.75%.

Vegetative Buffer Strips: The cost of $1,000 per acre was arrived at using average cost of installation figures from the conservation districts within the watershed and cost estimates from the KSU Vegetative Buffer Tool developed by Craig Smith.

Terraces: In consulting with numerous conservation districts it was determined by Josh Roe that the average cost of building a terrace at this point in time is $1.25 per foot.

Minimum Tillage: This BMP is an off shoot of no-till, this allows producers some tillage within a continuous no-till system, the amount of tillage will be further defined by the SLT, there is no NRCS cost-share for this practice, the SLT decided producers should be reimbursed at half the rate of no-till or $5 per acre for 10 years, or a net present value of $38.85 per acre upfront assuming the NRCS discount rate of 4.75%

Summarized Derivation of Livestock BMP Cost Estimates
Vegetative Filter Strip: The cost of $714 an acre was calculated by Josh Roe and Mike Christian figuring the average filter strip in the watershed will require four hours of bulldozer work at $125 an hour plus the cost of seeding one acre in permanent vegetation estimated by Josh Roe.

Fence Off Streams: The average cost of ½ mile of fence at $4,106 was determined by current fencing and labor prices, assuming the fence has a 20 year life, and taking the net present value of future repairs at the NRCS discount rate of 4.75%.

Relocated Pasture Feeding Site: The cost of moving a pasture feeding site of $2,203 was calculated by Josh Roe figuring the cost of building ¼ mile of fence, a permeable surface, and labor.

Off-Stream Watering System: The average cost of installing an alternative watering system of $3,500 was estimated by Herschel George, Marais des Cygnes Watershed Specialist, who has installed numerous systems and has detailed average cost estimates.

Rotational Grazing: The average cost of implementing a rotational grazing system for $7,000 was estimated by Herschel George, Marais des Cygnes Watershed Specialist who has installed numerous systems and has detailed average cost estimates. More complex systems that require significant cross fencing and buried water lines will come with a much higher price.

7.1 Costs of Implementing BMPs and Information and Education

Table 33. Estimated Costs and Net Costs for Cropland Implemented BMPs in the SWAT Targeted Area. Individual sub watershed costs are provided in the Appendix. *Expressed in 2009 dollar amounts.*

Annual Cost, Cropland BMPs						
Year	Waterways	No-Till	Buffers	Terraces	Minimum Till	Total
1	$13,234	$25,705	$11,029	$16,874	$12,852	$79,694
2	$13,631	$26,476	$11,360	$17,380	$13,238	$82,085
3	$14,040	$27,270	$11,700	$17,901	$13,635	$84,547
4	$14,462	$28,088	$12,051	$18,439	$14,044	$87,083
5	$14,895	$28,931	$12,413	$18,992	$14,465	$89,696
6	$15,342	$29,799	$12,785	$19,561	$14,899	$92,387
7	$15,803	$30,693	$13,169	$20,148	$15,346	$95,158
8	$16,277	$31,613	$13,564	$20,753	$15,807	$98,013
9	$16,765	$32,562	$13,971	$21,375	$16,281	$100,954
10	$17,268	$33,539	$14,390	$22,017	$16,769	$103,982

Annual Cost, Cropland BMPs, Cont.						
Year	Waterways	No-Till	Buffers	Terraces	Minimum Till	Total
11	$17,786	$34,545	$14,822	$22,677	$17,272	$107,102
12	$18,320	$35,581	$15,266	$23,357	$17,791	$110,315
13	$18,869	$36,648	$15,724	$24,058	$18,324	$113,624
14	$19,435	$37,748	$16,196	$24,780	$18,874	$117,033
15	$20,018	$38,880	$16,682	$25,523	$19,440	$120,544
16	$20,619	$40,047	$17,182	$26,289	$20,023	$124,160
17	$21,237	$41,248	$17,698	$27,078	$20,624	$127,885
18	$21,874	$42,486	$18,229	$27,890	$21,243	$131,722
19	$22,531	$43,760	$18,776	$28,727	$21,880	$135,673
20	$23,207	$45,073	$19,339	$29,588	$22,537	$139,743
3% Annual Cost Inflation						

Annual Cost After Cost-Share, Cropland BMPs						
Year	Waterways	No-Till	Buffers	Terraces	Minimum Till	Total
1	$6,617	$15,680	$1,103	$8,437	$12,852	$44,689
2	$6,816	$16,150	$1,136	$8,690	$13,238	$46,030
3	$7,020	$16,635	$1,170	$8,951	$13,635	$47,411
4	$7,231	$17,134	$1,205	$9,219	$14,044	$48,833
5	$7,448	$17,648	$1,241	$9,496	$14,465	$50,298
6	$7,671	$18,177	$1,279	$9,781	$14,899	$51,807
7	$7,901	$18,722	$1,317	$10,074	$15,346	$53,361
8	$8,138	$19,284	$1,356	$10,376	$15,807	$54,962
9	$8,382	$19,863	$1,397	$10,688	$16,281	$56,611
10	$8,634	$20,459	$1,439	$11,008	$16,769	$58,309
11	$8,893	$21,072	$1,482	$11,339	$17,272	$60,058
12	$9,160	$21,704	$1,527	$11,679	$17,791	$61,860
13	$9,435	$22,356	$1,572	$12,029	$18,324	$63,716
14	$9,718	$23,026	$1,620	$12,390	$18,874	$65,627
15	$10,009	$23,717	$1,668	$12,762	$19,440	$67,596
16	$10,309	$24,429	$1,718	$13,144	$20,023	$69,624
17	$10,619	$25,161	$1,770	$13,539	$20,624	$71,713
18	$10,937	$25,916	$1,823	$13,945	$21,243	$73,864
19	$11,265	$26,694	$1,878	$14,363	$21,880	$76,080
20	$11,603	$27,495	$1,934	$14,794	$22,537	$78,362
3% Annual Cost Inflation						

Table 34. Estimated Annual Costs in the Livestock Targeted Area. Sub watershed costs are provided in the Appendix. *Expressed in 2009 dollar amounts.*

Annual Cost of Implementing Livestock BMPs						
Year	**Vegetative Filter Strip**	**Fenced Off Streams**	**Relocate Pasture Feeding Site**	**Off Stream Watering System**	**Rotational Grazing**	**Annual Cost**
1	$357	$2,053	$2,203	$3,795		**$8,408**
2	$368	$2,115	$2,269	$3,909	$3,605	**$12,265**
3	$379	$2,178	$2,337	$4,026		**$8,920**
4	$390	$2,243	$2,407	$4,147	$3,825	**$13,012**
5	$402	$2,311	$2,479	$4,271		**$9,463**
6	$414	$2,380	$2,554	$4,399	$4,057	**$13,805**
7	$426	$2,451	$2,630	$4,531		**$10,040**
8	$439	$2,525	$2,709	$4,667	$4,305	**$14,645**
9	$452	$2,601	$2,791	$4,807		**$10,651**
10	$466	$2,679	$2,874	$4,952	$4,567	**$15,537**
11	$480	$2,759	$2,961	$5,100		**$11,300**
12	$494	$2,842	$3,049	$5,253	$4,845	**$16,483**
13	$509	$2,927	$3,141	$5,411		**$11,988**
14	$524	$3,015	$3,235	$5,573	$5,140	**$17,487**
15	$540	$3,105	$3,332	$5,740		**$12,718**
16	$556	$3,199	$3,432	$5,912	$5,453	**$18,552**
17	$573	$3,294	$3,535	$6,090		**$13,492**
18	$590	$3,393	$3,641	$6,273	$5,785	**$19,682**
19	$608	$3,495	$3,750	$6,461		**$14,314**
20	$626	$3,600	$3,863	$6,655	$6,137	**$20,881**
3% Annual Cost Inflation						

Table 35. Estimated Streambank Stabilization Costs and Net Costs for Implemented Projects. *Not inclusive of ARRA Streambank Project costs.*

Annual Streambank Stabilization Costs	
Year	**Cost**
1	$92,157
2	$94,922
3	$97,769
4	$100,702
5	$103,724
6	$106,835
7	$110,040
8	$113,341
9	$116,742
10	$120,244

Table 36. ARRA Streambank Project Costs.

Annual Streambank Stabilization Costs	
Priority Area	**Cost**
1	$681,683
2	$472,508
3	$356,901
Average Cost per Linear Foot	***$41.66***

Table 37. Technical Assistance Needed to Implement BMPs.

<table>
<tr><th colspan="2" rowspan="2">BMP</th><th colspan="2">Personnel Needed to Implement BMP</th></tr>
<tr><th>Technical Assistance</th><th>Projected Annual Cost</th></tr>
<tr><td rowspan="5">Cropland</td><td>1. Waterways</td><td>SCC Buffer Technician
KRC River Friendly Farms Technician
Watershed Specialist</td><td rowspan="11">NRCS District Conservationist
No Charge

Conservation District Soil Technician
No Charge

SCC Buffer Technician
No Charge

WRAPS Coordinator
$25,000

Watershed Specialist
$11,500

KRC River Friendly Farms Technician
$20,000

Kansas State Forester
No Charge</td></tr>
<tr><td>2. No-till</td><td>WRAPS Coordinator
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>3. Buffers</td><td>SCC Buffer Technician
WRAPS Coordinator
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>4. Terraces</td><td>SCC Buffer Technician
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>5. Minimum till</td><td>SCC Buffer Technician
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td rowspan="5">Livestock</td><td>1. Vegetative filter strips</td><td>SCC Buffer Technician
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>2. Fence off streams</td><td>KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>3. Relocate pasture feeding sites</td><td>KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>4. Establish off stream watering systems</td><td>KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>5. Rotational grazing</td><td>KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td>Streambank</td><td>1. Stabilization</td><td>SCC Buffer Technician
WRAPS Coordinator
KRC River Friendly Farms Technician
Watershed Specialist</td></tr>
<tr><td colspan="2">Total</td><td></td><td>$56,500</td></tr>
</table>

Table 38. Total Costs for BMPs if All are Implemented in the Watershed in Support of Attaining TMDLs. Annual 3% inflation rate.

Annual Cost of Cropland, Livestock, Streambank BMPs, I&E, and Technical Assistance adjusted for Cost Share						
	BMPs Implemented			I&E and Technical Assistance		
Year	Cropland	Livestock	Streambank	I&E	Technical Assistance	Total
1	$44,689	$8,408	$92,157	$74,550	$56,500	$276,304
2	$46,030	$12,265	$94,922	$76,787	$58,195	$288,199
3	$47,411	$8,920	$97,769	$79,090	$59,941	$293,131
4	$48,833	$13,012	$100,702	$81,463	$61,739	$305,749
5	$50,298	$9,463	$103,724	$83,907	$63,591	$310,983
6	$51,807	$13,805	$106,835	$86,424	$65,499	$324,370
7	$53,361	$10,040	$110,040	$89,017	$67,464	$329,922
8	$54,962	$14,645	$113,341	$91,687	$69,488	$344,123
9	$56,611	$10,651	$116,742	$94,438	$71,573	$350,015
10	$58,309	$15,537	$120,244	$97,271	$73,720	$365,081
11	$60,058	$11,300	$120,244	$100,189	$75,932	$367,723
12	$61,860	$16,483	$120,244	$103,195	$78,210	$379,992
13	$63,716	$11,988	$120,244	$106,291	$80,556	$382,795
14	$65,627	$17,487	$120,244	$109,479	$82,973	$395,810
15	$67,596	$12,718	$120,244	$112,764	$85,462	$398,784
16	$69,624	$18,552	$120,244	$116,147	$88,026	$412,593
17	$71,713	$13,492	$120,244	$119,631	$90,666	$415,746
18	$73,864	$19,682	$120,244	$123,220	$93,386	$430,396
19	$76,080	$14,314	$120,244	$126,917	$96,188	$433,743
20	$78,362	$20,881	$120,244	$130,724	$99,074	$449,285

7.2 Potential Funding Sources

Table 39. Potential BMP funding sources.

Potential Funding Sources	Potential Funding Programs
Natural Resources Conservation Service	Environmental Quality Incentives Program (EQIP) Wetland Reserve Program (WRP) Conservation Reserve Program (CRP) Wildlife Habitat Incentive Program (WHIP) Forestland Enhancement Program (FLEP) State Acres for Wildlife Enhancement (SAFE) Grassland Reserve Program (GRP) Farmable Wetlands Program (FWP)

Potential BMP Funding Sources, Cont.	
Potential Funding Sources	**Potential Funding Programs**
EPA/KDHE	319 Funding Grants KDHE WRAPS Funding Clean Water Neighbor Grants
Kansas Alliance for Wetlands and Streams	
State Conservation Commission	State Cost Share
Conservation Districts	
No-Till on the Plains	
Kansas Forest Service	
US Fish and Wildlife	
National Wild Turkey Federation	
Quail Unlimited	
Ducks Unlimited	

Table 40. Service Providers for BMP implementation. *

BMP		Services Needed to Implement BMP		Service Provider **
		Technical Assistance	***Information and Education***	
Cropland	1. Waterways	Design, cost share and maintenance	BMP workshops, tours, field days	NRCS KRC SCC No-Till on the Plains KSRE CD RC&D KDWP
	2. No-till	Design, cost share and maintenance	BMP workshops, tours, field days	
	3. Buffers	Development of management plan	BMP workshops	
	4. Terraces	Design, cost share and maintenance	BMP workshops, field days, tours	
	5. Minimum till	Design, cost share and maintenance	BMP workshops, field days, tours	
Livestock	1. Vegetative filter strips	Design, cost share and maintenance	BMP workshops, field days, tours	KSRE NRCS SCC KRC CD RC&D KDWP
	2. Fence off streams	Design, cost share and maintenance	BMP workshops, field days, tours	
	3. Relocate pasture feeding sites	Design, cost share and maintenance	BMP workshops, field days, tours	
	4. Establish off stream watering systems	Design, cost share and maintenance	BMP workshops, field days, tours	
	5. Rotational grazing	Design, cost share and maintenance	BMP workshops, field days, tours	

Service Providers for BMP Implementation, Cont.				
BMP		**Services Needed to Implement BMP**		**Service Provider ****
		Technical Assistance	***Information and Education***	
Streambank	Streambank restoration	Design, cost share and maintenance	BMP workshops, field days, tours	KAWS NRCS KFS KSRE CD RC&D
***** See Appendix for service provider directory***				

** All service providers are responsible for evaluation of the installed or implemented BMPs and/or other services provided and will report to SLT for completion approval.*

8.0 Timeframe

The plan will be reviewed every five years starting in 2015. In 2013, the SLT will request a review of data by KDHE for the Neosho Basin. It is this year that the TMDLs will officially be reviewed for additions or revisions. The timeframe of this document for BMP implementation to meet both sediment and phosphorus TMDLs would be twenty years from the date of publication of this report. Sediment and phosphorus reductions in the water column will not be noticeable by the year 2015 due to a lag time from implementation of BMPs and resulting improvements in water quality. Therefore, the SLT will review sediment and phosphorus concentrations in year 2020. They will examine BMP placement and implementation in 2015 and every subsequent five years after.

Table 41. Review Schedule for Pollutants and BMPs.

Review Year	Sediment	Phosphorus	BMP Placement
2015			X
2020	X	X	X
2025			X
2030	X	X	X

The interim timeframe for all BMP implementation would be ten years from the date of publication of this report. Targeting and BMP implementation might shift over time in order to achieve TMDLs.

- Timeframe for reaching the **sediment TMDL** will be attained the first year of implementation of the ARRA Neosho River streambank stabilization projects. After the sediment TMDL is achieved, the process will become one of protection instead of restoration.
- The WRAPS estimate timeframe for the **phosphorus TMDL** will be sixteen years. At this time, if all BMPs have been implemented, the TMDL should be met.

9.0 Measureable Milestones

9.1 Adoption Rates for BMP Implementation

Milestones will be determined by number of acres treated, projects installed, contacts made to residents of the watershed and water quality parameters at the end of every five years. The SLT will examine these criteria to determine if adequate progress has been made from the current BMP implementations. If they determine that adequate progress has not been made, they will readjust the implementation projects in order to achieve the TMDL by the end of twenty years.

Table 42. Short, Medium and Long Term Goals for BMP Cropland Adoption Rate. Sub watershed adoption rates are provided in the Appendix.

		Acres of Cropland BMPs Adopted Each Year					
	Year	**Waterway**	**No-Till**	**Buffers**	**Terraces**	**Minimum Till**	**Total Treated Acreage**
Short Term	1	165	331	165	165	331	1,158
	2	165	331	165	165	331	1,158
	3	165	331	165	165	331	1,158
Total		*496*	*993*	*496*	*496*	*993*	*3,474*
Medium Term	4	165	331	165	165	331	1,158
	5	165	331	165	165	331	1,158
	6	165	331	165	165	331	1,158
Total		*993*	*1,985*	*993*	*993*	*1,985*	*6,948*
Long Term	7	165	331	165	165	331	1,158
	8	165	331	165	165	331	1,158
	9	165	331	165	165	331	1,158
	10	165	331	165	165	331	1,158
	11	165	331	165	165	331	1,158
	12	165	331	165	165	331	1,158
	13	165	331	165	165	331	1,158
	14	165	331	165	165	331	1,158
	15	165	331	165	165	331	1,158
	16	165	331	165	165	331	1,158
	17	165	331	165	165	331	1,158
	18	165	331	165	165	331	1,158
	19	165	331	165	165	331	1,158
	20	165	331	165	165	331	1,158
Total		*3,309*	*6,617*	*3,309*	*3,309*	*6,617*	*23,160*

Table 43. Short, Medium and Long Term Goals for BMP Livestock Adoption Rate.

Livestock BMPs Adopted Each Year						
	Year	**Vegetative Filter Strip**	**Fenced Off Streams**	**Relocate Pasture Feeding Site**	**Off Stream Watering System**	**Rotational Grazing**
Short Term	1	1	1	2	2	
	2	1	1	2	2	1
	3	1	1	2	2	
Total		*3*	*3*	*6*	*6*	*1*
Medium Term	4	1	1	2	2	1
	5	1	1	2	2	
	6	1	1	2	2	1
Total		*6*	*6*	*12*	*12*	*3*

Livestock BMPs Adopted Each Year, Cont.						
	Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing
Long Term	7	1	1	2	2	
	8	1	1	2	2	1
	9	1	1	2	2	
	10	1	1	2	2	1
	11	1	1	2	2	
	12	1	1	2	2	1
	13	1	1	2	2	
	14	1	1	2	2	1
	15	1	1	2	2	
	16	1	1	2	2	1
	17	1	1	2	2	
	18	1	1	2	2	1
	19	1	1	2	2	
	20	1	1	2	2	1
Total		*20*	*20*	*40*	*40*	*10*

Table 44. Short, Medium and Long Term Goals for Information and Education Adoption Rates.

	Year	Demo Projects	Informational Meetings/ Workshops	Tours and Field Days	Presentations	Newsletter Inserts	One on One Meetings	Conference Attendees	Educational Events	Media Campaign	Contacts made by Tech Assistance
Short Term	1	4	4	9	1	1	4	5	5	3	250
	2	4	4	9	1	1	4	5	5	3	250
	3	4	4	9	1	1	4	5	5	3	250
	Total	*12*	*12*	*27*	*3*	*3*	*12*	*15*	*15*	*9*	*750*
Medium Term	4	4	4	9	1	1	4	5	5	3	250
	5	4	4	9	1	1	4	5	5	3	250
	6	4	4	9	1	1	4	5	5	3	250
	Total	*24*	*24*	*54*	*6*	*6*	*24*	*30*	*30*	*18*	*1,500*

Short, Medium and Long Term Goals for Information and Education, Cont.											
	Year	Demo Projects	Informational Meetings/ Workshops	Tours and Field Days	Presentations	Newsletter Inserts	One on One Meetings	Conference Attendees	Educational Events	Media Campaign	Contacts made by Tech Assistance
Long Term	7	4	4	9	1	1	4	5	5	3	250
	8	4	4	9	1	1	4	5	5	3	250
	9	4	4	9	1	1	4	5	5	3	250
	10	4	4	9	1	1	4	5	5	3	250
	11	4	4	9	1	1	4	5	5	3	250
	12	4	4	9	1	1	4	5	5	3	250
	13	4	4	9	1	1	4	5	5	3	250
	14	4	4	9	1	1	4	5	5	3	250
	15	4	4	9	1	1	4	5	5	3	250
	16	4	4	9	1	1	4	5	5	3	250
	17	4	4	9	1	1	4	5	5	3	250
	18	4	4	9	1	1	4	5	5	3	250
	19	4	4	9	1	1	4	5	5	3	250
	20	4	4	9	1	1	4	5	5	3	250
	Total	*80*	*80*	*180*	*20*	*20*	*80*	*100*	*100*	*60*	*5,000*

9.2 Benchmarks to Measure Water Quality and Social Progress

Over a twenty year time frame, this WRAPS project hopes to improve water quality throughout the watershed and in John Redmond Reservoir. Measurements taken at John Redmond Reservoir are important because it is the drainage endpoint of the watershed. Any water quality improvements will be observed by conducting tests in the reservoir. Social indicators will also be examined by tracking traffic in John Redmond Reservoir Park. An example of a healthy lake ecosystem is frequent visits by the public to enjoy the outdoor recreation of the reservoir and park. After reviewing the criteria listed in the table below, the SLT will assess and revise the overall strategy plan for the watershed. New goals will be set and new BMPs will be implemented in order to achieve improved water quality. Coordination with KDHE TMDL staff, Water Plan staff and the SLT will be held every five years to discuss benchmarks and TMDL update plans. Using data obtained by KDHE, KSU or the Tulsa District, US Army

Corps of Engineers, the following indicator and parameter criteria shall be used to assess progress in successful implementation to abate pollutant loads.

Table 45. Benchmarks to Measure Water Quality Progress.

Impairment Addressed	Criteria to Measure Water Quality Progress	Information Source
Sediment	Number of acres of buffers and grassed waterways installed indicating that there would be a reduction in sediment into John Redmond Reservoir	NRCS
	Secchi Disc depth in John Redmond Reservoir > 0.5 meters	KDHE
	Target storage in John Redmond Reservoir 65,000 acre feet in 2014	COE
	Fewer high event stream flow rates entering John Redmond Reservoir indicating better retention and slower release of storm water in the upper end of the watershed	USGS
Nutrients	No algal blooms are reported as the reservoir clarity improves	KDHE
	Summer Chlorophyll a concentrations in John Redmond Reservoir < 12 ug/l	KDHE
	Total Nitrogen concentration in John Redmond Reservoir < 0.62 mg.L	KDHE
	Total Nitrogen in stream average < 0.8 mg/L	KDHE
	BOD concentrations < 3.2 mg/l in the stream under critical flow conditions	KDHE
	No BOD concentration excursions < 5mg/l	KDHE
	Chlorophyll concentrations in Jones Park Pond </= 12 ug/L	KDHE
Fecal Coliform Bacteria	Number of livestock that have been relocated from close proximity to a stream indicating that there would be a reduction in fecal coliform bacteria into John Redmond Reservoir	Watershed Specialist
	Maintain Secondary Contact Recreation criteria of “not to exceed” 2,000 colonies per 100 ml water	KDHE

Impairment Addressed	Social Indicators to Measure Water Quality Progress	Information Source
Sediment Nutrients Fecal coliform bacteria	Visitor traffic to John Redmond Reservoir	KDWP
	Boating traffic in John Redmond Reservoir	KDWP
	Trends of quantity and quality of fishing in John Redmond Reservoir	KDWP
	Economic indicators indicating effect of John Redmond Reservoir’s impact on local businesses	Coffey County Economic Development
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception	KSRE
	Number of attendees at workshops and field days	KSRE
	BMP adoptability rates	NRCS

9.3 Milestones Used to Determine Water Quality Improvements

9.3.1 Phosphorus and Sediment Milestones in 2015

At the end of five years, the SLT will be able to examine water quality data for phosphorus (eutrophication determination) and suspended solids (sediment determination) to determine if progress has been made in improving water quality. It is estimated that it will require five years to see progress after BMP implementation on phosphorus and sediment reduction in the waterways. KDHE has outlined water quality milestones for total phosphorus and total suspended solids. These goals are presented below.

Table 46. Water Quality Goals for Phosphorus and Sediment

	Current Condition (2000-2009) Median TP	Improved Condition (2010-2014) Median TP	Reduction Needed	Current Condition (2000-2009) 90% TSS	Improved Condition (2010-2014) 90% TSS	Reduction Needed
Sampling Sites	**Total Phosphorus (median of data collected during indicated period), ppb**			**Total Suspended Solids (median of data collected during indicated period), ppm**		
Neosho River near Americus	125	100	**20%**	66	30	**55%**
Neosho River below Emporia	157	127	**19%**	200	64	**68%**

9.3.2 BMP Implementation Milestones from 2010 to 2020

The SLT will review the number of acres, projects or contacts made in the watershed at the end of three, six and twenty years (2030). At the end of each period, the SLT will have the option to reassess the goals and alter BMP implementations as they determine is best. Below is the outline of BMP implementations over a ten year period.

Table 47. BMP Implementation Milestones from 2010 to 2020

Cumulative Total												
	Cropland						***Livestock***				***Information and Education***	
Year	**Water- ways,** acres	**No-Till,** acres	**Buffers,** acres	**Terraces,** acres	**Minimum Till,** acres	**Vegetative Filter Strip,** acres	**Fenced Off Streams,** number	**Relocate Pasture Feeding Site,** number	**Off Stream Watering System,** number	**Rotational Grazing,** number	**Workshops and Field Days,** number	**Contacts made,** number
2010	165	331	165	165	331	1	1	2	2		13	250
2011	165	331	165	165	331	1	1	2	2	1	13	250
2012	165	331	165	165	331	1	1	2	2		13	250
Total	***496***	***993***	***496***	***496***	***993***	***3***	***3***	***6***	***6***	***1***	***39***	***750***
2013	165	331	165	165	331	1	1	2	2	1	13	250
2014	165	331	165	165	331	1	1	2	2		13	250
2015	165	331	165	165	331	1	1	2	2	1	13	250
Total	***993***	***1,985***	***993***	***993***	***1,985***	***6***	***6***	***12***	***12***	***3***	***78***	***1,500***
2017	165	331	165	165	331	1	1	2	2		13	250
2018	165	331	165	165	331	1	1	2	2	1	13	250
2019	165	331	165	165	331	1	1	2	2		13	250
2020	165	331	165	165	331	1	1	2	2	1	13	250

BMP Implementation Milestones, Cont.												
Cumulative Total												
	Cropland						*Livestock*				*Information and Education*	
Year	**Water- ways,** acres	**No-Till,** acres	**Buffers,** acres	**Terraces,** acres	**Minimum Till,** acres	**Vegetative Filter Strip,** acres	**Fenced Off Streams,** number	**Relocate Pasture Feeding Site,** number	**Off Stream Watering System,** number	**Rotational Grazing,** number	**Workshops and Field Days,** number	**Contacts made,** number
2021	165	331	165	165	331	1	1	2	2		13	250
2022	165	331	165	165	331	1	1	2	2	1	13	250
2023	165	331	165	165	331	1	1	2	2		13	250
2024	165	331	165	165	331	1	1	2	2	1	13	250
2025	165	331	165	165	331	1	1	2	2		13	250
2026	165	331	165	165	331	1	1	2	2	1	13	250
2027	165	331	165	165	331	1	1	2	2		13	250
2028	165	331	165	165	331	1	1	2	2	1	13	250
2029	165	331	165	165	331	1	1	2	2		13	250
2030	165	331	165	165	331	1	1	2	2	1	13	250
Total	***3,300***	***6,620***	***3,300***	***3,300***	***6,620***	***20***	***20***	***40***	***40***	***12***	***260***	***5,000***

10.0 Monitoring Water Quality Progress

The KDHE sampling data will be reviewed by the SLT every year. Data collected in the Targeted Areas will be of special interest. A composite review of BMPs implemented and monitoring data will be analyzed for effects resulting from the BMPs. The SLT will also ask KDHE to review analyzed data from all monitoring sources on a yearly basis.

KDHE has ongoing monitoring sites in the watershed. There are two types of monitoring sites utilized by KDHE: permanent and rotational. Permanent sites are continuously sampled, whereas rotational sites are only sampled every fourth year. All sampling sites will be continued into the future. Each site is tested for nutrients, metals, ammonia, solid fractions, turbidity, alkalinity, pH, dissolved oxygen, E. coli bacteria and chemicals. Not all sites are tested for these pollutant indicators at each collection time. This is dependent upon the anticipated pollutant concern as well as other factors.

Stream flow data is collected by the USGS and will be available for SLT review. At publication time of this report, depending on the sampling site, up to six different parameters are sampled: water temperature, specific conductance, gage height, discharge, precipitation and turbidity. Samples are automatically taken every 15 minutes. Reviewing this data will indicate whether rainfall events in the upper reaches of the watershed have been slowed by BMPs such as dry ponds and sediment basins.

The COE has three sampling sites in John Redmond Reservoir and one site immediately below the dam. Reservoirs are sampled on a rotational basis around the Tulsa District. Since there are 36 projects in the District, John Redmond Reservoir was last sampled in 1997. Samples taken are analyzed for temperature, dissolved oxygen, alkalinity, hardness, pH, conductivity, total dissolved solids, chloride, sulfate, turbidity, total suspended solids, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, iron, copper, zinc, manganese, cadmium, chromium, mercury, arsenic, lead, nickel and selenium.

Much of the evaluative information can be obtained through the existing networks and sampling plans of KDHE, USGS and the Tulsa District, COE. Public engagement can be obtained through observations of reservoir clarity, ease of boating and the physical appearance of the reservoir. Some communications with the COE will supplement any information on the conditions in the Neosho River drainage and in John Redmond Reservoir.

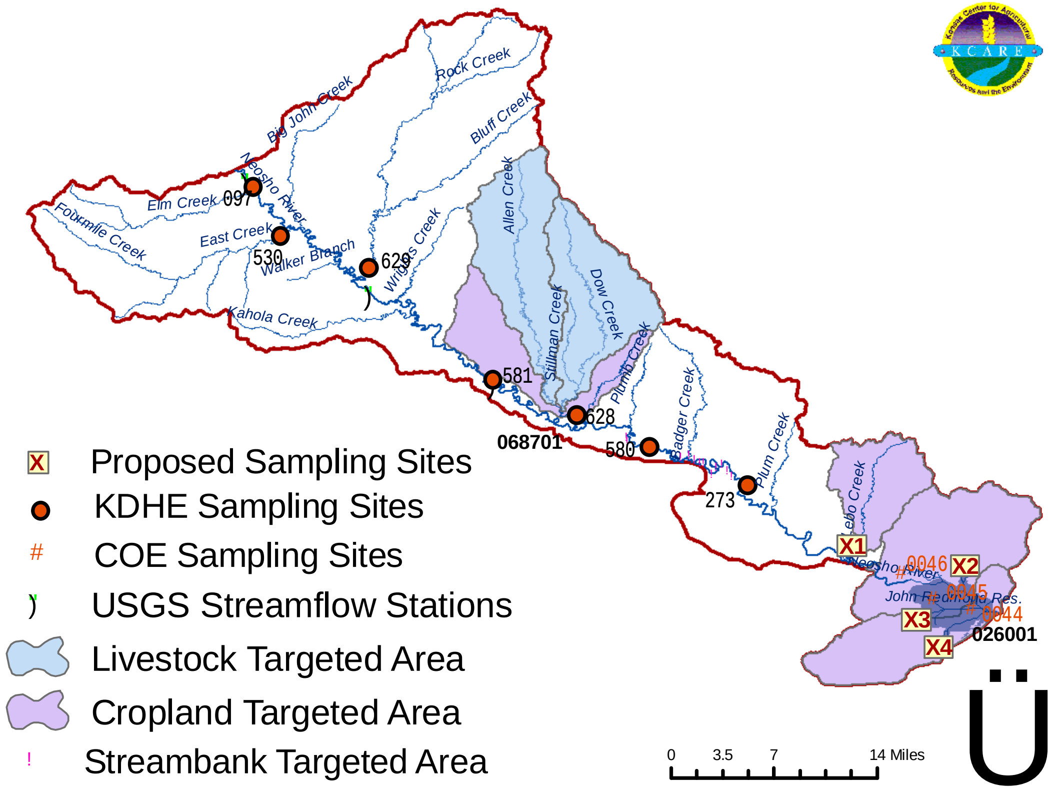


Figure 39. Monitoring Sites in the Watershed. [41] KDHE monitoring sites, 2009. USGS Streamflow Stations, 2001. COE provided sites, John Redmond Report, 1999.

Monitoring data will be used to direct the SLT in their evaluation of water quality progress. KDHE will be requested to provide any additional monitoring sites that need to be installed. The table below indicates which current monitoring sites data will be used by the SLT in determination of effectiveness of BMP implementation.

Table 48. Monitoring Sites and Tests Needed to Direct SLT in Water Quality Evaluation.

Cropland Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	628	Sediment, Phosphorus	Allen/Dows Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	026001	Sediment, Phosphorus	John Redmond Reservoir	Secchi Disk Depth, TSS, pH, DO, Phosphorus, Nitrogen
COE	0044	Sediment, Phosphorus	John Redmond Reservoir	Secchi Disk Depth, TSS, pH, DO, Phosphorus, Nitrogen

Monitoring Sites and Tests Needed, Cont.				
Cropland Targeted Area, Cont.				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
COE	0045	Sediment, Phosphorus	John Redmond Reservoir	Secchi Disk Depth, TSS, pH, DO, Phosphorus, Nitrogen
COE	0046	Sediment, Phosphorus	John Redmond Reservoir	Secchi Disk Depth, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X1 (refer to map above)	Sediment, Phosphorus	Lebo Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X2 (refer to map above)	Sediment, Phosphorus	Hickory Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X3 (refer to map above)	Sediment, Phosphorus	Jacobs Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site X4 (refer to map above)	Sediment, Phosphorus	Otter Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
Range and Livestock Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	628	Phosphorus, E. coli bacteria	Allen/Dows Creek	pH, DO, Phosphorus, Nitrogen, E.coli bacteria
Streambank Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	581	Sediment Phosphorus	Neosho River	TSS, pH, DO, Phosphorus, Nitrogen
KDHE	273	Sediment Phosphorus	Neosho River	TSS, pH, DO, Phosphorus, Nitrogen
KDHE	026001	Sediment, Phosphorus	John Redmond Reservoir	TSS, pH, DO, Phosphorus, Nitrogen
COE	0044	SedimentPhosphorus	John Redmond Reservoir	TSS, pH, DO, Phosphorus, Nitrogen
COE	0045	Sediment Phosphorus	John Redmond Reservoir	TSS, pH, DO, Phosphorus, Nitrogen

Monitoring Sites and Tests Needed, Cont.				
Streambank Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
COE	0046	Sediment Phosphorus	John Redmond Reservoir	TSS, pH, DO, Phosphorus, Nitrogen

Monitoring site data that is being generated at this time will be helpful to the SLT. Many of the existing monitoring sites will benefit multiple Targeted Areas and the sites in John Redmond Reservoir will benefit all Targeted Areas.

Below is a summary of site placement (existing and proposed) to support BMP evaluation in the targeted areas:

- The *Cropland Targeted Area* can utilize KDHE sampling site 628 for sediment and nutrient determination for the upper section of the targeted area. All sites in John Redmond Reservoir would be utilized to analyze sediment and nutrient concentrations from the entire watershed. The lower section of the cropland targeted area could benefit with additional monitoring on streams directly entering John Redmond Reservoir:
    - Site X1 - Lebo Creek as it enters John Redmond Reservoir.
    - Site X2 – Hickory Creek as it enters John Redmond Reservoir.
    - Site X3 – Jacobs Creek as it enters John Redmond Reservoir.
    - Site X4 – Otter Creek as it enters John Redmond Reservoir.
- The *Livestock Targeted Area* has one KDHE sampling site (628). This sampling site should be sufficient since it drains the entire targeted area prior to the creeks entering the Neosho River.
- The *Streambank Targeted Area* has several KDHE monitoring sites. Site number 581 is upstream of the Tier One Restoration Projects and can be used as a control reference. Site number 273 is downstream of the Restoration Projects and can be used to detect changes in sediment and nutrients after the projects are completed. All COE and KDHE sites in the reservoir can be used to determine if there has been a difference in sediment and nutrients over time.

Analysis of the data generated will be used to determine effectiveness of implemented BMPs. If the SLT decides at some point in the future that more data is required, they can discuss this with KDHE. All KDHE and COE data will be shared with the SLT and can then be passed on to the watershed residents by way of the information and education efforts discussed previously.

Monitoring data will be used to direct the SLT in their evaluation of water quality progress. KDHE will be requested to meet with the SLT to review the monitoring data accumulated by their sites on a yearly basis. However, the overall strategy and alterations of the WRAPS plan will be discussed with KDHE immediately after each update of the 303d list and subsequent TMDL designation. The upcoming years for this in the Neosho Headwaters Watershed is 2013 and 2018.

At this time, the plan can be altered or modified in order to meet the water quality goals as assigned by the SLT in the beginning of the WRAPS process.

11.0 Review of the Watershed Plan in 2015

In the year 2015, the plan will be reviewed and revised according to results acquired from monitoring data. At this time, the SLT will review the following criteria in addition to any other concerns that may occur at that time:

1. The SLT will ask KDHE for a report on the milestone achievements in **sediment** load reductions. The 2015 milestone for sediment should be based on the total suspended solids concentration in the watershed. In 2015, the milestones for total suspended solids reductions for the Neosho River near Americus and the Neosho River below Emporia should be 30 and 64 ppm, respectively.
2. The SLT will request from KDHE a report on the milestone achievements in **phosphorus** load reductions. The 2015 milestone for phosphorus should be based on the phosphorus concentration in the watershed. In 2015, the milestones for phosphorus reductions for the Neosho River near Americus and the Neosho River below Emporia should be 100 and 127 ppb, respectively.
3. The SLT will request a report from KDHE concerning the revisions of the TMDLs from 2013.
4. The SLT will request a report from KDHE, USCOE and Kansas Department of Wildlife and Parks on trends in water quality in John Redmond Reservoir.
5. The SLT will report on progress towards achieving the adoption rates listed in Section 9.1 of this report.
6. The SLT will report on progress towards achieving the benchmarks listed in Section 9.2 of this report.
7. The SLT will report on progress towards achieving the BMP implementations in Section 9.3 of this report.
8. The SLT will discuss impairments on the 303d list and the possibility of addressing these impairments prior to them being listed as TMDLs.
9. The SLT will discuss the effect of implementing BMPs aimed at specific TMDLs on the impairments listed on the 303d list.
10. The SLT will discuss necessary adjustments and revisions needed in the targets listed in this plan.

12.0 Appendix

12.1 Service Providers

Table 49. Potential Service Provider Listing

Organization	Programs	Purpose	Technical or Financial Assistance	Phone	Website address
Environmental Protection Agency	Clean Water State Revolving Fund Program Watershed Protection	Provides low cost loans to communities for water pollution control activities. To conduct holistic strategies for restoring and protecting aquatic resources based on hydrology rather than political boundaries.	Financial	913-551-7003 913-551-7003	www.epa.gov
Flint Hills RC&D	Natural resource development and protection	Plan and Implement projects and programs that improve environmental quality of life.	Technical	620-340-0133	www.ks.nrcs.usda.gov/
Kansas Alliance for Wetlands and Streams	Streambank Stabilization Wetland Restoration Cost share programs	The Kansas Alliance for Wetlands and Streams (KAWS) organized in 1996 to promote the protection, enhancement, restoration and establishment wetlands and streams in Kansas.	Technical	620-289-4663	www.kaws.org
Kansas Dept. of Agriculture	Watershed structures permitting.	Available for watershed districts and multipurpose small lakes development.	Technical and Financial	785-296-2933	www.accesskansas.org/kda

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
Kansas Dept. of Health and Environment	**Nonpoint Source Pollution Program** Municipal and livestock waste Livestock waste Municipal waste State Revolving Loan Fund	Provide funds for projects that will reduce nonpoint source pollution. Compliance monitoring. Makes low interest loans for projects to improve and protect water quality.	Technical and Financial	785-296-5500	www.kdhe.state.ks.us

Kansas Department of Wildlife and Parks	Land and Water Conservation Funds Conservation Easements for Riparian and Wetland Areas Wildlife Habitat Improvement Program North American Waterfowl Conservation Act MARSH program in coordination with Ducks Unlimited Chickadee Checkoff Walk In Hunting Program F.I.S.H. Program	Provides funds to preserve develop and assure access to outdoor recreation. To provide easements to secure and enhance quality areas in the state. To provide limited assistance for development of wildlife habitat. To provide up to 50 percent cost share for the purchase and/or development of wetlands and wildlife habitat. May provide up to 100 percent of funding for small wetland projects. Projects help with all nongame species. Funding is an optional donation line item on the KS Income Tax form. Landowners receive a payment incentive to allow public hunting on their property. Landowners receive a payment incentive to allow public fishing access to their ponds and streams.	Technical and Financial	620-672-5911 785-296-2780 620-672-5911 620-342-0658 620-672-5911	www.kdwp.state.ks.us/

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
Kansas Forest Service	Conservation Tree Planting Program Riparian and Wetland Protection Program	Provides low cost trees and shrubs for conservation plantings. Work closely with other agencies to promote and assist with establishment of riparian forestland and manage existing stands.	Technical	785-532-3312 785-532-3310	www.kansasforests.org
Kansas Rural Center	The Heartland Network Clean Water Farms-River Friendly Farms Sustainable Food Systems Project Cost share programs	The Center is committed to economically viable, environmentally sound and socially sustainable rural culture.	Technical and Financial	913-873-3431	www.kansasruralcenter.org
Kansas Rural Water Association	Technical assistance for Water Systems with Source Water Protection Planning.	Provide education, technical assistance and leadership to public water and wastewater utilities to enhance the public health and to sustain Kansas' communities	Technical	785-336-3760	www.krwa.net

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
Kansas State Research and Extension	Kansas Center for Agricultural Resources and Environment (KCARE)	Provide programs, expertise and educational materials that relate to minimizing the impact of rural and urban activities on water quality.	Technical		www.kcare.ksu.edu
	Kansas Environmental Leadership Program (KELP)	Educational program to develop leadership for improved water quality.		785-532-7108	www.ksre.ksu.edu/kelp
	Kansas Local Government Water Quality Planning and Management	Provide guidance to local governments on water protection programs.		785-532-2643	www.ksre.ksu.edu/olg
	Rangeland and Natural Area Services (RNAS)	Reduce non-point source pollution emanating from Kansas grasslands.		785-532-0416	www.ksre.ksu.edu/olg
	WaterLINK	Service-learning projects available to college and university faculty and community watersheds in Kansas.			www.k-state/waterlink
	Kansas Pride: Healthy Ecosystems/Healthy Communities	Help citizens appraise their local natural resources and develop short and long term plans and activities to protect, sustain and restore their resources for the future.		785-532-5840	www.kansasprideprogram.ksu.edu/
	Citizen Science	Education combined with volunteer soil and water testing for enhanced natural resource stewardship.			www.ksre.ksu.edu/kswater/

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
Kansas Water Office	Public Information and Education	Provide information and education to the public on Kansas Water Resources	Technical and Financial	785-296-3185	www.kwo.org
No-Till on the Plains	Field days, seasonal meetings, tours and technical consulting.	Provide information and assistance concerning continuous no-till farming practices.	Technical	888-330-5142	www.notill.org

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
State Conservation Commission and Conservation Districts	Water Resources Cost Share Nonpoint Source Pollution Control Fund Riparian and Wetland Protection Program Stream Rehabilitation Program Kansas Water Quality Buffer Initiative Watershed district and multipurpose lakes	Provide cost share assistance to landowners for establishment of water conservation practices. Provides financial assistance for nonpoint pollution control projects which help restore water quality. Funds to assist with wetland and riparian development and enhancement. Assist with streams that have been adversely altered by channel modifications. Compliments Conservation Reserve Program by offering additional financial incentives for grass filters and riparian forest buffers. Programs are available for watershed district and multipurpose small lakes.	Technical and Financial	Morris Co 620-767-5111 Wabaunsee Co 785-765-3329 Lyon Co 620-343-2812 Coffey Co 620-364-2313	www.accesskansas.org/kscc www.kacdnet.org

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
US Army Corps of Engineers	Planning Assistance to States Environmental Restoration	Assistance in development of plans for development, utilization and conservation of water and related land resources of drainage Funding assistance for aquatic ecosystem restoration.	Technical	816-983-3157 816-983-3157	www.usace.army.mil
US Fish and Wildlife Service	Fish and Wildlife Enhancement Program Private Lands Program	Supports field operations which include technical assistance on wetland design. Contracts to restore, enhance, or create wetlands.	Technical	785-539-3474 785-539-3474	www.fws.gov
US Geological Survey	National Streamflow Information Program Water Cooperative Program	Provide streamflow data Provide cooperative studies and water-quality information	Technical	785-832-3539	ks.water.usgs.gov Nrtwq.usgs.gov

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Phone	Website address
USDA-Natural Resources Conservation Service and Farm Service Agency	Conservation Compliance Conservation Operations Watershed Planning and Operations Wetland Reserve Program Wildlife Habitat Incentives Program Grassland Reserve Program, EQIP, and Conservation Reserve Program	Primarily for the technical assistance to develop conservation plans on cropland. To provide technical assistance on private land for development and application of Resource Management Plans. Primarily focused on high priority areas where agricultural improvements will meet water quality objectives. Cost share and easements to restore wetlands. Cost share to establish wildlife habitat which includes wetlands and riparian areas. Improve and protect rangeland resources with cost-sharing practices, rental agreements, and easement purchases.	Technical and Financial	Morris Co 620-767-5111 Wabaunsee Co 785-765-3329 Lyon Co 620-343-2812 Coffey Co 620-364-2313	www.ks.nrcs.usda.gov

12.2 BMP Definitions

***** (reduction explanations are provided on pages 40-41)***

Cropland

Vegetative Buffer
-Area of field maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife.
-On average for Kansas fields, 1 acre buffer treats 15 acres of cropland.
-50% erosion reduction efficiency, 50% phosphorous reduction efficiency
-Approx. $1,000/acre, 90% cost-share available from NRCS.

Grassed Waterway
-Grassed strip used as an outlet to prevent silt and gully formation.
-Can also be used as outlets for water from terraces.
-On average for Kansas fields, 1 acre waterway will treat 10 acres of cropland.
-40% erosion reduction efficiency, 40% phosphorous reduction efficiency.
-$800 an acre, 50% cost-share available from NRCS.

No-Till
-A management system in which chemicals may be used for weed control and seedbed preparation.
-The soil surface is never disturbed except for planting or drilling operations in a 100% no-till system.
-75% erosion reduction efficiency, 40% phosphorous reduction efficiency.
-WRAPS groups and KSU Ag Economists have decided $10 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share available from NRCS.

Conservation Crop Rotation
-Growing various crops on the same piece of land in a planned rotation.
-High residue crops (corn) with low residue crops (wheat, soybeans).
-Low residue crops in succession may encourage erosion.
-25% Erosion Reduction Efficiency, 25% phosphorous reduction efficiency
-WRAPS groups and KSU Ag Economists have decided $5 an acre for 10 years is an adequate payment to entice producers to convert.

Terraces
-Earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
-One of the oldest/most common BMPs
-30% Erosion Reduction Efficiency, 30% phosphorous reduction efficiency
-$1.02 per linear foot, 50% cost-share available from NRCS

Nutrient Management Plan
-Managing the amount, source, placement, form and timing of the application of nutrients and soil amendments.
-Intensive soil testing
-25% erosion and 25% P reduction efficiency.
-WRAPS groups and KSU Ag Economists have decided $7.30 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share is available from NRCS.

Subsurface Fertilizer Application
-Placing or injecting fertilizer beneath the soil surface.
-Reduces fertilizer runoff.
-0% soil and 50% P reduction efficiency.
-$3.50 an acre for 10 years, no cost-share.
-WRAPS groups and KSU Ag Economists have decided $3.50 an acre for 10 years is an adequate payment to entice producers to convert, 50% cost-share is available from NRCS.

Livestock

Vegetative Filter Strip
-A vegetated area that receives runoff during rainfall from an animal feeding operation.
-Often require a land area equal to or greater than the drainage area (needs to be as large as the feedlot).
-10 year lifespan, requires periodic mowing or haying, average P reduction: 50%.
-$714 an acre

Relocate Feeding Sites
-Feedlot- Move feedlot or pens away from a stream, waterway, or body of water to increase filtration and waste removal of manure. Highly variable in price, average of $6,600 per unit.
-Pasture- Move feeding site that is in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (eg. move bale feeders away from stream). Highly variable in price, average of $2,203 per unit.
-Average P reduction: 30-80%

Alternative (Off-Stream) Watering System
-Watering system so that livestock do not enter stream or body of water.
-Studies show cattle will drink from tank over a stream or pond 80% of the time.
-10-25 year lifespan, average P reduction: 30-98% with greater efficiencies for limited stream access.
-$3,795 installed for solar system, including present value of maintenance costs.

Pond
-Water impoundment made by constructing an earthen dam.

-Traps sediment and nutrients from leaving edge of pasture.
-Provides source of water.
-50% P Reduction.
-Approximately $12,000

Rotational Grazing
-Rotating livestock within a pasture to spread manure more uniformly and allow grass to regenerate.
-May involve significant cross fencing and additional watering sites.
-50-75% P Reduction.
-Approximately $7,000 with complex systems significantly more expensive.

Stream Fencing
-Fencing out streams and ponds to prevent livestock from entering.
-95% P Reduction.
-25 year life expectancy.
-Approximately $4,106 per ¼ mile of fence, including labor, materials, and maintenance.

12.3 Sub Watershed Tables

12.3.1 Load Reduction Rates by Sub Watershed

Table 50. Sediment Reduction Rates by Sub Watershed

Sub-Watershed #34 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	44	166	55	33	83	381
2	88	331	110	66	166	761
3	132	497	166	99	248	1,142
4	177	662	221	132	331	1,523
5	221	828	276	166	414	1,904
6	265	993	331	199	497	2,284
7	309	1,159	386	232	579	2,665
8	353	1,324	441	265	662	3,046
9	397	1,490	497	298	745	3,427
10	441	1,655	552	331	828	3,807
11	486	1,821	607	364	910	4,188
12	530	1,986	662	397	993	4,569
13	574	2,152	717	430	1,076	4,950
14	618	2,318	773	464	1,159	5,330
15	662	2,483	828	497	1,242	5,711
16	706	2,649	883	530	1,324	6,092
17	750	2,814	938	563	1,407	6,473
18	795	2,980	993	596	1,490	6,853
19	839	3,145	1,048	629	1,573	7,234
20	883	3,311	1,104	662	1,655	7,615

Sub-Watershed #45 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	10	39	13	8	19	89
2	21	78	26	16	39	178
3	31	116	39	23	58	268
4	41	155	52	31	78	357
5	52	194	65	39	97	446
6	62	233	78	47	116	535
7	72	271	90	54	136	624
8	83	310	103	62	155	714
9	93	349	116	70	175	803

Sediment Reduction Rates by Sub Watershed, Cont.

10	103	388	129	78	194	892
11	114	427	142	85	213	981
12	124	465	155	93	233	1,070
13	134	504	168	101	252	1,160
14	145	543	181	109	271	1,249
15	155	582	194	116	291	1,338
16	165	621	207	124	310	1,427
17	176	659	220	132	330	1,516
18	186	698	233	140	349	1,606
19	196	737	246	147	368	1,695
20	207	776	259	155	388	1,784

Sub-Watershed #43 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	9	33	11	7	17	77
2	18	67	22	13	33	153
3	27	100	33	20	50	230
4	36	133	44	27	67	307
5	44	167	56	33	83	384
6	53	200	67	40	100	460
7	62	234	78	47	117	537
8	71	267	89	53	133	614
9	80	300	100	60	150	691
10	89	334	111	67	167	767
11	98	367	122	73	183	844
12	107	400	133	80	200	921
13	116	434	145	87	217	998
14	125	467	156	93	234	1,074
15	133	500	167	100	250	1,151
16	142	534	178	107	267	1,228
17	151	567	189	113	284	1,304
18	160	601	200	120	300	1,381
19	169	634	211	127	317	1,458
20	178	667	222	133	334	1,535

Sub-Watershed #14 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction

Sediment Reduction Rates by Sub Watershed, Cont.

1	20	75	25	15	37	172
2	40	149	50	30	75	343
3	60	224	75	45	112	515
4	80	298	99	60	149	686
5	99	373	124	75	186	858
6	119	448	149	90	224	1,029
7	139	522	174	104	261	1,201
8	159	597	199	119	298	1,372
9	179	671	224	134	336	1,544
10	199	746	249	149	373	1,716
11	219	821	274	164	410	1,887
12	239	895	298	179	448	2,059
13	259	970	323	194	485	2,230
14	278	1,044	348	209	522	2,402
15	298	1,119	373	224	559	2,573
16	318	1,193	398	239	597	2,745
17	338	1,268	423	254	634	2,917
18	358	1,343	448	269	671	3,088
19	378	1,417	472	283	709	3,260
20	398	1,492	497	298	746	3,431

Table 51. Phosphorus Reduction Rates by Sub Watershed

Sub-Watershed #34 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	40	79	20	30	50	218
2	79	159	40	60	99	437
3	119	238	60	89	149	655
4	159	318	79	119	199	874
5	199	397	99	149	248	1,092
6	238	477	119	179	298	1,311
7	278	556	139	208	347	1,529
8	318	635	159	238	397	1,747
9	357	715	179	268	447	1,966
10	397	794	199	298	496	2,184
11	437	874	218	328	546	2,403
12	477	953	238	357	596	2,621
13	516	1,033	258	387	645	2,839
14	556	1,112	278	417	695	3,058
15	596	1,191	298	447	745	3,276
16	635	1,271	318	477	794	3,495
17	675	1,350	338	506	844	3,713

Phosphorus Reduction Rates by Sub Watershed, Cont.

18	715	1,430	357	536	894	3,932
19	755	1,509	377	566	943	4,150
20	794	1,588	397	596	993	4,368

Sub-Watershed #45 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	8	17	4	6	10	46
2	17	33	8	13	21	92
3	25	50	13	19	31	138
4	33	67	17	25	42	184
5	42	84	21	31	52	230
6	50	100	25	38	63	276
7	59	117	29	44	73	322
8	67	134	33	50	84	368
9	75	151	38	56	94	414
10	84	167	42	63	105	460
11	92	184	46	69	115	506
12	100	201	50	75	126	552
13	109	218	54	82	136	598
14	117	234	59	88	146	644
15	126	251	63	94	157	690
16	134	268	67	100	167	736
17	142	285	71	107	178	783
18	151	301	75	113	188	829
19	159	318	80	119	199	875
20	167	335	84	126	209	921

Sub-Watershed #43 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	8	16	4	6	10	44
2	16	32	8	12	20	87
3	24	48	12	18	30	131
4	32	63	16	24	40	175
5	40	79	20	30	50	218
6	48	95	24	36	60	262
7	56	111	28	42	69	306

Phosphorus Reduction Rates by Sub Watershed, Cont.

8	63	127	32	48	79	349
9	71	143	36	54	89	393
10	79	159	40	60	99	436
11	87	175	44	65	109	480
12	95	190	48	71	119	524
13	103	206	52	77	129	567
14	111	222	56	83	139	611
15	119	238	60	89	149	655
16	127	254	63	95	159	698
17	135	270	67	101	169	742
18	143	286	71	107	179	786
19	151	302	75	113	188	829
20	159	317	79	119	198	873

Sub-Watershed #14 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total Load Reduction
1	29	58	14	22	36	159
2	58	115	29	43	72	317
3	87	173	43	65	108	476
4	115	231	58	87	144	635
5	144	289	72	108	180	793
6	173	346	87	130	216	952
7	202	404	101	151	252	1,111
8	231	462	115	173	289	1,269
9	260	519	130	195	325	1,428
10	289	577	144	216	361	1,587
11	317	635	159	238	397	1,745
12	346	692	173	260	433	1,904
13	375	750	188	281	469	2,063
14	404	808	202	303	505	2,221
15	433	866	216	325	541	2,380
16	462	923	231	346	577	2,539
17	490	981	245	368	613	2,698
18	519	1,039	260	389	649	2,856
19	548	1,096	274	411	685	3,015
20	577	1,154	289	433	721	3,174

12.3.2 Adoption Rates by Sub Watershed

Table 52. Short, Medium and Long Term Goals by Sub Watershed

	Sub-Watershed #34 Acres of Cropland BMPs Adopted Each Year						
	Year	Waterway	No-Till	Buffers	Terraces	Minimum Till	Total Treated Acreage
Short Term	1	50	99	50	50	99	348
	2	50	99	50	50	99	348
	3	50	99	50	50	99	348
Total		*149*	*298*	*149*	*149*	*298*	*1,044*
Medium Term	4	50	99	50	50	99	348
	5	50	99	50	50	99	348
	6	50	99	50	50	99	348
Total		*298*	*596*	*298*	*298*	*596*	*2,087*
Long Term	7	50	99	50	50	99	348
	8	50	99	50	50	99	348
	9	50	99	50	50	99	348
	10	50	99	50	50	99	348
	11	50	99	50	50	99	348
	12	50	99	50	50	99	348
	13	50	99	50	50	99	348
	14	50	99	50	50	99	348
	15	50	99	50	50	99	348
	16	50	99	50	50	99	348
	17	50	99	50	50	99	348
	18	50	99	50	50	99	348
	19	50	99	50	50	99	348
	20	50	99	50	50	99	348
Total		*994*	*1,988*	*994*	*994*	*1,988*	*6,958*

	Sub-Watershed #45 Acres of Cropland BMPs Adopted Each Year						
	Year	Waterway	No-Till	Buffers	Terraces	Minimum Till	Total Treated Acreage
Short Term	1	21	42	21	21	42	147
	2	21	42	21	21	42	147
	3	21	42	21	21	42	147
Total		*63*	*126*	*63*	*63*	*126*	*440*
Medium Term	4	21	42	21	21	42	147
	5	21	42	21	21	42	147
	6	21	42	21	21	42	147
Total		*126*	*251*	*126*	*126*	*251*	*879*
Long Term	7	21	42	21	21	42	147

Short, Medium and Long Term Goals by Sub Watershed, Cont.

	8	21	42	21	21	42	147
	9	21	42	21	21	42	147
	10	21	42	21	21	42	147
	11	21	42	21	21	42	147
	12	21	42	21	21	42	147
	13	21	42	21	21	42	147
	14	21	42	21	21	42	147
	15	21	42	21	21	42	147
	16	21	42	21	21	42	147
	17	21	42	21	21	42	147
	18	21	42	21	21	42	147
	19	21	42	21	21	42	147
	20	21	42	21	21	42	147
Total		*419*	*838*	*419*	*419*	*838*	*2,932*

Sub-Watershed #43 Acres of Cropland BMPs Adopted Each Year

	Year	Waterway	No-Till	Buffers	Terraces	Minimum Till	Total Treated Acreage
Short Term	1	28	55	28	28	55	193
	2	28	55	28	28	55	193
	3	28	55	28	28	55	193
Total		*83*	*166*	*83*	*83*	*166*	*579*
Medium Term	4	28	55	28	28	55	193
	5	28	55	28	28	55	193
	6	28	55	28	28	55	193
Total		*166*	*331*	*166*	*166*	*331*	*1,159*
Long Term	7	28	55	28	28	55	193
	8	28	55	28	28	55	193
	9	28	55	28	28	55	193
	10	28	55	28	28	55	193
	11	28	55	28	28	55	193
	12	28	55	28	28	55	193
	13	28	55	28	28	55	193
	14	28	55	28	28	55	193
	15	28	55	28	28	55	193
	16	28	55	28	28	55	193
	17	28	55	28	28	55	193
	18	28	55	28	28	55	193
	19	28	55	28	28	55	193
	20	28	55	28	28	55	193
Total		*552*	*1,104*	*552*	*552*	*1,104*	*3,863*

Short, Medium and Long Term Goals by Sub Watershed, Cont.

	Sub-Watershed #14 Acres of Cropland BMPs Adopted Each Year						
	Year	Waterway	No-Till	Buffers	Terraces	Minimum Till	Total Treated Acreage
Short Term	1	67	134	67	67	134	470
	2	67	134	67	67	134	470
	3	67	134	67	67	134	470
Total		*202*	*403*	*202*	*202*	*403*	*1,411*
Medium Term	4	67	134	67	67	134	470
	5	67	134	67	67	134	470
	6	67	134	67	67	134	470
Total		*403*	*806*	*403*	*403*	*806*	*2,822*
Long Term	7	67	134	67	67	134	470
	8	67	134	67	67	134	470
	9	67	134	67	67	134	470
	10	67	134	67	67	134	470
	11	67	134	67	67	134	470
	12	67	134	67	67	134	470
	13	67	134	67	67	134	470
	14	67	134	67	67	134	470
	15	67	134	67	67	134	470
	16	67	134	67	67	134	470
	17	67	134	67	67	134	470
	18	67	134	67	67	134	470
	19	67	134	67	67	134	470
	20	67	134	67	67	134	470
Total		*1,344*	*2,688*	*1,344*	*1,344*	*2,688*	*9,408*

12.3.3 Costs by Sub Watershed

Table 53. Costs by Sub Watershed.

Sub-Watershed #34 Annual Cost, Cropland BMPs						
Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$3,976	$7,722	$3,313	$4,970	$3,861	$23,843
2	$4,095	$7,954	$3,413	$5,119	$3,977	$24,558
3	$4,218	$8,193	$3,515	$5,273	$4,096	$25,295
4	$4,345	$8,438	$3,621	$5,431	$4,219	$26,054
5	$4,475	$8,692	$3,729	$5,594	$4,346	$26,835
6	$4,609	$8,952	$3,841	$5,762	$4,476	$27,640
7	$4,748	$9,221	$3,956	$5,934	$4,610	$28,470
8	$4,890	$9,498	$4,075	$6,112	$4,749	$29,324

9	$5,037	$9,782	$4,197	$6,296	$4,891	$30,203
10	$5,188	$10,076	$4,323	$6,485	$5,038	$31,110
11	$5,343	$10,378	$4,453	$6,679	$5,189	$32,043
12	$5,504	$10,690	$4,586	$6,880	$5,345	$33,004
13	$5,669	$11,010	$4,724	$7,086	$5,505	$33,994
14	$5,839	$11,341	$4,866	$7,299	$5,670	$35,014
15	$6,014	$11,681	$5,012	$7,518	$5,840	$36,065
16	$6,194	$12,031	$5,162	$7,743	$6,016	$37,146
17	$6,380	$12,392	$5,317	$7,975	$6,196	$38,261
18	$6,572	$12,764	$5,476	$8,215	$6,382	$39,409
19	$6,769	$13,147	$5,641	$8,461	$6,573	$40,591
20	$6,972	$13,541	$5,810	$8,715	$6,771	$41,809

3% Annual Cost Inflation

Sub-Watershed #45 Annual Cost, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$1,675	$3,254	$1,396	$2,094	$1,627	$10,046
2	$1,725	$3,351	$1,438	$2,157	$1,676	$10,347
3	$1,777	$3,452	$1,481	$2,222	$1,726	$10,657
4	$1,831	$3,555	$1,525	$2,288	$1,778	$10,977
5	$1,885	$3,662	$1,571	$2,357	$1,831	$11,307
6	$1,942	$3,772	$1,618	$2,428	$1,886	$11,646
7	$2,000	$3,885	$1,667	$2,500	$1,943	$11,995
8	$2,060	$4,002	$1,717	$2,575	$2,001	$12,355
9	$2,122	$4,122	$1,768	$2,653	$2,061	$12,726
10	$2,186	$4,245	$1,821	$2,732	$2,123	$13,107
11	$2,251	$4,373	$1,876	$2,814	$2,186	$13,501
12	$2,319	$4,504	$1,932	$2,899	$2,252	$13,906
13	$2,388	$4,639	$1,990	$2,986	$2,319	$14,323
14	$2,460	$4,778	$2,050	$3,075	$2,389	$14,752
15	$2,534	$4,921	$2,112	$3,167	$2,461	$15,195
16	$2,610	$5,069	$2,175	$3,262	$2,535	$15,651
17	$2,688	$5,221	$2,240	$3,360	$2,611	$16,120
18	$2,769	$5,378	$2,307	$3,461	$2,689	$16,604
19	$2,852	$5,539	$2,377	$3,565	$2,770	$17,102
20	$2,937	$5,705	$2,448	$3,672	$2,853	$17,615

3% Annual Cost Inflation

Sub-Watershed #43 Annual Cost, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total

Costs by Sub Watershed, Cont.

1	$2,207	$4,287	$1,839	$2,759	$2,143	$13,236
2	$2,273	$4,416	$1,895	$2,842	$2,208	$13,633
3	$2,342	$4,548	$1,951	$2,927	$2,274	$14,042
4	$2,412	$4,684	$2,010	$3,015	$2,342	$14,463
5	$2,484	$4,825	$2,070	$3,105	$2,412	$14,897
6	$2,559	$4,970	$2,132	$3,198	$2,485	$15,344
7	$2,636	$5,119	$2,196	$3,294	$2,559	$15,804
8	$2,715	$5,272	$2,262	$3,393	$2,636	$16,279
9	$2,796	$5,431	$2,330	$3,495	$2,715	$16,767
10	$2,880	$5,593	$2,400	$3,600	$2,797	$17,270
11	$2,966	$5,761	$2,472	$3,708	$2,881	$17,788
12	$3,055	$5,934	$2,546	$3,819	$2,967	$18,322
13	$3,147	$6,112	$2,622	$3,934	$3,056	$18,871
14	$3,241	$6,296	$2,701	$4,052	$3,148	$19,437
15	$3,339	$6,484	$2,782	$4,173	$3,242	$20,021
16	$3,439	$6,679	$2,866	$4,298	$3,339	$20,621
17	$3,542	$6,879	$2,952	$4,427	$3,440	$21,240
18	$3,648	$7,086	$3,040	$4,560	$3,543	$21,877
19	$3,758	$7,298	$3,131	$4,697	$3,649	$22,533
20	$3,870	$7,517	$3,225	$4,838	$3,759	$23,209

3% Annual Cost Inflation

Sub-Watershed #14 Annual Cost, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$5,376	$10,442	$4,480	$6,720	$5,221	$32,238
2	$5,537	$10,755	$4,614	$6,922	$5,377	$33,205
3	$5,703	$11,077	$4,753	$7,129	$5,539	$34,202
4	$5,875	$11,410	$4,895	$7,343	$5,705	$35,228
5	$6,051	$11,752	$5,042	$7,563	$5,876	$36,284
6	$6,232	$12,105	$5,194	$7,790	$6,052	$37,373
7	$6,419	$12,468	$5,349	$8,024	$6,234	$38,494
8	$6,612	$12,842	$5,510	$8,265	$6,421	$39,649
9	$6,810	$13,227	$5,675	$8,513	$6,614	$40,839
10	$7,014	$13,624	$5,845	$8,768	$6,812	$42,064
11	$7,225	$14,033	$6,021	$9,031	$7,016	$43,326
12	$7,442	$14,454	$6,201	$9,302	$7,227	$44,625
13	$7,665	$14,887	$6,387	$9,581	$7,444	$45,964
14	$7,895	$15,334	$6,579	$9,869	$7,667	$47,343
15	$8,132	$15,794	$6,776	$10,165	$7,897	$48,763
16	$8,376	$16,268	$6,980	$10,470	$8,134	$50,226
17	$8,627	$16,756	$7,189	$10,784	$8,378	$51,733
18	$8,886	$17,258	$7,405	$11,107	$8,629	$53,285

Costs by Sub Watershed, Cont.

19	$9,152	$17,776	$7,627	$11,440	$8,888	$54,884
20	$9,427	$18,309	$7,856	$11,784	$9,155	$56,530

3% Annual Cost Inflation

Sub-Watershed #34 Annual Cost After Cost-Share, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$1,988	$4,711	$331	$2,485	$3,861	$13,376
2	$2,048	$4,852	$341	$2,560	$3,977	$13,777
3	$2,109	$4,998	$352	$2,636	$4,096	$14,191
4	$2,172	$5,147	$362	$2,715	$4,219	$14,617
5	$2,238	$5,302	$373	$2,797	$4,346	$15,055
6	$2,305	$5,461	$384	$2,881	$4,476	$15,507
7	$2,374	$5,625	$396	$2,967	$4,610	$15,972
8	$2,445	$5,794	$407	$3,056	$4,749	$16,451
9	$2,518	$5,967	$420	$3,148	$4,891	$16,945
10	$2,594	$6,146	$432	$3,242	$5,038	$17,453
11	$2,672	$6,331	$445	$3,340	$5,189	$17,976
12	$2,752	$6,521	$459	$3,440	$5,345	$18,516
13	$2,834	$6,716	$472	$3,543	$5,505	$19,071
14	$2,919	$6,918	$487	$3,649	$5,670	$19,643
15	$3,007	$7,125	$501	$3,759	$5,840	$20,233
16	$3,097	$7,339	$516	$3,872	$6,016	$20,840
17	$3,190	$7,559	$532	$3,988	$6,196	$21,465
18	$3,286	$7,786	$548	$4,107	$6,382	$22,109
19	$3,384	$8,020	$564	$4,231	$6,573	$22,772
20	$3,486	$8,260	$581	$4,357	$6,771	$23,455

3% Annual Cost Inflation

Sub-Watershed #45 Annual Cost After Cost-Share, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$838	$1,985	$140	$1,047	$1,627	$5,636
2	$863	$2,044	$144	$1,078	$1,676	$5,805
3	$889	$2,106	$148	$1,111	$1,726	$5,979
4	$915	$2,169	$153	$1,144	$1,778	$6,158
5	$943	$2,234	$157	$1,178	$1,831	$6,343
6	$971	$2,301	$162	$1,214	$1,886	$6,533
7	$1,000	$2,370	$167	$1,250	$1,943	$6,729
8	$1,030	$2,441	$172	$1,288	$2,001	$6,931
9	$1,061	$2,514	$177	$1,326	$2,061	$7,139
10	$1,093	$2,590	$182	$1,366	$2,123	$7,353
11	$1,126	$2,667	$188	$1,407	$2,186	$7,574
12	$1,159	$2,747	$193	$1,449	$2,252	$7,801

Costs by Sub Watershed, Cont.

13	$1,194	$2,830	$199	$1,493	$2,319	$8,035
14	$1,230	$2,915	$205	$1,538	$2,389	$8,276
15	$1,267	$3,002	$211	$1,584	$2,461	$8,525
16	$1,305	$3,092	$217	$1,631	$2,535	$8,780
17	$1,344	$3,185	$224	$1,680	$2,611	$9,044
18	$1,384	$3,280	$231	$1,731	$2,689	$9,315
19	$1,426	$3,379	$238	$1,782	$2,770	$9,595
20	$1,469	$3,480	$245	$1,836	$2,853	$9,882

3% Annual Cost Inflation

Sub-Watershed #43 Annual Cost After Cost-Share, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$1,104	$2,615	$184	$1,380	$2,143	$7,426
2	$1,137	$2,693	$189	$1,421	$2,208	$7,648
3	$1,171	$2,774	$195	$1,464	$2,274	$7,878
4	$1,206	$2,858	$201	$1,507	$2,342	$8,114
5	$1,242	$2,943	$207	$1,553	$2,412	$8,357
6	$1,279	$3,032	$213	$1,599	$2,485	$8,608
7	$1,318	$3,122	$220	$1,647	$2,559	$8,866
8	$1,357	$3,216	$226	$1,697	$2,636	$9,132
9	$1,398	$3,313	$233	$1,748	$2,715	$9,406
10	$1,440	$3,412	$240	$1,800	$2,797	$9,689
11	$1,483	$3,514	$247	$1,854	$2,881	$9,979
12	$1,528	$3,620	$255	$1,910	$2,967	$10,279
13	$1,573	$3,728	$262	$1,967	$3,056	$10,587
14	$1,621	$3,840	$270	$2,026	$3,148	$10,905
15	$1,669	$3,955	$278	$2,087	$3,242	$11,232
16	$1,719	$4,074	$287	$2,149	$3,339	$11,569
17	$1,771	$4,196	$295	$2,214	$3,440	$11,916
18	$1,824	$4,322	$304	$2,280	$3,543	$12,273
19	$1,879	$4,452	$313	$2,349	$3,649	$12,641
20	$1,935	$4,585	$323	$2,419	$3,759	$13,021

3% Annual Cost Inflation

Sub-Watershed #14 Annual Cost After Cost-Share, Cropland BMPs

Year	Waterways	No-Till	Buffers	Terraces	Min. Till	Total
1	$2,688	$6,369	$448	$3,360	$5,221	$18,086
2	$2,769	$6,560	$461	$3,461	$5,377	$18,629
3	$2,852	$6,757	$475	$3,565	$5,539	$19,188
4	$2,937	$6,960	$490	$3,672	$5,705	$19,763

Costs by Sub Watershed, Cont.

5	$3,025	$7,169	$504	$3,782	$5,876	$20,356
6	$3,116	$7,384	$519	$3,895	$6,052	$20,967
7	$3,210	$7,605	$535	$4,012	$6,234	$21,596
8	$3,306	$7,833	$551	$4,132	$6,421	$22,244
9	$3,405	$8,068	$568	$4,256	$6,614	$22,911
10	$3,507	$8,311	$585	$4,384	$6,812	$23,598
11	$3,612	$8,560	$602	$4,516	$7,016	$24,306
12	$3,721	$8,817	$620	$4,651	$7,227	$25,035
13	$3,832	$9,081	$639	$4,791	$7,444	$25,786
14	$3,947	$9,354	$658	$4,934	$7,667	$26,560
15	$4,066	$9,634	$678	$5,082	$7,897	$27,357
16	$4,188	$9,923	$698	$5,235	$8,134	$28,178
17	$4,313	$10,221	$719	$5,392	$8,378	$29,023
18	$4,443	$10,528	$740	$5,554	$8,629	$29,894
19	$4,576	$10,843	$763	$5,720	$8,888	$30,790
20	$4,713	$11,169	$786	$5,892	$9,155	$31,714

3% Annual Cost Inflation

13.0 Bibliography

[1] Kansas Water Office. Reservoir Fact Sheets. http://www.kwo.org/reservoirinformation/reservoir%20information.htm

[2] Kansas Unified Watershed Assessment 1999. Kansas Department of Health and Environment and the United States Department of Agriculture Natural Resources Conservation Service. http://www.kdheks.gov/nps/resources/uwa.pdf

[3] Kansas Applied Remote Sensing Program,2005. Kansas Geospatial Community Commons

[4] Kansas Surface Water Register, 2004. Kansas Department of Health and Environment. http://www.kdheks.gov/befs/download/2004r_WR_ALL_052405.pdf

[5] US Fish and Wildlife Service. http://www.fws.gov/southwest/es/oklahoma/madtom.htm

[6] Kansas Department of Health and Environment. List of exceptional state waters (ESW), special aquatic life use waters (SALU) and outstanding national resource waters (ONRW). 2007. http://www.kdheks.gov/nps/resources/specwaterinfo.pdf

[7] Kansas Water Office. 2009.

[8] Internet source. http://www.pollutionissues.com/Pl-Re/Point-Source.html

[9] *Permitted Point Source Facilities*: BASINS. Online reference information available at: *http://www.epa.gov/waterscience/basins/index.htm*

[10] EPA estimates "10 to 20 % of onsite wastewater systems malfunction each year". http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=265 Technical team used best professional guess to claim the number of failing septic systems to be 10%.

[11] Kansas Geospatial Community Commons. Kansas Department of Health and Environment. Rural Water Districts, 2006, Public Water Supply, 1994. NPDES Treatment Facilities, 1994. http://www.kansasgis.org/catalog/catalog.cfm

[12] Kansas Geospatial Community Commons. http://www.kansasgis.org/catalog/catalog.cfm

[13] Kansas Department of Health and Environment. The Basics of TMDLs. http://www.kdheks.gov/tmdl/basic.htm#tmdl

[14] Kansas Department of Health and Environment. Kansas TMDL Development Cycle. 2009. http://www.kdheks.gov/tmdl/download/Kansas_TMDL_Development_Cycle.pdf

[15] Kansas Department of Health and Environment, 2002.
http://www.kdheks.gov/tmdl/ne/AllenCk_Cu.pdf
http://www.kdheks.gov/tmdl/ne/Allen(Dows)Cr_FCB.pdf
http://www.kdheks.gov/tmdl/ne/Allen(Dows)Cr_DO.pdf
http://www.kdheks.gov/tmdl/ne/RedmondE.pdf
http://www.kdheks.gov/tmdl/ne/RedmondSILT.pdf
http://www.kdheks.gov/tmdl/ne/JonesE.pdf

[16] Kansas Geospatial Community Commons. http://www.kansasgis.org/catalog/catalog.cfm

[17] Kansas Department of Health and Environment, 2002.
http://www.kdheks.gov/tmdl/ne/AllenCk_Cu.pdf
http://www.kdheks.gov/tmdl/ne/Allen(Dows)Cr_FCB.pdf
http://www.kdheks.gov/tmdl/ne/Allen(Dows)Cr_DO.pdf
http://www.kdheks.gov/tmdl/ne/RedmondE.pdf
http://www.kdheks.gov/tmdl/ne/RedmondSILT.pdf
http://www.kdheks.gov/tmdl/ne/JonesE.pdf

[18] Kansas Department of Health and Environment, 2008.
http://www.kdheks.gov/tmdl/download/2008_303d_List.pdf

[19] Kansas Department of Health and Environment. 2010.
http://www.kdheks.gov/tmdl/download/2010_303_d_Delistings.pdf

[20] Provided by KDHE TMDL Watershed Management Section, November 2009.

[21] Determined by KDHE TMDL Watershed Management Section, November, 2009.

[22] Provided by KDHE TMDL Watershed Management Section, November 2009.

[23] Kansas Water Office. http://www.kwo.org/ARRA_Neosho.htm

[24] Kansas Water Office http://www.kwo.org/rpt_CWSRF_FacilitiesPlan_061509_sm.pdf

[25] The Watershed Institute. TWI. 2007.

[26] Available at: http://www.oznet.ksu.edu/library/h20ql2/mf2572.pdf

[27] Available at:
http://www.mwps.org/index.cfm?fuseaction=c_Categories.viewCategory&catID=719

[28] MF-2737 Available at: http://www.oznet.ksu.edu/library/h20ql2/mf2737.pdf
MF-2454 Available at: http://www.oznet.ksu.edu/library/ageng2/mf2454.pdf

[29] NRCS T factor. http://www.nrcs.usda.gov/technical/NRI/2007/nri07erosion.html

[30] Kansas Geospatial Commons. US Department of Agriculture Natural Resources Conservation Service. SSURGO. http://www.kansasgis.org/catalog/catalog.cfm

[31] Kansas Geospatial Commons. US Department of Agriculture Natural Resources Conservation Service. SSURGO. http://www.kansasgis.org/catalog/catalog.cfm

[32] Rainfall data records. http://countrystudies.us/united-states/weather/kansas/manhattan.htm

[33] CAFO data provided by Kansas Department of Health and Environment, 2003. Grazing density obtained from US Department of Agriculture National Agricultural Statistics Service, 2002. http://nationalatlas.gov/atlasftp.html?openChapters=chpagri#chpagri

[34] Kansas Applied Remote Sensing Program, 2005. Kansas Geospatial Community Commons.

[35] EPA estimates “10 to 20 % of onsite wastewater systems malfunction each year”. http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=265 The KSU technical team used best professional guess to claim the number of failing septic systems to be 10%.

[36] US Census Bureau, 2008. http://quickfacts.census.gov/qfd/states/2008.html

[37] Kansas Geospatial Commons. US Census Bureau. Tiger 2000 Census Blocks. http://www.kansasgis.org/catalog/catalog.cfm

[38] USDA/NRCS National Water and Climactic Center.

[39] Kansas Geospatial Commons. Kansas Department of Health and Environment, 2006.

[40] 2007 Census of Agriculture National Agricultural Statistic Service. (www.agcensus.usda.gov)

[41] Kansas Department of Health and Environment. 2009. Environmental Lake Monitoring Sites 1994. USGS Realtime streamflow stations, 2004. http://www-atlas.usgs.gov/atlasftp.html#realstx